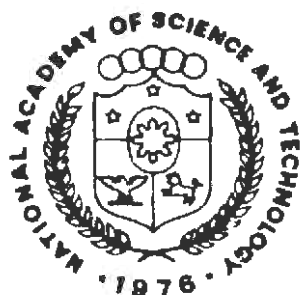


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**1983**  
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## **SOCIAL SCIENCES**



## AGRARIAN REFORM REVISITED: SOME POLICY IMPLICATIONS

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### Introduction

More than ten years have passed since the adoption of Martial Law and the issuance of Presidential Decree No. 27 liberating the farm workers from the bondage of the soil. And about twenty years have elapsed since the approval of the first Agricultural Land Reform Code in 1963. It is now time that our people look back and reassess the country's accomplishments in agrarian reforms in the light of policy goals set by reform legislation and the performance under martial law administration.

The policy goals set by agrarian reform legislation approved in 1963 are quite definite in regard to the redistribution of large landholdings and the provision of assistance to small farmers and landless workers. However, the slow and unsatisfactory implementation of land redistribution and the lack of financing for reform beneficiaries have forced the Congress to amend and approve R.A. No. 6389, now known as the Code of Agrarian Reform, on September 1, 1971. The new code reaffirmed the goals of agrarian land reforms and provided for the organization of the Department of Agrarian Reform, which is vested with the powers and functions of land reform implementation.

The implementation performance of the Ministry of Agrarian Reform is quite laudable and impressive in the setting of agrarian conflicts and social unrest in the last decade or so, and quite outstanding and far-reaching in terms of breaking up the large landholdings and redistributing them in small parcels to their occupants. The massive break-up of large landowner farms in rice and corn crops and their compulsory redistribution to their tiller-occupants is a distinct nationwide accomplishment which, set against the objectives of martial law administration, provides an exemplary manifestation of the political will in bringing about the much-delayed social justice through agrarian reforms. Such remarkable accomplishment must nevertheless be evaluated in relation to the primary goals of the Code of Agrarian Reform on 1971 and the socio-political dimensions of Martial Law administration, or the avowed purposes of the New Society. Has agrarian reform served as the cornerstone of the New Society? Are the benefits of land redistribution likely to contribute to an integrated rural development? Who are the real beneficiaries of the agrarian reform programs?

In attempting to answer these questions we would have helped in arriving at a serious appraisal of agrarian reform accomplishments, as seen in the light of public policy objectives and the goals of the New Society. Perhaps an impartial evaluation of the land reform programs could lead to an examination of the desirable policy alternatives and the programs or measures that should concretize or operationalize a feasible unified strategy, either by policy consensus or by gradual increments to a policy option that would merit popular support. In any case, a careful examination and assessment of the steps taken in the late 60's and during the 70's might lead the policy-makers and administrators to evolve action programs that would have relevance in the 80's and beyond.

### **The Achievements of Agrarian Reforms in the Decade of the 70's**

The accomplishments of the agrarian reform program in the 70's are integral components of the performance of the martial law administration inaugurated in 1972, barely two years after the approval of the Code of Agrarian Reform. These accomplishments, in their totality, form the cornerstone of the New Society. In the words of President Ferdinand Marcos.

"It (land reform) shall be the central point, the beacon towards which all programs of government must converge. The other programs must provide support to land reform. Our goal is to effect the most equitable sharing of all the wealth derived from our lands . . .<sup>1</sup>

With the above statement the President also made certain commitments, such as making the whole province of Nueva Ecija a land-reform area, directly to revise their rules and regulations governing financial assistance to small farmers, creating a separate single-line department of land reform, and generating adequate funds to support land reform.

An evaluation of the accomplishments of agrarian reforms in the New Society maybe made in the light of the socio-economic issues raised before the imposition of martial law and from the standpoint of the larger issues of an integrated approach towards agricultural and rural development without which no program for agrarian reforms could be successfully undertaken.

#### *Performance under land reform implementation*

The implementation of land redistribution in terms of landholdings transferred to the tillers, the number of leaseholds completed, and the number of farm lots titled, or granted CLT's and the amount of compensation made to farmer land-owners. In addition, the number of settlers and areas occupied in land settlement projects are part of the land redistribution program.

---

<sup>1</sup>From the address of President Ferdinand E. Marcos at the closing ceremonies of the 7th Anniversary of Land Reform at the SS Building, Quezon City, August 8, 1970.

		% of total
1. Number of CLT's completed	556,114	
Total area covered in ha.	730,734	
Number of CLT's issued to tenants	523,163	94%
Area covered by CLT's issued	624,723	85%
2. Land valuation and compensation		
a) Claims received and verified by MAR	396,082	
Claims verified and completed	119,221	30%
Area of claims verified and completed	192,787 ha.	26%
Number of landowners involved	6,949*	14%
b) Claims transmitted to the Land Bank of the Philippines		
Number of tenants with completed claims (out of a total 396,082)	113,704	29%
Area of landholdings involved	184,189 ha.	25%
Number of landowners involved	6,598*	13%
c) Approved by Land Bank for payment		
Number of tenants approved for payment	88,321	22%
Area of holdings involved	171,236 ha.	23%
Number of landowners involved	6,057	12%
Cost of land transferred	₱1,243M	
Cash payments made	₱182M	
3. Emancipation patents issued to those who have paid in full		
Number of tenants issued patents	1,684	0.43%
Number of patents issued	2,478	0.43%
Area covered by patents issued	1,539 ha.	0.21%
4. Leasehold contracts for tenants (completed as well as incomplete)		
Number of tenants with contracts	544,285	89%
Area with lease contracts	590,455	81%
5. Settlement projects administered and undertaken by MAR		
a) Number of projects administered by MAR	43	
Estimated area of settlements	708,750 ha.	
Number of settler families	47,431	

---

\*Out of a total of 49,221 landowners affected by land transfer



- b) Settlements established in Regions IX and XII for rebel-returnees and their families
- |                                   |       |
|-----------------------------------|-------|
| Number of settlements established | 11    |
| Number of families resettled      | 5,092 |
- c) World Bank-financed settlement projects
- |                     |                                      |
|---------------------|--------------------------------------|
| Number of projects  | 3 (Bukidnon, Agusan del Sur & Capiz) |
| Area covered in ha. | 77,000                               |
- Program components: infrastructure, land and forest development, rural health services, and food rationing.
6. Other supplementary projects
- a) Compact farms established by ACCA
- |                          |            |
|--------------------------|------------|
| Number of compact farms  | 685        |
| Number of farms involved | 20,448     |
| Area of compact farms    | 37,960 ha. |
- b) Cooperative farming
- Two fully established cooperative settlements one in Nueva Ecija and another in Magalang, Pampanga
- Thirty agriculturists are under training for the management of additional cooperative farms in different regions.
- c) Cooperative organization – to be organized in compact farms and in the settlements to be consolidated later into cooperative federations.

### *Interpretation of accomplishments*

Although the transfer of ownership to the tillers (tenants) on large holdings is deemed completed in 1980, much has yet to be done in the issuance of CLT's as well as in the verification of tenants' claims and the payment of compensation to landowners covered by land transfer. The capacity of the land settlements indicate that more tenants or landless farmers could be resettled through an aggressive and systematic resettlement program under the MAR.

By the end of 1980, only 94% of the targeted tenant beneficiaries have been issued land transfer certificates. Of the total area targetted for transfer to tenant-tillers, only 85% is covered by transfer certificates.

It is safe to say the least that only 30% of the beneficiaries have claims to their lots verified and completed. This means that less than 1/3 of the target clientele have their lots' location and boundaries verified and completely surveyed. The area covered is only 26% of the target area. Only 14% of the landowners affected have completed land surveys and land valuation for compensation pay-

ment. This indicates a very slow process of land survey and valuation by the land-reform authorities.

Transmittal of tenants' claims and compensation payments by the Land Bank are slower still, hampered mainly by land valuation problems and the difficulties of land surveys and titles of lands transferred. Out of total verified and completed by the MAR, only 113,704 or about 27% have been transmitted to the Land Bank. The area covered by compensation payments is about one-fourth (25%) of the total area verified and completed, affecting only 13% of the total number of landowners (49,221 landowners) involved in land transfer. One critical problem remains: how to speed up the transfer of tenants' claims for compensating payment by the Land Bank.

Up to the end of 1980, only 88,321 tenants or about 22% of total tenants targetted for land transfer, covering less than one-fourth (23%) of the area for transfer, have been covered by Land Bank compensation payments. A total of 6,057 landowners, or a little over one-tenth of the land-owners involved have received compensation payments amounting to P1,243M. Of this amount about P182.7M was paid in cash and the balance, in government bonds.

The completion of leasehold contracts on existing tenancies is more encouraging. The vast majority (89%) of the identified tenant farmers have lease contracts, covering about 81% of the total area under tenancies. This is about 105% of the tenant farmers in rice and corn lands (Census 1971).<sup>2</sup>

On the land settlements, much has yet to be done by resettling a larger number of tenants and landless workers from the subdivided estates and the densely populated communities and thus partly relieve the pressure on available cultivable lands. These settlers must also be provided technical and financial assistance in order to improve their productivity and income.

#### *Issues raised before the imposition of martial law*

In my paper read before the first seminar-symposium on land reform in September 1972, I raised economic and social issues which are directly related to land reform implementation.<sup>3</sup> Among the economic issues are: (1) productivity of the small farms in terms of net income per hectare or per farm; (2) the problem of equity, or equality of earnings from occupation on the land and equality of opportunity for employment in the various sectors of agriculture; (3) consideration of the factors that influence farm production, size, new technology, and mechanization; and (4) the economics of institution-building in the rural communities.

---

<sup>2</sup>Apparently, more rice tenancies have leasehold contracts than the total number of tenants on rice and corn farms covered by the Census 1971, owing to a large number of farm workers on small holdings who have been considered tenants under the Land Reform Code.

<sup>3</sup>Dalisay, A.M. Economic issues in land reform: the Philippines case. UPLB, Agrarian Reform Institute, Occasional Paper No. 4, 15 February 1976.

There are other issues that should have received proper attention, such as the importance of development planning at the regional and local levels, the decentralization of extension and other public supporting services, improvement and reorientation of on-going socio-economic institutions to help achieve the objectives of reform, and the capability for political and administrative functions for the tasks of reform implementation.

I said then at the Agrarian Reform Institute in Diliman, Quezon City, that the issues of farm productivity, "face rough sailing in the years ahead," mainly because of the slow development of outside market and the paucity of cost-reducing innovations and management skills most suitable to small farm units. Reinforcing a plea for more attention to the family-type farm, I pointed out:

"The intensive utilization of family labor together with the improvement of traditional farming practices could be the salvation of the small farm unit, or family-type farm. The shift to diversified or mixed farming and eventually to a high degree of production specialization is not a matter of extension or program objectives; this will depend mainly on the growth of the national or regional economy and the further expansion of the urban or industrial markets.<sup>4</sup>

Of course, it was also recognized that during the early years of reform, provisions must be made for the effective dissemination of research information (on new breeds or varieties and improved technology) direct extension assistance on the use of improved technology and the adoption of cost-reducing farming technique. The main task, then and now, of the agrarian reform authorities, is to coordinate the various projects and program at the local level and reorient the supporting services toward more effective reform implementation.

The problems of implementation were also discussed, particularly those related to the organization of a separate Department (now Ministry) of Agrarian Reform. While these administration problems were directly related to the attainment of higher productivity and income of the small parcels or farm lots transferred to the land-reform beneficiaries, others had relevance to the attainment of human resources and institutional development towards a higher quality of life.<sup>5</sup> The eventual organization and operation of the Ministry of Agrarian Reform have pointed at the extent of gravity and the complexity of these problems for the realization of land-reform goals. Some of these continue to persist up to the present time, underlining the inadequacies of the program now being implemented.

### *Inadequacies of the present land reform accomplishments*

The inadequacies of land-reform implementation in the last eight to ten

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<sup>4</sup>Dalisay, op. cit., p. 15

<sup>5</sup>For further details, see A.M. Dalisay, Land reform and problems of implementation, *Trade and Industry Journal*, vol. I No. 1, December 1963; also *CB News Digest*, vol. XVI, No. 5, January 28, 1964

years are apparent in the low productivity of small holdings of the land reform beneficiaries, increasing income inequality in the rural communities, the disarray among the public supporting system, and the low performance in institution-building in the rural areas.

The low productivity and consequent low incomes among the beneficiaries are shown in recent surveys in different parts of the country. For instance, in a study of 914 land reform beneficiaries distributed over 22 provinces, with farm lots, of less than two hectares, the average income per farm family amounted to ₱6,407; with average farm expenditures amounting to ₱3,376. Household expenditures varied by the size of the family, with the average household expenditures amounting to ₱4,648.00, thus resulting in a negative balance of ( ₱1,272.00).<sup>6</sup>

Even for IEDP farms covered by the study, with gross incomes relatively higher than the average for all farms surveyed, the net income could hardly cover the basic needs of the household for family members of farm and above. These would indicate that the land-reform beneficiaries covered by the survey have not attained a level of viability for their farms.

In a study completed by the Center for Policy and Development Studies, U.P. at Los Banos for the Land Bank of the Philippines,<sup>7</sup> results show that in the subdivided landed estates, with farms averaging 1.61 ha., the average income farm production per farm amounted to ₱11,818.00 for two crops of rice. With farm expenditures averaging 3,858 per farm per year, there is apparently some gross returns from farm operation. However, with household expenditures ranging from ₱5,471 to ₱12,961 per household, the available gross returns from farm production would not be able to provide for the basic needs of the farm family, much less meet amortization payments and other loans.

Even granting that the highest average income farm production per individual farm was about ₱8,252 from two crops of rice, on an average-size farm of 2.12 ha. (Gabaldon Estate, Nueva Ecija); with farm expenditures amounting to about ₱4,000 per year, the gross returns from the farm was hardly adequate to pay for household expenditures amounting to ₱19,253 per farm family. Again the viability of the family farm of the land-reform beneficiary is in question, unless income from off-farm and other services would be available in the future.

Earlier field surveys have indicated that although a significant increase in yields per hectare has been attained in areas where land reform has been implemented (Nicolas, 1974), with the amortizing owners having relatively higher yields than the CLT holders and the leaseholders, the net income effects were not clear, owing

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<sup>6</sup>Project Sunshine - A study of factors affecting land amortization payment by agrarian reform beneficiaries. Land Bank of the Philippines Task Force, March 1981 (Mimeo).

<sup>7</sup>CPDS. Integrated Credit Delivery System for the Countryside. A study supported by the Land Bank of the Philippines, U.P. at Los Baños, March 1981.

to increasing costs of inputs and the rising family or household expenditures. Studies by Mangahas *et al.* and by Sandoval and Gaon (1971) reveal that the effect of land tenure on productivity is neutral, that is, the average production of rice per hectare was roughly the same for all tenure groups. Moreover, the increased productivity was more a result of the adoption of improved rice technology than any tenurial change.

The low income among land-reform beneficiaries in the former landed estates is due mainly to small farm size, lack of credit facilities and other supporting services, and lack of technical and management guidance.

A later survey conducted in Central Luzon for the World Bank has shown that there is little or no difference in productivity hectares tenanted and owner-cultivated farms. The real constraint to productivity is the inadequacy of productive services and lack of access to irrigation facilities.<sup>8</sup>

Even if the land transfer program has a positive impact on the level of income of the land-reform beneficiaries, the tenants are observed to have remained at the same subsistence level owing to the additional financial burden arising from the high amortization schedules and lack of capital. Some tenants still prefer, in spite of the land transfer certificates, to remain share tenants because they are not sure whether they could afford to pay the amortization schedules. And they still have to consider the household expenses, including health and education expenditures.<sup>9</sup>

*Disarray of supporting services.* The increase in the number of extension service workers, or farm management technicians (FMT's), in the rural communities have not favored the land-reform beneficiaries. And the benefits of vocational and informal education courses in agricultural schools and colleges have not yet filtered down to the communities covered by land reform. Credit extension or financial support for farming activities among land-reform beneficiaries is spotty, if not entirely inadequate. In spite of the proliferation of formal credit institutions in the rural areas, including the rural banks, only 10-15 per cent of the farmers and landless workers have had access to rural credit.

The social physical infrastructures in agriculture, including the irrigation systems, have reached only a small portion of the land-reform beneficiaries. And the post-harvest marketing and processing facilities in the countryside are accessible mainly to large and well-to-do farmers. The land-reform beneficiaries have yet to build their warehouse and drying facilities, particularly for cereals, and possibly with the assistance of the Ministry of Agrarian Reform, set up the marketing and processing plants in selected land-reform areas.

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<sup>8</sup>World Bank: Profile of the Rural Sector. *Philippine Labor Review*, Vol. 1, No. 4. (1976), as cited by Librero and Manuel (1981).

<sup>9</sup>See Librero, Aida R. and P.C. Manuel. Social services and institutions for improved income and equity. Paper presented at the 27th PAEDA Annual Convention, Makati, Metro Manila. June 5, 1981.

The protracted reorganization of the Ministry of Agriculture (MA) which emphasizes the decentralization of its planning, regulatory, and productivity functions, has delayed a more dynamic production and marketing thrust in the high productivity areas, thus slowing down the growth of productivity and income in small agriculture. More important, the delayed reorganization and decentralization of powers and functions of the MA have held back the essential extension thrust for land-reform beneficiaries and the integration of production and marketing activities for all types of farming systems under various tenure changes or adjustments. Logically, the first to benefit from a decentralized MA administration would be the leaseholders and new owners (or CLT holders). This set up would also give focus on program coordination and implementation at the farm level. Without the proper local planning and implementation orientation among MA field personnel in collaboration with field staffs of higher ministries, little assistance could be extended to land-reform beneficiaries. Little or no accomplishment might be expected in rural development.

More than eight years ago I attempted a kaleidoscope of future MA activities, in the face of an expanded agrarian reform program, prognosticating that such functions or activities as agricultural marketing administration, collection and dissemination of agricultural statistics, agricultural research, and management of natural resources would remain with the MA. Other activities - promotional and educational activities in crops and livestock production, development of cooperatives, further expansion of the rural credit system, the development of handicrafts and small rural industries, and the strengthening of economic supports for community development - would be taken over by the MAR. This rested on the conviction that the job of coordinating and integrating the activities of the regular public agencies at the community level is the primary task of the Ministry of Agrarian Reform. Further, it is my firm belief that the economic and social underpinnings of agrarian reform must be realized through the integrative activities of the MAR if rural development in this country is to make any headway.

*Weaknesses of institution-building in the rural areas.* The weaknesses of institution-building, including those among the land-reform beneficiaries, are manifested in the slow, snail-pace growth of the agricultural cooperatives, and the poor performance of the national marketing system.

The pre-cooperative rural organizations or Samahang Nayan (SN), were established under the auspices of the MLGCD to assist their members carry out land reform operations and for other self-help purposes. While many of them are still in their organizational stage, others have become operational by engaging in activities pursuant to their objectives. However, some of them have become viable rural associations in the sense of fairly establishing their operations and making themselves indispensable in servicing the continuing needs of their members. In fact, a recent study by the Agricultural Credit and Cooperatives Institute (ACCI) at U.P. Los Baños, has revealed that the SNs continued to decline mainly because of loss of

interest among their members, lack of sustained training of their officers and members, and neglected supervision by the MLGCD representatives in the collection of the barrio guarantee and barrio savings funds.<sup>10</sup> It was shown that only 35% of the 806 SN samples completed training in the major courses required for members. Only a little half of the 5,347 officers and members attended all the training sessions, and of the total samples only 19% put up at least one of the required projects while 80% did not have any.

Implementation of training programs for SNs was constrained by lack of resource persons and logistical support for public agencies concerned, as well as lack of time for attendance among farmer-members. After the organizational stage, few of the SNs continued training activities for old and new members alike (Dumagat, 1981).

It should be noted that as of December 1978, there were 21,089 SNs organized with over one million members, and 17,596 were registered with 921,358 members. The bigger percentages of SNs organized and registered were in the regions of Western Visayas, Southern Tagalog and Central Luzon; smaller percentages were in Western and Northwestern Mindanao and the Cagayan Valley.

The organization and registration of area marketing cooperatives (AMC) was the next phase of the cooperative development program. As of December 1978, there were 52 organized AMCs, most of which were found in Central Luzon, Western Visayas. Not unlike the SNs, the AMCs are generally in the operational stage. Both the AMCs and the SNs are still trying to stabilize norms and operating procedures, hence very little is done towards the achievement of organizational objectives (Dumagat, 1981).

Dumagat has pointed out that the general inability of the SNs to maintain collection of the barrio guarantee and savings funds has limited the resources of the AMCs, compelling most of the latter to depend on loans for the CDLF of the Bureau of Cooperatives Development.<sup>11</sup> Partly for this reason, AMCs are unable to save the marketing needs of SN members. Moreover, AMCs tend to dissipate their capital resources and limit their business operations by permitting the increase of overdue receivables, big inventories, high cost of goods sold and operating expense. Subsequently, this results in net losses. Both the AMCs and SNs still have to find reliable market outlets for farm products. Most AMCs usually make profit only in their trading of farm inputs.

As the financing arm of the SNs cooperative rural banks (CRBs) have been organized in different regions to provide operating loans and extend technical assistance to the reform beneficiaries. As of March 1980, there were 22 CRBs operating with a combined paid-up capital of ₱28.1 million. Affiliated with these CRB's

<sup>10</sup>See ACCI, *The Samahang Nayon After the Plan II Development Training Program: an evaluation*. Unpublished Report, U.P. at Los Baños, 1977.

<sup>11</sup>Dumagat, F.L., *Some reflections on the factors of effectiveness and viability of rural organizations*. Published in the *Journal of Agricultural Economics and Development*, January 1981.

were 5,383 SNs with a total individual membership of 231,974.<sup>12</sup> Not unlike the other rural organizations and the SNs, those CRB's have become dependent on financing by the government and all suffer from the lack of competent management. Lately, these CRBs have declined in their lending operations because of high defaults on loan repayments from SN members and the consequent heavy operating losses.

On the further development of cooperatives among the supplementary program in land reform, one may ask why most of the compact farms have not been organized into cooperatives. One also wonders how the marketing cooperatives can be expected to grow on the basis of weak or cooperative primary cooperatives organization and on inefficient or non-operating SNs. It would be extremely sensible and indeed economically desirable to determine how past mistakes in organizational and operational stages can be conceived and new approaches adopted towards the reconstruction and further development of the marketing cooperatives as well as the cooperative rural banks.

There is a growing recognition in our society that the development of local organizations and institutions for the effective implementation of agrarian reforms cannot be left to government agencies alone. The public supporting services are expecting to provide initiative in this regard. But if they are to attain measure of success in organizing and strengthening development-oriented institutions, they must extend assistance to local organs of self-help, usually traditional organizations, and assist them in selecting and training local leadership potential.

Certain technical and financial incentives must be provided by the government for the more rapid development of local leadership. In this regard, the public supporting services, particularly agricultural extension and rural credit, have a distinct role to play in training local leaders for the growth and effectiveness of all types of cooperatives and for the improvement of marketing, storage and processing facilities in the rural communities. While the regular ministries, in cooperation with the existing financial institutions, could help establish and finance local organizations as these are related to the problems and issues of land reform, the traditional ones must be assisted in directing their activities towards increased productivity and better living conditions among the reform beneficiaries. What I emphasized some eight years ago<sup>13</sup>, may be worth repeating at this time:

"... definite outlays of public funds must be made available for the sustenance of a systematic approach to institution-building. It is not a question of whether public funds can be made available or not. The crucial decision is whether agrarian reform ... can afford to neglect the development of essential institutions."

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<sup>12</sup>Terso, Clemente E., Jr. Participation of the Bureau of Cooperatives Development in Agrarian Reform. Paper presented at the Agrarian Reform Seminar sponsored by the Agrarian Reform Institute, U.P. at Los Baños, January 24, 1981.

<sup>13</sup>Dalisay, op. cit., p. 9



*The larger issues of agrarian reform*

The larger issues consist in the determination of a socio-economic framework for, and feasibility of, an integrated approach to agrarian reform. Such a framework should lead to the adoption of an operation model or strategy, which would incorporate an action program towards increased productivity and a better quality of life for the reform beneficiaries. The approach would ensure in the long run the realization and effectiveness of countryside development. In the short run, the transfer of small holdings to the tillers, together with the diffusion of improved technology and essential support services would have become a reality.

A unified, comprehensive framework for agrarian reforms in this country derives its rationale from the extensive experience in community development during the last three decades. Public production programs in the last eight to ten years, notably the Masagana 99 and other production programs involving livestock, fisheries, and tree farming, have also yielded results that buttress community action programs in food self-sufficiency. Moreover, efforts in institution-building, particularly in the organization of agricultural marketing cooperatives, credit units, and community-based rural banks, although fraught with weaknesses in several aspects, have yielded insights that should fortify the resolve to continue the development of primary cooperatives and other farmers' associations at the community level and establish useful linkages among them. Lessons from martial law administration would support, to say the least, group action for local and regional development by systematic, pragmatic planning in the use of local resources and the alignment of local programs with those of the region and the entire country. All these contribute to a rational approach to the development of a definite framework for agrarian reforms.

**The Framework of Agrarian Reforms**

The framework for the implementation of genuine agrarian reforms may be derived from the elements or forces at work in an underdeveloped society, as perceived by authorities on agrarian reform in different countries or regions. It may also be conceived in terms of the structural and institutional support for effective land reform implementation, as prerequisites to comprehensive agrarian reforms. More important perhaps is the political will as expressed in public policy affecting land transfer and the infrastructure and institutional support that would bring it about. In the Philippine case, the political will is manifested not only in the political considerations which led to the approval of land-reform legislation (e.g. the Agrarian Land Reform Code), but also in the political decisions which brought about effective land reform implementation in the last decade.

*Elements and forces in a feasible agrarian reform framework*

Defining land reform as the redistribution of property or rights in land for the benefit of small farmers or agricultural laborers, Doreen Warriner, an authority on

agrarian reform in the Middle East and in Central Europe, emphasized that land reform should mean more than land redistribution, but it should at least mean that. What is the motivation of land reform? Warriner declares that it must be political; without political will no effective land reform is possible, even if legislation is passed as in the case of India and the Philippines.<sup>14</sup>

What can land reform expect to achieve? Warriner is positive that it can hope "to raise peasant living standards by raising peasant incomes." Casting aside aspersions on the inability of peasant recipients to improve their lot, Warriner points out that small farmers can farm with knowledge and skill, often better than larger farmers.

A more optimistic note is expressed by W. R. Cline, an American economist, who stated that land reform is "the most hopeful of all available policies for improving income distribution and production," based on the following conditions: (a) land is underutilized; (b) land is carried through with speed and certainty; (b) land is carried through with speed and certainty; and (c) credit and modern inputs are made available.<sup>15</sup>

However, in a more cautious approach, Warriner maintains that there are other constraints which persist even after the structure has been reformed, and these may even cause a reversion to the old structure. She enumerates such constraints as shortages of land and water, lack of infrastructure and others.

On structure and technology, Dale Adams, an American agricultural economist, questions the Hayami-Ruttan thesis that technological change produces structural and institutional adjustment, and expresses categorically that structural change is in many cases a prerequisite for development. He agrees with Warriner that the relative emphasis on reform and technological development depends on the circumstances of particular countries.<sup>16</sup>

It is now recognized that land reform will take place in many countries for political reasons. Some of them will have socio-economic goals, and practically all will emphasize the importance of improving the living standards of poor peasants and landless workers. The particular emphasis in an underdeveloped country will depend largely on the type of approach to rural development.

#### *The technocratic vs. reformist strategy in rural development*

The type of approach to rural development determines in many ways the emphasis or objectives of land reform. As emphasized by Griffin, the technocratic strategy and the radical strategy are the extreme points on a spectrum, while the reformist strategy rests at the middle. These strategies differ in their objectives, the ideology used to mobilize support and action, the dominant form of land-tenure

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<sup>14</sup>See Hunter, Guy (ed.), *Strategies for agricultural development in the 1970's: a summary and critique. Food Research Institute Studies*, Vol. XII, No. 1, 1973.

<sup>15</sup>As cited by Hunter, *op. cit.*, p. 45.

<sup>16</sup>Hunter, *op. cit.*, p. 46.

institution, and the way the benefits of the economic system are distributed. These strategies of rural development constitute differences in style.<sup>17</sup>

The *technocratic strategy*, as exemplified by the Philippines, Brazil, and Ivory Coast, has the prime economic objective of increasing agricultural output by incorporating more conventional inputs such as land (Brazil) and encouraging farmers to adopt an improved technology (Philippines). According to Griffin, its ideology is a liberal capitalist one, with emphasis on competition, free markets, and widely dispersed private property. In practice, however, property ownership is highly concentrated, as reflected in the dominant forms of land tenure institutions: plantations, large corporate farms, various forms of tenancy arrangements. The benefits of technical change and increased output, as cited by Griffin, accrue to the landholding elite and other men of property. And the concentration of income and wealth is to be regarded as one of the ways by which increased output is to be achieved and by which the generated savings of the rich would contribute to faster accumulation and growth.

On the other extreme of the spectrum is the *radical strategy* which, as emphasized by Griffin, has the first and foremost objective of achieving a rapid social change and a redistribution of political power, and the next priority the redistribution of wealth and income and, lastly, higher production. In case of conflict among these main objectives, the growth objective would give way to search for social, political, and economic equality. This strategy is exemplified by China, Cuba, and Algeria.

Its ideology is that of socialism. And in Asia, agrarian socialism is based on the assumption that it is possible to mobilize an untapped resource potential, the human labor. Under this ideology, institutional development aims at the establishment of collectives, communes or state farms which tend to favor small peasants and landless laborers. As applied to China, this strategy concentrates attention to the locality, with emphasis on local initiative rather than an outside assistance. This approach places relatively little emphasis on national agricultural planning and the manipulation of macro-economic aggregates or price signals.

With considerable experimentation on alternative means of organizing production and consumption in each locality and with institutional changes and even morality considered as capable of change, or as independent variables in a process of change, the motivations and institutional reforms involved in a radical strategy seems to be beyond the reach or capacity of many LDC's including the Philippines. One has therefore to place relatively more emphasis on a reformist strategy.

In the *reformist strategy*, as typified by Mexico and Egypt, the main objective of rural development places priority on redistribution income to some sections of the community and lower priority to increasing agricultural output. According to Griffin, attempts are made to reconcile greater equity with faster growth by changing agrarian institutions.

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<sup>17</sup>See Griffin, Keith. The political economy of agrarian changes (1974), pp. 198-203.

Basically, a compromise between two extreme positions in the spectrum of rural development, the reformist strategy manifests the tendency of governments adopting such a strategy to vascillate in the choice of policies. Thus inconsistencies frequently appeared between what a government proclaims and what it actually does. The reforms adopted are therefore partial, fragmented and incomplete, and these are concentrated in certain regions of the country. In the case of Mexico, this style has created a dualistic or bimodal agricultural sector. And in Egypt, while the original thrust of reform was to encourage labor-intensive farming on cooperatives and small holdings, there has been recently a shift to more capital-intensive techniques on larger farms particularly in reclaimed land.

Under this strategy, the ideology is nationalist and occasionally populist. And the dominant land tenure institutions tend to be family farms. However, where dualism is pronounced as in Mexico, there are small cooperatives and minifundia confronting large capitalist farms. The beneficiaries of this strategy are middle peasants on family farms and larger farmers on substantial holdings.

Apparently, some LDC's can move from the technocratic to the reformist strategy by the exercise of political will. And while the redistribution of income is largely from the upper income groups to the middle, those in the lowest income groups may be assisted in achieving higher income through greater employment opportunities and the improvement and reorientation of rural institutions. This is perhaps the main challenge to the Philippines.

#### *Structural and institutional support for land reforms*

As emphasized recently by the United Nations Development Programme (1979), land reform programs cannot lead to permanent agrarian reforms unless a range of agricultural support services, training opportunity and infrastructural needs are provided in sufficient quantity<sup>18</sup>. Experience in several Latin American countries, more than those in Africa and other regions, has demonstrated that rapid expropriation of land resulted in production losses caused mainly by loss of traditional credit sources, managerial problems in operating larger farm units, and a tendency to resent management advice of government-supported farm directors.

Moreover, if gains from land reform are to be permanent as the UNDP has pointed out, they must be seen in terms of their potential effects on agricultural employment and production and as a first step of a basic government strategy for agrarian reform and social justice.<sup>19</sup> In other words, land reform in terms of land redistribution and tenure adjustments is only a first step in a series of reforms towards economic equality and social transformation, which are the primary goals of comprehensive agrarian reforms.

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<sup>18</sup>Rural Development: Issues and Approaches for Technical Cooperation. New York: U.N. Development Programme Evaluation Study No. 2. June 1979.

<sup>19</sup>Ibid, p. 167.

It has also been observed that many reforms have stopped short of helping the smallest peasant and landless workers. As manifested in restrictive programs (including those in Pakistan, Thailand and the Philippines), the land reforms tend to favor the better-off sections and could actually contribute to rural poverty.<sup>20</sup>

*Elements/components of integrated rural development*

In the last decade or so, the emphasis of rural development in any LDC is on increased productivity on small farms through the adoption of improved technology. Recently emphasis was made on the additional provision of essential infrastructure and social services, (in order to assist the small producers to raise their productive capacity and improve their standard of living), together with measures to expand their participation in the development process. Such a shift in rural development strategy in Southeast Asia and other regions is due primarily to the dissatisfaction with the low yields and income arising from (new technology on) small holdings and from the tenure adjustments under land reform. Hence, the new emphasis in any rural development approach is to include institutional development and the significant role of human resources in such development.

Here in the Philippines, the strengthening of agrarian reform has come into the rural development strategy through the recognition of the importance of participatory mechanisms and the active involvement of the rural poor in rural development programs for community improvement. To raise the productivity and standard of living of the land-reform beneficiaries, who comprise the majority of the rural poor, there must be measures to improve their organizational and management capability. These are the same measures essential to the successful implementation of a dynamic and realistic rural development program.

I have always maintained that agrarian reform, besides its main goal of land redistribution, must cover such other essential elements as the diffusion of improved technologies, the provision of extension, credit, and market services, as well as a minimum of physical infrastructure (e.g. roads, irrigation, and water supply). While some of these measures have been implemented in some areas to transform small holdings into productive farms, certain shortcomings continue to persist. These are, among others, the inadequacy of extension and credit services to provide for the immediate needs of the small cultivators; the total aspect of institution-building, including the organization of farmers' associations and cooperatives which is slow and protracted; and inefficient marketing and distribution services in the land reform areas, which are not effectively linked to the production activities of small cultivators. Together with weak or absence of participatory mechanisms

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<sup>20</sup>Ibid, p.167.

and the weaknesses of local government, these deficiencies are identical to the primary obstacles to a more effective rural development program.<sup>21</sup>

From the standpoint of agrarian reform implementation, effective institution-building and the extension of all types of assistance to the land-reform beneficiaries will depend largely on the infusion of such values as well-being, social cooperation, and social justice or equality (as manifested in *kaginhawalan*, *pagtutulungan*, and *pagkakapantay-pantay*).

*Political will or commitment to an agrarian reform package.*

The motivation for land reform in many countries is political: to change the wealth and power structure and enable the mass of small farmers and agricultural laborers to participate in the economic and socio-political activities of the community. The political will or commitment is expressed in terms of: (a) the political considerations in the passage of land reform legislation; (b) political considerations in the passage of land reform legislation; (h) political decisions toward effective land-reform implementation; and (c) the adoption of an administrative policy on the integration of government activities in land-reform areas and the centralization of control through a department of ministry for agrarian reforms.

*Political considerations in land reform legislation.* Political support or lack of it affects the effectiveness of land-reform legislation. Political support is almost necessary for the approval of land-reform legislation, including expropriation of large estates, subdivision and distribution of small parcels to their occupants, and tenure adjustments in exploitative tenancy systems. In some countries weak implementation of land-reform has been due to rather high retention ceilings and cumbersome procedures provided in reform legislation. Particularly in Southeast Asia, agrarian reform programs have been impeded by land-owners' political influence, the harassment of tenants, and protracted court litigations. On the whole, agrarian reforms in the region have been of limited scope and their implementation weak and frustrating, owing mainly to the governments' lack of political will to carry out reforms and their low administrative capability for implementation.<sup>22</sup>

In the Philippines the passage of the first agricultural Land Reform Code in 1963 required the full support of the Liberal Party under President Macapagal, with the assistance of the Manahan-Manglapus faction in the Senate. However, the resulting legislation lacked the provisions on the means of financing land-reform operations as well as those pertaining to mediation of local land disputes, which

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<sup>21</sup>For more details, see Dalisay, A.M. Values in policy formulation for rural development. Occasional paper No. 9. MARD Program, U.P. at Los Baños, 1980. pp. 21-23.

<sup>22</sup>See Asian Agricultural Survey 1976. pp. 97-101.

were omitted through the intervention of powerful landholding legislators. According to President Marcos, the political factors operating through the Conference Committee of the Senate and the House led to the removal of one whole chapter (in the original Land Reform Code) which provides for a tax on all idle land as the source of financing land reform and the Land Bank.<sup>23</sup>

At the 7th Anniversary of Agrarian Reform held in Quezon City on August 8, 1970, before a large audience composed mostly of agrarian reform beneficiaries, President Marcos made certain pledges which, among others, he would carry out through this leadership and with the support of the Nacionalista Party which he heads — such as introducing amendments to the Land Reform Code to strengthen its implementation, declaring the entire country as a land-reform area, making land reform the epicenter of all government activities, establishment of a single-line department of land reform, providing additional sources of funding for the Land Bank, and organization of cooperatives among the reform beneficiaries.<sup>24</sup>

These pledges were carried out in succession, if not altogether, as shown by events in the next few years. First, the approval of the necessary amendments to the original Code was made by Congress on September 10, 1971, with the full backing of President Marcos and the support of his party, barely a year after his Quezon City pledges. Secondly, the other pledges were fulfilled in a series of Presidential decrees<sup>25</sup> issued after the declaration of Martial Law on September 21, 1972. The most significant of these decrees was PD No. 27, which emancipated the small tillers from their bondage and transferred to them the land they till. The series of Presidential decrees during the martial-law administration not only strengthened the foundations of agrarian reforms, but also indicated the direction of social and political development in the years to come.

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<sup>23</sup>See "Address of the President at the closing ceremonies of the 7th Anniversary of Land Reform, August 8, 1970, p. 12.

<sup>24</sup>Address of the President, *op. cit.*

<sup>25</sup>P.D. No. 57 November 19, 1972 - exempting landowners affected by land transfer from the capital gains tax.

P. D. No. 84, December 22, 1972 - authorizing the secretary of Agrarian Reform to sign land transfer certification (on behalf of the President of the Philippines).

P. D. No. 152, March 13, 1973 - prohibiting the use of share tenants in public lands transferred or titled to the present owners.

P. D. No. 239, July 9, 1973 - withdrawing the authority of the Land Registration Commission to approve original survey plans (which had been solely exercised by the Bureau of Lands).

P. D. No. 251, July 21, 1973 - amending the provisions of R. A. No. 3844 as amended to strengthen the powers of the Land Bank of the Philippines as the financial arm of Land reforms.

*Political commitments for strong administrative policy in agrarian reform.* It took the passage of the Code of Agrarian Reform, as amended, on September 10, 1971, to consolidate the six-agency implementation machinery of land reform into a single-line, comprehensive agency, the Department (now the Ministry) of Agrarian Reform. This is about eight years after the approval of the original Agricultural Land Reform Code, during which a cumbersome administrative machinery carried on the task of land redistribution, the conversion of tenancies into leaseholds, and settlements in selected land-reform areas.

The issuance of several decrees by the President after the proclamation of martial law in 1972 strengthened the government machinery for the implementation of agrarian reforms. The entire country was first declared a land-reform area (PD No. 2) and the tenants-farmers were then emancipated from their bondage and made owners of their holdings (PD No. 27). Other decrees followed in the next three or four years that saw the restructuring of the Land Bank of the Philippines, as the financial arm of land reform; the creation of additional fund sources for the financing of reform implementation; and laying down the bases for the organization and development of farmers' cooperatives (PD No. 175).

The above Presidential acts fulfilled the pledges made by President Marcos to land-reform beneficiaries in his Quezon City Address. In practice, these measures created the underpinnings for the integrated action of the Department of Agrarian Reform in the break-up of the landed estates and the transfer of ownership to the tenant-tillers, the conversion of other tenancies into leaseholds, and the related activities on the tilling of the lands transferred and the administration of land settlements. However, the principal supportive services remain outside the jurisdiction of the MAR.

Other decrees that followed served to provide additional assistance to the land-reform beneficiaries by prohibiting the ejectment of tenant-tillers from their holdings, by prescribing penalties for ejectment or removal of tenant-farmers from their lands, by establishing the procedure for the acquisition by small farmers of shares of stock in rural banks, and by improving the structure of the Court of Agrarian Relations for the settlement of land disputes and other matters.<sup>26</sup>

Countries in other regions have also experienced the influence of top-level political commitment in reinforcing the administrative policy on agrarian reforms. In Peru, for instance, the political commitment of its leaders dynamized its

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<sup>26</sup> For particulars, see the following decrees:

P. D. No. 316, on October 22, 1973, prohibits the ejectment of tenant-tillers from their holdings.

P. D. No. 583, on November 16, 1974 - prescribes penalties for unlawful ejectment or removal of tenant-farmers from their holdings.

P.D. No. 584, on November 16 1974 - establishes the procedure for the acquisition of shares of stock in rural banks.

P. D. No. 946, on June 17, 1976 - reorganizes the CAR by establishing 16 regional districts throughout the country.



comprehensive land reform legislation approved in the early 60's. Although the compensation provisions of the law were generous, the political opposition to implementation was widespread, and with poor administrative staff and inadequate financing very little land redistribution could take place. By 1973, owing to political commitment for accelerated reform implementation, over half of the estates to be appropriated had been subdivided, thus resulting in six times more land appropriated and redistributed and eleven times more land adjudicated for redistribution to landless farmers than all previous land reform legislation.<sup>27</sup> These have demonstrated the need for quick action to take advantage of the government's power and commitment as well as the efficacy of administrative organization created for the purpose.

Here and in other countries of Southeast Asia, the political commitment of the highest level of leadership is necessary not only to improve upon the existing reform legislation, but also in effectively implementing land reform and other measures of rural transformation. As explained by Rondinelli and Ruddle, such a political commitment must involve a strong, pervasive, and sustained determination to achieve the goals of rural transformation, economic reorganization, and social equity.<sup>28</sup> A concomitant must be a broad base of political support from government agencies, political groups, and cooperative associations.

#### *Insights from other development and agrarian reform experience*

In spite of the above structures, the developing countries especially the Philippines, must continue to derive insights from development and agrarian reform experience in other countries under similar conditions. The rationale for this must be based on a socio-economic approach to the improvement of the development process itself towards efficiency and effectiveness and the creation and strengthening of organizations/institutions that will accelerate the process of growth and transformation. The over-riding goal is to forge a unified or comprehensive model (strategy) that can be implemented through a consensus among the social, economic and political interests involved and with massive participation and support of reform beneficiaries. For economists and administrators, Guy Hunter (1978) expresses an encouraging and hopeful note: "Economists can at least join hands with administrators in working out . . . an economic and administrative tool kit which will help them to avoid the worst dangers of a political decision (to implement reform) and achieve the best economic compromise . . ."<sup>29</sup> He thinks, quite correctly, that a total retreat of economists from the frustration of reform is not necessary.

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<sup>27</sup>See Rural Development - Evaluation Study No. 2, op. cit., p. 166.

<sup>28</sup>Rondinelli, Dennis A. and Kenneth Ruddle. Urbanization and rural development. New York: Praeger Publishers, 1978. pp. 139-154.

<sup>29</sup>Hunter, Guy (ed). op. cit., p. 46

### **An Operational Model for the 80's and Beyond: Policy Implications**

An operational model or strategy for the 80's and beyond should now be adopted and implemented without further delay. It must be based on the following considerations: (a) the need for an integrated approach which requires cooperation among several ministries in a multipronged, multi-faceted thrust towards national growth and structural transformation; (b) priority emphasis on institution-building and the socio-political aspects of peasant organizations and other participatory mechanisms in the rural areas; and (c) a strong administrative policy governing the decentralization of the public supporting systems to the different regions and integrating those services with local and regional programs for overall development.

1. *An integrated approach to agrarian reforms involves both the program for increased productivity and income among the agrarian-reform beneficiaries and the social and infrastructural overhead essential to human-resource development and mass participation in development planning and administration.* Such an approach must go beyond the present confines of land transfer and tenure adjustments, together with land settlement programs. It must deal directly with the problems of urban-rural linkages, strengthening and further extension of support services, and the creation of off-farm employment opportunities through cottage and small industries in the rural communities. For effective implementation, this approach must be based unequivocally on:

(a) active participation and involvement of the reform beneficiaries in the different programs and projects through participatory mechanisms organized for the purpose, and/or (b) government support for the creation of peasant organizations designed to strengthen the role of reform beneficiaries in the social, economic and political activities of their communities.

2. *Institutional aspects must be given more importance towards social and human-resource development.* Higher priority should now be given to the development of essential organizations/institutions in all the land-reform areas, which will assist the reform beneficiaries in their efforts to increase their own communities. Farmers' associations and all types of cooperatives must be developed, based on need and the management capacity of the small farmers and lessees.

Sometime ago I pointed out that the development of local institutions cannot be left to the government agencies alone.<sup>30</sup> The private sector has a mutual responsibility, particularly in the establishment of farmers' associations and various types of cooperatives. For the productivity and efficiency of the family farm do not result only from technological improvements and market forces, but also from the human values, attitudes, and the social institutions that give it recognition and support.

It should also be noted that the motivation and aspirations of the reform recipients are quite as important, if not more so, as the improved technologies and

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<sup>30</sup>Dalisay, *Economic issues . . .*, op. cit., p. 9

management practices recommended for farm productivity and efficiency. And the institutions that develop reflect not only the aspirations and motivations of the agrarian reform beneficiaries, but also the social values that will ensure their response to technological and social changes.

Fortunately for this country, the people may now count on the realization of the President's pledge to implement a land-reform program with massive support from the cooperatives. In this regard, the disappointing performance of the MLGCD in the organization of viable marketing cooperatives and cooperative rural banks should not discourage the voluntary movement from trying again to build on the present meager gains. And the administrators of the Ministry of Agriculture (MA) designated recently to undertake the rehabilitation and reformation of the cooperatives should take heed from the recommendations of the leaders of the voluntary movement in the new and, let us hope, more realistic approach to cooperative reorganization and development in the different regions.

Moreover, the integrated estate development program (IEDP) of the Land Bank, as a comprehensive strategy for the amortizing owners in the expropriated landed estates based on agribusiness concepts, need to be expanded to include the reform beneficiaries outside the landed estates. Built around management-trained manpower with a core of IEDP coordinators and supported by community banks, now known as *Land Bank sa Bukid* (LBSB), the approach promises to be an effective implementation of integrated rural development buttressed by adequate financing of farm business operations (through the LBSB) and the availability of support services and the necessary infrastructures. The scope of this Land Bank strategy is mainly constrained by the number and competence of IEDP coordinators and the speed with which LBSB's could be organized and made operational.

3. *Significance of a strong administrative policy for agrarian reform implementation.* The weaknesses of the MAR organization and administrative capability are now apparent. These weaknesses, particularly in the coordination of essential activities for reform outside its immediate jurisdiction and strengthening of farmers' cooperatives, must now be remedied if the country is to achieve an integrated reform approach in the 80's and beyond.

The principal aspects of organization and coordination as they are brought to bear on the productivity and efficiency of the individual family farms among the agrarian reform beneficiaries must be given greater attention under a reoriented and unified administrative policy of the present administration, which should embrace the MAR and other pertinent ministries. Among the program and activities that should be coordinated and strengthened at all levels are the following:

(a) The public supporting services, particularly agricultural extension and rural credit are still strongly biased towards well-to-do farmers and the larger towns, whereas the small farmers, amortizing owners, and lessees require special attention and assistance. The agricultural technicians, including the farm management specialists, should henceforth concentrate their activities on the reform beneficiaries in the barangays.

(b) More attention must be given to the problems of unemployment and of job-generating enterprises in the rural communities; hence, the importance of small industries and cottage enterprises based on local materials and skills that can provide remunerative jobs to unemployed youth and adults.

(c) The task as well as the credit for rural development is now splintered among several public agencies engaged in such community improvement programs as food production and nutrition, population control, public welfare services, public health and sanitation, and others. To minimize the confusion of goals for community development in the land-reform areas and get these public agencies to work as a team, a Presidential Order is necessary to place the agency representatives under a local development coordinator.

Furthermore, special attention to the problems and needs of the agrarian reform beneficiaries demands that the following activities must be coordinated by the Ministry of Agrarian Reform: (a) diversification of agricultural production through intensive cropping systems, livestock and agriculture enterprise with emphasis on the family-type farm, (b) tying up local production activities with marketing and processing facilities in the urban centers; (c) developing social and infrastructure service facilities in the subdivided landed estates and other land-reform areas; and (d) local development planning to ensure both technology adoption and the necessary infrastructures for storage and marketing as well as farmers' participation in planning and implementation.

All these would require expanded administrative and management capacity in the MAR and close working relationships with other ministries. Thus, a strong but flexible administrative policy for agrarian reform and related activities must cope with the problems and issues of higher farm efficiency and productivity, manpower trainings, and the reorientation of public administration to the improvement of rural life - the gamut of programs and projects for agricultural transformation and modernization. While the specific tasks of the MAR have to do with land redistribution and tenure adjustments, its primary responsibility must be towards the development of social conditions and the infusion of social values among the reform beneficiaries that would ensure higher efficiency on the individual farms and social stability in the communities where they live. These would mean the MAR taking on more of the functions and activities that now belong to the Ministry of Agriculture and linking them up effectively with other relevant ministries.

The continuing challenge to the MAR and the related ministries is to make good on the pledges made by President Marcos and the present Administration. To do less is to negate the goals and objectives of agrarian reform and obstruct the efforts towards agricultural growth and change.

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### Pedro Sandoval, Discussant

Agrarian reform is one program of development that indeed merits periodic and continuous review, a "revisiting" as Dr. Amando Dalisay said. The objective of such "revisiting" or review has also been clearly set by Dr. Dalisay for all of us that: "policy-makers and administrators might be led to evolve action program that would have relevance in the 80's and beyond."

The core programs of agrarian reform are the leasehold and the land transfer programs. The Ministry of Agrarian Reform's position is that the operative act of transferring landownership to the tenant-farmers is PD 27 itself; which means that the tenant farmers became owners of the land they are tilling as of October 21, 1972. It is the documentation of this transfer which is the task of the Ministry of Agrarian Reform. It is the slowness of this documentation process that Dr. Dalisay and other evaluators of the program point out. This commentary on the implementation phase of PD 27, it may be noted, has not been lost on the Ministry of Agrarian Reform and some steps had been taken to remedy the situation. On the leasehold operation, Certificates of Agricultural Leasehold (CAL) has been issued since 1981 to farmers working in landholdings of 7 hectares and below – in effect strengthening their land tenure position as lessees. Parenthetically though, only 8.54% of the targeted lessees has so far been issued the Certificate of Agricultural Leasehold by the end of 1982.<sup>1</sup> On the Operation Land Transfer, the generation/issuance of Emancipation Patents was accelerated during the year by virtue of MAR'S New policy of allowing its generation upon payment of two annual land amortizations. Thus, the Ministry of Agrarian Reform reported an increase in the number of Emancipation Patent recipients totalling 1,799 or .42% of its target beneficiaries in 1981 to 34,913 or 8.16% at the end of 1982.<sup>2</sup> Despite this reported accomplishment, the effort needed a push if the momentum gained by the program is not to be lost on the farmer-beneficiaries. However, the structural change brought about by tenure reform is only a beginning of concerted efforts in uplifting the plight of the farmer-beneficiaries. Desired increases in farm productivity become possible with sustained institutional support granted by the cooperating agencies in the program.

While the problems of agrarian reform are not new, as many have noted and as summarized in Dr. Dalisay's paper, they have gained in perceived importance with the availability of new high-yielding grain varieties. The new plant varieties hold the promise of increased yields per hectare, while on the other hand, requiring improved farm production conditions such as complementary chemical fertilizers, increased irrigation and water control, and appropriate weeding, to offset the dwarf features of the new varieties.

Attempts to deal with the institutional requirements of the new technology have generally fallen into three categories. First, Dalisay argues that production

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<sup>1</sup>Ministry of Agrarian Reform 1982 Annual Report, p. 8.

<sup>2</sup>*Ibid.* p. 9.



constraints must be lessened so that farm productivity levels can be increased. He suggests the need to provide basic production support services and increased access to irrigation water.

The second approach suggested by Dr. Dalisay is the promotion of integrative activities in the planning and implementation of agrarian reform, along the lines of integrated rural development programs. Participatory schemes for mobilizing rural beneficiaries of land reform are cited as the means by which equality of opportunity through employment-generating projects is made.

The third approach focuses on the development of institutions that rely more on local systems of cooperation and control with respect to access to credit, marketing, storage, and processing facilities. The increased use of traditional community cooperative groups is proposed as an alternative to formal, often bureaucratic-type, of government sponsored organizations.

The conceptual framework presented by Dr. Dalisay follows what he labels as a "reformist" approach, in the economic tradition set by Griffin (1972). In carrying out the reformist approach, Dr. Dalisay recommends a re-examination of the "political will" as the basis for the land reform program. These are sub-divided into the political aspects of development affecting (1) legislation and the legal foundations of nationwide re-distribution, (2) implementation of policies that encompass efficiency as well as equity objectives, and (3) the administration of programs that facilitate the conduct of (1) and (2).

In the last section, Dalisay suggests three major program revisions. First, he advocates a strong, integrated approach to agrarian reform that has, as its final goal, increased income and output levels. Secondly, he calls for an expanded institutional development program that is geared toward the improvement of social and human resources. Lastly, he considers the crucial role of "administrative reform" especially in the implementation of land reform legislation. In particular, he cites the need for the MAR to absorb some of the extension and credit functions of the Ministry of Agriculture, and the strengthening of institutional linkages with other line ministries, in the conduct of post-reform activities.

As suggested above, a large variety of organizational and administrative arrangements for implementing land reform are possible. Dalisay's use of local-level solutions, rather than bureaucratic and macroeconomic approaches, offers some important insights regarding the direction that agrarian reform should follow in the future. Within this range of choices are many issues that require a re-examination in the light of Dalisay's suggested framework for integrated rural development.

Two issues will be discussed that may help clarify some of the points raised by Dalisay. These are (1) the need to evaluate the dynamic interrelationships of tenure reform and productivity, and (2) the necessity of broadening the rural agricultural base that benefits from the agrarian reform program.

### **Reform and Productivity**

The studies of Schultz (1940), Ready (1947), and Drake (1952) have ques-

tioned the logical deduction among neo-classical economists that owner-operated systems achieve a better system of pricing factor inputs, and reduces the constraints of decision-making on the use of technological inputs. The Philippine case studies of Estarislao (1965), Sandoval and Gaon (1972), and Mangahas, Miralao, and de los Reyes (1976) support the hypothesis that in an economy, such as the Philippines, share tenancy does not act as a "restraint" on growth of output (Ruttan: 1965).

However, it has also been pointed out that share tenure limits the landlord's incentive to invest in productivity-increasing projects. This has had its historical roots. McLennan (1973) notes that 18th century tenancy relations affecting the development of irrigation in Nueva Ecija have clearly been in terms only of maintaining the landlord's network of dependents. McLennan describes it more succinctly:

Capital investment focused upon one element only -- land . . . the easiest path by which landowners will increase their income was by the acquisition of more tenancies, not by investment in the improvement of land with the goal of increasing yields, for that would involve them in the managerial problems inherent in introducing and supervising more intensive land use practices . . . Irrigation canals were a means to guarantee annual production and expand the tillage within a hacendero's holding, not essentially a means to increase yields (p. 415).

Furthermore, Clark (1905) observes that Central Luzon landowners increase their income not only from rent collection and interest rate payments, but also by manipulating rice production activities. One method has been to capitalize on annual fluctuations in the price of rice. The other method is by compelling tenants to use the *tilyadors* or threshers and to transport rice in the landlord's truck, where exorbitant transport rates are charged.

The 18th and 19th century documentations of landlord-tenant relationships (Pelzer, 1945; Takahashi, 1969) are not without present-day counterparts. In arguing for the productivity hypothesis of tenure reform, these historical conditions have often been set aside and essentially technical and economic approaches have been applied. The result is a list of production support services which have little value when viewed merely in the context of yield-increasing goals.

### **Expanding the Agricultural Base of Agrarian Reform**

By extending Dalisay's argument for institution-building, the alternative approach to increase productivity using tenure reform is to analyze, first, the social and economic factors underlying share tenancy and agricultural lease systems, then provide support services that address the social problems of unequal access to production resources directly.

In expanding the agricultural base of agrarian reform, attention has been



focused on including crops other than rice and corn in the reform program. While decisions towards this end are yet to be made, serious studies in the meantime are being undertaken which hopefully would help in evolving desirable reform programs.

Another sector of the agrarian society that deserves immediate attention is the group of agricultural landless laborers.

The initial efforts of the agrarian reform program had focused on the tenant farmers in order to uplift their deplorable conditions. After a decade of implementation, the time has come when the program of rural development has to extend to the landless agricultural laborers who constitute a greater portion of the farming population.

Landless agricultural workers form a social class which is, almost always, found at the base of the social pyramid. They emerge as a group more disadvantaged than farmers in terms of employment and income. Farmers can supplement their income by hiring out their services while those mainly dependent on income from hired labor have to compete with an ever-increasing number of entrants in the labor market. If development means reaching the poorest segments of the population, and if the reform efforts are aimed at narrowing the visible disparities in our society, then agricultural laborers are a logical target of such efforts.

Constituting one-fourth of the country's labor force, the landless agricultural workers should be the focus of more serious concerns particularly their status, life conditions, problem and constraints. Hopefully, a beginning to a determined endeavor towards more systematic efforts at trying to meet the plight of this rural group could be made, if it has not begun yet, by concerned government agencies.

## **RURAL ELECTRIFICATION AND FERTILITY CHANGE IN MISAMIS ORIENTAL, PHILIPPINES: A CASE STUDY ON THE DEMOGRAPHIC IMPACT OF RURAL DEVELOPMENT PROGRAMS**

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### **Introduction**

Development programs traditionally pursued for non-demographic objectives may nevertheless have important demographic consequences. Consideration of these demographic effects could provide additional criteria for the selection of alternative programs. Thus far, however, very little systematic effort has been made to assess the demographic impact of development programs in the Philippines and elsewhere. This may be due partly to the complexity of socioeconomic-demographic interrelationships and to the difficulty of controlling specific factors in actual non-experimental settings.

This paper reports on partial results of an on-going assessment of the fertility impact of a large-scale rural electrification project in Misamis Oriental. Interest in this study arose from the fact that data from an independent demographic measurement project in a rural segment of this province reveal a significant decline in fertility from 46 births per thousand population in 1972 to slightly less than 30 in 1975 when the last survey was conducted.<sup>1</sup> The data indicate that the decline was largely due to a drop in marital fertility, especially among women aged 25-39 years, rather than to a change in the proportion of married women or in the age structure (Herrin, 1979). In late 1971, about the time that this demographic data collection began, a large-scale rural electrification project was implemented in this rural area. The rapid decline in the birth rate was recorded as starting a year or so after a large segment of this area has been energized, an observation temporally consistent with the view that changes related to the rural electrification project were a factor contributing to the observed fertility decline.

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\*A longitudinal research strategy is kept in mind in the overall design of this project, and a second survey can be fielded as additional funding becomes available.

<sup>1</sup>The Research Institute for Mindanao Culture, Xavier University conducted an intensive demographic study in Misamis Oriental from April 1971 through May 1976, the purpose of which was to test alternative demographic measurement methodologies with special focus on the dual-records approach to the collection of vital statistics.

Exploratory studies on the impact of rural electrification in 1975 and in 1977 suggest that this important infrastructure generated widespread social and economic changes (Madigan, Herrin and Mulcahy, 1976; Herrin and Madigan, 1977; Herrin, 1979). In addition, demographic surveys conducted in 1976 and 1977 reveal widespread acceptance and practice of family planning by currently married women in the province in general, and in the rural electrified areas, in particular (Madigan, *et al.*, 1976; 1977).

Putting these sets of evidence together, one is led to hypothesize that the provision of rural electrification, interacting with other rural development inputs generated social and economic changes, which among others, changed the structure of costs and benefits of children, at least as perceived by parents. This changed structure in turn led to a decreased demand for additional births, which was then made effective by the lowered cost of contraception generated by the effects of the family planning program. The data from a survey of 1,200 households in 1980 to be described below do in fact show that rural electrification is significantly related to lower current fertility and to greater use of family planning methods in Misamis Oriental, a finding consistent with the above hypothesis.

In Section II we briefly describe the rural electrification program, the progress of the Misamis Oriental rural electrification project, and the development trends in the province to provide a contextual background for subsequent discussions. Section III presents the conceptual framework for analyzing the dynamics of socioeconomic change generated by rural electrification and fertility based upon theoretical considerations as well as upon empirical findings from earlier exploratory studies. Section IV describes the research strategy adopted in this study, highlighting among others, the problems and the limitations of non-experimental designs. Section V describes the characteristics of the sample areas and households, while Section VI presents the results of partial analysis of the data collected for this study. Section VII concludes, highlighting the implications of the study for prospects of fertility transition in less developed countries.

### Background

*The National Rural Electrification Program.* The rural electrification program is a major infrastructure program of the government aimed at improving the quality of life of the poor majority in the rural areas. The national rural electrification program officially started in 1962 with the creation of the Electrification Administration. However, electrification then was characterized by small generating units (30-60 kw capacity) serving only one municipal town center on a dusk-to-midnight basis, and generally for lighting purposes only. Limited funding, mostly loaned to private and municipal franchises reportedly hampered the development of the program.

In August 1969 the National Electrification Administration Act was passed creating the National Electrification Administration (NEA), and declaring the

national policy objective of total electrification of the country on an area coverage basis, with electric cooperatives as the primary medium for program implementation. Under the area coverage concept, rural electrification is to be provided by larger power plants each serving not only one municipal town center, but from five to ten municipalities including all the villages (*barangays*) therein on a 24-hour basis. In 1971, two pilot rural electrification projects were established, namely, the Misamis Oriental Rural Electric Service Cooperative (MORESCO I) in western Misamis Oriental, and the Victorias Rural Electric Service Cooperative (VRESCO) in northern Negros Occidental. The success of these two pilot projects paved the way for the subsequent establishment of electric cooperatives throughout the country.

The National Electrification Administration (NEA), a government agency assigned to undertake the rural electrification program, was converted into a public corporation in August 1973. As a result, additional powers and funding have been granted the NEA for the speedy implementation of the rural electrification program. Since then, the NEA has made significant progress both in the development of the physical facilities of the electric systems, and in the establishment of electric cooperatives throughout the country. As of July 31, 1981, the NEA reports that a total of 107 electric cooperatives have been energized. These electric cooperatives serve 1,589,210 households in 1,204 municipalities and 12,325 villages throughout the country, representing 30 percent of the total potential household connections in the covered areas.

*Misamis Oriental Rural Electrification Projects.* Misamis Oriental which comprises 24 municipalities and two chartered cities, had a 1975 census population of 560,490 living in an area of 3,570 square kilometers. A rural electrification project was first implemented in late 1971 in the 10 municipalities located west of the provincial capital, Cagayan de Oro, through the Misamis Oriental Rural Electric Service Cooperative (MORESCO I). In 1975, these municipalities had a population of 124,510 people or about one-fifth of the provincial population living in approximately the same proportion of provincial territory. As of July 1981, MORESCO I was serving 12,404 households in 118 villages of the 10 municipalities, representing about half of the total potential household connections. In addition to households, the electric cooperative was supplying electricity to business enterprises, irrigation systems, water systems, and public buildings and facilities, including educational institutions and health units.

The eastern segment of the province comprising 14 municipalities (excluding Gingoog City) had a population of 222,474 in 1975, representing 35 percent of the provincial population. Gingoog City itself, the second chartered city in the province had a 1975 population of 66,377. In June 1978, a second electric cooperative (MORESCO II) was established to serve these 14 municipalities and Gingoog City. As of July 1981, a total of 12,038 households in 136 villages were provided electric connection, representing 30 percent of potential households connections in the covered areas.

*Development Trends in Misamis Oriental.* The provincial economy is still basically agricultural. In 1975, more than half (56 percent) of the gainful population 10 years old and over was engaged in farming and related activities. Developments since the 1970s, however, are expected to place Misamis Oriental among the fastest growing provinces, especially with respect to agro-industrial growth and infrastructure development.

According to the country's development plan, the Northern Mindanao region where Misamis Oriental is located, is envisioned to become a major industrial region of the south, having the advantages of early availability of hydroelectric power, strategic location, available agricultural lands, and abundant forest and mineral resources. The physical development scheme is laid out along the following industrial zones: Misamis Oriental Province for heavy and agri-based industries; Agusan del Norte for wood-based industries; Surigao del Norte for mineral-based and fish processing industries; Bukidnon and Agusan del Sur for agro-processing industries. Misamis Oriental's development will be facilitated by its strategic location, it being the center of the region, and having excellent access to sea and air transportation. In addition to its role as an industrial center, Misamis Oriental, with its capital city of Cagayan de Oro, is expected to become the financial and commercial center of the region.

Misamis Oriental, like the rest of the Philippine provinces, has implemented social and economic development programs in conjunction with the national efforts and regional thrust of the government. In agriculture, the province has implemented the nation's food production program through the formation of cooperatives, extension programs, price supports and input subsidies, and the provision of technical assistance and credit facilities to farmers.

In industry, notable changes in the 1970s include the emergence of agriculture-based or natural resource-based export-oriented enterprises, including a sorghum processing enterprise, three chemical plants, and several large timber processing plants. In addition, a large 3,000 hectare industrial estate has been developed, and an iron sintering plant has been in operation since 1976. Expected to locate in this estate are various other medium and heavy industries, including an integrated steel plant. Other agriculture-based enterprises are also planned for the province, including a coco-chemical plant.

In the area of health and sanitation, several programs were implemented in the 1970s to expand and improve health facilities in rural areas, including the construction of small emergency hospitals (5-10 bed capacities) in some municipalities. In addition, a vigorous campaign for the construction of sanitary facilities was conducted, and strong support was given to municipal and barangay governments in the construction of potable water supply systems.

In the early 1970s family planning education and motivation efforts as well as the provision of contraceptive services were first implemented through the rural health units' network. In 1976, the province became one of seven pilot provinces where the Commission on Population's Total Integrated Development Approach (TIDA) was implemented. This approach broadened the role to be played by pro-

vincial and local governments in the implementation of the population program. In 1977, the Commission's Outreach Program was launched. This program called for a new organizational set-up to expand family planning information and services beyond the usual network of rural health units and family planning clinics. Full-time outreach workers were trained and fielded in all barangays to provide intensive motivation, visits and referrals. Barangay Contraceptive Supply Points (BSP) were set up in the barangays to provide continuous supply of contraceptives.

In line with the national nutrition program's aim to help combat malnutrition especially among infants and children, a combined nutritional and educational program for young children was launched in 1976 with the establishment of day care centers in barangays.

Another major development effort in the province in the 1970s was the improvement of infrastructure. This included the building of farm-to-market roads, the construction of a concrete highway connecting the capitals of two adjacent provinces and traversing the entire length of Misamis Oriental, the expansion and improvement of port facilities both sea and air, and the building or improvement of various public buildings and facilities. The one infrastructure that stands out, however, and one that has influenced the pace and character of provincial development is the rural electrification project established in the western segment of the province in 1971, and in the eastern segment in 1978.

Under such a dynamic development setting, one would expect fertility to decline in the province in the same way that fertility has declined in other regions of the Philippines. The question, however, is whether the presence of rural electrification had generated economic and social impact that accelerated the observed fertility decline in the project areas more than what could be expected from the impact of existing development programs uninfluenced by the catalytic effect of so important an infrastructure as the large-scale rural electrification project.

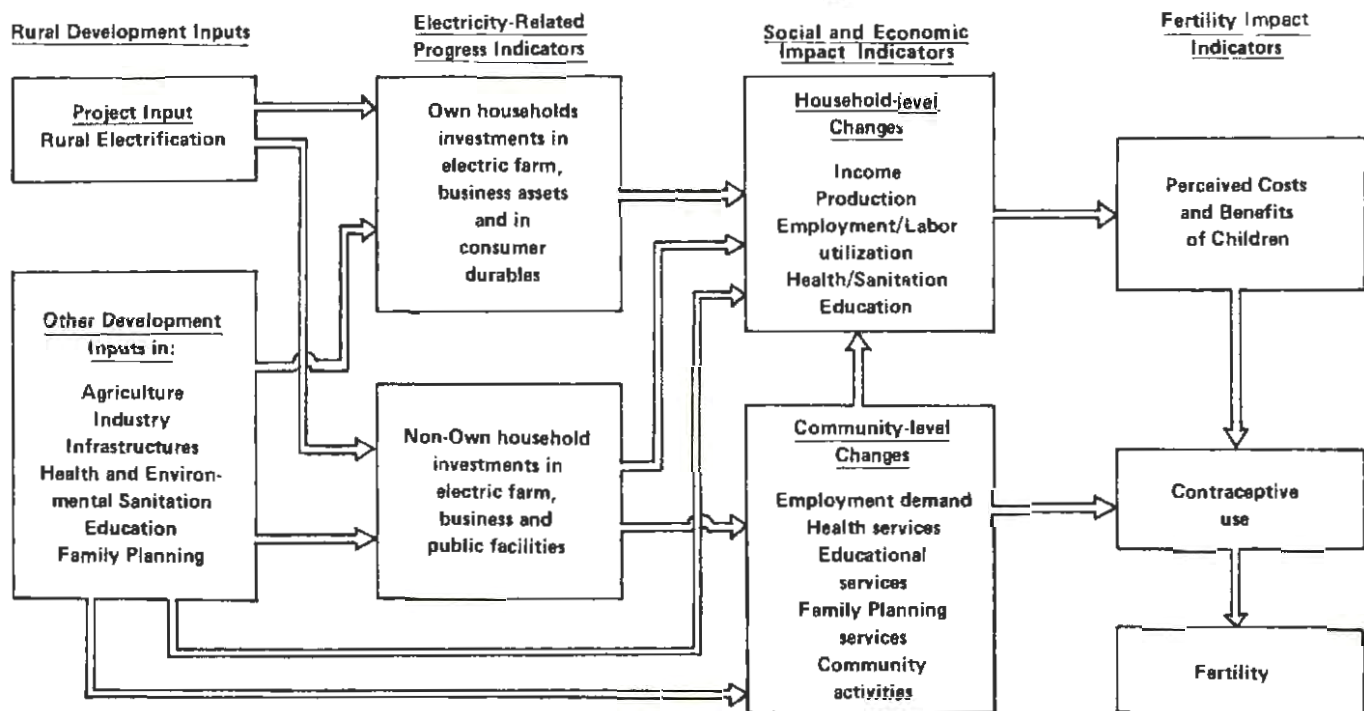
### Conceptual Framework

A framework for analyzing the relationship between fertility change and the economic and social change resulting from rural electrification and other development inputs can be described with the aid of Figure 1. Rural electrification, interacting with the other rural development inputs, generates investments in electricity use, which in turn affect economic and social factors, and ultimately fertility behavior. Note that the impact of rural electrification on a particular household (or other microunit) arises not only directly through its own use of electricity, but also indirectly through the use of electricity by other households or by the community as a whole. The specific mechanisms involved are outlined below as determined from the results of the earlier exploratory studies (Herrin and Madigan, 1977).

*Income, Production and Employment.* Rural electrification is expected to affect total household income through (a) increased agricultural production/pro-

Figure 1

# CONCEPTUAL FRAMEWORK FOR ANALYZING THE FERTILITY IMPACT OF RURAL ELECTRIFICATION IN THE CONTEXT OF OTHER RURAL DEVELOPMENT INTERVENTIONS



ductivity generated by household or public investments in electricity-dependent irrigation systems in areas where alternative systems are either not feasible or are relatively costly; (b) increased business or trade income/productivity generated by household investments in electricity-dependent machineries, tools and appliances; (c) increased food production/productivity from livestock, poultry and backyard gardening activities generated by household or public investments in electricity-dependent water supply systems; (d) increased home production/productivity generated by household investments in electric lighting and electric durables; and (e) increased paid employment of household members, including women, generated by new job opportunities from the operation of electricity-dependent business enterprises.

*Health, Nutrition and Sanitation.* Rural electrification is expected to affect health, nutrition and environmental sanitation indirectly through its effect on income and food production, and through (a) the increased availability of adequate and safe water supply generated by household or public investments in electricity-dependent water supply systems; and (b) the increased availability of, and the improved health and medical services generated by public investments in electricity-dependent facilities and durables.

*Education.* Rural electrification is expected to increase enrollment rates and improve the quality of education through its effects on household income, on the one hand, and on the other, through (a) expansion of educational services generated by the possibility of conducting night classes; and (b) the improvement in the quality of instruction through the use of electricity-dependent tools, appliances, and teaching aids. In addition, the proper illumination afforded by electric lighting in the homes is expected to improve class preparation by teachers, on the one hand, and to encourage and facilitate reading and completion of homework by students, on the other.

*Fertility.* Finally, rural electrification is expected to affect current fertility decisions, on the one hand, through its effect in changing income, employment, and investment and consumption opportunities (including health and education of children), thus increasing the opportunity costs of children; and on the other hand, through its effect in improving family planning services in the health units, thus helping to reduce the effective cost of contraception.

### Research Strategy

*Research Design.* The main hypothesis of the study is that rural electrification significantly influences fertility and family planning behavior of rural households through various mechanisms. Ideally, the classical experimental design is a first choice testing hypothesis about causal relationships. A principal feature of this design is the random assignment of study units to experimental and control groups. The random assignment of study units insures that there are no pre-existing differences between the two groups prior to the exposure of the experimental group



to the treatment, other than those that would be expected due to chance alone. However, the implementation of this ideal design is often not feasible in practice. Very often, as in the present case, the rural development program has already been underway or will soon be implemented in predetermined areas based on criteria not related to impact evaluation. Hence, the requirement of random assignment of study units to experimental and control groups cannot be met. As a result, the evidence ruling out other possible causal factors are the most difficult to obtain. Alternative quasi-experimental designs, e.g. a before-and-after, with-and-without design, can be set up to approximate the ideal experimental situation. However, time and budgetary limitations often constrain implementation of such designs. In this particular research only a with-and-without design can be implemented, and only imperfectly at that.\* In view of this, efforts to minimize the potential selection bias inherent in such a design, through appropriate sampling and multivariate statistical techniques, constituted an important component of the research strategy.

*Selection of Study Areas.* The with-and-without research design called for the selection of study areas to include areas that are electrified and areas that are not. Since no prior randomization was possible, the latter group is merely a comparison group rather than strictly a control group in the experimental sense. The western part of the province comprising of ten (10) municipalities west of Cagayan de Oro City, where a rural electrification project was established in late 1971, constituted the electrified area.

The eastern segment of the province (excluding Gingoog City), comprising 14 municipalities with a population of 22,474 in 1975 comprising 36 percent of the total provincial population has not yet been provided with electric service at the time the original proposal of this research was made. This area was to serve as the non-electrified area. However, the municipal towns and coastal villages of this area has since then been provided by such service starting in June 1978, two years after field surveys actually began.<sup>2</sup> In spite of this timing problem, the province still provides a natural laboratory-type situation in which a comparative study could be made between electrified and non-electrified or recently electrified rural areas in view of the similarities of the two provincial segments in major socio-economic characteristics other than the degree to which the rural electrification project has penetrated the areas. The basic with-and-without character of the study design is, therefore, not significantly altered.

The sampling plan called for a multi-stage stratified sampling, whereby the province is first divided into two segments: the western electrified segment represented by the area coverage of the MORESCO I electric cooperative, and the eastern segment represented by the area coverage of the MORESCO II electric cooperative. For study purposes, each of these segments was further restricted to include only six contiguous municipalities in MORESCO I area, and six contiguous

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\*The following discussion is excerpted from Herrin (1982).

<sup>2</sup>Funding problems delayed implementation of the research as originally scheduled.

municipalities in the MORESCO II area, to represent areas with more or less similar socioeconomic characteristics and access to Cagayan de Oro City, as well as to minimize travel cost of field operations. Excluded municipalities in the west, namely, Naawan, Manticao and Lugait are much closer to Iligan City in the adjacent province. Excluded municipalities in the east, Balingoan, Talisayan, Medina and Mag-saysay, are much closer to Gingoog City and have a different type of climate than the rest of the province; while Tagoloan, Villanueva and Jasuan are part of a recently developed industrial estate. Claveria in the east is a class by itself, a frontier municipality mostly engaged in cattle ranching and vegetable growing.

Each restricted segment of the province was further subdivided into approximately homogenous substrata to reflect possible community-level variations in socioeconomic characteristics and access to development inputs. Ideally, one needs to stratify barangays in each segment according to physical, economic and demographic characteristics and to level of development based on several indicators including presence of educational and health facilities, road access, agricultural output, etc. Unfortunately, such indicators were not available prior to the survey. Nevertheless, a close approximation to the division of each segment into homogeneous strata can be made by initially dividing barangays in each segment into three geographic strata, namely: (a) municipal poblacion, (b) rural coastal barangay, and (c) rural inland barangay. In Misamis Oriental, this division reflects the differential developmental characteristics including crops cultivated, other economic activities, distance to markets, and access to basic social and other services as data from the community survey of this study later verified.

Sample selection was done as follows. All of the six municipal poblacions in the east and six in the west were selected. Where a poblacion consisted of more than one barangay, a simple random sampling was used to obtain the final barangay poblacion. In each sample municipality, a sample barangay each from the respective strata was drawn by simple random sampling. From each sample barangay, approximately 40 eligible households (households with head of household and spouse present, and the spouse is between 15 to 49 years old) were drawn by systematic sampling from a household list prepared earlier by the research team during its mapping and household listing operations.

A total of 1,402 households in 36 barangays were interviewed from September to November 1980. The breakdown of this is shown below.

<i>Strata</i>	<i>W e s t</i>		<i>E a s t</i>	
	<i>Barangays</i>	<i>Households</i>	<i>Barangays</i>	<i>Households</i>
Municipal Poblacion	6	240	6	233
Rural Coastal	6	240	6	233
Rural Inland	6	240	6	216
Total	18	720	18	682

*Data Collection and Processing.* Four sets of surveys were conducted, namely, (a) a household survey to determine the social, economic and demographic characteristics of households; (b) a community survey to determine the locational and socioeconomic characteristics of the sample barangays; (c) a user survey of business enterprises, educational and health units and other establishments to determine the type and amount of investments in electrical capital items, and the specific uses of these items; (d) an experience survey of village leaders, school officials, health personnel, and other key persons on their observations and assessment regarding social and economic changes associated with rural electrification. This last survey was conducted only in the East, which has recently been energized, since such a survey has been conducted earlier by the Research Institute and reported elsewhere (e.g., Herrin and Madigan, 1977).

### **Profile of Sample Areas and Households**

Given the non-experimental nature of the study design, the problem of selection bias becomes an important consideration in the analysis of the impact of rural electrification. Differences in the measures of the areas of concern, e.g. income, female employment, fertility, family planning behavior, etc., between the electrified and non-electrified groups may not only be due to rural electrification, but also due to their prior differences in background characteristics. It is therefore important to control for such prior differences in the impact analysis. The sampling scheme adopted for this study was primarily designed with the view of minimizing such possible selection bias. Additional controls will be made through multivariate analysis, as will be described later. This section presents some of the major background characteristics of the sample areas and households with the view of determining significant prior differentials in characteristics that may confound the relationship between rural electrification and fertility change.

*Sample Areas.* In the community survey, we obtained various barangay-level indicators such as population size, access to transportation, educational and health services, types of economic activities, social and farm organizations, and barangay development activities. Preliminary analysis reveals that access to educational and health services and the type of economic activities were found to be highly correlated with several locational variables, namely: distance to the national highway, distance to the provincial capital; and for rural barangays, distance to the municipal poblacions. The level of activity of social and farm organizations and of the barangay councils were found not to be significantly different across areas. Thus only locational variables and population appear at first glance to differ across areas. These are shown in Table 1.

A regression analysis shown in Table 4 reveals, however, that the western (totally electrified) and eastern (partially electrified) sample areas differ only significantly with respect to distance from Cagayan de Oro. Overall electrified areas are much closer to Cagayan de Oro since most are located in the west, and

are mainly in poblacions and coastal areas since the eastern inland areas have not yet been electrified.

*Sample Households.* For the demographic analysis conducted in this study, the sample was restricted to consist only of those households where both husband and wife are present, the husband is the household head, and the wife is once-married, age 15-49 years, and fecund, i.e. was ever pregnant and is reported to be still menstruating. Out of the total 1,403 households interviewed, 1,257 households (couples) were eligible. The characteristics of these households classified by areas (west vs. east) and strata (municipal poblacion, coastal barangay and inland barangay) are shown in Tables 1 to 3.

A regression analysis, presented in Table 5, reveals which characteristics significantly differentiate between (a) households in the western and eastern segments; and (b) between households in the electrified and non-electrified areas of either segment. For example, among others, western households compared to eastern households tend to be characterized by (a) younger wives with lower level of educational attainment; (b) less proportion of houses made of light materials; (c) less proportion owning homelots or agricultural land; (d) higher proportion of households engaged in corn and tobacco production and less on rice; and (e) more women in paid employment. These differences may have some influence over their fertility differentials shown in Table 6, hence, they need to be controlled for in analyzing the impact of rural electrification on fertility and other related behavior.

Table 7 and 8 describe differential characteristics of electrified versus non-electrified households in western Misamis Oriental and in the electrified areas of both segments respectively. It is readily apparent that electrified households compared with non-electrified households tend to be characterized, among others, by (a) higher level of educational attainment of the wife, (b) less proportion with houses made of light materials, (c) greater proportion owning their homelots, and (d) greater proportions found in poblacions and coastal areas than in inland areas. These background differences can be expected to influence their observed fertility differentials.

Finally, Table 9 shows indicators of electricity use in the households. In the west, 47 percent of the sample households have electric connections. The strata percentages are 66, 49 and 25 for poblacions, coastal and inland barangays, respectively. In the east where areas were electrified as early as June 1978, the percentage of households with electric connection is 28 percent. Only the poblacion and the coastal barangays have so far been electrified as of survey time in mid-1980. As Table 9 reveals, in addition to lighting, electricity is used mostly for ironing and for operating various types of appliances or consumer durables, most commonly radios and phonographs.

Examples of electric use in the community as well as in the household were described earlier in Herrin and Madigan (1977). The uses include the operation of community water supply systems, and various use in health units, schools and

Table 1. Selected Area and Household Characteristics, Misamis Oriental, 1980

Indicator	West				East			
	Total West	Municipal Poblacion	Coastal Barangay	Inland Barangay	Total West	Municipal Poblacion	Coastal Barangay	Inland Barangay
<i>Area Characteristics</i>								
1. Mean Population, 1975	1,513	2,485	998	1,057	1,058	1,513	961	699
2. Number of areas	18	6	6	6	18	6	6	6
3. Mean distance in kilometers to:								
Poblacion	2.53	0.0	2.42	5.17	1.61	0.0	2.22	2.61
National highway	1.89	0.0	1.08	4.58	0.79	0.0	0.0	2.38
Cagayan de Oro	33	26	35	38	62	60	60	7
<i>Household Characteristics</i>								
1. Sample households	650	218	214	218	607	206	203	198
2. Percent of housing with light materials	69.1	52.8	75.7	78.9	69.7	56.8	75.4	77.3
3. Percent owning house	85.2	77.1	89.7	89.0	82.5	74.3	87.2	86.4
4. Percent owning homelot	33.8	34.4	25.7	41.3	32.1	34.5	27.6	34.3
5. Percent owning agri. land	26.0	16.1	21.0	40.8	24.1	15.5	18.7	38.4
6. Percent by type of water system:								
Pipe or private pump	8.3	23.9	0.9	0.0	11.2	25.7	2.5	5.1
Public artesian	74.2	71.1	90.7	61.0	59.1	69.4	56.2	51.5
Others	17.5	5.0	8.4	39.0	29.7	4.9	41.4	43.4

Table 2. Educational and Occupational Characteristics, Misamis Oriental, 1980

<i>Indicator</i>	<i>West</i>				<i>East</i>			
	<i>Total West</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>	<i>Total West</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>
<i>Sample Households</i>	650	218	214	218	607	206	203	198
<i>Education of Husband (% in Category)</i>								
Elementary	66.3	46.8	76.2	76.1	62.1	48.5	60.6	78.2
High School	21.5	31.2	16.9	16.5	26.5	31.0	28.5	19.9
College	10.2	21.7	4.3	4.6	10.9	20.4	10.3	1.5
No schooling	2.0	0.5	2.8	2.8	0.3	0.0	0.5	0.5
Mean years completed	6.73	8.51	5.83	5.85	7.24	8.43	7.19	6.05
<i>Education of Wife (% in Category)</i>								
Elementary	66.2	51.1	74.8	73.0	58.4	44.7	60.1	70.6
High School	21.3	26.6	17.3	20.3	31.1	36.9	31.5	24.8
College	10.8	21.6	6.0	4.6	10.2	18.0	8.4	4.0
No schooling	1.7	0.9	1.9	2.3	0.3	0.5	0.0	0.5
Mean years completed	6.88	8.24	6.21	6.14	7.47	8.50	7.18	6.58
<i>Occupation of Husband (% in Category)</i>								
Farm owners	28.0	14.2	28.0	42.7	22.2	15.5	16.7	34.8
Tenants	28.5	17.0	25.7	42.7	21.4	9.2	15.8	39.9
Farm workers	9.4	12.4	15.9	0.0	13.7	15.5	20.2	5.1
Fishermen	2.9	1.4	5.1	2.3	12.4	6.8	18.7	11.6
Non-agricultural	30.9	55.0	25.2	12.4	30.3	52.9	28.6	8.6

Table 3. Selected Indicators of Employment and Production, Misamis Oriental, 1980

<i>Indicator</i>	<i>W e s t</i>				<i>E a s t</i>			
	<i>Total West</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>	<i>Total West</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>
<i>Sample households</i>	650	218	214	218	607	206	203	198
<i>Percent of HH in own production activities:<sup>a</sup></i>								
Rice	2.6	1.8	2.3	3.7	5.8	3.4	8.9	5.1
Corn	61.1	37.2	56.5	89.4	25.9	10.2	15.3	53.0
Coconut	12.9	14.7	11.7	12.4	12.7	8.3	7.9	22.2
Tobacco	25.1	17.0	24.3	33.9	0.0	0.0	0.0	0.0
Fishing	14.9	16.5	21.5	6.9	18.0	21.8	26.1	8.6
Business	16.5	25.7	15.0	8.7	14.3	25.2	13.3	4.0
<i>Percent of in paid employment:</i>								
Husbands	33.2	50.9	28.0	20.6	47.9	51.0	51.2	41.4
Wives	8.2	18.8	2.8	2.8	7.4	13.6	6.9	1.5

<sup>a</sup>Households engaged in multiple activities.

Table 4. Differential Area Characteristics between Western and Eastern Segments and between Electrified and Non-Electrified Areas in Both Segments, Misamis Oriental, 1980: A Regression Analysis

<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>AWEST</i>		<i>AELEC</i>	
			<i>Coefficient</i>	<i>t-value</i>	<i>Coefficient</i>	<i>t-value</i>
POP/1,000	1.285	0.776	0.154	1.483	-0.025	-0.306
DISTHWY	1.342	3.139	0.040	0.473	-0.107	-1.614
DISTCGY	48.917	16.834	-0.022***	-6.133	-0.009***	-3.241
COASTAL	0.333	0.478	0.169	0.418	-0.095	-0.297
INLAND	0.333	0.478	0.295	1.398	-0.626***	-3.759
COASTAL x DISTPOB	0.772	1.173	-0.010	-0.061	0.057	0.449
INLAND x DISTPOB	1.297	3.173	-0.036	-0.403	0.134*	1.917
Constant			1.232		1.484	
$R^2$			0.575		0.523	
F			7.768		6.484	
n			36		36	
Mean			0.500		0.833	

\*\*\*, \*\*, \* Significant at 0.01, 0.05, 0.10 levels, respectively. For definition of the variables, see Annex A.



Table 5. Differential Household Characteristics, Misamis Oriental, 1980: A Regression Analysis

Variable	Mean	Standard Deviation	IIHWEST		HHAEEC	
			Coefficient	t-value	Coefficient	t-value
1. AGEW	34.175	8.017	-0.002*	-1.722	-0.005	-0.543
2. EDW	7.173	3.347	-0.007**	-2.847	-0.002	-0.648
3. OCCH1	0.254	0.435	0.012	0.384	-0.020	-0.772
4. OCCH2	0.251	0.434	-0.066**	2.322	-0.062***	-2.630
5. OCCH3	0.115	0.319	-0.015	-0.369	-0.052	-1.515
6. OCCH4	0.075	0.435	-0.025	-0.739	0.001	0.024
7. YCRES	0.862	0.345	0.039*	1.711	0.013	0.692
8. HOUSE	0.694	0.461	-0.031*	1.669	0.011	0.690
9. OWNHOUSE	0.839	0.367	-0.008	-0.341	-0.004	-0.187
10. OWNLOT	0.330	0.470	-0.078***	3.945	0.001	0.085
11. OWNLAND	0.251	0.434	-0.092***	-3.007	-0.035	-1.398
12. COASTAL	0.332	0.471	0.081	1.378	-0.133***	-2.719
13. INLAND	0.331	0.471	0.215***	6.881	-0.643***	-24.840
14. COASTAL x DISTPOB	0.775	1.160	0.036	1.499	0.077***	3.919
15. INLAND x DISTPOB	1.282	3.065	0.010*	0.752	0.154***	14.647
16. DISTHWY	1.332	3.026	0.002	0.131	-0.123***	-12.507
17. DISTCGY	48.107	16.308	-0.020***	-35.996	-0.008***	-16.455
18. POPN/1,000	1.306	0.762	0.150***	10.512	-0.030**	-2.129
19. WATER1	0.097	0.296	0.071**	2.002	0.036	1.208
20. WATER2	0.669	0.471	0.107***	5.121	0.049***	2.845
21. RICE	0.041	0.199	-0.211***	5.194	0.031	0.928
22. CORN	0.441	0.497	0.179***	7.846	0.074***	3.935
23. TOBACCO	0.130	0.336	0.204***	7.770	0.185***	8.476
24. COCONUT	0.128	0.334	0.006	0.238	-0.074***	-3.462
25. FISHING	0.169	0.375	0.020	0.610	0.020	0.712
26. BUSINESS	0.154	0.361	0.009	0.414	0.014	0.750
27. WEMP	0.078	0.268	0.097***	2.580	0.027	0.947
Constant			1.124		1.358	
R <sup>2</sup>			0.713		0.628	
F			116.678		79.627	
n			1,257		1,257	
Mean			0.517		0.842	
Standard Deviation			0.500		0.364	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 0-10 levels, respectively. For definition of the variables, see Annex A.

public buildings. In addition, electricity was found to be used in the irrigation of some farms. In this sample, however, of the 15 households in the west and 26 in the east which uses irrigation, all use gravity systems rather than electric pump sets. Hence, the effect of electrification on farm production through irrigation will not be captured by the data.

The use of electricity in business, schools and health units based on the user survey conducted for this study will be presented in a separate report.

Table 6. Fertility and Family Planning Indicators, Misamis Oriental, 1980

<i>Indicator</i>	<i>West</i>				<i>East</i>			
	<i>All West</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>	<i>Total East</i>	<i>Municipal Poblacion</i>	<i>Coastal Barangay</i>	<i>Inland Barangay</i>
Number of Sample Households (Eligible Women)	650	218	214	218	607	206	203	198
Mean Children Ever Born	4.58	4.41	4.71	4.62	5.13	5.46	4.65	5.25
% With Live Birth Past 2 Years	42.5	38.6	42.7	46.1	41.1	44.2	40.7	38.4
% With Live Birth Past 5 Years	67.3	58.1	71.4	73.3	68.9	68.4	66.5	71.7
% Ever Used FP Methods	66.9	78.0	63.6	58.3	53.7	62.6	57.6	40.4
% Ever Used Modern FP Methods	42.8	50.0	47.2	31.2	26.5	31.1	28.1	20.2
% Current Use of FP Methods	50.3	60.6	45.8	44.5	35.6	37.4	44.8	24.2
% Current Use of Modern FP Methods	29.1	34.0	31.3	21.1	18.6	20.9	22.7	12.1
% Ever Visited FP Clinic	70.3	75.7	41.5	63.8	53.2	51.5	61.6	46.5

Table 7. Differential Household Characteristics between Electrified and Non-Electrified Households, Western Misamis Oriental, 1980: A Regression Analysis

<i>Variables</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>HELECW</i>	
			<i>Coefficient</i>	<i>t-value</i>
1. AGEW	33.322	7.693	0.004*	1.764
2. EDW	6.885	3.471	0.023***	3.839
3. OCCH1	0.283	0.451	-0.098	1.520
4. OCCH2	0.285	0.452	-0.144**	-2.261
5. OCCH3	0.094	0.292	0.277***	2.941
6. OCCH4	0.029	0.169	-0.140	-1.344
7. YCRES	0.866	0.341	0.041	0.826
8. HOUSE	0.691	0.463	-0.157***	-3.798
9. OWNHOUSE	0.852	0.355	-0.028	-0.543
10. OWNLOT	0.338	0.474	0.098**	2.242
11. OWNLAND	0.260	0.439	0.086	-1.363
12. COASTAL	0.329	0.470	0.385***	2.926
13. INLAND	0.335	0.472	0.007	0.088
14. COASTAL x DISTPOB	0.810	1.224	-0.185***	-3.690
15. INLAND x DISTPOB	1.662	3.986	-0.098***	3.632
16. DISTHWY	1.831	3.927	0.090***	3.596
17. DISTCGY	35.883	9.966	0.001	-0.541
18. POPN/1,000	1.512	0.886	0.010	0.212
19. WATER1	0.083	0.276	0.156*	1.723
20. WATER2	0.742	0.438	0.089*	1.645
21. RICE	0.026	0.160	0.028	-0.264
22. CORN	0.611	0.488	-0.033	-0.601
23. TOBACCO	0.251	0.434	0.069	1.536
24. COCONUT	0.129	0.336	0.047	0.831
25. FISHING	0.149	0.357	-0.125*	-1.725
26. BUSINFSS	0.165	0.371	0.230***	4.873
27. WEMP	0.082	0.274	0.098	1.300
Constant			0.225	
$R^2$			0.324	
F			12.530	
n			650	
Mean			0.465	
Standard Deviation			0.499	

\*\*\*, \*\*, \* Significant at 0.01, 0.05, 0.10 levels, respectively.

For definition of variables, see Annex A.

Table 8. Differential Household Characteristics between Electrified and Non-Electrified Households, Western Misamis Oriental, 1980: A Regression Analysis

<i>Variables</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>HELECWE</i>	
			<i>Coefficient</i>	<i>t-value</i>
1. AGEW	34.097	7.934	0.004***	2.275
2. EDW	7.284	3.463	0.031***	6.133
3. OCCH1	0.237	0.425	-0.106**	1.995
4. OCCH2	0.222	0.416	-0.152***	-3.083
5. OCCH3	0.126	0.332	0.019	0.282
6. OCCH4	0.067	0.250	-0.138**	-2.315
7. YCRES	0.859	0.348	0.082**	2.117
8. HOUSE	0.679	0.467	0.198***	-6.031
9. OWNHOUSE	0.834	0.372	0.078	0.205
10. OWNLOT	0.327	0.469	0.059*	1.712
11. OWNLAND	0.226	0.418	-0.016	-0.317
12. COASTAL	0.393	0.489	0.171*	1.786
13. INLAND	0.206	0.405	0.042	0.664
14. COASTAL x DISTPOB	0.916	1.208	-0.072*	-1.839
15. INLAND x DISTPOB	1.022	3.228	-0.083***	-3.370
16. DISTHWY	1.125	3.205	0.072	3.184
17. DISTCGY	44.759	15.173	-0.002	2.117
18. POPN/1,000	1.414	0.772	0.050**	2.027
19. WATER1	0.106	0.308	0.105*	1.655
20. WATER2	0.699	0.459	0.045	1.132
21. RICE	0.040	0.195	0.110	-1.511
22. CORN	0.424	0.494	-0.012	0.289
23. TOBACCO	0.154	0.361	0.076*	1.753
24. COCONUT	0.111	0.314	0.049	1.030
25. FISHING	0.184	0.387	0.018	0.331
26. BUSINESS	0.176	0.381	0.199***	5.430
27. WEMP	0.090	0.286	0.019	0.344
Constant			0.113	
R <sup>2</sup>			0.278	
F			16.083	
n			1,057	
Mean			0.446	
Standard Deviation			0.497	

\*\*\*, \*\*, \* Significant at 0.01, 0.05, 0.10 levels, respectively.  
For definition of variables, see Annex A.

Table 9. Indicators of Electricity Use in the Household, Misamis Oriental, 1980

Indicator	West				East			
	Total West	Municipal Poblacion	Coastal Barangay	Inland Barangay	Total East	Municipal Poblacion	Coastal Barangay	Inland Barangay
Sample Households	650	218	214	218	607	206	203	198
Percent of HH with electricity	46.5	66.1	48.6	24.8	28.0	51.5	31.5	0.0
Number of HH with electricity	302	144	104	54	170	106	64	0
Percent of HH using electricity other than for lighting:*								
Cooking	7.9(24)	15.3(22)	1.9(2)	0.0(0)	0.5(1)	0.9(1)	0.0(0)	0.0(0)
Ironing	24.5(74)	42.4(61)	7.7(8)	9.3(5)	15.3(26)	17.0(18)	12.5(8)	0.0(0)
Water supply	1.3(4)	2.8(4)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
Appliances	57.3(173)	63.2(91)	62.1(55)	50.0(27)	37.6(64)	42.5(45)	29.7(19)	0.0(0)

\*Number in parenthesis are actual number of households.

### Statistical Analysis

This section presents the results of exploratory statistical analysis to determine the relationships between rural electrification and fertility/family planning, as well as between rural electrification and other factors that are likely to affect fertility/family planning in a dynamic context, i.e., household income, female employment and new consumption possibilities. In view of the cross-section nature of our survey data, the approach adopted in our analysis is to view current fertility, family planning practice, and other important household changes as *jointly* determined by a common set of exogenous factors, including the presence of rural electrification. The following set of semi-reduced form equations are estimated using ordinary least squares regression analysis.

- (1) FERT: I, H, LOC, YAELEC
- (2) FPLAN: I, H, LOC, YAELEC
- (3) HHINCOME: I, H, LOC, YAELEC
- (4) WEMP: I, H, LOC, YAELEC
- (5) HELEC: I, H, LOC, YAELEC

where

FERT	=	current fertility
FPLAN	=	current practice of family planning methods
HHINCOME	=	household income from all sources during the past 12 months
WEMP	=	current wife's labor force participation
HELEC	=	presence of electricity in the home, which proxies for the demand for new consumption goods

For the definition of specific variables used in actual regressions to be described below, see Annex A.

*Current Fertility.* Table 10 presents the regression on fertility during the past five years (FERT 5). The sample of women used in this regression was further restricted to include only those who were married prior to the beginning of the current reference period. The results show that while the coefficient of the rural electrification variable (YAELEC) is negative as hypothesized, it is significant only at the 0.20 level, i.e., below the usually acceptable levels of significance. Because the electrification variable reflects the *total* effects of electrification on fertility, it may be possible that its various potential positive and negative effects tend to cancel out, thus leaving an overall effect that is not highly significant.

Table 11 presents the regression on fertility during the past two years (FERT 2). In addition to previous restrictions, the sample for this regression was restricted to women who have been married two years or more. The coefficient of YAELEC is now significant at the usual levels, and is consistent with our hypothesis that rural electrification is negative related to current fertility behavior.

Table 10. Regression on Live Births During the Past Five Years Misamis Oriental, 1980

Variables	Mean	Standard Deviation	FERT 5	
			Coefficient	t-value
AGEW	35.845	7.216	- 0.079***	-13.485
EDW	6.897	3.276	- 0.015	- 1.454
PPACITY5	4.204	2.951	0.016	1.175
OCCH1	0.268	0.443	0.140	- 1.229
OCCH2	0.254	0.436	- 0.082	- 0.894
OCCH3	0.118	0.323	0.133	1.252
OCCH4	0.069	0.253	0.205	1.550
YCRES	0.861	0.346	0.220**	- 2.552
HOUSE	0.673	0.469	0.233***	3.414
OWNHOUSE	0.874	0.332	- 0.250***	2.652
OWNLOT	0.354	0.479	0.008	0.110
OWNLAND	0.262	0.440	- 0.011	- 0.099
COASTAL	0.329	0.470	- 0.445**	1.966
INLAND	0.334	0.472	0.008	0.069
COASTAL x DISTPOB	0.773	1.161	0.077	0.839
INLAND x DISTPOB	1.232	2.921	- 0.038	0.823
DISTHWY	1.294	2.879	0.029	0.665
DISTCGY	48.127	16.305	0.002	0.630
POPNI/1,000	1.306	0.766	- 0.075	1.332
YAELEC	4.303	3.695	- 0.017	- 1.280
Constant			4.527	
$R^2$			0.292	
F			23.206	
n			1,078	
Mean			1.210	
Standard Deviation			1.120	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.  
For definition of variables, See Annex A.

An examination of the other variables in both regressions reveal that only a few are significant. This is not surprising since our sampling approach was in fact designed to minimize prior differences in background characteristics other than the presence of rural electrification. Of the significant coefficients, however, all are of the expected signs.

*Current Family Planning Practice.* Given a time lag in which rural electrification begins to affect a large proportion of the population, we might also expect a corresponding lag in measurable response on fertility. The significant coefficient of YAELEC on FERT 2 but not on FERT 5 may also be interpreted in this light.

Table 11. Regression on Live Births During the Past Two Years  
Misamis Oriental, 1980

<i>Variables</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>FERT 2</i>	
			<i>Coefficient</i>	<i>t-value</i>
AGEW	34.664	7.761	- 0.463***	-15.117
FDW	7.093	3.336	- 0.003	- 0.503
PPARITY2	4.547	3.001	0.035***	4.600
OCCH1	0.256	0.437	0.872	- 1.316
OCCH2	0.253	0.435	- 0.738	- 1.397
OCCH3	0.115	0.319	- 0.011	- 0.184
OCCH4	0.075	0.264	0.073	0.990
YCRES	0.861	0.346	- 0.036	- 0.724
HOUSE	0.688	0.463	0.090**	2.248
OWNHOUSE	0.855	0.352	0.090**	2.248
OWNLOT	0.338	0.473	0.015	0.344
OWNLAND	0.254	0.435	- 0.017	- 0.268
COASTAL	0.331	0.471	- 0.147	- 1.132
INLAND	0.332	0.471	0.043	0.639
COASTAL x DISTPOB	0.773	1.159	0.015	0.283
INLAND x DISTPOB	1.272	3.039	- 0.008	- 0.296
DISTHWY	1.326	2.999	0.008	0.311
DISTCGY	48.138	16.326	0.001	0.396
POPNI/1,000	1.306	0.765	- 0.010	- 0.313
YAELEC	4.321	3.701	- 0.015*	- 31.899
Constant			2.228	
$\bar{R}^2$			0.246	
F			20.633	
n			1,207	
Mean			0.558	
Standard Deviation			0.664	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.  
For definition of variables, See Annex A.

If this interpretation is correct, then we should expect to see a strong observable impact of rural electrification on the practice of family planning methods in the current period, i.e., at time of interview. Table 12 does in fact reveal a strong positive relationship between YAELEC and the practice of family planning methods, especially the modern methods (pill, IUD or sterilization).

*Other Household Changes.* Tables 13 to 15 present regressions on specific household changes that are in turn expected to influence fertility in a dynamic context. Table 13 suggests that the total effect of rural electrification on current household income is positive and significant, after controlling for other factors. We inter-



Table 12. Regression on the Use of Family Planning Methods  
Misamis Oriental, 1980

<i>Variables</i>	<i>FPUSEA</i>		<i>FPUSEM</i>	
	<i>Coefficient</i>	<i>t-value</i>	<i>Coefficient</i>	<i>t-value</i>
AGEW	-0.002	-0.989	-0.005**	-2.557
EDW	0.021***	4.330	0.014	0.330
CEB	0.009	1.564	0.008	1.548
OCCH1	0.084	-1.580	-0.059	-1.259
OCCH2	-0.048	-1.139	-0.028	-0.745
OCCH3	-0.027	-0.548	0.053	1.226
OCCH4	-0.052	-0.886	-0.086*	-1.638
YCRES	-0.062	-1.552	-0.069**	-1.979
HOUSE	-0.056*	-1.731	-0.056**	-1.957
OWNHOUSE	0.004	0.106	0.044	1.248
OWNLOT	0.014	0.416	0.074**	2.391
OWNLAND	-0.002	-0.033	-0.010	-0.213
COASTAL	0.238**	2.310	0.106	1.170
INLAND	-0.035	0.633	0.038	-0.786
COASTAL x DISTPOB	0.075*	1.816	0.024	-0.668
INLAND x DISTPOB	0.063***	2.924	0.027	1.405
DISTHWY	-0.071***	-3.482	-0.034*	-1.906
DISTCGY	-0.004***	-2.659	0.001	0.833
POPNI/1,000	-0.014	-0.527	0.002	0.095
YAELEC	0.014**	2.286	0.018***	3.369
Constant	0.575		0.309	
R <sup>2</sup>	0.092		0.048	
F	7.332		4.148	
n	1,257		1,257	
Mean	0.432		0.240	
Standard Deviation	0.495		0.427	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.

For definition of variables, See Annex A.

pret this significant relationships in terms of the effect of rural electrification on the generation of new production and employment opportunities in the project area. The growth of these opportunities have likewise increased female employment, as revealed in Table 14. Opportunities for female employment may be looked upon as providing an alternative source of satisfaction previously provided by having many children. Hence, we would expect fertility to decline further as female employment expands in the future.

Finally, Table 15 suggests that the number of households having electric connections increases over time, after controlling for other income-related variables.

Table 13. Regression on Family Income, Misamis Oriental

<i>Variables</i>	<i>HHINCOME</i>		<i>HHINCOMEX</i>	
	<i>Coefficient</i>	<i>t-value</i>	<i>Coefficient</i>	<i>t-value</i>
AGEW	0.019***	3.481	0.032***	4.076
EDW	0.034**	2.546	0.089***	4.624
OCCH1	0.135	-0.891	-0.402*	- 1.817
OCCH2	0.136	1.134	- 0.076	- 0.436
OCCH3	-2.266***	-16.248	- 0.023***	-11.122
OCCH4	-0.436***	- 2.601	- 0.197	- 0.805
YCRES	-0.024	- 0.215	0.011	0.067
HOUSE	-0.422***	- 4.611	- 0.569***	- 4.263
OWNHOUSE	-0.078	0.688	0.139	- 0.835
OWNLOT	- 0.043	- 0.436	- 0.081	- 0.564
OWNLAND	0.223	1.545	- 0.011	- 0.054
COASTAL	1.084***	3.716	0.553***	3.654
INLAND	0.109	0.702	0.287	1.270
COASTAL x DISTPOB	-0.353***	- 3.023	- 0.500***	- 2.938
INLAND x DISTPOB	-0.644	- 1.055	- 0.191**	- 2.147
DISTHWY	0.183***	3.150	0.362***	4.277
DISTCGY	-0.003	0.829	-0.005	0.880
POPNI/1,000	0.203***	2.732	2.261**	2.412
YAELEC	0.058***	3.350	0.123***	4.853
Constant	6.899		5.643	
$\bar{R}^2$	0.324		0.231	
F	32.631		20.878	
n	1,257		1,257	
Mean	8.233		8.015	
Standard Deviation	1.629	2.2	2.227	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.  
For definition of variables. See Annex A.

This implies that the impact of rural electrification may not be easily measurable until such time that a critical number of households have had effective use of electricity in their homes. The use of electricity in the home reduces the effective cost of electricity-dependent consumer durables, and hence increases the demand for such goods. This new consumption opportunities may generate aspirations for new lifestyles that may no longer be consistent with high fertility.

### Conclusion and Discussion

The results obtained thus far suggest that rural electrification is significantly related to current fertility and current contraceptive behavior, as well as to house-

Table 14. Regression on Wife's Labor Force Participation, Misamis Oriental, 1980

<i>Variables</i>	<i>WEMP</i>	
	<i>Coefficient</i>	<i>t-value</i>
AGEW	0.008***	7.118
EDW	0.034***	14.922
CEB	- 0.013***	- 4.649
OCCH1	- 0.064**	- 2.516
OCCH2	- 0.048**	- 2.364
OCCH3	- 0.061**	- 2.570
OCCH4	- 0.013	- 0.450
YCRES	0.009	0.487
HOUSE	- 0.035**	- 2.252
OWNHOUSE	- 0.015	- 0.798
OWNLOT	- 0.011	- 0.672
OWNLAND	0.003	0.108
COASTAL	- 0.028	- 0.579
INLAND	- 0.021	- 0.813
COASTAL x DISTPOB	0.009	0.466
INLAND x DISTPOB	0.006	0.554
DISTHWY	- 0.001	- 0.010
DISTCGY	0.001	0.800
PPN/1,000	0.020	1.586
YAELEC	0.055*	1.857
Constant	- 0.375	
$\bar{R}^2$	0.290	
F	26.683	
n	1,257	
Mean	0.078	
Standard Deviation	0.268	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.  
For definition of variables, see Annex A.

hold incomes, female employment, and consumption behavior. In view of the cross-section, non-experimental nature of the data, however, cause-and-effect interpretations must be made with caution at this point. A proposed second phase of this research to be implemented sometime in 1985, would allow for a quasi-experimental design, i.e. a before-after, modified with-and-without design. The results of this second phase should add more confidence to our conclusions.

The study of the demographic impact of development programs is more than just of an academic interest. Fertility has declined in the Philippines as elsewhere in several less developed countries. But the rate of fertility decline in the Philippines has not been sufficiently fast enough in the recent past to merit optimism that the fertility goals implied in the current development plan can be achieved, i.e. replace-

Table 15. Regression on the Presence of Electricity in the Household, Misamis Oriental, 1980

<i>Variables</i>	<i>Electrified Household (HELEC)</i>		<i>Year Electrified (YHELEC)</i>	
	<i>Coefficient</i>	<i>t-value</i>	<i>Coefficient</i>	<i>t-value</i>
AGEW	0.005***	3.099	0.040***	4.825
EDW	0.031***	7.859	0.081***	3.973
OCCH1	0.129***	-2.858	-0.755***	-3.223
OCCH2	0.169***	-4.754	-0.547***	-2.958
OCCH3	-0.022	-0.528	0.157	0.727
OCCH4	-0.137**	-2.758	-0.413	-1.596
YCRE5	0.050	1.485	0.452***	2.595
HOUSE	-0.182***	-6.662	0.732***	5.175
OWNHOUSE	0.010	0.300	0.203	1.155
OWNLOT	0.091***	3.109	0.431***	2.827
OWNLAND	-0.032	-0.736	0.215	0.965
COASTAL	0.094	1.082	1.165***	2.587
INLAND	-0.180***	-3.891	0.333	1.389
COASTAL x DISTPOB	-0.054	-1.546	-0.480***	-2.657
INLAND x DISTPOB	-0.046**	-2.551	-0.405***	-4.299
DISTHWY	0.046***	2.673	0.406***	4.522
DISTCGY	-0.001	-0.642	-0.011*	-1.916
POPNI/1,000	0.018	0.806	0.065	0.569
YALEC	0.025***	4.862	0.193***	7.160
Constant	0.096		1.233	
R <sup>2</sup>	0.323		0.244	
F	32.504		22.286	
n	1,257		1,257	
Mean	0.376		1.145	
Standard Deviation	0.484		2.380	

\*\*\*, \*\*, \* Significant at 0.01, 0.05 and 0.10 levels, respectively.  
For definition of variables, See Annex A.

ment fertility by the year 2000 or thereabouts. An analysis of recent fertility decline in the Philippines up to 1975 suggests that the most rapid decline in marital fertility occurred among highly educated parents with high incomes and living in the urbanized areas of Metro Manila, Southern Luzon and Central Luzon (Herrin, 1982).<sup>\*</sup> On the basis of fragmentary evidence, this decline is understandable in terms of (a) the changing structure of costs and benefits of children, as perceived by parents, associated with urbanization, industrialization, and educational advancement, and (b) the socioeconomic and locational advantage of these parents in terms of access to contraceptive information and supplies provided by both program and

<sup>\*</sup>The following discussion is excerpted from Herrin (1982).

non-program outlets. Further fertility decline in these areas may be expected from the impact of development and family planning programs already in place through some diffusion process, perhaps along the Western-type demographic transition. But what are the prospects for fertility decline for the rest of the population? Are high levels of Western-type modernization a necessary condition for rapid fertility decline in the future? If so, can the extent and pace of broad-based socioeconomic development expected in the decades ahead sufficient to depress fertility to levels consistent with current development goals? If not, then where does this leave us?

An analysis of recent fertility change in some countries seem to provide a basis for viewing the determinants of fertility change in a different light. While Western-type modernization may be a sufficient condition for sustained fertility decline, it need not be a necessary condition. In a recent appraisal of theories of fertility decline, Freedman (1979) suggested hypotheses that have important policy significance for population planning in less developed countries, such as the Philippines. These hypotheses are: "(1) that subsets of objective development alterations, much smaller than those that characterized the West, can provide motivations for lower fertility today; and (2) that under modern conditions, ideas and aspirations for a different way of life transcending what is actually available are also important in motivating lower fertility." (Freedman, 1979, p. 65).

What are these "subsets of objective development alterations"? This study is designed primarily to identify specific aspects of development short of massive socioeconomic transformation, than can significantly influence current fertility and family planning behavior in a rural setting.

Viewed from the perspective of Freedman's hypotheses, one may interpret small but cumulative changes associated with rural electrification as potential motivating factors for changed behavior in both economic and demographic spheres. For example, the convenience afforded by electric illumination in the home, normally taken for granted by city folks, may have a profound aspirational impact among rural households who never thought such a facility would ever be possible in their lifetime. The same can be said for electrically operated water supply systems in the community. The reduced cost of operating electrically powered communication items, e.g. radio, TV in some cases, etc., may help spread out modern ideas and new lifestyles quickly in a predominantly rural setting. From these small changes, one can add new sets of economic opportunities that might arise associated with the advent of rural electrification, e.g. new businesses and industrial enterprises providing additional employment in the area, or other changes that signal to households possibilities for a new life consistent with a small family size.

The identification of these subsets of development can provide a basis for designing development programs and projects that indirectly affect demographic behavior while they achieve their specific sectoral objectives.

**Annex A**  
**List of Variables**  
**(n = 1,257)**

<i>Symbol</i>	<i>Definition/M Measurement</i>	<i>Mean</i>	<i>Standard Deviation</i>
<i>A. Dependent</i>			
1. AELEC	Area electrification status, all sample areas (1 = if barangay is electrified; 0 = otherwise)	.833	—
2. AWEST	Area electrification status in Western segment (1 = if barangay in West is electrified; 0 = otherwise)	.500	—
3. FERT 5	Fertility during the past five years (actual number of live births)	1.210	1.120
4. FERT 2	Fertility during the past two years (1 = if the woman has had a live birth; 0 = otherwise)	.558	0.664
5. FPUSFA	Current use of any family planning methods (1 = if the woman is currently using any method; 0 = otherwise)	0.432	0.495
6. FPUSEM	Current use of modern family planning methods (1 = if wife current uses either pill, IUD or either spouse is sterilized; 0 = otherwise)	0.240	0.427
7. HELEFC	Electrification status of the household in all sample areas (1 = if house is electrified; 0 = otherwise)	0.576	0.484
8. HELECW	Electrification status of the household in Western segment (1 = if house is electrified, 0 = otherwise)	0.465	0.499
9. HELECWE	Electrification status of the household in Western and Eastern electrified areas (1 = if house is electrified; 0 = otherwise)	0.446	0.497
10. HHALLEC	Location of household by area electrification status (1 = if household is in the electrified areas; 0 = otherwise)	0.842	0.364

<i>Symbol</i>	<i>Definition/M Measurement</i>	<i>Mean</i>	<i>Standard Deviation</i>
11. HHWEST	Location of household by provincial segment (1 = if household is located in the Western segment; 0 = otherwise)	0.517	0.500
12. HHINCOME	Natural logarithm of total annual household income from all sources, inclusive of wife's income	8.233	1.629
13. HHINCOMEX	Natural logarithm of household income exclusive of the wife's income	8.015	2.227
14. WEMP	Current labor force participation of the wife (1 = if wife works in paid employment or in own business; 0 = otherwise)	0.078	0.268
15. YHELEC	Number of years the household has had electric connection.	1.145	2.380
<b>B. Independent</b>			
1. AGEW	Age of the wife in completed years	34.175	8.017
2. CEB	Total number of children ever born	4.847	2.965
3. COASTAL	Coastal area (1 = barangay is located in coastal area; 0 = otherwise)	0.332	0.471
4. COASTAL x DISTPOB	Distance of coastal area from poblacion (interaction term between COASTAL and DISTPOB)	0.775	1.160
5. DISTHWY	Distance of barangay to the national highway in kilometers	1.332	3.026
6. DISTCGY	Distance of barangay to Cagayan de Oro in kilometers	48.107	16.308
7. EDW	Highest grade of schooling completed by the wife	7.173	3.347
8. HOUSE	Type of material used in house construction (1 = light materials; 0 = mixed or heavy materials)	0.694	0.461
9. INLAND x DISTPOB	Distance of inland area to poblacion: (interaction term between INLAND and DISTPOB)	1.282	3.065

<i>Symbol</i>	<i>Definition/M Measurement</i>	<i>Mean</i>	<i>Standard Deviation</i>
10. OCCHK	Occupation of the husband (1 = if in category k; 0 = otherwise where k is coded as 1 = Farm owners 2 = Tenants 3 = Farm workers 4 = Fishermen 5 = Non-agricultural occupations	0.254 0.251 0.115 0.075	0.435 0.434 0.319 0.263
11. OWNHOUSE	Ownership of house (1 = if own house; 0 = otherwise)	0.839	0.367
12. OWNLOT	Ownership of homelot (1 = if own homelot; 0 = otherwise)	0.330	0.470
13. OWNLAND	Ownership of agricultural land (1 = if own agricultural land; 0 = otherwise)	0.251	0.434
14. PPARITY5	Number of children ever born five years prior to the current period	4.204	2.951
15. PPARITY2	Number of children ever born two years prior to the current period	4.547	3.001
16. POPN/1,000	Population size of the barangay divided by 1,000	1.307	0.763
17. YCRES	Years in current residence (1 = if the couple has resided in the barangay before 1971; 0 = otherwise)	0.862	0.345
18. YAELEC	Number of years since the barangay was electrified	4.305	3.698
19. WATERK	Type of water supply (1 = if in category k; 0 = otherwise where k is coded as 1 = Piped into house 2 = Artesian wells 3 = others	0.097 0.669	0.296 0.471
20. RICE	1 = if household engaged in rice crop production in the past 12 months; 0 = otherwise	0.041	0.199
21. CORN	1 = if engaged in corn production; 0 = otherwise	0.441	0.497



<i>Symbol</i>	<i>Definition/M Measurement</i>	<i>Mean</i>	<i>Standard Deviation</i>
22. TOBACCO	1 = if engaged in tobacco production; 0 = otherwise	0.130	0.336
23. COCONUT	1 = if engaged in coconut production; 0 = otherwise	0.128	0.334
24. FISHING	1 = if engaged in fishing; 0 = otherwise	0.169	0.375
25. BUSINESS	1 = if engaged in business; 0 = otherwise	0.154	0.361

### Annex B

#### List of Sample Areas

#### Misamis Oriental West

	<i>1975 Census Household Count</i>	<i>1980 Actual Count</i>	<i>No. of Interviews</i>
<i>I. Municipal Poblacion</i>			
1. El Salvador	464	581	40
2. Alubijid	380	404	40
3. Laguindingan	255	291	40
4. Gitagum	260	255	40
5. Libertad	400	453	40
6. Initao	681	735	40
Sub-total	2,440	2,719	240
<i>II. Rural Coastal Barangay</i>			
1. Kibonbon, El Salvador	126	162	40
2. Loguilo, Alubijid	173	252	40
3. Liberty, Laguindingan	162	157	40
4. Burnay, Gitagum	145	148	40
5. Gimaylan, Libertad	174	208	40
6. Tubigan, Initao	224	236	40
Sub-total	1,004	1,163	240
<i>III. Rural Inland Barangay</i>			
1. Calungonan, El Salvador	270	328	40
2. Lagtang, Alubijid	123	131	40
3. Kibaghot, Laguindingan	241	248	40

	<i>1975 Census Household Count</i>	<i>1980 Actual Count</i>	<i>No. of Interviews</i>
4. Tala-o, Gitagum	109	112	40
5. Lubluban, Libertad	108	119	40
6. Canitoan, Initao	213	187	40
Sub-total	1,064	1,125	240
Grand Total	4,508	5,007	720

**Annex B**  
**List of Sample Areas**  
**Misamis Oriental East**

	<i>1975 Census Household Count</i>	<i>1980 Actual Count</i>	<i>No. of Interviews</i>
<b>I. Municipal Poblacion</b>			
1. Balingasag (Bgy. 3)	212	239	38
2. Lagonglong	330	281	40
3. Salay (Tagontong)	205	114	37
4. Binuangan	143	159	40
5. Sugbongcogon	236	251	39
6. Kinoguitan	220	227	39
Sub-total	1,346	1,271	233
<b>II. Rural Coastal Barangay</b>			
1. Cogon, Balingasag	245	300	40
2. Tabok, Lagonglong	155	177	40
3. Inubulan, Salay	239	229	37
4. Dampias, Binuangan	81	106	40
5. Kiraging, Sugbongcogon	56	47	37
6. Buko, Kinoguitan	137	162	39
Sub-total	913	1,021	233
<b>III. Rural Inland Barangay</b>			
1. San Isidro, Balingasag	219	218	40
2. Gastor, Lagonglong	117	153	40
3. Alipustan, Salay	157	81	36
4. Valdeconcha, Binuangan	69	67	38

	<i>1975 Census Household Count</i>	<i>1980 Actual Count</i>	<i>No. of Interviews</i>
5. Silad, Sugbongcogon	74	51	26
6. Salicapawan, Kinogitan	51	57	36
Sub-total	687	627	216
Grand Total	2,946	2,919	682

## Annex C

### Household Survey Coverage

#### *Wife Interview*

- |       |    |                                       |
|-------|----|---------------------------------------|
| Block | 1  | Household Composition                 |
|       | 2  | Marriage and Pregnancy History        |
|       | 3  | Family Planning                       |
|       | 4  | Morbidity and Mortality               |
|       | 5  | Housing/Homelot                       |
|       | 6  | Consumer Durables                     |
|       | 7  | Food Expenditures and Consumption     |
|       | 8  | Savings and Adjustment to Consumption |
|       | 9  | Paid Employment                       |
|       | 10 | Organizational Participation          |
|       | 11 | Costs and Benefits of Children        |

#### *Husband Interview*

- |       |    |                                     |
|-------|----|-------------------------------------|
| Block | 12 | Agricultural Crop Production        |
|       | 13 | Farm Crop Capital Items             |
|       | 14 | Marine Fishing                      |
|       | 15 | Business or Trade                   |
|       | 16 | Household Income from Other Sources |
|       | 17 | Organization Participation          |
|       | 18 | Cost and Benefits of Children       |
|       | 19 | Migration                           |

## Annex D

### Community Survey Coverage

Block	1	Identification
	2	Population
	3	Transportation
	4	Educational Services
	5	Health Services
	6	Economic Activities
	7	Electricity
	8	Communications and Other Services
	9	Social and Farm Organizations
	10	Barangay Activities and Development Projects

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### Vicente B. Paqueo, Discussant

Professor Herrin's paper which is a partial report of a research project designed to analyze the demographic impact of large scale rural electrification is very interesting. Holding constant a number of socio-economic and locational characteristics, he observes through multivariate analysis a positive correlation between electrification of a village and fertility-related indicators. This result was obtained by estimating a reduced form fertility related equation based on a set of simultaneous equations (1 to 7). Hence I will focus my remarks on those equations.

I think that the wife's labor force participation equation (5) is misspecified. This equation relates WEMP (a labor force participation variable) to the woman's earnings from business or paid employment, measured as the product of her wage rate and the amount of time she wants to devote to income generating activities. Theoretically, at least in the literature, the relevant variable should be a measure of the wife's opportunity cost of time; for example the market wage of the wife. Second, if the market wage rate or similar opportunity cost of time is otherwise used in equation 5 instead of Y, then one needs to specify an equation relating the wife's market wage rate or opportunity cost of time to factors that determine those variables.

In this paper, rural electrification appears to be accompanied by high potential income. The question then, is, what is the effect of income on fertility in the study area like Misamis Oriental? It also appears that rural electrification is accompanied by a high probability of wife's employment, then, what is the effect of wife's employment on fertility in the study area? Professor Herrin's empirical analysis does not clearly answer these questions. His fertility related equations do not as yet provide estimates of the effects of income, wage rate or wife's employment on fertility. These issues which I understand will be examined in a more complete version of his paper are important in understanding the observed negative correlation between rural electrification and fertility.

Finally, one might ask the question whether there are situations or subgroups of women where the negative effect of rural electrification on fertility may not be observed or in fact may be reversed. In raising this question, I have in mind Professor Encarnacion's model of fertility. In this model, an increase in income tends to raise the fertility of poor families. If this positive income effect is large for some poor villages or households, the fertility effect of rural electrification might be attenuated or possibly lead to a positive effect. My suggestion in this regard is the extension of the study whereby regression analysis will be done for low-income and high-income groups separately.



# **MATHEMATICS**





## STRUCTURAL CHARACTERIZATION OF FINITE TOPOLOGICAL GRAPHS

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### Introduction

A topological space gives rise to a graph in a very natural way. Let  $\tau$  be a topology on a set  $X$ . Construct a graph  $G$  whose vertex-set is  $X$ , and where two distinct vertices  $x$  and  $y$  are adjacent if and only if  $U \cap V \neq \phi$  for all  $U, V \in \tau$  such that  $x \in U, y \in V$ . Equivalently,  $x$  and  $y$  are non-adjacent if and only if there exist  $U, V \in \tau$  such that  $x \in U, y \in V$  but  $U \cap V = \phi$ . We shall call  $G$ , and every graph which can be constructed in this manner, a *topological graph*. We shall also say that the topology  $\tau$  (or the topological space  $(X, \tau)$ ) induces the graph  $G$ , and symbolically we shall write  $\tau \rightarrow G$ .

**Example.** Consider the topological space  $(X, \tau)$ , where  $X = \{1, 2, 3, 4, 5\}$  and  $\tau = \{\phi, X, \{1\}, \{2\}, \{1, 2\}, \{1, 4\}, \{1, 2, 4\}\}$ . The induced topological graph is shown in Fig. 1.1.

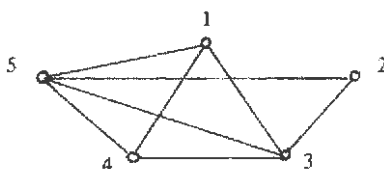


Fig. 1.1 A topological graph

Obviously, two homeomorphic topological spaces induce isomorphic graphs. However, non-homeomorphic topological spaces may induce isomorphic graphs. For example, the topology  $\tau' = \{\phi, X, \{1\}, \{2\}, \{1, 2\}, \{1, 4\}, \{1, 2, 4\}, \{1, 2, 3, 4\}\}$  on the same set  $X$  in the last example induces the same graph as  $\tau$  does although  $(X, \tau)$  and  $(X, \tau')$  are non-homeomorphic.

For convenience, we shall adopt the following notations:

$A$  = the closure of the subset  $A$  of a topological space  $X$ .

$[x, y]$  = the edge of a graph with end vertices  $x$  and  $y$ .

$P_4$  = a path with four vertices. This will also be denoted by  $[a, b, c, d]$ , where  $[a, b], [b, c], [c, d]$  are distinct edges.

$d_G(x, y)$  = the length of a shortest path in  $G$  whose end-vertices are  $x$  and  $y$ . Thus,  $d_G(x, x) = 0$ ;  $d_G(x, y) = 1$  if and only if  $x$  and  $y$  are adjacent;  $d_G(x, y) = \infty$  if there is no path joining  $x$  and  $y$ .

$\deg_G(x) =$  the number of edges in  $G$  containing the vertex  $x$ . This is called the *degree* of  $x$  in  $G$ .

### Preliminary Results

The following two lemmas are easy and their proofs are omitted.

**Lemma 2.1.** Let  $\beta$  be a base for a topology  $\tau$  on  $X$  and  $\tau \rightarrow G$ . Then two vertices  $x, y$  in  $G$  are adjacent if and only if  $U \cap V \neq \emptyset$  for all  $U, V \in \beta$  such that  $x \in U, y \in V$ .

**Lemma 2.2.** Let  $\tau, \tau'$  be topologies on  $X$  and  $\tau \rightarrow G, \tau' \rightarrow G'$ . If  $\tau$  is finer than  $\tau'$  ( $\tau \supseteq \tau'$ ), then  $G$  is a subgraph of  $G'$  ( $G \subseteq G'$ ).

The next result is due to Diestio who is also doing some investigation on topological graphs.

**Theorem 2.1.** Let  $\tau$  be a topology on  $X$  and  $\tau \rightarrow G$ . Then for each  $x \in X, \cap [\bar{0} : 0 \in \tau \text{ and } x \in 0] \sim [x]$  is the set of all vertices adjacent to  $x$ .

*Proof:* Let  $y$  be a vertex adjacent to  $x \in X$ . If  $0 \in \tau$  and  $x \in 0$ , then  $U \cap 0 \neq \emptyset$  for each  $U \in \tau$  that contains  $y$ . This implies that  $y \in \bar{0}$ . Therefore,  $y \in \cap [\bar{0} : 0 \in \tau \text{ and } x \in 0] \sim [x]$ .

Conversely, let  $y \in \cap [\bar{0} : 0 \in \tau \text{ and } x \in 0] \sim [x]$ . Let  $U, 0 \in \tau$  such that  $y \in U, x \in 0$ . Since  $y \in \bar{0}$ , it follows that  $U \cap 0 \neq \emptyset$ . Hence,  $y$  is adjacent to  $x$ .

Let  $(X, \tau)$  be a topological space and  $\tau \rightarrow G$ . For each  $x \in X$ , let us define  $S_G(x) = \{y \in X : y \neq x \text{ and } y \text{ is not adjacent to } x\}$ . In view of theorem 2.1, this set is in  $\tau$  since it is the complement of the closed set  $\cap [\bar{0} : 0 \in \tau \text{ and } x \in 0]$ . If  $A$  is a finite subset of  $X$ , then the set  $S_G(A) = [x \in X : x \notin A \text{ and } x \text{ is not adjacent to any vertex in } A] = \overline{x \in A : S_G(x) \in \tau}$ . Furthermore, if  $A$  and  $B$  are finite subsets of  $X$ , then  $S_G(A) \cap S_G(B) = S_G(A \cup B)$ . Thus, the sets  $S_G(A)$ , where  $A$  ranges over all finite subsets of  $X$ , form a base for some topology  $\tau'$  on  $X$ . We shall call  $\tau'$  the topology induced by the graph  $G$ . Observe that if  $G$  is any graph (not necessarily a topological graph), then it induces a topology with base consisting of the sets  $S_G(A)$ , where  $A$  ranges over all finite subsets of  $X$ , the vertex-set of  $G$ . If  $G$  induces the topology  $\tau'$  we shall write symbolically  $G \rightarrow \tau'$ .

**Theorem 2.2.** If  $\tau$  is a topology on  $X$  and  $\tau \rightarrow G \rightarrow \tau' \rightarrow G'$ , then  $\tau \supseteq \tau'$  and  $G \subseteq G'$ .

*Proof:* We have already noted before that the sets  $S_G(A) = [x \in X : x \notin A \text{ and } x \text{ is not adjacent to any vertex in } A]$ , where  $A$  ranges over all finite subsets of  $X$ , are all in  $\tau$  and that they form a base for  $\tau'$ . Consequently,  $\tau \supseteq \tau'$ . By Lemma 2.2,  $G \subseteq G'$ .

**Theorem 2.3.** Let  $G$  be a finite graph and  $G \rightarrow \tau \rightarrow G'$ . Then  $G' \subseteq G$ .

*Proof:* Denote by  $X$  the vertex-set of  $G$ . We shall show that two vertices which are not adjacent in  $G$  must be non-adjacent in  $G'$ . Let  $x, y \in X$  be non-adjacent vertices in  $G$ ; let  $A = \{v \in X : d_G(v, x) \geq 2\}$  and  $B = \{v \in X : d_G(v, y) \geq 2\}$ . Then  $S_G(A), S_G(B) \in \tau$  and  $x \in S_G(A), y \in S_G(B)$ . We claim that  $S_G(A) \cap S_G(B) = \emptyset$ . Suppose that  $z \in S_G(A) \cap S_G(B)$ . Then  $z \notin A \cup B$  and  $z$  is not adjacent (in  $G$ )

to any vertex in  $A \cup B$ . It follows that  $d_G(z, x) \leq 1$  and  $d_G(z, y) \leq 1$ . Now,  $z$  cannot be  $x$  or  $y$  since  $d_G(x, y) \geq 2$ . Therefore,  $d_G(z, x) = d_G(z, y) = 1$ . Since  $y \in A$  and  $z$  is adjacent to  $y$ , then  $z \notin S_G(A)$ . This is a contradiction. Hence,  $S_G(A) \cap S_G(B) = \emptyset$ . This implies that  $x$  and  $y$  are not adjacent in  $G'$ .

The preceding theorem does not hold for infinite graphs. Consider a graph with an infinite number of connected components. If we denote this graph by  $G$ , and if  $G \rightarrow \tau \rightarrow G'$ , then it is easy to show that  $G'$  is complete, i.e., every pair of distinct vertices forms an edge in  $G'$ . This shows that  $G'$  properly contains  $G$ .

Combining Theorems 2.2 and 2.3, we get the following:

**Theorem 2.4.** Let  $G$  be a finite graph and  $G \rightarrow \tau \rightarrow G'$ . Then  $G$  is a topological graph if and only if  $G = G'$ .

### Main Result

For convenience, we shall introduce the notion of a *triangulator*. If  $e$  is an edge of a graph  $G$ , then any vertex  $x$  in  $G$  which is adjacent to both end-vertices of  $e$  shall be called a triangulator of  $e$ . The set of all triangulators of  $e$  in  $G$  shall be denoted by the symbol  $T_G(e)$ , or simply  $T(e)$ .

**Theorem 3.1.** A finite graph  $G$  is a topological graph if and only if for every subgraph  $P_4 = [x_1, x_2, x_3, x_4]$  such that both end-vertices  $x_1$  and  $x_4$  are not triangulators of the middle edge  $e = [x_2, x_3]$ , there exists a triangulator  $v$  of  $e$  such that each vertex  $u \notin e$  which is adjacent to  $v$  is itself a triangulator of  $e$ .

*Proof:* Let  $G$  be a finite topological graph and let  $P_4 = [x_1, x_2, x_3, x_4]$  be a subgraph whose end-vertices do not belong to  $T(e)$ , where  $e = [x_2, x_3]$ . Let  $X$  denote the vertex-set of  $G$  and  $A = [x \in X: d_G(x, x_2) \geq 2]$ ,  $B = [x \in X: d_G(x, x_3) \geq 2]$ . Observe that  $x_4 \in A$  but  $x_2 \notin A$ . It is easy to see that  $x_2 \in S_G(A)$ . Similarly,  $x_3 \in S_G(B)$ . By Theorem 2.4,  $x_2$  and  $x_3$  are adjacent in  $G'$ , where  $G \rightarrow \tau \rightarrow G'$ . Therefore, since  $S_G(A), S_G(B) \in \tau$ , it follows that  $S_G(A) \cap S_G(B) \neq \emptyset$ . Let  $z \in S_G(A) \cap S_G(B)$ . Then  $z \notin A \cup B$  and  $z$  is not adjacent (in  $G$ ) to any vertex in  $A \cup B$ . It follows that  $d_G(z, x_2) = d_G(z, x_3) = 1$ . Hence,  $z \in T(e)$ . In fact, we have shown that  $\emptyset \neq S_G(A) \cap S_G(B) \subset T(e)$ .

Now suppose that for all  $v \in T(e)$ ,  $v$  is adjacent to some vertex  $u \notin e \cup T(e)$ . Consider again the sets  $A$  and  $B$  defined earlier. Take any  $z \in S_G(A) \cap S_G(B)$ . Then  $z$  is adjacent to some  $u \notin e \cup T(e)$ . We can assume, without loss of generality, that  $u$  is not adjacent to  $x_2$ . Therefore,  $u \in A$ . This is a contradiction since  $z$  is not adjacent to any vertex in  $A$ .

To prove the converse, let  $G$  be a finite graph with the property that for every subgraph  $P_4 = [x_1, x_2, x_3, x_4]$  each of whose end-vertices is not a triangulator of the middle edge  $e = [x_2, x_3]$ , there exists a triangulator  $v$  of  $e$  such that every vertex  $u$  that is adjacent to  $v$  is in  $e \cup T(e)$ . Let  $G \rightarrow \tau \rightarrow G'$ . By Theorem 2.4, we need to show only that  $G = G'$ . By Theorem 2.3 we know that  $G' \subseteq G$ . Hence, it remains to prove that  $G \subseteq G'$ . Let  $x$  and  $y$  be adjacent vertices in  $G$ . We claim that these vertices are also adjacent in  $G'$ . If one end-vertex of the edge  $[x, y]$  is of

degree 1 in  $G$ , say  $\deg_G(x) = 1$ , then each  $S_G(A) \in \tau$  containing  $y$  necessarily contains  $x$ . Thus,  $[x, y]$  is an edge in  $G'$ . So let us assume that  $\deg_G(x) > 1$ ,  $\deg_G(y) > 1$  and consider the following cases:

**Case 1.**  $[x, y]$  is not the middle edge of any subgraph  $P_4$ , both end-vertices of which are not triangulators of  $[x, y]$ .

In this case we can assume, without loss of generality, every vertex  $v \neq y$  which is adjacent to  $x$  is a triangulator of  $[x, y]$ . Let  $A$  be a (finite) set of vertices in  $G$  such that  $y \in S_G(A)$ . We claim that  $x \in S_G(A)$ . Suppose that  $x \notin S_G(A)$ . Then  $x$  is adjacent to some vertex in  $A$ , say  $u$ . By assumption,  $u$  is a triangulator of  $[x, y]$  and hence  $u$  is adjacent to  $y$ . This is a contradiction since  $y \in S_G(A)$ . Thus,  $x \in S_G(A)$ . It follows that  $x$  and  $y$  are adjacent in  $G'$ .

**Case 2.**  $[x, y]$  is the middle edge of some subgraph  $P_4 = [r, x, y, s]$  such that both  $r$  and  $s$  are not triangulators of  $[x, y]$ .

By assumption, there exists a triangulator  $v$  of  $[x, y]$  such that every vertex  $u$  adjacent to  $v$  is in  $e \cup T(e)$ , where  $e = [x, y]$ . Let  $A, B$  be (finite) subsets of the vertex-set of  $G$  such that  $x \in S_G(A)$ ,  $y \in S_G(B)$ . We claim that  $v \in S_G(A)$ . Suppose that  $v \notin S_G(A)$ . Then  $v$  is adjacent to some vertex  $u \in A$ . The vertex  $u$  cannot be  $x$  or  $y$  since  $x \notin A$  and  $y \notin A$ . Therefore,  $u \in T(e)$  and consequently, it is adjacent to both  $x$  and  $y$ . This is a contradiction since  $x$  is not adjacent to any vertex in  $A$ . Therefore,  $v \in S_G(A)$ . By a similar argument, we can show that  $v \in S_G(B)$ . Hence,  $S_G(A) \cap S_G(B) \neq \emptyset$ . It follows that  $x$  and  $y$  are adjacent in  $G'$ .

The following Corollaries are immediate consequences of Theorem 3.1:

**Corollary 1.** A finite graph  $G$  with girth  $g \geq 4$  is not a topological graph.

*Proof:* If  $G$  is a finite graph with girth  $g \geq 4$ , then there exists a cycle  $x_1, x_2, \dots, x_g, x_1$  in  $G$  and this cycle has the shortest length. This cycle contains the path  $P_4 = x_1, x_2, x_3, x_4$  and obviously  $x_1$  and  $x_4$  cannot be triangulators of the middle edge  $x_2, x_3$ . Moreover,  $x_2, x_3$  does not have any triangulator since there are no cycles in  $G$  of length 3. Therefore,  $G$  is not a topological graph.

**Corollary 2.** Let  $G$  be a finite graph. If for every subgraph  $P_4$ , at least one of the end-vertices is a triangulator of the middle edge, then  $G$  is a topological graph.

**Corollary 3.** A finite and connected bipartite graph is a topological graph if and only if it is a star.

*Proof:* A bipartite graph does not contain odd cycles. Therefore, no edge of a bipartite graph can have a triangulator. Consequently, a finite and connected bipartite graph  $G$  is a topological graph if and only if it does not contain a subgraph  $P_4$ . Hence,  $G$  must be the complete bipartite graph  $K_{1, n}$ , i.e., a star.

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# MEDICINE



## **THE RUBELLA ANTIBODY STATUS OF ADOLESCENT GIRLS IN PHILIPPINE RURAL AND URBAN COMMUNITIES (1981-1982)**

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### **Introduction**

In recent years, awareness of the teratogenic effects of rubella virus on the fetus has awakened interest in the disease. However, in the Philippines rubella continues to be poorly reported not only because it is still considered a mild disease but also because its diagnosis is often missed. Thus the national health statistics hardly depict its incidence. Oftentimes it is retrospectively diagnosed when congenital anomalies or defects occur in the newborn, at which time the physician and health professionals would inquire more closely into the history of rubella in the mother. Hence in hospitals and in medical circles rubella is now identified so that it may appear in hospital statistics.

It will be recalled that rubella has become a dreaded disease in view of two epidemics that are medically historical; namely, the 1941 epidemic in Australia when congenital eye defects were noted in alarming proportions in newborns subsequently traced to rubella in parturients, followed by a coast to coast rubella epidemic in the USA (1964) and in other countries. The latter stands as a nightmare in view of 20,000 newborn deaths and defects, a tremendous loss to the country.

In the Philippines epidemiologic surveys in different age groups have been reported by the following: del Mundo (1972); Campos, *et al.* (1973); Chan *et al.* (1978) and Alday *et al.* (1981). From these studies it is evident that by 30 years of age, 65 to 70% of the population have had the disease.

Although the general principles of the epidemiology of rubella are now known, including ways in which the rubella virus spreads and the level of susceptibility to infection among women in the reproductive age, it is advised that epidemiologic studies should be conducted on an ongoing basis to minimize impact of the disease on newborns.



With the advent of an effective and safe vaccine, such studies can serve as guides for policies on vaccination, particularly on its need, priorities of age to vaccinate, and the need for repeat doses. Justifiable dread for pre-natal or congenital rubella, has resulted in various studies on susceptibility of women during the reproductive period. In most of the studies, both locally and abroad, susceptibility of the disease in this period is about 30%.

There are reports that when children are vaccinated early, a number are questionably immune by the time they reach the reproductive age; hence it is suggested that vaccination be repeated some time before that period. Others feel it would be advisable to vaccinate girls during adolescence, at which time they are close to the child-bearing age. A recent opportunity to determine rubella antibody status in some subjects, allowed the authors to conduct the present study among adolescents.

### Objectives

General objectives of this study are:

To determine rubella antibody status of adolescents girls in rural and urban settings of the Philippines.

To contribute to local studies on the subject.

Specific objectives are:

To observe susceptibility to rubella at adolescence (10-19 years), an age group close to the reproductive period.

To determine any change in the rubella antibody status of adolescents girls from that of previous years.

To try the use of kits available for the determination of rubella antibodies by HI tests.

To obtain further information on the epidemiology of rubella.

### Materials and Methods

In 1981, Testerub Kits for the determination of rubella antibody by hemagglutination-inhibition test became available to the authors. Each testing kit contains inactivated lyophilized antigen, a diluent buffer S.A.G.A.G. powder, 25% Kaolin suspension, solution of Alsever, sterile syringe, 12 testing walled plates and instruction on the procedure. A 0.2% goose (adult male) RBC was prepared for the antigen titration and HI test.

Five (5) cc venous blood was obtained from adolescent girls in urban and rural communities. The blood was allowed to clot for about 2 hours at room temperature and about 5 hours for full retraction in the refrigerator.

The vacutainer tubes containing the specimens were centrifuged at 2500 rpm for 15 minutes. The serum was separated into a sterile vial with a sterile capillary pipette. The sera were stored at 20° and then transported to the viral laboratory.

Table 1. Prevalence of HI Antibodies Against Rubella Among Urban Filipino Adolescent Girls, 1981

<i>Age in Years</i>	<i>Number Tested</i>	<i>*Positive Tests</i>	<i>Percentage Positive</i>
10	6	5	83.3
11	2	0	0
12	5	2	40
13	8	7	87.5
14	25	14	56
15	25	15	60
16	29	22	75.8
17	17	7	41
18	17	13	76
19	23	16	69.5
20	12	9	75
Total	169	110	65

\*Positive for HI antibodies at 1:8 serum dilution.

It was decided to use these testing kits for adolescent girls in both urban and rural communities, not only because of increasing concern for adolescents and various aspects in their health care but also because there are inquiries if adolescents should be vaccinated against rubella. A screening by HI antibody test could give the basis for a reply to this inquiry.

Adolescent girls (79) included in this study reside in rural\* areas about 70 kilometers northeast of Manila while 169 urban\*\* girls reside in Metro Manila. The number was about equal in both areas at the time of collection but difficulties of transporting and handling in remote communities caused a number of specimens to be unsatisfactory for titrations.

The Testerub Kits are handy and convenient. However, the tests will have to be performed in a laboratory with equipment like cold centrifuge and refrigerators. This staff should also be familiar with serologic work of this nature.

### Results and Discussion

A total of 248 specimens were found satisfactory for rubella HI antibody titrations. In this group 169 were obtained from urban and 79 from rural adolescent girls. This difference in number did not allow comparative studies between the

\*In the four municipalities of San Luis, Candaba, Mexico and Arayat, Pampanga.

\*\*In Quezon City and Manila.

Table 2. Prevalence of HI Antibodies Against Rubella Among Philippine Rural Adolescent Girls (1981)

<i>Age in Years</i>	<i>Number Tested</i>	<i>*Positives</i>	<i>Percentage Positive</i>
10	0	0	0
11	1	1	10.0
12	5	4	80.0
13	17	10	58.8
14	13	11	84.6
15	10	6	60.0
16	11	9	81.8
17	12	8	66.6
18	7	6	85.7
19	3	3	10.0
20	0	0	0
Total	79	58	73.0

\*Positive for HI antibodies at 1:8 serum dilution.

two areas but the data gathered when considered as two separate groups gave useful information.

The incidence of positive rubella antibody titer for rural adolescents is shown in Table I and that for urban areas in Table II. The attack rates are 73% for rural and 65% for urban adolescents girls.

In this study, susceptibility among urban adolescent girls is 35% (Table III) and that of the rural group is 27% (Table IV). Overall susceptibility for the two groups of adolescent girls is 31%. Population density in these areas was not considered. Although some workers claim this is an important factor other studies conclude that in epidemiologic surveys, factors other than density should be considered.

Distribution of HI antibodies to rubella by age was determined in both urban (Table V) and rural (Table VI) settings but the number per year of age were not equal nor were they sufficient to allow comparative studies. Evidently however the disease has occurred in a significant number per age, within the adolescent group.

This susceptibility rate in unvaccinated adolescents as obtained in previous years by different workers during the past decade, has remained about the same. This is true in other countries in the region.

Studies similar to this one are encouraged as basis for policies in the use of the vaccine and also for their practical value. It is a fact that serious and justifiable concern for rubella continues to be due to the deleterious effects of rubella infection in the fetus. The susceptibility rate of 30% to 40% among our adolescent

Table 3. Susceptibility to Rubella Among Urban Philippine Adolescent Girls (1981)

<i>Age in Years</i>	<i>Number Tested</i>	<i>*Negative Tests</i>	<i>Percentage Negative</i>
10	6	1	16.6
11	2	2	10.0
12	5	3	60.0
13	8	1	12.5
14	25	11	44
15	25	10	40
16	29	7	24
17	17	10	58.8
18	17	4	23.5
19	23	7	30.4
20	12	3	25
Total	169	59	35.0

\*Negative for HI antibody at less than 1:8 serum dilution.

Table 4. Susceptibility to Rubella Among Philippine Rural Adolescent Girls (1981)

<i>Age in Years</i>	<i>Number Tested</i>	<i>*Negatives</i>	<i>Percentage Negative</i>
10	0	0	0
11	1	0	0
12	5	1	20
13	17	7	41
14	13	2	15
15	10	4	40
16	11	2	18
17	12	4	33
18	7	1	14
19	3	0	0
20	0	0	0
Total	79	21	27.0

\*Negative for HI antibody at less than 1:8 serum dilution.

girls is high. This being an age (10-14) close to or at the start of childbearing, preventive measures through vaccination with the safe and effective vaccine may be considered.

Table 5. Distribution of HI Antibody to Rubella Among Philippine Urban Adolescent Girls 1981.

Age in Years	Number Tested	Reciprocal of HI Antibody Titer							Percentage Positive
		8	8	16	32	64	128	256	
10	6	1		1		3	1		83.3
11	2	2							0
12	5	3			1			1	40
13	8	1	3		3		1		87.5
14	25	11	7	1	2	3	1		56
15	25	10	10		3	1	1		60
16	29	7	13	1	2	3	3		75.8
17	17	10		2	2	2	1		41.1
18	17	4	7	1		4	1		76.4
19	23	7	7		1	4	3	1	69.5
20	12	3	1	1	2	2	2	1	75
Total	169	59	48	7	16	22	14	3	65

Alday *et al.* recommend three approaches to the prevention of infection in pregnant women and they feel a good approach is to vaccinate adolescents and adult women. This view is shared by others and is based on seroepidemiologic surveys.

### Summary and Conclusions

In 1981 a group of 248 adolescent girls (both urban and rural) were tested for rubella HI antibodies. This was made possible through available kits containing the materials for titrations (Testerub Kits).

Adolescents were chosen for this study not only because of increasing concern for their health care but also because this is the age (10-19 years) close to or at the beginning of the childbearing period.

The susceptibility rate for rubella in this study is 31% which is approximately the same as among unvaccinated adolescents in many countries as well as locally. Practically there has been no change in the past decade.

Dread for rubella is due to congenital rubella resulting from infection among parturients, particularly in the first trimester of pregnancy. The rate obtained is fairly high and so it may be expected that the group constitutes a risk for congenital rubella.

Mass immunization of all children as practiced in developed countries diminishes the incidence of rubella but where resources and the vaccine are limited

Table 6. Distribution of HI Antibody to Rubella Among Philippine Rural Adolescent Girls 1981.

Age in Years	Number Tested	Reciprocal of HI Antibody Titer							Percentage Positive
		8	8	16	32	64	128	256	
10	0								0
11	1							1	10
12	5	1	2			2			80
13	17	7	4			1	5		58.8
14	13	3	5	2	1		2	1	84.6
15	10	4	1	1	1	3			60
16	11	2	4			2	1	2	81.8
17	12	4			1	3	3	1	66.6
18	7	1	1		1	4			85.7
19	3		2	1					10
20	0								0
Total	79	21	19	4	4	15	11	5	73.4

as in developing countries, adolescent girls may be considered as the group to vaccinate.

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### \*HEMAGGLUTINATION – INHIBITION TEST FOR RUBELLA

#### COLLECTION

1. Clotted blood at room temperature for about 2 hours.
2. Allow full retraction in the refrigerator for 5 hours.
3. Centifuge vacutainer tubes at 2,500 rpm for 15 minutes.
4. Separate serum into a *Sterile vial* using *sterile capillary pipet*.  
N.B. Label vials before transferring serum.
5. *Store sera in – 20° C.*
6. Transport to virus lab. Institute of Public Health in ice (use double container) with complete list of subject's name, date extracted, place of bleeding and age of subject.

#### WASHING OF GOOSE RBC

1. Collect goose (adult, male) blood in an equal amount of Alsever's solution.
2. Age the blood for 24 hours at 4° C.
3. Add 10 volumes of S.A.B.A.G. to an aliquot volume of blood and spin at 2,500 rpm for 10 minutes.
4. Wash 3 times.
5. After 3rd centrifugation, prepare needed suspensions:
  - a. packed
  - b. 10% RBC suspension
6. For antigen titration and HI test – use 0.2% goose RBC.  
to prepare: dilute 10% suspension 50x.

#### S.A.B.A.G. – Diluent Buffer

1. Dissolve powder in bottle with 300 ml. of sterile distilled water at 56° C. Take an aliquot of 5 ml., cool to room temperature and check pH of solution; pH of solution should be between 6.2 – 6.4.
2. Aliquot solution in 50 ml. amounts and keep at 4° C for future use.

#### TREATMENT OF SERUM

1. To 0.1 ml. of serum, add 0.3 ml. of S.A.B.A.G. and 0.4 ml. of 25% kaolin. Mix and stand at room temperature for 30 minutes. Agitate from time to time.
2. Spin at 2,500 rpm for 10 minutes using a refrigerated centrifuge.
3. Add 1 drop of packed goose RBC (20 drops/ml. dropper). Mix gently without disturbing the kaolin sediment and stand at 4° C for 1 hour.
4. Spin at 2,500 rpm for 10 minutes, using refrigerated centrifuge. Collect supernate with a final serum dilution of 1.8. Store frozen.

Note: All materials must be put in ice bath.

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\*As performed by two of the authors.



## REAGENT

1. Kaolin -- 25% suspension (provided in the kit). shake well before use.
2. Alsever -- provided in the kit
3. SABAG -- Diluent buffer.
  - a. Dissolve powder in bottle in a total volume of 300 ml. sterile distilled water at 56°C. Take an aliquot of 10 ml. and check pH of solution. It should be 6.2 -- 6.4. If not adjust with HCl or NaOH.
  - b. Aliquot remaining aseptically in 50 ml. amounts and keep at 4°C.

## ANTIGEN TITRATION

1. Reconstitute the antigen with sterile distilled water as indicated by the manufacturer -- use 1.5 ml. distilled water to dissolve the antigen in the bottle. Guaranteed titer -- 1:16.
2. After reconstitution, prepare 8 wells containing 0.025 ml. of S.A.B.A.G. each.
3. Add 0.025 ml. of the reconstituted antigen.
4. Mix with 0.025 ml. microdilutor and serially dilute till the 7th tube.
5. Add 0.025 ml. of S.A.B.A.G. in all 8 wells.
6. Add 0.025 of 2% goose RBC in each well.
7. Mix and incubate at 4°C for 1 hour.
8. Determine 1 HA unit -- highest dilution showing + + + + and + + + agglutination. Compute for 4 HA units/0.025 ml. for use in HI Test.

HI - Screening Test for Serum -- use only 1 dilution 1:8

1. Drop 0.025 ml. of 1:8 serum in each 2 wells.
2. Add 0.025 ml. of antigen containing 4 HA units/0.025 ml. of the first well (entire first column wells for the other specimens).
3. Incubate at room temperature for 1 hour.
4. Add 0.025 ml. of 0.2% goose RBC to the first and second wells (1st and 2nd column wells) second column wells -- serum controls.
5. Prepare 1 well as buffer control -- 0.05 ml. S.A.B.A.G. + 0.025 ml. of goose RBC.
6. Shake and incubate for 1 hour at 4°C. In another plate, prepare an antigen unitage check: (in duplicate). Note: Unitage has same final dilution as in control. Add diluent.
  1. Dilute the antigen containing 4HA units 2-fold in 0.025 ml. amounts such that:
    - 1st dilution 1:2 = 2 HA units
    - 2nd dilution 1:4 = 1 HA units
    - 3rd dilution 1:8 = 1/2 HA units
  2. Add 0.025 ml. of 0.2% goose RBC in all the tubes.

HI for serum positive in the screening test:

1. Dilute the screening test positive serums serially in 0.025 ml. amounts such that 1st well will be 1:16 carry the dilution of 1:256.
2. Add 0.025 ml. antigen containing 4HA units to all tubes.
3. Incubate at room temperature for 1 hour.
4. Proceed as in the screening test alone.

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**Urbano A. Mendoza, Discussant**

First, allow me to congratulate Dr. Fe del Mundo for this important contribution to rubella statistical study in the Philippines. In the study of Dr. Fe del Mundo, I can imagine the drawbacks of getting enough subjects for the study. In the study, there are ages where only one or two or three are available which is not statistically significant to be analyzed and evaluated scientifically. If there were at least 25 subjects for each age, then we can make better evaluation to base our decision regarding the age when to give rubella vaccine immunization. There are data for example in the rural area setting where the 11 and 19 years old subjects had 100% positive titer or positive reaction; and in the urban area setting at 11 years old subjects based on two with no positive titer. It will be rather risky to make a decision on these meager number as a true representative reactions of those ages. I also agree that growth population density plays an important factor to consider in the dissemination of the disease, that is, there will be more in the barong barong areas than in the provinces where houses are far apart.

In the study, it is interesting to note that positive titer were noted in the statistically significant numbers for 10 and 13 years old subjects which will greatly influence the decision when to start our immunization in the adolescent group. It will be enlightening to know and correlate the incidence of rubella in the area where the statistical study was done. However, as Dr. Fe del Mundo pointed out, the national statistical data available through our Disease Intelligence Center Annual Report, latest is 1978, which can not be wisely correlated with the study data of 1981. So, what will be the age target for rubella vaccine immunization in the Philippines for our adolescents to minimize the significant 35% low unprotective titer? It has been noted that the pregnancy age in the Philippines have become younger with increasing incidence of adolescent pregnancy which is an important factor to consider on deciding the age when to give the rubella vaccine immunization. Another factor that will greatly effect the success of our prevention of rubella syndrome is the type of vaccine to administer. At present, most of the vaccine used in the immunization is the U.S.A. preparation which study have shown that 26% of those immunized do not have any more protective titer after 5 years and a repeat dose is necessary. The vaccine used in Europe, the RA 273, confers a protective titer that more or less resembles that of the natural disease which is practically throughout life. With the prevailing economic condition of the country, the factor obviously has to be seriously considered.



## STRATEGY FOR MEDICAL RESEARCH IN THE PHILIPPINES

Geminiano T. de Ocampo, M.D.

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In a "System of Medical Research" (1) which I published more than a decade ago, there is no chapter on strategy. I intend in this communication to emphasize some pointers on strategy for medical research in the Philippines. In 1963, Dr. J. Salcedo (2) appointed a committee to make a survey of medical research in the Philippines. After two years, a report was made on the Status of Medical Research in the Philippines. Two years ago in 1981 in the first Congress on Medical Research in the Philippines, Campos (3) reported on the "Status of Health Research in the Philippines".

*Leadership.* We have to scout for, attract, train, hold and support leaders for medical research in the undergraduates, post-graduates, graduates and faculty. In this time of economic stress we have to devise a plan to have and to hold them in our research faculty. Whether on full-time or part-time they must be sufficiently compensated. What happens now is that after sending abroad prospective medical researchers for training and broadening, many do not come back or if they do, after two or more years stay here they return to the States for practice and/or research. In my experience, barely half of those I have sent abroad stay here. If our aim is to have a core of medical researchers we must have two or more members in a subspecialty at a certain time. There is discontinuity in many of our medical research undertakings.

*Ideagenesis and Brainstorming.* The centerpoint in modern medical research is brainstorming. For an effective research set-up brainstorming session is very essential. Cooperative or collaborative research and group or departmental research cannot take its place. Hence, we must not just establish a system of professorial chairs but we must organize this group into research teams and train them to be brainstormers for medical research. The solitary investigator, research group or multidisciplinary teams are not sufficient. They could be more effective and efficient in a brainstorming organization.

*International Cooperative Research.* This is a new twist in medical research and it seems proper to start with the United States. It is a challenge more to the Third World than to the rich countries. What with costly, constantly changing models of sophisticated research instruments which the Third World medical researchers can hardly afford. We should start joint ventures in medical research as in business. Bright ideas originate in single minds but must be developed by many researchers with the aid of brainstorming, cooperative approach and economic support.

*National Medical Research Institute.* This should be patterned after the U.S. Institute of Health but not as extensive. It should target such prevalent diseases as infections and parasitic diseases, as well as cancer, immunological and degenerative diseases in the Philippines. Ideagenesis and brainstorming should be one of its important activities. It could be an instrument and a venue for international cooperative or collaborative medical investigation.

*Research Training.* Although there is much that is inborn, training is of great help in any investigative work. It is a great advantage if one can have the opportunity to work with a competent and productive researcher. His attitudes, his manner of questioning and analysis are of great importance. I think there is truth in the belief that one measure of greatness of a teacher are pupils who attain greater heights than himself. One contribution of a medical researcher of some worth is to inspire, train and produce investigators greater than himself. A great man is judged not only by his works but also by the men he has influenced in one way or another, who are imbued with the manner he has solved or tried to solve research problems.

*Biomedical Research.* In many aspects, medicine is the highest form of biology. The biological aspects of medicine, development, differentiation, protection and proliferation based on the concept of the segmentation of the genome deserve more investigation and confirmation than what is done now. We must not emphasize the mechanical, physical and chemical aspects of medicine but we must pay more attention to its biological aspect. The phenomena of life can be understood more through biology than thru physics, mechanics and chemistry. The life sciences should be utilized more in understanding medicine.

*Theoretical Medicine.* (4), (5) This should be given more attention than what is now included in the curriculum of medicine. As a matter of fact, the theoretical aspect of medicine is almost entirely ignored now in our medical curriculum. In the Nobel prizes, theoretical physics, theoretical economics and theoretical medicine are given prime importance. Many physicians do not even know that there is such a discipline as theoretical medicine. What they know and have been taught are mostly and mainly in the realm of practical clinical medicine with very little of experimental medicine. Theoretical medicine is strange to them.

*Human Subjects in Medical Research.* Animal experiments in medicine is becoming very costly. The cost of experimental animals has increased very much. This is a drawback to experimental animal research. This leaves the hospital patients and out-patients as the most practical subjects for medical research. This has advantages but also limitations. One aspect of human volunteers for drug and other forms of research is the utilization of those confined at the National Penitentiary. This should be seriously considered in our medical research.

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### Alberto G. Romualdez, Jr., Discussant

Although I have been out of the medical school for eighteen years now I find myself still learning much from the ideas of Dr. Geminiano de Ocampo.

Please let me approach Dr. de Ocampo's paper by going over some of the ideas he presented and in the process point out how the National Science and Technology Authority, through the Philippine Council for Health Research and Development, is trying to implement those ideas.

On the question of leadership and attracting research workers to do research, NSTA is working for the establishment of a Scientific Career System that would offer people who want to go into a lifetime of research better career opportunities. NSTA has for the last year been haggling with the Ministry of the Budget and the Civil Service Commission for this. But I think the main obstacle has been the difficult economic situation that has prevailed in the country over the last year and a half, or two. The prospect, it seems, is that the situation will not improve until 1985. NSTA, however, continues to work on this and it is anticipated that we should at least have a system established although not quite as well as we want it to be.

The second thing that we are trying to do, and which we have started at PCHRD, is to develop a truly nationwide health research network. The thrust is toward developing and strengthening research capabilities in regions outside Metro Manila. We believe that making available research opportunities in the regions will encourage those who previously did not have the access to go into a career in research. Likewise, we are improving the local training opportunities. As Dr. de Ocampo mentioned, we have already lost many of those we sent for training abroad. One solution to this, I suppose, is for us to provide better local training opportunities.

Dr. de Ocampo suggested creating groups or research teams for the purpose of brainstorming on issues concerning medical research. At PCHRD, we have in fact put together technical committees which sometimes function as brainstorming teams. In addition, within each of these technical committees emerged smaller groups that deal with narrower problems. Dr. Edito Garcia is here. He is a member of the schistosomiasis group which is composed of people from U.P., the Ministry of Health, and other sectors that are interested in schistosomiasis research. We also have an acute respiratory infection technical working group that functions similarly and we will continue to encourage other groups to engage in discussions and cooperation in research.

In the area of international cooperative research, we have many isolated examples of people engaged in such activity. Much of our schisto works, much of our acute respiratory infection works, have been done in collaboration with foreign groups and supported by either multilateral or bilateral arrangements. The multilateral arrangements generally operate with organizations like the World Health Organization and UNDP. In the PCHRD, we are trying to coordinate our relationships, both multilateral and bilateral. An example of bilateral assistance that has



been ongoing is that from JICA. JICA assists both the schisto groups in Palo, Leyte and the Research Institute for Tropical Medicine in Alabang. Also, the Australian Development Assistance Bureau is supporting research on acute respiratory infection which includes works being done in Papua, New Guinea and some parts of Africa.

I also would like to endorse the idea of Dr. de Ocampo that institutional cooperation, the institution-to-institution arrangement, be encouraged. There had been some examples of this and we are trying to encourage more of this as time goes on. I understand that the National Medical Research Institute has been proposed at U.P. and Minister Javier is likewise supportive of its establishment. There are two problems, however. One is economic. Now is not a good time to request for funds for such a facility because of the situation. The second, which I think is the more important consideration, is how it is to be operated. Who will operate the institute and how will it link up with other institutions engaged in research? This is very important because the institute should be truly national and should be linked to implementing agencies in the field of health, with private schools, private practitioners, and so forth. That way it should be a truly cooperative undertaking that includes in its operation consideration of linkages with other institutions.

In research training, I think the best way to learn research is to do it. If we are able to increase research activities over the next few years, this will automatically enhance local training opportunities.

In bio-medical research, one of the areas that the Council emphasizes is the development of an immuno-biology group in the country. At present, we have put together people from the Research Institute for Tropical Medicine in Alabang, the new Kidney Center which will be coming up within a month or so, and the UP-PGH. This group is now formulating a program for immunology development in the country.

The last comment I would like to make is with respect to the use of human subjects in medical research. I agree that very often it is not only expedient to do human experimentation but in fact necessary in order to confirm if our findings in animal researches are also applicable or true to humans. I would like to emphasize that when we do human experimentations we should make sure that we have an appropriate ethical review committee in our institution to advise us on the matter.

#### **Angelina Arcilla Latonio, Discussant**

I consider it a privilege to have been chosen by my former professor, Dr. de Ocampo, for allowing me to express my viewpoints, to discuss in a sort of personal way what I think about strategy of medical research in our country. Before I went into this, I looked up Webster and looked for the meaning of "strategy." There are

two definitions. The first is "skillful employment and coordination of tactics" and the second one is the "artful planning and management." So you see, there is some art in this strategy and I am glad we might probably have to ask the Fine Arts sector to help us some way later in order to attain a good strategy on research.

I dissected each of his disciplines and there were seven of them and let me just give you my comments, my expressions on what I feel about each topic. Because coming from a hospital, where people think we do not do research. I wish to tell you that we are deeply involved in research at the Veterans Memorial Medical Center. In fact, when I got my award for outstanding scientist of the UP Medical Alumni Association, there was a note there in the plaque, in the trophy which says, "for working in a non-research center". So I thought they did not know anything about my work area.

On leadership, I admit there is a dearth of leadership especially in the private sector. From personal communications, from colleagues who happen to be non-medical people, and people from private universities, I have been observing that the stimulus generated in the public sector is in contrast to the lack of such in the private sector. This I think we should look into if we have to generate cooperative efforts for our strategy. Sometimes when I talk to these individuals they say they feel left out but they have a multitude of bright ideas so that if we can just invite them to join us, I think we will have a better orientation of our strategy.

Now the compensation; only a handful of full-time research leaders are available. I always say a fully compensated worker is a well-motivated follower. Most researchers are, you must admit this, on part-time basis and doing their thing just for the sake of extra compensation and for some prospects for promotion. While we have our top scientists, when we look at the multitude of enthusiastic researchers, anybody who wants to start on studies, projects, I think they are not really that much oriented because they feel that there is not enough compensation to do a full-time job. The more successful researchers as mentioned by the first two speakers are either pirated abroad or transferred to more progressive institutions. Well, time and again, in my institution, we notice this but we always find others who can qualify to take their place. It is an unending story of disappointment but somehow all the institutions can manage to replace these workers who have left.

On the discontinuity of medical researches undertaken — I have been doing researches of my own alone and then when I was made a member of the research committee of the Philippines Medical Association, we have discussed time and again the practical applications of the research winning papers which somehow find their final resting place in the shelves of the medical libraries. We don't follow up our prize-winning ideas. Once you win a prize, it is forgotten. You got the ₱2,500.00. You got the plaque. So what is the meaning of this research if we don't apply it to our laymen, even among our medical colleagues. It will be truly rewarding if such research papers and their winners can report on annual updates of their pet projects if only to realize what impact it has given the concerned people on the health status of the public. Also on this research committee, maybe you are not all

aware about it, are grants from the Abbott laboratories, the Ciba-Geigy, the Raul Rivas who are trying to incite stimulus even to a small extent among medical practitioners in the rural areas, even to report an interesting case. The Raul Rivas gives a very substantial \$2,000 dollar reward for any paper on Tropical Medicine. Even my own society, the Society of Microbiology and Infectious Diseases, finds ways to get some funding from drug companies and even without promoting their own products, we are able to put up prizes for junior and senior research workers in our society. So you see, there exists a scientific gap but it can be made to go widespread, decentralize if we want to involve the private sector.

I consider it timely at this time through modern researches of global target of health for all in the year 2000. We were privileged also to go to the USSR to participate in a yearly workshop on Zoonoses. The target there was to save human and animal life if only to solve the food shortage we are facing within the next few decades. So whichever country it is, if they can find a way to stimulate interest among veterinarians, among medical people to save animal life to eradicate rabies, eradicate brucellosis, I think there should be no barrier when it comes to the common interest of saving human and animal life. In simple medical language, let us publish the ideas behind such papers. For the information of the lay public, this will allow to be discussed our potential researches among our research leaders, among those companies who have tried to help us with our research grants. Let us confine our findings among our medical colleagues. Our concern for the well-being of our people is of utmost importance.

Well, on brainstorming, again I looked up the meaning of "brainstorming". It means a "sudden aberration or inspiration." If one has to make a sudden action on research, I think it is a good enough word to say brainstorming to incite motivation. My comment is this. If this is to be done, then let us include the private researchers who need only a shot in the arm to get motivated. If multidisciplinary teams are not sufficient, then let us involve the various medical disciplines, the various specialties like microbiology, parasitology, veterinary medicine, if we have to make a brainstorming move among themselves. Solitary investigators however should not be left out. They are probably the nucleus of this brainstorming operation. Also he may be the leader that Dr. de Ocampo wants to emphasize, who finds fulfillment in seeing his followers, his students gain acceptance into the research field.

On biomedical research. During the last three decades, studying the living process of man and animals has been one of mankind's greatest intellectual and technical achievements; electronmicroscopy deals with the greatest intellectual and technical achievements at the very core of life which we have finally confirmed the unity of living matter by demonstrating the universality of the genetic code and while this sounds so distant from one local source we have started anyway with ultrastructures among our own electronmicroscopists.

The international cooperative research -- I am tropical disease-oriented; while I don't do anything on biomedical research, we have among today's tools the control of tropical diseases; we have relatively new methods but we always have to

remind them whatever it will amount to: they must be safe, they must be effective, they must be cheap for coming to a developing country. In the tropics: we have low funding, with frequent isolation of workers on malaria, schistosomiasis, filariasis; there have been no new major remedies for the last 30 years except probably for a little breakthrough for schistosoma-therapy. Because of this low funding, we need a long-term collaborative effort involving workers in many countries. And as I mentioned, the USSR has done this by spending half a million dollars inviting about 20 developing countries and involving 30 medical doctors and veterinarians, on zoonoses management if only to solve the food shortage which we are facing for the global strategy of "health for all" in the year 2000. Most laboratories in developing countries are inadequately staffed, equipped and funded, too narrowly-specialized to make even an effective contribution to tropical disease so we need to attract first class scientists.

Finally, the involvement in developing countries are divided into two tasks -- the task force and the network. The task force consists of the scientists; the network are the existing research institutes and universities. The research training can be extended or can be requested from the WHO, UNDP, FAO or the World Bank. There is nothing impossible in this world, I think, if you want it, you will get it. You will only have to look for it. To me, one who does not pursue, one who stops when he thinks there is nothing else forthcoming, I have pity for him.

The human subjects for medical research -- At one time, we had ideas of using people in Muntinlupa, for therapeutic trials as in schistosoma treatment; it never worked because we ended up saying we need to save human life, whatever.

As a parting word, I want to talk about self-reliance. Self-reliance really means that even in a developing country, it does not mean you need a universal institution to help. In your own small way, you can start and then if you look around, you will find that San Lazaro Hospital, other government hospitals, the College of Veterinary Medicine, even the Bureau of Animal Industry: all these are potential research areas and there is so much help you can get, not necessarily monetary but among your colleagues they can give you ideas on how to start in your own small way. So let us be self-reliant. We should ask money from the bigger institution only after looking around immediate neighborhood. But I always think don't ever give up. There is always a way you can start. I believe that one should not give up easily with persistence, self-reliance, he can go a long way with his objectives.

Those are my comments on the good paper of Dr. Geminiano de Ocampo.



## **A COMPARATIVE STUDY ON THE EFFECT OF MASS TREATMENT OF THE ENTIRE COMMUNITY AND SELECTIVE TREATMENT OF CHILDREN ON THE TOTAL PREVALENCE OF SOIL-TRANSMITTED HELMINTHIASIS IN TWO COMMUNITIES, MINDORO, PHILIPPINES**

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### **Introduction**

The soil-transmitted helminths also called geohelminths are the causative agents for ascariasis, trichuriasis and hookworm infection. They are quite common and widespread, with greatest frequency in most of the tropical, subtropical and developing countries like the Philippines. Of the three helminthic infections, ascariasis and trichuriasis in rural communities are about parallel in prevalence at times the latter may even be slightly higher and followed by hookworm infection (Pesigan, *et al.*, 1958; Juco, *et al.*, 1973 and 1980; Cabrera *et al.*, 1975). The female ascaris worm is capable of ovipositing approximately 200,000 eggs per day and with an average life span of about 12 months, it can produce about 25,000,000 eggs during its life time. The fully embryonated eggs found in the soil are the infective stage to man and can remain alive and infective for about 18 or more months under favorable condition.

The objective of mass treatment or deworming program in a community is not to eliminate the worms totally from the population but rather to reduce the worm burden or intensity of infection as well as the frequency of transmission of the soil-transmitted helminthiasis.

It has been found and is now agreed that periodic mass treatment of the community is the most effective means of controlling soil-transmitted helminthiasis. By this method, the number of intestinal worms or worm burden in an individual as well as in the entire community is undoubtedly reduced. When the worm burden is reduced the number of eggs in the feces is also reduced hence there are less eggs that could pollute the soil. This will eventually lead to less chances of individuals acquiring the infection.

The control of soil-transmitted helminthiasis is successful in Japan (Morishita, (1980) Kobayashi, (1980)) and some of the methodology used are now being applied in Taiwan (Chou, *et al.* (1980)) and Korea (Seo (1980)) which followed Japan in the nationwide control of these geohelminths.

It has been observed that soil-transmitted helminthiasis are more common among children than among adults, although the infection affects all age-groups. Ideally, the most effective control of soil-transmitted helminthiasis are directed towards, (1) personal hygiene, (2) proper and hygienic disposal of human faeces so as not to pollute the soil where both children and adults come in contact with (3) health education and environmental sanitation and (4) mass treatment of the community to eliminate sources of eggs which may pollute the environment and thereby serve as the residual focus of infection. Mass treatment of the community although considered practical and effective is quite expensive because of the high cost of anthelmintics. On the other hand, selective treatment of children alone might probably reduce the overall prevalence of soil-transmitted helminthiasis in a community. This premise is based on several factors namely: that children are the most exposed or high risk group to the infection; they have the highest prevalence as well as high intensity of infection; they are the ones responsible in the indiscriminate pollution of the surrounding environment and they get reinfected earlier and faster than adults.

In the Philippines, particularly in the provinces, 50 percent of the population are children 0-14 years of age, while the remaining half are adults. Hence, treatment of soil-transmitted helminthiasis in children alone already takes care of half of the population having the highest prevalence and the highest intensity of infection. This treated half of the population are responsible mainly in the spread of the infection thru the indiscriminate pollution of the environment with human faeces loaded with thousands of geohelminths ova.

We believe that the administration of anthelmintics will give the fastest at the same time the most visible and tangible impact in the control of soil-transmitted helminthiasis. However, because of their high cost, we have to determine a method that is most appropriate, most economical yet readily applicable and acceptable by the people. It is therefore for this reason, that this simple and readily applicable project was started. Should the project prove promising or even successful, it is our plan to submit the results to both the Ministry of Health and the Ministry of Education and Culture for assessment and implementation of the project if possible, on a gradually increasing scale until it will eventually involve the entire nation. It is envisioned that the Ministry of Education and Culture could take charge in the treatment of school children 7 to 14 years while the Ministry of Health could take charge in the treatment of pre-schoolers 0-6 years of age thru their several provincial/municipal health units all over the country.

### **Materials and Methods**

The project started with the search for the study area located at Victoria town, Oriental Mindoro. In the selection of the study area, two barangays that are almost identical with respect to the socio-economic status of the people and the sanitary condition of the environment will be chosen. In addition, because of the

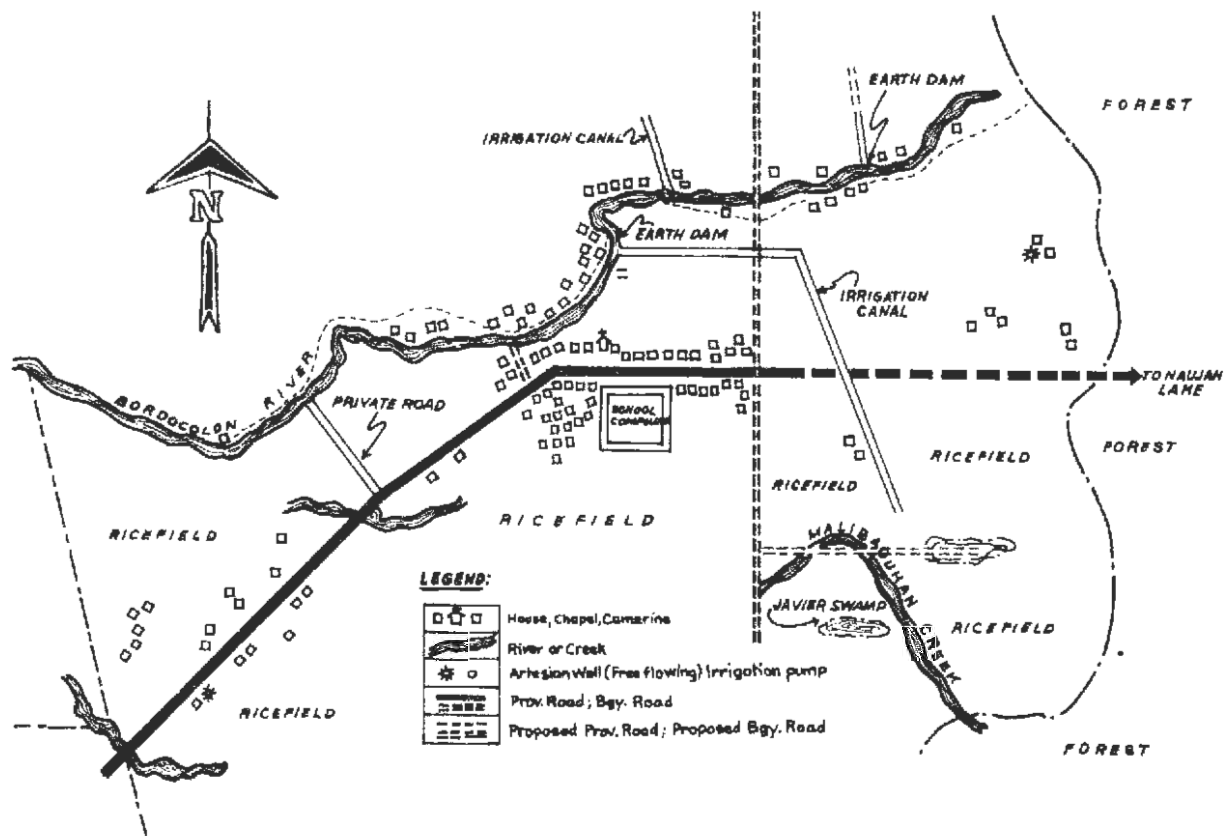


Figure A. Spot map of San Narciso, Victoria, Oriental Mindoro.



high cost of anthelmintics, the two barangays should have a small population each, approximately 1,000 in one and about 700 in the other. Barangay San Narciso with total population of 647 and Barangay Ordovilla with total population of about 1,000 were chosen. (Figs. A & B)

At the start of the project, barangay meetings were held separately for the two areas attended by municipal, barangay and school officials. The objective as well as the mechanics in undertaking the project were discussed during these meetings, with emphasis on the type and the amount of cooperation expected of the local officials in the implementation of such a project.

For the baseline data, stool collection and examination were done on at least 35% of the population in each of the study area. After establishment of the baseline data on prevalence of soil-transmitted helminthiasis in the two areas, treatment of cases every 4 months or 3 times a year for a period of 3 years will be done and post-treatment prevalence rates every end of the year will also be determined. It is hoped that reinfection rate studies could be done on the fourth year.

For San Narciso, the entire population (children and adults) will be given treatment or what is termed as mass treatment. For Ordovilla, only children 0-14 years will be treated or what is termed as selective treatment, however, the post-treatment prevalence at the end of each year will also include adults. The drugs used for three years were Pyrantel Pamoate (Combantrin) and Oxantel-Pyrantel (Quantrel) at half of the recommended dose for the first two years and Oxantel-Pyrantel (Quantrel) given at the recommended dose in the third year.

Analysis of the baseline data together with the prevalence data obtained after every end of the year for a period of three years will be done.

## Results

In the establishment of the baseline data, approximately 36% of the 1,000 population of Ordovilla and 56% of the 647 population of San Narciso were examined.

The baseline data on the pre-treatment prevalence of soil-transmitted helminthiasis among males for the two areas are shown in tables 1A and 2A; among females in tables 1B and 2B and for both sexes in tables 1C and 2C. The picture depicted among females is the same as that among males whereby ascariasis and trichuriasis are both prevalent in San Narciso than in Ordovilla but hookworm is more prevalent in Ordovilla. For ascariasis, prevalences of 74.9% and 71.6% were found among females, 74.6% and 65.4% among males for San Narciso and Ordovilla respectively; but for hookworm, 10.3% and 28.4% among females, 18.5% and 30.9% among males for San Narciso and Ordovilla respectively. This high prevalence of ascariasis and trichuriasis in San Narciso compared to Ordovilla among both sexes is maintained and so with the high hookworm prevalence in Ordovilla (29.7%) as compared to San Narciso's (14.6%). The pre-treatment prevalence of geohelminths among children and adults is shown in Fig. 1.

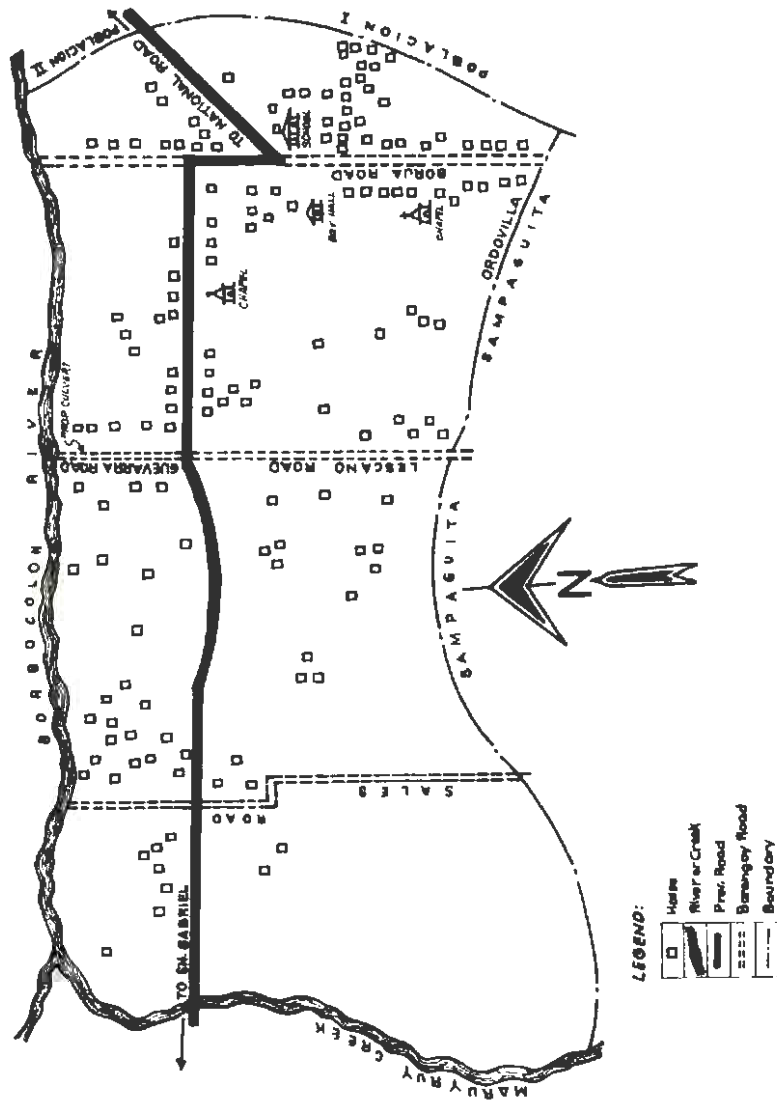


Figure B. Spot map of Ordovilla, Victoria, Oriental Mindoro.

Table 1A. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	38	25	65.8	22	57.9	5	13.2
7 - 14	99	69	69.7	85	85.9	35	35.4
15 +	51	29	56.9	36	70.6	18	35.3
TOTAL	188	123	65.4	143	76.1	58	30.9

Table 2A. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	37	31	83.8	33	89.2	6	16.2
7 - 14	73	54	74.0	61	83.6	18	24.7
15 +	79	56	70.9	62	78.5	11	13.9
TOTAL	189	141	74.6	156	82.5	35	18.5

Table 1B. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, Ordovilla, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	33	26	78.8	22	66.7	8	24.2
7 - 14	81	58	71.6	68	84.0	21	25.9
15 +	62	42	67.7	42	67.7	21	33.9
TOTAL	176	126	71.6	132	75.0	50	28.4

Table 2B. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, San Narciso, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	23	19	82.6	19	82.6	2	8.7
7 - 14	74	56	75.7	66	89.2	9	12.2
15 +	78	56	71.8	68	87.2	7	9.0
TOTAL	175	131	74.9	153	87.4	18	10.3

Table 1C. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, Ordevilla, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	71	51	71.8	44	62.0	13	18.3
7 - 14	180	127	70.6	153	85.0	56	31.1
15 +	113	71	62.8	78	69.0	39	34.5
TOTAL	364	249	68.4	275	75.5	108	29.7

Table 2C. Pre-Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, San Narciso, Victoria, Mindoro Oriental (1979)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	60	50	83.3	52	86.7	8	13.3
7 - 14	147	110	74.8	127	86.4	27	18.4
15 +	157	112	71.3	130	82.8	18	11.5
TOTAL	364	272	74.7	309	84.9	53	14.6

The results of the first year post-treatment among males is shown in tables 1D and 2D; among females in tables 1E and 2E and for both sexes, in tables 1F and 2F. Although the result in ascariasis among males appears to be better in mass treatment (San Narciso), the results for trichuriasis and hookworm appear to be better in the selective treatment (Ordovilla). A similar picture is depicted among females. For both sexes the trend is maintained, namely mass treatment appears better than selected in ascariasis but selective appears better than mass treatment in trichuriasis and hookworm infection. The difference in prevalence between the two areas for ascaris and hookworm is not statistically significant but for trichuris the difference between the two areas is quite significant. The first year post-treatment prevalence among children and adults is shown in Fig. 2. There was marked decrease in prevalence of soil-transmitted helminthiasis from the pre-treatment to the first year post-treatment in San Narciso where mass treatment was applied. For ascariasis among children from 77.3% to 10.8% and among adults from 71.3% to 12.1%; for trichuriasis among children from 86.5% to 33.7 and among adults from 82.8% to 45.4%; for hookworm among children, from 17% to 4.0% and among adults there was practically no change in prevalence. In Ordovilla where selective treatment was applied, the changes are as follows: for ascariasis among children from 70.9% to 15.0% and among adults from 62.8% to 20.0%; for trichuriasis among children from 78.5% to 22.6% and among adults from 69% to 22%; for hookworm among children from 27.5% to 2.2% and among adults from 34.5% to 13%.

The results of the second year post treatment prevalence among males are shown in tables 1G and 2G, among females in tables 1H and 2H and for both sexes in tables 1I and 2I. All the three tables maintained the same trend as revealed by the data obtained in the first year post treatment data. The data on prevalence among children and adults is shown in Fig. 3. There was further decrease in prevalence of the soil-transmitted helminthiasis from the first year to the second year post-treatment prevalence.

The results of the third year treatment among males are shown in tables 1J and 2J, among females in tables 1K and 2K and for both sexes, in tables 1L and 2L. The difference in prevalence between the two areas with regards to ascaris and hookworm are not statistically significant whereas for trichuris the difference remained highly significant. The third year post-treatment prevalence according to age and method of treatment is shown in Fig. 4. Among children, selective treatment appears to be better than mass treatment in all the three geohelminths but among adults, mass treatment appears to be better than selective in the three parasites.

Figs. 5, 6 and 7 compare the effect of mass and selective treatments on prevalence of geohelminths in the two study areas among children and among adults respectively. Among children mass treatment is slightly better than selective in ascariasis but selective is better than mass treatment in trichuriasis and hookworm infection. Among adults mass treatment appears better than selective in

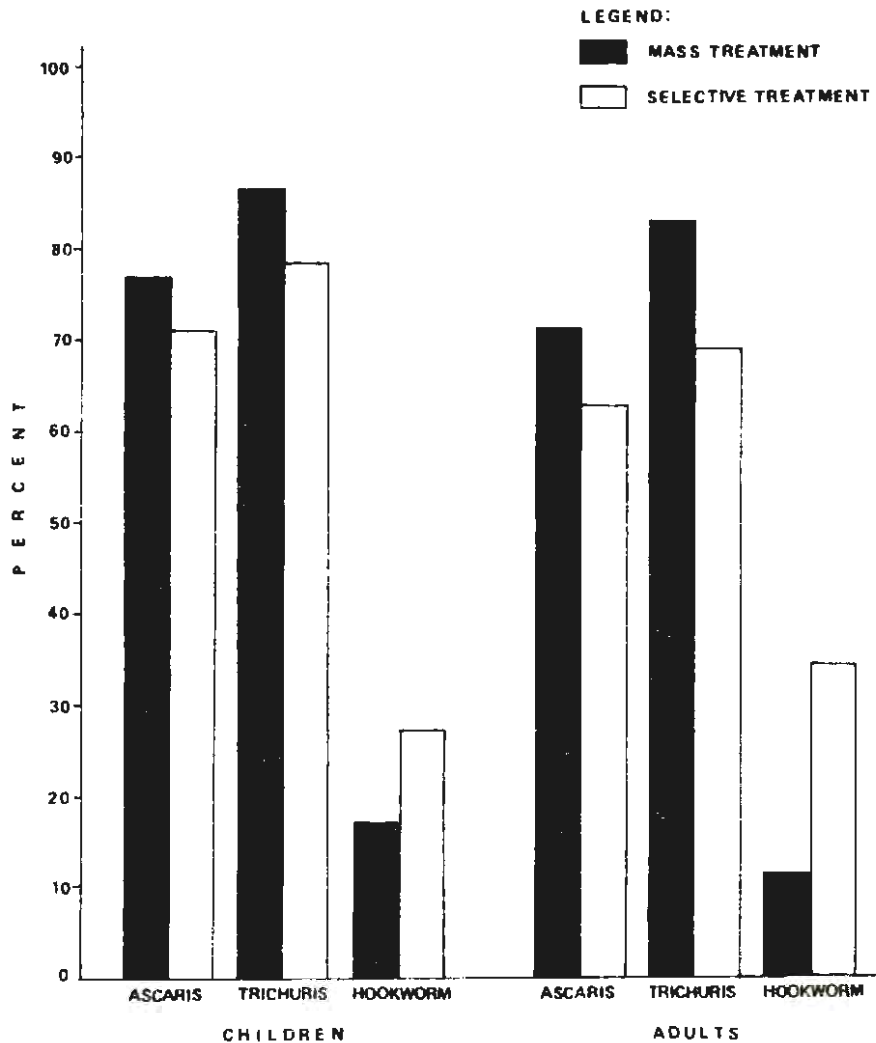


Figure 1. Pre-treatment prevalence of geohelminths among children and adults, Mindoro, Philippines, 1979.

ascariasis and hookworm infection but selective seems to be better than mass treatment in trichuriasis.

Fig. 8 shows the effect of mass treatment of an entire barangay (San Narciso) and selective treatment of children in another barangay (Ordovilla) on the total prevalence of geohelminths in the two areas. Mass treatment appears to be better than selective up to the third year observation in ascariasis and hookworm infection

Table 1D. First Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental, (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	36	5	13.9	8	22.2	1	2.8
7 - 14	145	21	14.5	30	20.7	6	4.1
15 +	44	6	13.6	9	20.5	7	15.9
TOTAL	225	32	14.2	47	20.9	14	6.2

Table 2D. First Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental, (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	33	4	12.1	15	45.5	2	6.1
7 - 14	64	6	9.4	19	29.7	4	6.3
15 +	69	6	8.7	26	37.7	10	14.5
TOTAL	166	16	9.6	60	36.1	16	9.6

Table 1E. First Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, Ordovilla, Victoria, Mindoro Oriental, (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	22	5	22.7	7	31.8	0	0
7 - 14	116	17	14.7	27	23.3	2	1.7
15 +	56	14	25.0	13	23.2	6	10.7
TOTAL	194	36	18.6	47	24.2	8	4.1

but selective appears to be better in trichuriasis. The difference in prevalence however are not statistically significant in ascariasis and hookworm infection but significant in trichuriasis.

Comparison of the three post-treatment prevalences with the pre-treatment prevalence to determine percent decrease of the three geohelminths in the two

Table 2E. First Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis. Among Females by Age, San Narciso, Victoria, Mindoro Oriental (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	22	4	18.2	7	31.8	0	0
7 - 14	56	5	8.9	18	32.1	1	1.8
15 +	63	10	15.9	34	54.0	6	9.5
TOTAL	141	19	13.5	59	41.8	7	5.0

Table 1F. First Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, Ordovilla, Victoria, Mindoro Oriental (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	58	10	17.2	15	25.9	1	1.7
7 - 14	261	38	14.6	57	21.8	6	2.3
15 +	100	20	20.0	22	22.0	13	13.0
TOTAL	419	68	16.2	94	22.4	20	4.8

Table 2F. First Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis, of Both Sexes by Age, San Narciso, Victoria, Mindoro Oriental (1980)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	55	8	14.5	22	40.0	2	3.6
7 - 14	120	11	9.2	37	30.8	5	4.2
15 +	132	16	12.1	60	45.4	16	12.1
TOTAL	307	35	11.4	119	38.8	23	7.5

barangays are shown in tables 3A, 3B and 3C. For ascariasis, decrease in prevalence as a result of mass treatment is higher than in selective treatment in the three years observation. For trichuriasis and hookworm infection however, the percent decreases are higher in selective than in mass treatment. A similar table by broad age groups is shown in table 4.



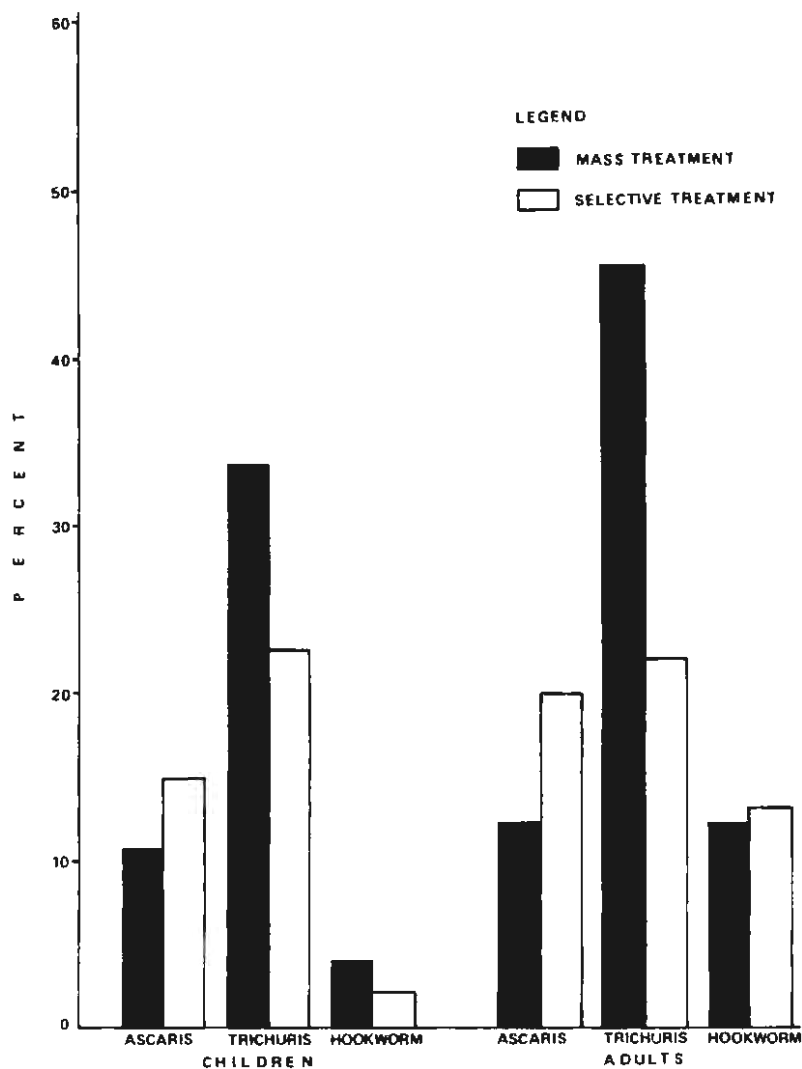


Figure 2. First year post-treatment prevalence of geohelminths, Mindoro, Philippines, 1980.

### Discussion

In the baseline data gathered in 1979, the prevalence of ascariasis and trichuriasis are higher in San Narciso than in Ordovilla. For ascariasis, prevalences of 74.7% and 68.4% and for trichuriasis 84.9% and 75.5% were obtained for San

Table 1G. Second Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	51	5	9.8	9	17.6	0	0
7 - 14	94	14	14.9	10	10.6	4	4.3
15 +	56	9	16.1	24	42.9	12	21.4
TOTAL	201	28	13.9	43	21.4	16	7.9

Table 2G. Second Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, San Narciso, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	33	4	12.1	12	36.4	0	0
7 - 14	52	1	2.0	19	37.0	4	7.7
15 +	60	2	3.3	17	28.3	6	10.0
TOTAL	145	7	5.0	48	33.1	10	7.0

Table 1H. Second Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, Ordovilla, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	48	7	14.6	8	16.7	1	2.1
7 - 14	81	6	7.4	12	14.8	2	2.5
15 +	88	20	22.7	23	26.1	8	9.1
TOTAL	217	33	15.2	43	19.8	11	5.1

Narciso and Ordovilla respectively. For hookworm however, Ordovilla has higher prevalence than San Narciso 29.7% and 14.6% respectively.

From Fig. 9, it appears that both study areas experienced marked decline in the overall prevalence of the three soil-transmitted helminthiasis from the first year post-treatment prevalence and remained at about the same level through the

Table 2H. Second Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, San Narciso, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	22	5	23.0	8	36.4	0	0
7 - 14	51	5	10.0	19	37.3	0	0
15 +	54	8	15.0	23	43.0	3	6.0
TOTAL	127	18	14.1	50	39.4	3	2.4

Table 1I. Second Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, Ordovilla, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	99	12	12.1	17	17.2	1	1.0
7 - 14	175	20	11.4	22	12.6	6	3.4
15 +	144	29	20.1	47	32.6	20	13.9
TOTAL	418	61	14.6	86	20.6	27	6.5

Table 2I. Second Year Post Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, Ordovilla, Victoria, Mindoro Oriental (1981)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	55	9	16.4	20	36.4	0	0
7 - 14	103	6	5.8	38	36.8	4	3.9
15 +	114	10	8.8	40	35.1	9	7.9
TOTAL	272	25	9.2	98	36.0	13	4.8

third year post-treatment. Despite a difference in the method of intervention, the two barangays had similar overall prevalence of ascariasis and hookworm infection from the first year post-treatment to the end of the observation period. The higher prevalence of hookworm infection in Ordovilla compared to San Narciso as shown

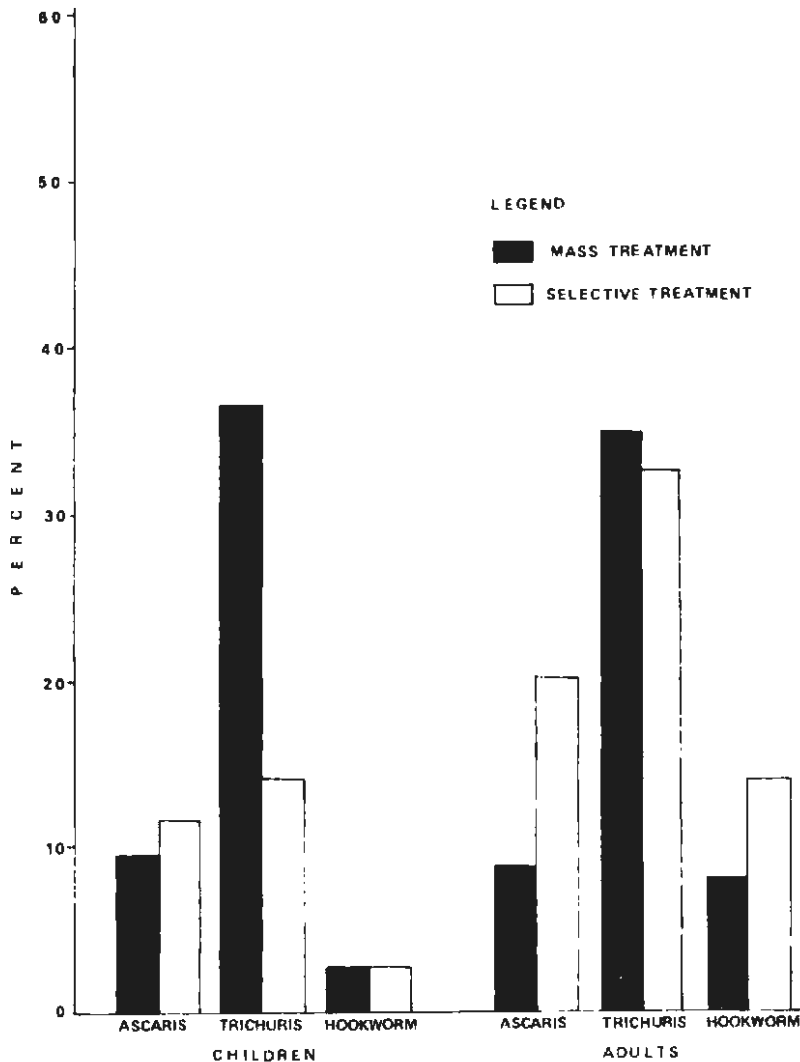


Figure 3. Second year post-treatment prevalence of geohelminths, Mindoro, Philippines, 1981.

in the baseline data did not persist once intervention was started. Trichuriasis on the other hand was consistently higher in San Narciso than in Ordovilla.

Fig. 10 shows the prevalence of geohelminths by sex in the two barangays. It appears that sex did not seem to have significant influence on the prevalence of the

Table 1J. Third Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, Ordovilla, Victoria, Mindoro Oriental (1982).

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	59	6	10.2	2	3.4	0	0
7 - 14	48	2	4.2	10	20.8	1	2.1
15 +	50	6	12.0	27	54.0	12	24.0
TOTAL	157	14	8.9	39	24.8	13	8.3

Table 2J. Third Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Males by Age, San Narciso, Victoria, Mindoro Oriental (1982).

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	29	2	6.9	9	31.0	0	0
7 - 14	48	4	8.3	17	35.4	4	8.3
15 +	81	5	6.2	23	28.4	5	6.2
TOTAL	158	11	7.0	49	31.0	9	5.7

Table 1K. Third Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, Ordovilla, Victoria, Mindoro Oriental (1982)

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	28	5	17.8	0	0	0	0
7 - 14	57	3	5.3	4	7.0	1	1.7
15 +	73	14	19.2	32	43.8	6	8.2
TOTAL	158	22	13.9	36	22.8	7	4.4

three soil-transmitted helminthiasis. The same figure depicts the comparable trends in the prevalence throughout the duration of the study in males and females.

The effect of selective and mass treatments on the overall prevalence of the soil-transmitted helminthiasis is shown in table 4 and Fig. 7. Apparently the pre-

Table 2K. Third Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis Among Females by Age, San Narciso, Victoria, Mindoro Oriental (1982).

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	24	5	20.8	6	25.0	0	0
7-14	44	4	9.1	10	22.7	1	2.3
15 +	82	6	7.3	34	41.5	3	3.6
TOTAL	150	15	10.0	50	33.3	4	2.7

Table 1L. Third Year Post-Treatment Prevalence of Soil-Transmitted Helminthiasis of Both Sexes by Age, Ordovilla, Victoria, Mindoro Oriental (1982).

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	87	11	12.6	2	2.3	0	0
7 - 14	105	5	4.8	14	13.3	2	1.9
15 +	123	20	16.3	59	47.9	18	14.6
TOTAL	315	36	11.4	75	23.8	20	6.3

Table 2L. Third Year Post-Treatment Prevalence of Soil-Treatment Helminthiasis of Both Sexes by Age, San Narciso, Victoria, Mindoro Oriental (1982).

AGE GROUP	NO. EXAM.	ASCARIS		TRICHURIS		HOOKWORM	
		+	%	+	%	+	%
0 - 6	53	7	13.2	15	28.3	0	0
7-14	92	8	8.7	27	29.3	5	5.4
15 +	163	11	6.7	57	35.0	8	4.9
TOTAL	308	26	8.4	99	32.1	13	4.2

valence of the soil-transmitted helminthiasis did not differ much in children and adults. Among children the decline of the prevalence rate during the intervention period relative to its baseline figure in the two barangays is about the same for ascariasis; for trichuriasis and hookworm infection however, Ordovilla (selective

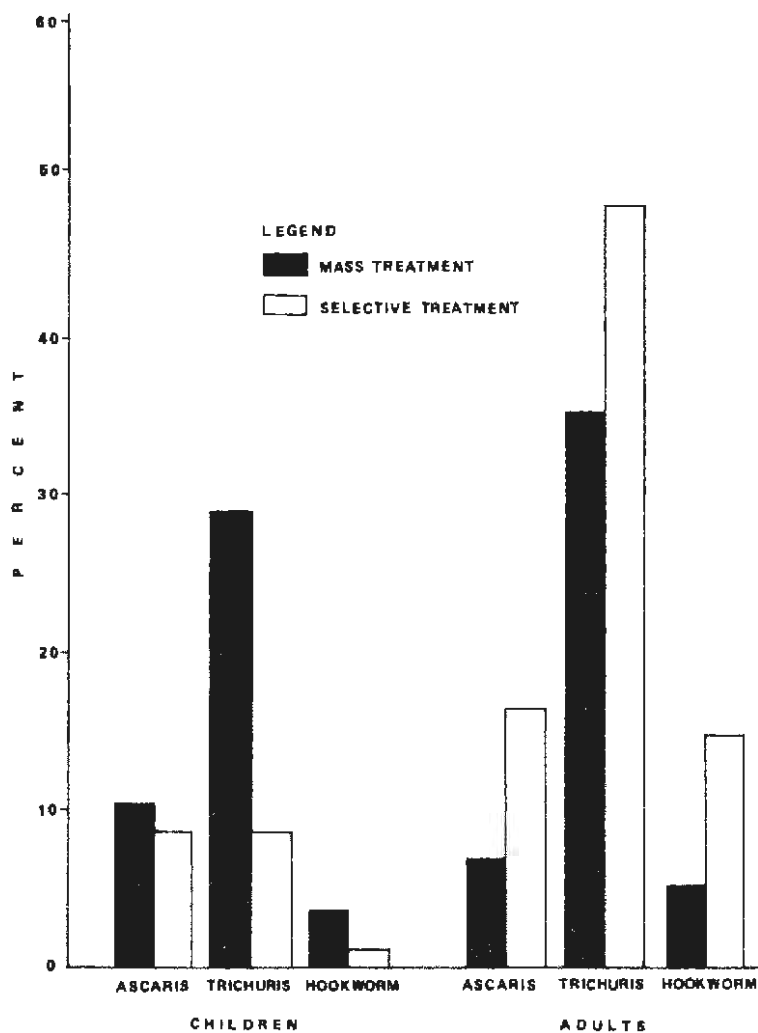


Figure 4. Third year post-treatment prevalence of geohelminths, Mindoro, Philippines, 1982.

treatment) showed a greater decline than San Narciso (mass treatment). Among adults, San Narciso had a higher percent decline compared to Ordovilla for ascariasis and trichuriasis, but for hookworm infection, the same relative decline in the two barangays was registered.

It is worthwhile to note that in children and in adults the prevalence showed a considerable decline following the first year post-treatment follow-up in both Ordovilla and San Narciso even if in the former only children were given treatment.

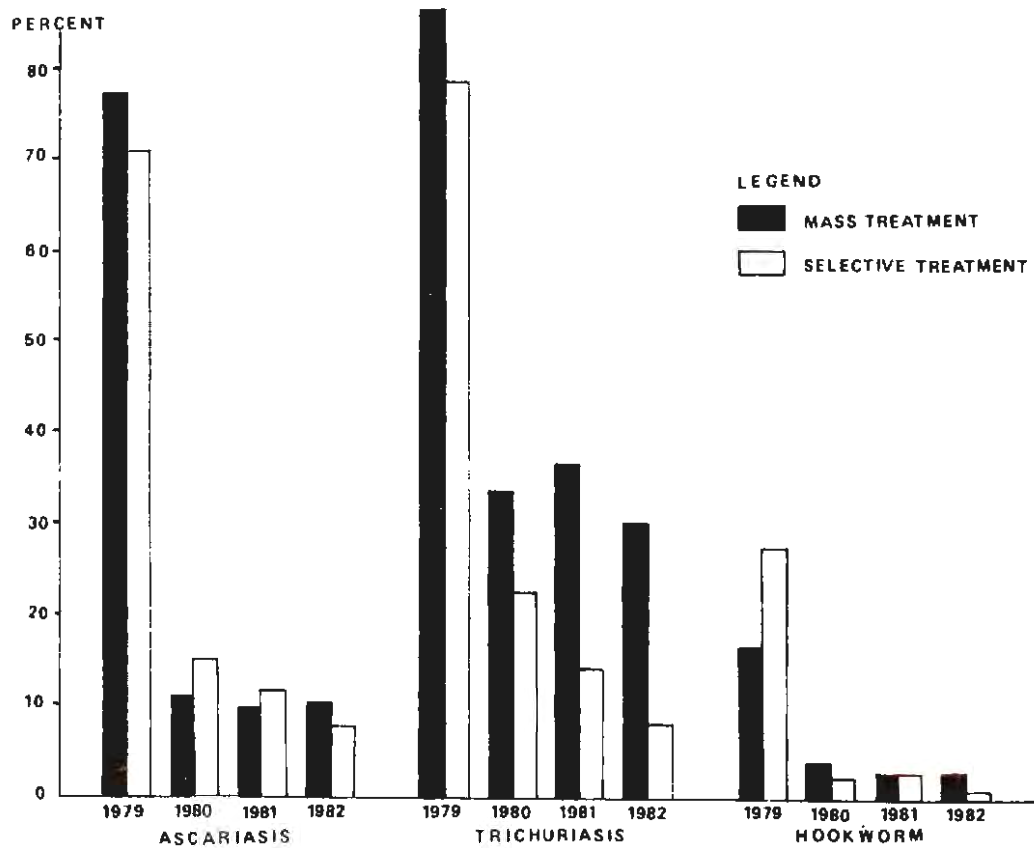
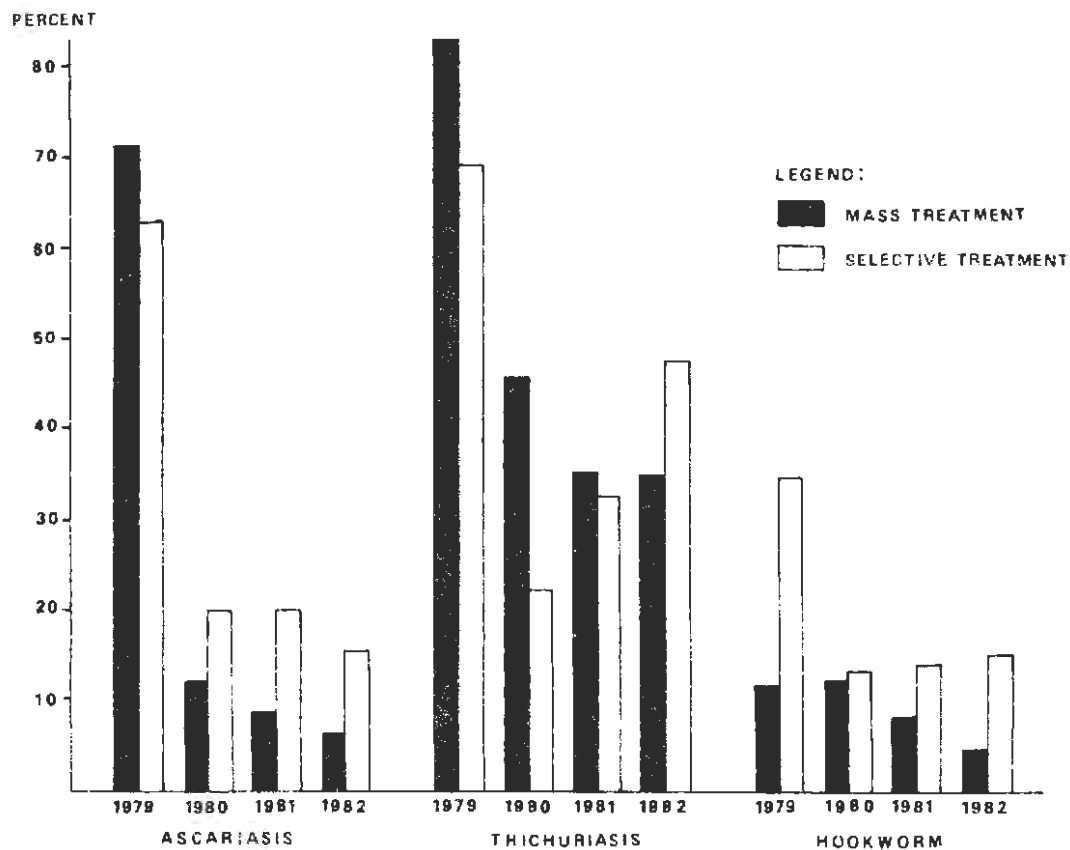


Figure 5. Mass vs. selective treatment among children on prevalence of geohelminths in two barangays, Mindoro, Philippines, 1979-1982.





Figures 6. Mass vs. selective treatment among adults on prevalence of geohelminths in two barangays, Mindoro, Philippines, 1979-1982.

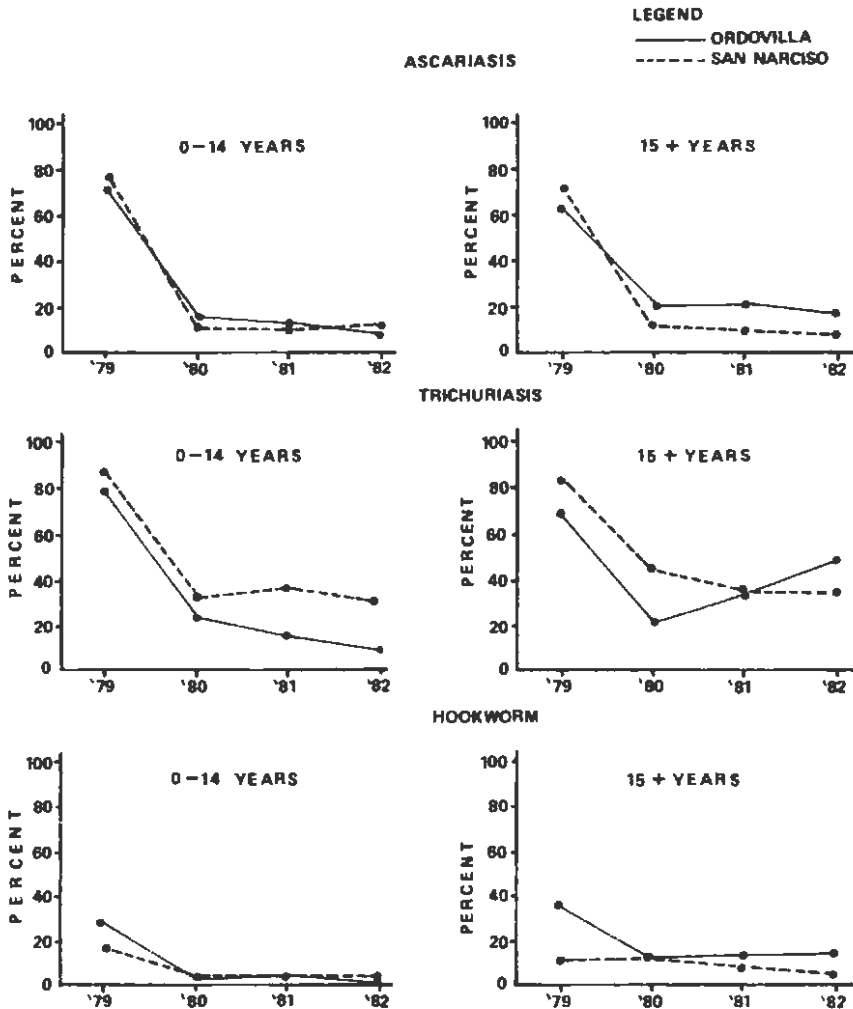


Figure 7. Prevalence of soil-transmitted helminthiasis in children and adults, Ordovilla and San Narciso, Victoria, Mindoro Oriental, 1979-1982.

This is probably due partially to the short life span of the worm in the case of ascariasis. Evidently, the advantage of mass treatment is only manifested among adults and only for ascariasis and trichuriasis. Among children mass treatment did not have a distinct advantage over selective treatment; on the contrary, selective

Table 3A. Comparison of Three Post-Treatments with Pre-Treatment Prevalence Rates of Ascariasis (% Decreases) in Two Barangays, Victoria, Mindoro Oriental, 1979-1982.

SEX	ORDOVILLA				SAN NARCISO			
	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX
MALES	65.4	78.3	78.7	86.4	74.6	87.1	93.3	90.7
FEMALES	71.6	74.0	78.8	80.6	74.9	82.0	81.2	86.6
TOTAL	68.4	76.3	78.6	83.3	74.7	84.7	87.7	88.7

Table 3B. Comparison of Three Post-Treatments with Pre-Treatment Prevalence Rates of Trichuriasis (% Decreases) in Two Barangays, Victoria, Mindoro Oriental, 1979-1982.

SEX	ORDOVILLA				SAN NARCISO			
	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX
MALES	76.1	72.5	71.9	67.4	82.5	56.2	59.9	62.4
FEMALES	75.0	67.7	73.6	69.6	87.4	52.2	54.9	61.9
TOTAL	75.5	70.3	72.7	68.5	84.9	54.3	57.6	62.2

Table 3C. Comparison of Three Post-Treatments with Pre-Treatment Prevalence Rates of Hookworm (% Decreases) in Two Barangays, Victoria, Mindoro Oriental, 1979-1982.

SEX	ORDOVILLA				SAN NARCISO			
	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX	PRE-RX	1st YEAR POST-RX	2nd YEAR POST-RX	3rd YEAR POST-RX
MALES	30.9	79.9	74.4	73.1	18.5	48.1	62.2	69.7
FEMALES	28.4	85.6	82.0	84.5	10.3	51.4	76.7	73.8
TOTAL	29.7	83.8	78.1	78.8	14.6	48.6	67.1	71.2

Table 4. Prevalence Rates (%) and Relative Decline in the Prevalence of Soil-Transmitted Helminthiasis by Broad Age Groups, Ordovilla and San Narciso, Victoria, Mindoro Oriental, 1979-1982

YEAR	ASCARIS		TRICHURIS		HOOKWORM	
	ORDOVILLA	Sn. NARCISO	ORDOVILLA	Sn. NARCISO	ORDOVILLA	Sn. NARCISO
0 -- 14 YEARS						
1979	70.9	77.3	78.5	86.5	27.5	16.9
1982	8.3	10.3	8.3	29.0	1.0	3.4
% DECLINE	88.3	86.7	89.4	66.5	96.4	80.0
15 + YEARS						
1979	62.8	71.3	69.0	82.8	34.5	11.5
1982	16.3	6.7	47.9	34.9	14.6	4.9
% DECLINE	74.0	90.6	30.6	57.8	57.7	57.4
ALL AGES						
1979	68.4	74.7	75.5	84.9	29.7	14.6
1982	11.4	8.4	23.8	32.1	6.3	4.2
% DECLINE	83.3	88.8	68.5	62.2	78.8	71.2

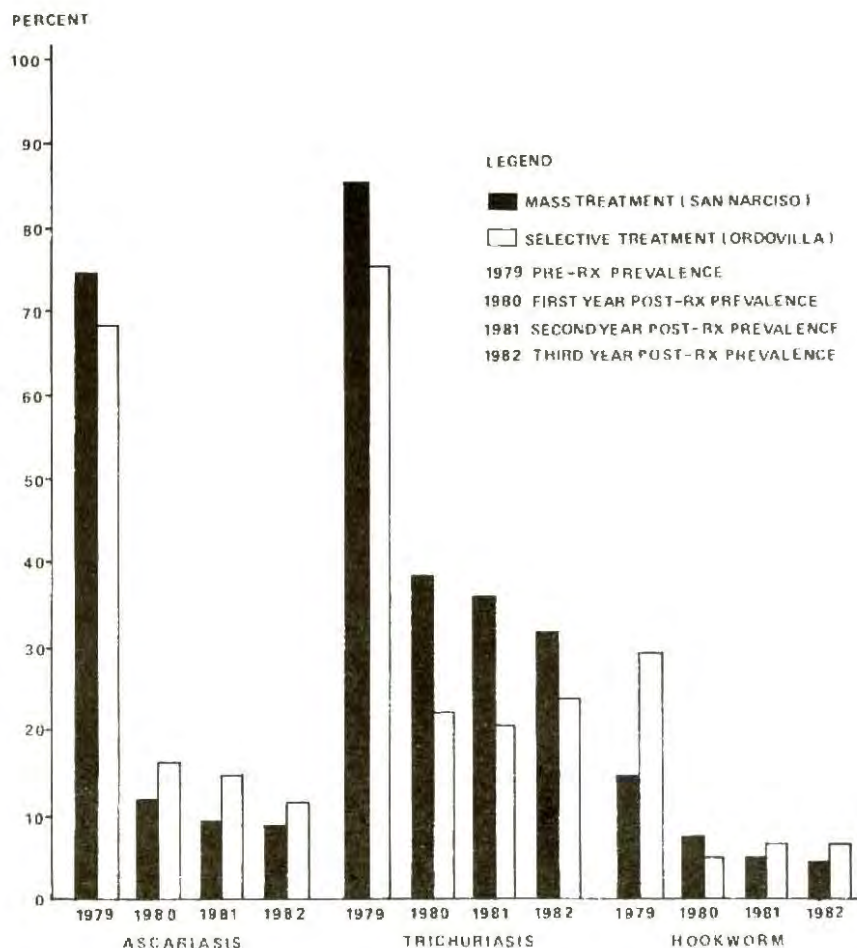


Figure 8. Comparison between effect of mass treatment and selective treatment of children 0-14 years on the prevalence of geohelminths in two communities of Victoria, Mindoro Oriental, 1979-1982.

treatment appeared to be better than mass treatment for trichuriasis and hookworm infections.

On the overall prevalence rates, selective and mass treatment did not have considerable differences as shown by the similar percent decline in the prevalence of each of three geohelminths.

The importance and/or significance of this study is that the government could save 50% of funds intended for the purchase of anthelmintics if it chooses

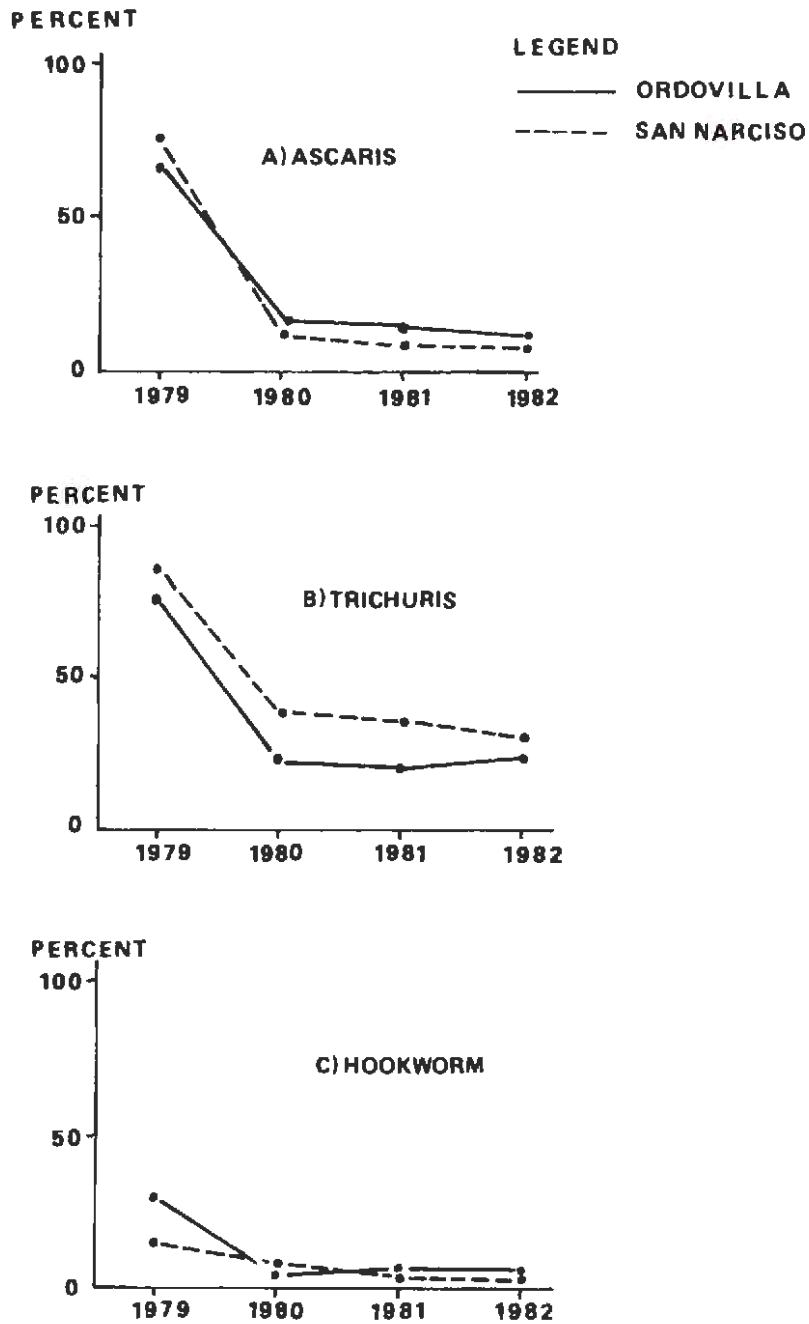


Figure 9. Prevalence of soil-transmitted helminthiasis, Ordovilla and San Narciso, Victoria, Mindoro Oriental, 1979-1982.

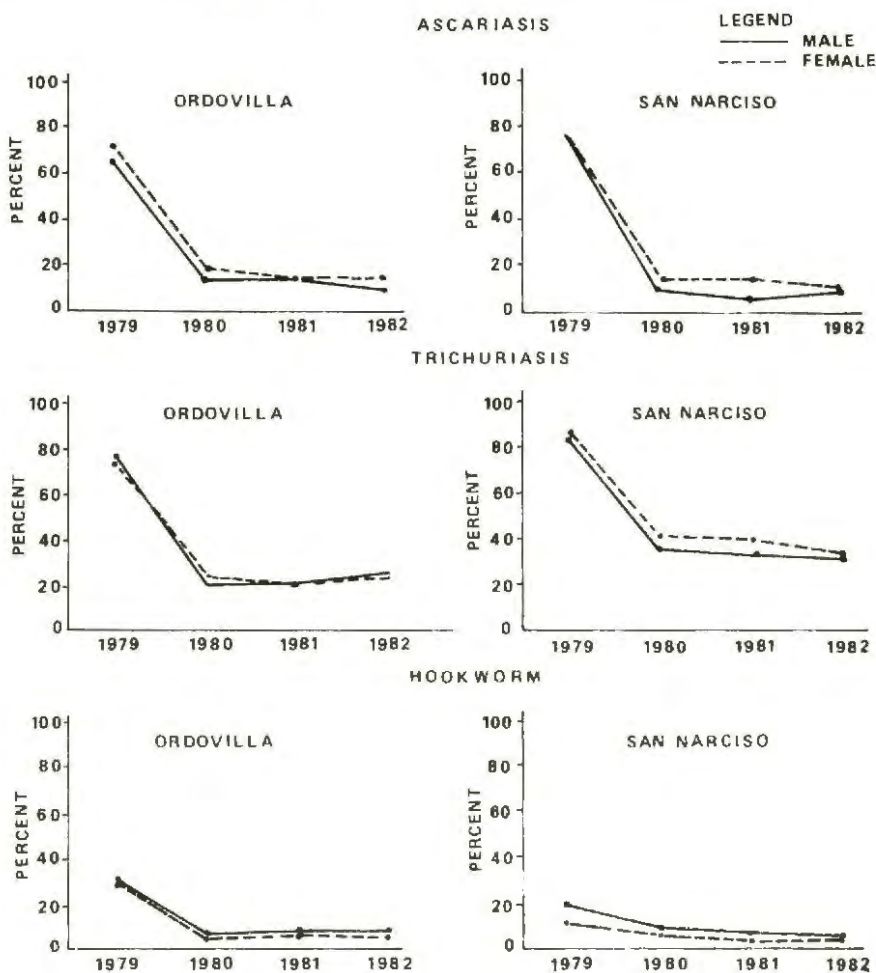


Figure 10. Prevalence of soil-transmitted helminthiasis by sex, Ordovilla and San Narciso, Victoria, Mindoro Oriental, 1979-1982.

the use of selective rather than mass treatment. Selective treatment will likewise save on time, effort and manpower. I believe that the idea of focussing on the most sensitive and most susceptible group of the population to the infection, could be the key to the control, if not eradication of soil-transmitted helminthiasis or possibly other parasitic infections as well.

### Summary and Conclusion

Two comparative barangays in Mindoro constitute the study area. Selective treatment was applied in Ordovilla and mass treatment was applied in San Narciso. Treatment, using pyrantel pamoate and oxantel-pyrantel at half the recommended dose, were given for the first two years and oxantel-pyrantel at full dose in the third year. The effect of these two interventions on the total prevalence of geohelminths was determined.

Both areas experienced a marked decline in the prevalence of the three geohelminths from the first treatment year to the third or last treatment year, when compared with baseline data.

Among children, the percentage of decline in prevalence in the two areas is about the same for ascariasis; for trichuriasis and hookworm, selective treatment showed a greater percentage of decline than mass treatment.

Among adults, mass treatment showed a greater percentage of decline than selective treatment for ascariasis and trichuriasis, but the percentage of decline were equal for hookworm.

In terms of overall prevalence, neither intervention had an appreciable difference for the three geohelminths, as shown by the similar percentage decline.

In conclusion, the three-year observation seems to indicate that there is no need to apply mass treatment of an entire community in attempting to reduce prevalence of these geohelminths inasmuch as selective treatment will provide the same result. There will therefore be considerable savings on funds, time, effort and manpower on the part of the sponsor involved in this type of project.

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**Edito G. Garcia, Discussant**

As stated by Dr. Cabrera, the usual and generally accepted effective measures for controlling soil-transmitted helminths include deseeding the environment of eggs by sanitary disposal of human feces. But on account of our failure to do this, we have the continuing problem of soil-transmitted helminths. This failure of our population to utilize toilets is probably an indication of the ineffectiveness of our primary education to inculcate basic health habits and also the failure of the Ministry of Health's education and sanitation program. Apparently, the intent of Dr. Cabrera is to sell selective mass therapy as an alternative method for sanitary disposal of human feces. He further states that his data shows that limiting mass treatment to children would be as effective as treating the whole population although without defining the exact epidemiologic situation where the study was done.

Ascariasis and other soil-transmitted helminths exist under different epidemiological situations. These are: 1) areas where there is a level of sanitation with the adult population using toilets and consequently not be seeding the environment while the younger ages do so, and 2) a situation where there is minimal amount of sanitary disposal of feces with both adults and children seeding the environment. The first type of epidemiological situation is where Dr. Cabrera's model will work. In the second type, in an area where there are very minimal amount of sanitary facility, the adults will be defecating in the bushes or some other places, similar to what the children do. I suppose that in such situation, treatment of the population below 15 years will not be sufficient.

Dr. Cabrera wants to have this method of controlling soil-transmitted helminths implemented and I am very glad that he does because there have been earlier remarks that many of our researchers do not see to it that application of the results of their study is done. To make it easier for him to sell his idea it might help if he is able to show that the two communities where the study was done, were really comparable particularly with reference to data relating to amount of sanitation. Although he stated that the study areas are identical, it is probably better if he includes these data in his report.

Another consideration is how soon after treatment or how early before re-treatment were the children examined. This should be mentioned because the probability of getting a negative or a positive result depends on how soon after treatment or how early before re-treatment was stool examination done.

To me, a mass treatment program should be done only to accelerate disappearance of soil-transmitted helminths and only where there is already an effective program of sanitation with increasing segment of the population using the toilets. This program (mass treatment) has been claimed to be effective in Japan and in Korea. I suspect success in said countries was due to concomitant progress in sanitation.

**Bonifacio C. Dazo, Discussant**

I congratulate Dr. Cabrera for his excellent work. While we now talk on biomedical engineering, hybridoma technology, vaccines for malaria, vaccines for leprosy, and so forth, I am very pleased that there is a revival of interest in the age-old problem of the common intestinal worms. As you know, in the Manila Regional of WHO, it has been a long battle before the top management was convinced that the lowly worms, the intestinal worms, could play a vital role by linking it with the modern concept of primary health care. Everybody says that immunization is the priority programme, the same thing applies to diarrheal diseases control and acute respiratory infections since our children's health is our great concern. You are wasting your time and in the present situation wherein resources are so scanty, why do you indulge in the soil-transmitted helminths? Well, I said has it ever occurred to you that in the poor developing countries, the communities will never be able to understand what you are talking about. For instance, family planning, they will say why stop us from having more children when we are underpopulated. And yet, we still keep on pressing this programme. We all know that the level of intelligence of the community is very low so the idea of starting with the lowly worms came to our mind. The community would never be able to grasp what you are telling them. In the highlands of Papua New Guinea, for instance, I told them, "look your children are anemic, and this is due to malaria and hookworm infection." Suddenly the word click, and the reply was, "oh yes, we know they have worms, intestinal worms." So immediately there is rapport. The communication gap narrows down and when you have a dialogue, the community listens and becomes aware of the problem and then you get their participation. So these are my general comments.

Now I would like to go to the specific comments. The objectives of Dr. Cabrera are happily parallel to ours. It is not to eradicate the intestinal parasitic infections. We are telling lies if we say that we will eradicate these intestinal helminths. But we tell people that we are here to decrease or reduce the worm load. If the reduction in number of worms from 2000 to 20 or to ten, the child would be able to grow and have more of the nutrition rather than giving the nutrients to the worms then I think you are being very objective.

Regarding measures for control, I cannot but agree with Professor Cabrera that personal hygiene, proper disposal of human feces, health education to elicit community awareness and participation and mass drug treatment are fundamental measures for control. However, I would like to add one more factor and that is the provision of good water supply. After all in many developing countries, one of the primary necessities of life is shelter, food and water. Effective control by chemotherapy I also agree with Professor Cabrera. That is immediate and it will bring results with the least possible cost in manpower, in funds and so on. However, there should be some word of caution. Indonesia where I worked for few years, we find in special cases like in the coal mining town of Sawah Lunto the situation is very different. There the adults, the working force, are the ones that are heavily

infested with intestinal worms. And the same thing is true with the sugarcane workers in Jogjakarta, in the island of Java.

The last comment that I have is on the control efforts. In Japan, Korea and Taiwan, control efforts are being implemented successfully not by the government efforts alone. The private sector has been very much involved. Likewise, the community is very much involved. I hope the same linkage, the same collaborative efforts will be elicited here. There is the highly motivated private group like the Jaycees, the Rotarians, the Lions Club, etc. I think all should have a hand in the control of soil-transmitted helminths among our population especially among children.



## MUTAGENICITY AND CLASTOGENICITY POTENTIAL OF MEXAFORM\*

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### ABSTRACT

Mexaform, an anti-amoebic drug, was used in this study. By Rec Assay, it was shown to possess slight DNA damaging capacity. However, by the use of the Ames test, it was not mutagenic before metabolic activation. After metabolic activation, it is transformed to a base-pair mutagen. It also possesses chromosome breaking effects, as measured by the number of micronucleated polychromatic erythrocytes in bone marrow cells of mice. It is therefore, a clastogen. Its clastogenic property, however, was greatly reduced by cysteine.

### Introduction

Mexaform, which contains a hydrogenated hydroxyquinoline, is used for the treatment of amoebic dysentery. The parent compound, quinoline, was found to be a hepatocarcinogen in rats (1).

Since the drug can be purchased over the counter, many who are involved in self-medication are exposed to it. It is, therefore, imperative to study the effects of this drug on DNA, the genetic substance of the living cell.

### Review of Literature

Mexaform is a luminal or contact amoebicide that contains two active components, 7-iodo-5-chloro-8-hydroxyquinoline, the major active component and 4,7-phananthroline -5,6-dione (2).

Studies in Japan established a relationship between mexaform and a neurological syndrome described as sub-myelo optic neuropathy (SMON). This was attributed to iodochlorhydroxyquinoline, the major component of mexaform (3).

When fed to rats, iodochlorhydroxyquinoline produced benign and malignant tumors of the liver (4).

Another quinoline derivative, 8-hydroxyquinoline, induced chromatid aberrations in human leukocytes (5).

This study is undertaken to find out if mexaform is genetically toxic.



### Materials and Method

Mexaform used in this study was a Ciba-Geigy Ltd. product. *Bacillus subtilis* mutants for the Rec assay were gifts from Dr. T. Kada, National Institute of Genetics, Mishima, Japan. *Salmonella typhimurium* strains 1535, 1537, 98, and 100 were obtained from Dr. Bruce N. Ames, Department of Biochemistry, University of California, Berkeley. *Salmonella typhimurium* G46 was a gift from Dr. Masaaki Moriya, Tokyo, Japan.

Fetal calf serum was obtained from Grand Island Biological Co., New York. Giemsa and May-Grunwald stains were Merck products. The experimental mice came from the Bio-organic colony of the Department of Chemistry, University of the Philippines, Diliman, Q.C.

Rec assay was done based on the method of Kada (6). Cultures of wild and recombinant deficient strains were streaked on broth agar plates from one point. Mexaform suspension was applied to filter paper discs which were placed on that point. Zones of inhibition were measured after 20 hours of incubation at 37°C.

Mutations induced without metabolic activation were studied using the method of Ames (7). *Salmonella typhimurium* mutants TA 1535, TA 1537, TA 98 and TA 100 were used. In this method, the bottom of a sterile petri dish was covered with minimal bottom agar containing Vogel Bonner E medium. A mixture of 0.1 ml suspension of the test organism with 2 ml of molten top agar premixed with histidine-biotin solution was poured into the hardened bottom agar. After the top agar hardened, a sterile paper disc with a diameter of 8 mm, containing mexaform suspension was placed in the center of the plate. Different concentrations of mexaform were used. The plates were incubated for 48 hours at 37°C after which the revertant colonies visible as small, white opaque dots were counted.

To find out if mexaform is metabolized to mutagens or to non-mutagens, the host-mediated assay of Legator and Gabridge (8), was employed. This is a combination of in-vivo mamalian metabolism and microbial mutation tests. An indicator bacteria, *Salmonella typhimurium* G 46, is injected into the peritoneal cavity of the experimental mouse and mexaform is administered to the animal orally by gavage. After 3 hours, when the bacteria have come in contact with the metabolites of mexaform, they are withdrawn from the peritoneal cavity and induced mutation frequency is determined.

Chromosome breaking effects of mexaform was determined using the micro-nucleus test of Schmid (9). It is an in-vivo method for screening chemical systems for chromosome breaking effects. Mexaform was administered intraperitoneally. A subacute treatment over 30 hours was chosen. Applications were given 30 and 6 hours before the animal was killed. Mice, 7-12 weeks old were used. Micronucleated polychromatic erythrocytes were scored for every thousand erythrocytes.

Table 1. DNA Damaging Capacity of Mexaform as Measured by the Rec Assay Using *Bacillus subtilis* Strains H17 and M45.\*

<i>Test system</i>	<i>Strain</i>	<i>Zone of Inhibition mm</i>
Mexaform	H17 Rec+	2.18
	M45 Rec—	4.97
Quinoline**	H17 Rec+	22.59
	M45 Rec—	29.21
Control	H17 Rec+	0.00
	M45 Rec—	0.00

\*About 0.05 ml of mexaform suspension was used on paper disc.

\*\*Quinoline is used as positive control. (0.02 ml of a solution 1 mg/ml)

Table 2. Mutagenicity Potential of Mexaform Without Metabolic Activation Using *Salmonella typhimurium* TA 1535

<i>Test System</i>	<i>Revertants per plate*</i>
Pure mexaform	3.96
90% mexaform in corn oil	6.52
80% mexaform in corn oil	4.88
Ethylmethane sulfonate**	Too numerous to count
Control	7.63

\*Average of 25 plates

\*\*Positive control

### Results and Discussion

Table 1 shows that mexaform has DNA damaging capacity. This is indicated by the greater inhibition of growth of the Rec strain which does not possess the recombination repair system. The Rec strain was also inhibited to a lesser extent. Although it has the recombination repair system, it could not completely cope up with the stress given by high concentrations of mexaform.

The data depicted in Tables 2 to 5 are the results of the tests using the Ames method to determine whether mexaform interacts with DNA without metabolic activation. The data suggest that mexaform does not react directly with DNA with-



Table 3. Mutagenicity Potential of Mexaform Without Metabolic Activation Using *Salmonella typhimurium* TA 1537

<i>Test System</i>	<i>Revertants per plate*</i>
Pure mexaform	8.84
90% mexaform in corn oil	3.60
80% mexaform in corn oil	3.81
9-aminoacridine**	Too numerous to count
Control	9.24

\*Average of 25 plates

\*\*Positive control

Table 4. Mutagenicity Potential of Mexaform Without Metabolic Activation Using *Salmonella typhimurium* TA 100

<i>Test System</i>	<i>Revertants per plate*</i>
Pure mexaform	98.52
90% mexaform in corn oil	76.27
80% mexaform in corn oil	65.96
Ethylmethane sulfonate**	Too numerous to count
Control	106.17

\*Average of 25 plates

\*\*Positive control

out metabolic activation. It is not a direct base-pair mutagen nor a direct frameshift mutagen.

The results of the host-mediated assay are shown in Table 6. The data show that the test organism was reverted to prototrophy by metabolites of mexaform. Thus mexaform is metabolized to a mutagen in the experimental mouse. This has some bearing with the biotransformation iodochlorhydroxyquinoline to its metabolites in the liver and the kidney (10). Urakubo and coworkers identified 5-chloro-8-hydroxyquinoline as a metabolite (11). This was shown to be mutagenic to *Salmonella typhimurium* TA 98 and TA 100 in the presence of liver enzymes (12). Hollstein and coworkers (13) proposed that quinoline is converted to a 2,3-epoxide by human and rat liver enzymes. This intermediate actively alkylates DNA.

The effect of mexaform at the chromosomal level in the bone marrow cells can be analyzed from the data shown in Table 7. The data based on the micronucleus test reveal chromosome breaking effects of mexaform. The micronucleus test is based on the principle that mitotic cells with chromatid breaks lag behind when the centric elements migrate towards the spindle poles and that after telo-

Table 5. Mutagenicity Potential of Mexaform Without Metabolic Activation Using *Salmonella typhimurium* TA 98

<i>Test System</i>	<i>Revertants per plate*</i>
Pure mexaform	36.48
90% mexaform in corn oil	25.87
80% mexaform in corn oil	22.19
Malathion**	Too numerous to count
Control	39.56

\*Average of 25 plates

\*\*Positive control

Table 6. Mutagenicity Potential of Mexaform After Metabolic Activation Based on Host-Mediated Assay Using *Salmonella typhimurium* G46 as Indicator Organism

<i>Test System</i>	<i>Revertants/10<sup>8</sup> survivors</i>
Mexaform	19.87
Dimethylnitrosoamine**	43.10
Control	1.10

\*\*Positive control

phase, a sizable portion of such displaced chromatid is not included in the nuclei of the daughter cells but forms a single or multiple micronuclei in the cytoplasm of these cells. A few hours after their last mitosis, erythroblasts expel their nuclei but the micronuclei remain behind in the cytoplasm. Staining allows to distinguish micronucleated polychromatic erythrocytes.

It is therefore suggested that mexaform is metabolically transformed to a clastogenic metabolite. Thus mexaform can cause damage of the chromosomes. This is in agreement with the finding by others (14) that quinoline and its derivatives can cause gaps and fragmentation of chromosomes.

The effect of cysteine on the mutagenic and clastogenic potential of mexaform is shown in Table 8. The reducing effect of cysteine shows that it is an anti-mutagen to mexaform. The presence of the sulfhydryl group in cysteine allows it to be very reactive with mexaform metabolites that possess electrophilic sites. An epoxide metabolite can be readily inactivated by cysteine, preventing its tendency to alkylate some bases of DNA.

### Summary

Mexaform possesses DNA damaging capacity. Although it is not a direct mutagen, it is metabolized to a base-pair mutagen. Aside from its being mutagenic

Table 7. Clastogenicity Potential of Mexaform on Bone Marrow Cells

	<i>Number of micronucleated polychromatic Erythrocytes per thousand</i>
Mexaform	
4 ml/kg	6.45
6 ml/kg	7.68
8 ml/kg	10.86
Control	2.34

Table 8. Effect of Cysteine on the Clastogenicity Potential of Mexaform

	<i>Number of micronucleated polychromatic Erythrocytes per thousand</i>
Mexaform (8 ml/kg)	10.86
Mexaform + cysteine*	2.77

\*214 mg/kg

after metabolic activation, mexaform induces chromosome damage. It is therefore a clastogen. Its chromosome breaking effects, however, are greatly reduced by cysteine.

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## **MIGRATION, MODERNIZATION AND HYPERTENSION: Blood Pressure Levels in Four Philippine Communities**

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### **Introduction**

Recent research has firmly established hypertension as a key risk factor in coronary heart disease, increasing scientific interest in circumstances surrounding blood pressure dynamics (1-4). In a series of papers, Cassel argues that elevation of blood pressure with age occurs only in modern societies (5-7).

The first of these propositions has gained acceptance. The second, which implicates sociocultural factors more specifically, is being debated vigorously (8-10). The issues have been complicated by conceptual inelarity. Neither Cassel nor his critics have distinguished clearly between comparisons involving lifelong residents of traditional and modern communities, and comparisons of persons who change residence from traditional to modern communities. The former are at risk for the impact of modernization upon blood pressure levels, the latter incur for the consequences of adaptation to a new environment in addition (11).

If psychosocial discontinuity increases hypertension risk, then migrants from traditional to modern communities incur the "double jeopardy" of modernization plus adaptation, and should be at greater risk than sedentary residents of modern communities. While both the foregoing circumstances may operate within a single society and culture, there is a third variable, culture change, which is introduced when migrants choose to relocate to a destination within another culture. To extend

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the language employed above, this would be a "triple jeopardy" situation: modernization, adaptation and culture change would all be implicated.

The 1979 Report of the Working Group on Heart Disease Epidemiology (12) advises migration research on genetically homogeneous population in environments representing contrasting levels of modernization and culture change to resolve the points raised above. Major studies now in progress in Puerto Rico and Honolulu are focused on both intracultural (rural to urban Puerto Rican migrants) and intercultural (trans-Pacific Japanese migrants) changes of residence to destination at a higher level of modernization (13-14).

Filipinos in the Philippines and United States are a third population which offers an opportunity for parallel research. Several pilot studies initiated by the Philippine Heart Center for Asia and Institute of Behavioral Science, University of Colorado, have been completed. These include measurement of blood pressure and prevalence of hypertension in rural and urban Philippine communities (15-17), and cardiovascular disease mortality among Filipinos in Hawaii and California (18-20).

The present paper brings together the results of several blood pressure studies from rural and urban areas of the Philippines. It is one of several manuscripts now in progress which will consolidate and interpret the pilot studies thus far completed. When combined with the forthcoming report on cardiovascular disease mortality, they will provide the basis for more definitive hypothesis testing.

### Methods

The four Philippine communities selected for the blood pressure study provide comparative data which have a bearing upon the conceptual issues introduced above. A conservative rural locale and a metropolitan urban center were chosen from Luzon, the oldest site of colonization in the Philippines, with primarily sedentary populations. A progressive rural locale and a metropolitan urban center were also chosen from Mindanao, the most recent site of settlements in the Philippines, with primarily sedentary populations.

The study design is illustrated below:

Figure 1. Predicted Bank Order of Hypertension Prevalence in Sedentary and Migrant Communities

	Sedentary Locations (Luzon)	Migratory Locations (Mindanao)
Rural Locations	Pangasinan Province (0)	Davao Province (2)
Urban Locations	Quezon City (1)	Davao City (3)

The subscript numbers predict comparative levels of hypertension by increasing degree of psychosocial discontinuity, as follows:

- 0 = absence of psychosocial discontinuity in a rural, sedentary community setting.
- 1 = modernization within a sedentary urban setting.
- 2 = adaptation by migrants to a rural community.
- 3 = modernization and adaptation by migrants to an urban community.

The study will present data on both blood pressure levels and prevalence of hypertension to assess the accuracy of this predictive model.

### *Study Sites*

Since environmental differences are the independent variable utilized as predictors, a brief description of each study site emphasizing its distinguishing characteristics is presented below:

#### A. The Sedentary Locations

##### 1. Rural Pangasinan

This sedentary agricultural region, producing rice and sugar under the hacienda system since Spanish times, has been historically associated with landlord-tenants and laborers. The most densely settled province of the Ilocos administrative region, with a predominantly Ilocano-speaking adult population, Pangasinan has been the major source of migrants to Manila and Quezon City from the Island of Luzon since 1900 (21).

Within Pangasinan, two coastal municipalities, San Fabian and Lingayen, were sampled by multistage methods, yielding a study population of 8,874 males and 10,191 females. Data were collected by the Research Division, Philippine Heart Center for Asia, as part of a field screening program for rheumatic heart disease, Ischemic heart disease and hypertension (22).

##### 2. Quezon City

While Quezon City, with 957,000 population in 1975, is the suburb within the Metropolitan Manila area manifesting the highest rate of growth since 1960, it is designated "sedentary" for the purpose of this study because the major source of its "immigrant" population has been the central city (Manila proper), i.e., the vast majority of its adult population consists of lifetime metropolitan urbanites who are native Tagalog speakers. Quezon City was established as the national capital in 1936. It is an administrative center with a predominantly white-collar, middle class population, sharing in the greatest concentration of commercial and industrial wealth in the nation.

The metropolitan urban sample was drawn from 16 municipalities, 3,002 persons were surveyed. Of these, 1,139 were males and 1,863 were females. Data,



once again, were collected by the Research Division, Philippine Heart Center for Asia.

## B. The Migrant Province

### 1. Rural Davao Province

On the Island of Mindanao, at the opposite end of the country, a rich reservoir of unoccupied farm land was opened for settlement a half-century ago. However, the bulk of the Cebuano-speaking population of the present provinces of Davao del Sur and Davao del Norte arrived after World War II with 1950-55 representing the peak interval of migration (24). The provinces themselves were not established until 1967. The bulk of immigrants to Mindoro originate from the central provinces of Cebu and Bohol which like Pangasinan are concentration points for rural poverty (21).

Rural Davao represents a high technology farming area where multinational corporations have recently established the most profitable banana and pineapple plantations in Asia. Corporate farms employing industrial labor alternate with homesteaded family farms producing rice, corn and coconut. The mean household income of the administrative region, Southeast Mindanao, in which these provinces are located is second only to that of Metropolitan Manila within the Philippines (24).

The rural Davao sample was evenly divided between the two provinces to the north and south of Davao City: 921 subjects (417 males and 504 females) were drawn from Davao del Sur, and 898 (372 males and 526 females) from Davao del Norte. Data were collected by Davao Research and Planning Foundation, Inc., for the Institute of Behavioral Science.

### 2. Davao City

This metropolitan community of one-half million people is the administrative capital of the southern Philippines, with an explosive annual growth rate of 5.5%. Four-fifths of its present population represents post World War II growth. It is an important timber-processing center and contains other heavy industries. Also a relatively wealthy community, it has an urban mean family income second only to that of Manila. Its labor force is more diversified than that of Quezon City with substantial blue collar and small business components. Although predominantly Cebuano-speaking like its hinterland provinces, Davao City is a polyglot community with a substantial minority of immigrants from Luzon.

In Davao City, a city-wide sample frame was employed to select 1,432 individuals. Of these 670 were males and 762 were females. As in the rural Davao provinces, data were collected by Davao Research and Planning Foundation, Inc., for the Institute of Behavioral Science.

### *Examination*

A single casual blood pressure reading taken after five minutes' rest was used in the survey. In Quezon City and Pangasinan, blood pressures were measured using one of four random-zero blood pressure apparatuses (Hawkesley). In Davao Province and Davao City, conventional mercury manometers were employed. Standardization of blood pressure readings and training in measurement were done according to WHO recommended procedures (25). Criteria used for the diagnosis of high blood pressure were also those advised by WHO. Persons with blood pressure greater than 160/95 mm Hg are considered "definite" hypertensives.

Heights and weights were measured to the nearest 0.5 cm. and 0.1 kg. History questionnaires were administered and tabulated for the two urban populations: Davao City and Quezon City. The interview included risk factor data: smoking history, fats and salt consumed in the diet, socioeconomic characteristics and social support. The interviewers utilized by Davao Research and Planning Foundation were trained by Philippine Heart Center personnel to insure comparability of results. All measurements and interview were restricted to persons ages 15 and above.

## **Results**

The results of the four-community study will be presented in three sections: (1) blood pressure comparisons; (2) hypertension prevalence comparisons; (3) associated variables. The hypothesis represented in Figure 1 provides the framework for the discussion.

### **A. Blood Pressures by Age-Sex and Community**

Mean systolic and diastolic blood pressure readings by sex for all four communities appear in Table 1. The direction and significance of differences between communities by type are presented in Table 2. Source tables with detailed age-specific blood pressure readings by sex for all four communities appear in the appendix (A1-A4).

The analysis of mean differences presented in Table 2 produces mixed results. In both the sedentary area (Luzon) and the migratory area (Mindanao), rural mean blood pressure values are higher than urban (panels A-B, Table 2). The diastolic blood pressure differences are all sufficient to attain statistical significance. These interpretations are not affected by age-adjustment (Table 1).

However, blood pressure levels in migrant communities are higher than in sedentary communities (panel C, Table 2). Once again, the diastolic blood pressure values attain a more consistent pattern with greater statistical significance. These interpretations, likewise, are not altered by age-adjustment (Table 1). The pattern of male difference is more uniform than the female pattern.



Table 1. Mean Blood Pressures, Systolic and Diastolic, Age-Adjusted and Unadjusted for Males and Females, Ages 15-74, from Four Philippine Communities: Migrant and Sedentary, Rural and Urban<sup>1</sup>.

	SBP	Unadjusted SD	DBP	SD	Age-adjusted SBP	DBP
A. Sedentary						
1. Rural Pangasinan						
Male	123.41	15.59	28.59	10.26	122.07	78.09
Female	119.95	17.30	76.83	10.97	117.90	75.95
2. Quezon City						
Male	119.06	17.70	77.70	11.51	118.14	77.25
Female	112.55	18.60	72.65	11.51	111.45	72.23
B. Migrant						
1. Rural Davao						
Male	124.45	13.78	04.36	9.44	122.46	82.89
Female	118.15	13.27	81.01	9.39	117.40	80.43
2. Davao City						
Male	124.03	12.00	80.50	12.67	123.49	80.26
Female	117.80	20.05	77.32	13.62	117.99	77.40

<sup>1</sup>Age-adjusted to 1975 population of the Philippines.

The Philippine population is quite young, with a median age of 21.5. Mean blood pressure values in the present study, in which subjects range from 15 to 74 years of age, will be biased in favor of the younger age groups. Since blood pressure differences in younger subjects tend to fall within the subcritical range, they are less interesting in a study focused upon risk of coronary heart disease than the readings for older persons. Also the rank order of means represented by the total population of the four communities may not reflect the status of blood pressures among the older age groups.

These speculations led to a reformulation of age-adjusted data by age groups in Table 3. The SBP and DBP measures for subjects in the 15-24 and 25-44 categories confirm the inferences from Tables 1-2 concerning the rural-urban comparison: the former continue to be higher than the latter. However, the rank order is reversed for subjects in the 45-64 age groups within which the urban readings *tend to be higher than rural*. For age groups 25 and above, *migrant communities continue to have higher readings than sedentary communities*.

The reversal of rank order between rural and urban communities disclosed by the separation and comparison of younger and older age groups results from sharply differentiated patterns of elevation of blood pressure with age in the two types of communities. These patterns are disclosed in Figures 2-3 in which diagrams have

Table 2. Mean Differences in Systolic and Diastolic Blood Pressures Between Communities By Sex With Significance Tests

<i>Systolic</i>			<i>Diastolic</i>	
<i>Mean Difference</i>	<i>P</i>		<i>Mean Difference</i>	<i>P</i>
A. SEDENTARY LOCATIONS (Luzon)				
<i>Rural - Urban (RP - QC)</i>				
Male	4.35	.001	.89	.05
Female	7.40	.001	4.18	.001
B. MIGRANT LOCATIONS (Mindanao)				
<i>Rural - Urban (RD &gt; DC)</i>				
Male	.42	n.s.	3.86	.001
Female	.35	n.s.	3.69	.001
C. MIGRANT-SEDENTARY COMPARISONS (Mindanao-Luzon)				
<i>Rural - Rural (RD &gt; RP)</i>				
Male	1.04	.10	5.77	.001
Female	1.80	.01	4.18	.001
<i>Rural - Urban (RD &gt; QC)</i>				
Male	5.39	.001	6.66	.001
Female	5.60	.001	8.36	.001
<i>Urban - Rural (DC &gt; RP)</i>				
Male	.62	n.s.	1.91	.001
Female	-2.15	.01	.49	n.s.
<i>Urban - Urban (DC &gt; QC)</i>				
Male	4.97	.001	2.60	.001
Female	5.25	.001	4.67	.001

RP - Rural Pangasinan

QC - Quezon City

RD - Rural Davao

DC - Davao City

been constructed from the systolic (Figure 2) and diastolic (Figure 3) data in Table 3.

In both figures, when panels C-D describing urban sites are compared with panels A-B describing rural sites, two important differences emerge:

- 1) urban readings for ages 15-44 fall below rural readings for the same age groups for both sexes in most cases;
- 2) urban blood pressures elevate much more sharply between ages 24-44 holds for both sexes.

Table 3. Age-Adjusted Mean Male and Female Systolic and Diastolic Blood Pressures for Selected Age Groups in Four Philippine Communities: Migrant and Sedentary, Rural and Urban

		<i>Male</i>		<i>Female</i>	
		<i>SBP</i>	<i>DBP</i>	<i>SBP</i>	<i>DBP</i>
<b>A. Sedentary</b>					
1. <i>Rural Pangasinan</i>					
Ages	15-24	117.69	75.26	113.16	76.34
	25-44	122.14	79.14	117.27	76.65
	45-64	127.48	81.70	125.52	80.59
2. <i>Quezon City</i>					
Ages	15-24	111.01	72.16	104.59	68.44
	24-44	117.68	78.50	109.28	71.92
	45-64	127.04	83.30	124.81	79.36
<b>B. Migrant</b>					
1. <i>Rural Davao</i>					
Ages	15-24	115.49	77.95	112.09	77.34
	25-44	124.28	84.90	117.29	80.84
	45-64	128.69	86.82	125.74	84.49
2. <i>Davao City</i>					
Ages	15-24	115.46	74.63	107.70	70.60
	25-44	125.20	81.88	117.29	78.17
	45-64	133.05	87.20	133.68	86.66

<sup>1</sup> Age-adjusted to the Philippine population, 1975

The uniformity of these two patterns for both SBP and DBP causes the urban readings in panels C-D to describe longer lines ascending at steeper angles than those of panels A-B.

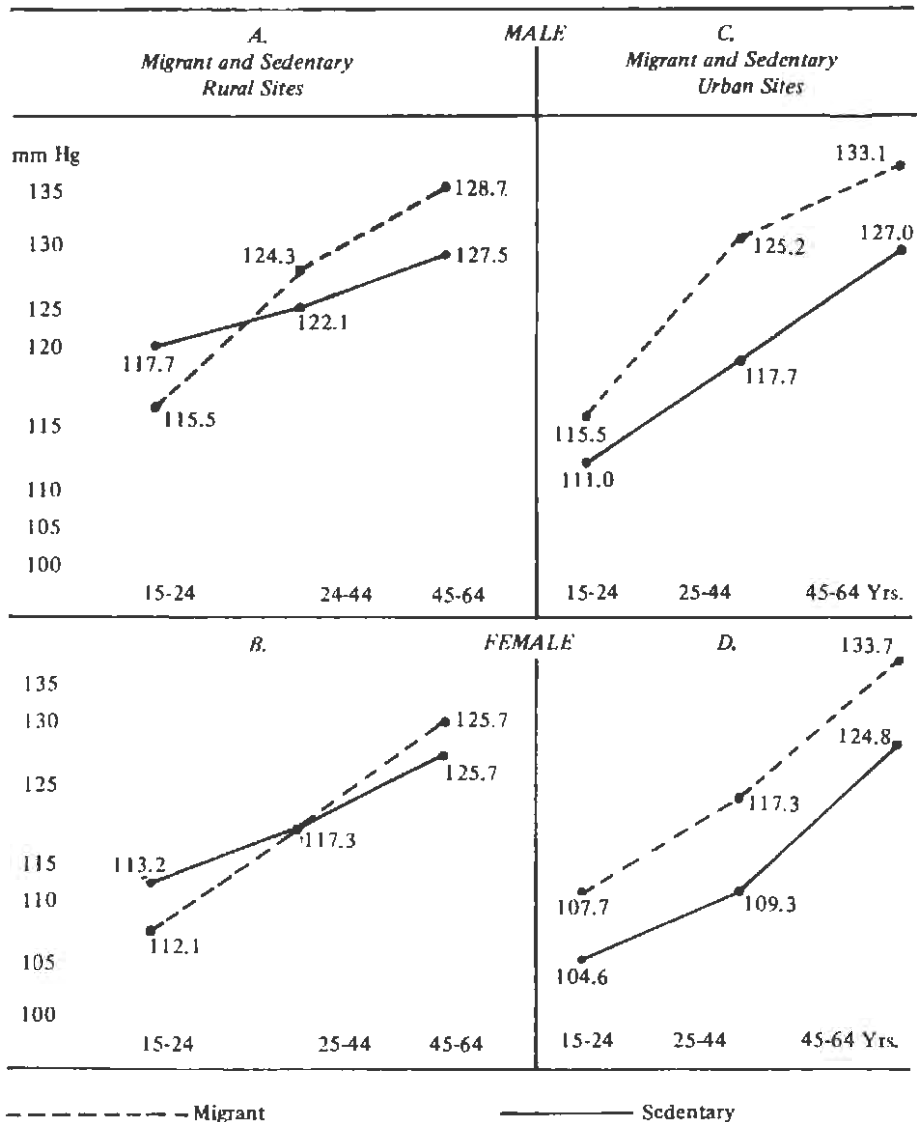
Within each of the four panels of Figures 2-3, a migrant and sedentary community are compared. Once again, two important differences may be noted:

- 1) the migrant member of each pair of communities disclosed blood pressure readings rising to a higher level than that of its sedentary partner;
- 2) the urban migrant communities (panels C-D) disclose blood pressures rising to a higher level among persons 45-64 than do rural migrant communities (panels A-B).

As mentioned earlier in the interpretation of data from Tables 1-2, the diastolic patterns (Figure 3) are more completely differentiated between communities than the systolic patterns (Figure 2).

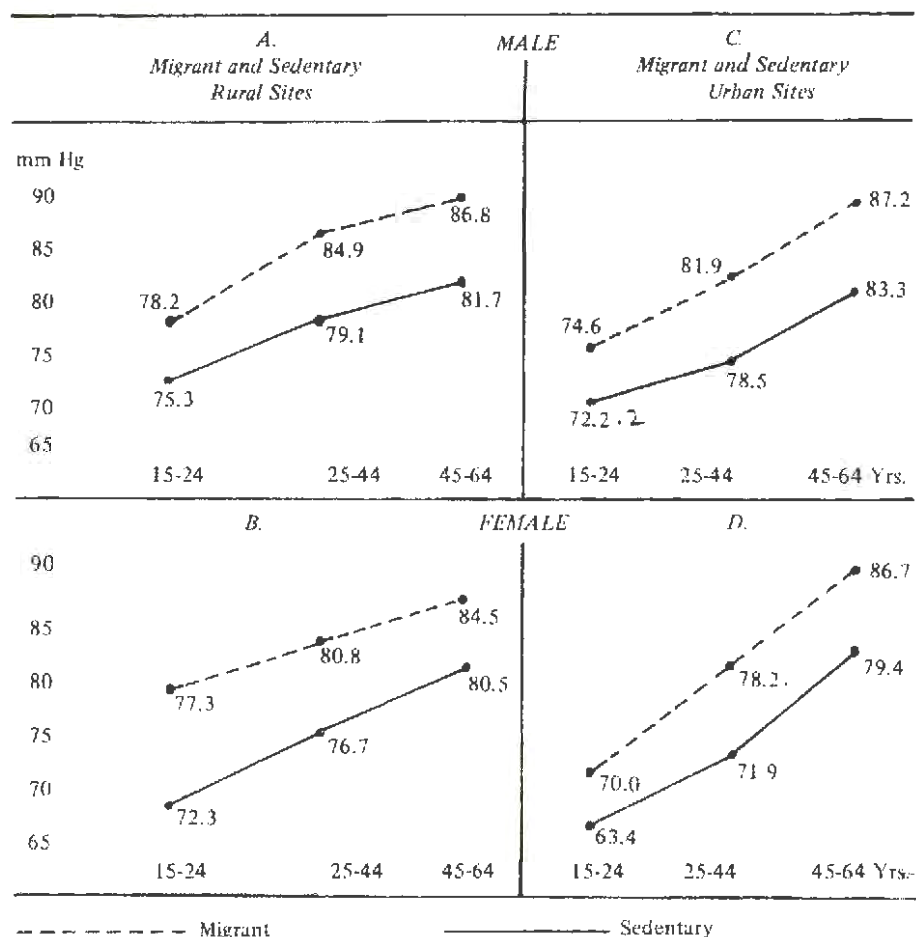
Those two sets of interpretations of the age-adjusted data for specific age-sex groups (Table 3) tend to confirm the assertions presented in Figure 1: urban blood

Figure 2. Age Adjusted Male and Female Systolic Mean Blood Pressures for Selected Age Groups in Migrant and Sedentary Locations: Rural Compared with Urban.



pressures, which are subject to modernization, should be higher than rural; migrant blood pressures, which require adaptation, should be higher than sedentary. Finally, where the two forces interact, migrant urban blood pressures, subject to both modernization and adaptation, should be the highest of all. However, these observa-

Figure 3. Age Adjusted Male and Female Diastolic Mean Blood Pressures for Selected Age Groups in Migrant and Sedentary Locations: Rural Compared with Urban.



tions appear to be true only for the older age groups within the four communities, i.e., persons 45-64. These conclusions await confirmation from the hypertension prevalence data to be reviewed in the following section.

The inferences concerning age patterns would be on firmer ground if supported by other studies. While migrant-sedentary comparisons are lacking from Southeast Asia, urban and rural Chinese blood pressure measures can be secured from two well-known Taiwanese studies (26, 27). In Table 4, the Chinese data have been regrouped to match Table 3, with the following results:

- 1) urban readings for ages 15-44 fall below rural readings for the same groups for both sexes;

Table 4. Age-Adjusted Mean Male and Female Systolic and Diastolic Blood Pressures for Selected Age Groups by Sex: Rural and Urban Taiwan<sup>1</sup>

		<i>Male</i>		<i>Female</i>	
		<i>SBP</i>	<i>DBP</i>	<i>SBP</i>	<i>DBP</i>
<i>Urban Taipei</i>					
<i>Ages</i>	15-24	116.31	69.18	109.00	66.44
	25-44	119.64	73.95	113.47	72.05
	45-64	130.55	84.21	136.65	82.79
<i>Rural Taiwan</i>					
	15-24	123.27	76.00	121.38	78.46
	25-44	123.96	79.44	123.44	79.31
	45-64	127.64	82.26	135.49	84.49

<sup>1</sup> Age-adjusted to the Philippine population, 1975

- 2) but urban blood pressures elevate much more sharply between ages 25-44 and 45-64 than do rural blood pressures;
- 3) finally, urban blood pressures among older persons (45-64) tend to be higher than those found in the rural community.

These conclusions correspond to those provided earlier for the urban and rural Philippine locations.

#### B. *Hypertension Prevalence by Sex and Community*

The age-adjusted prevalence rates for males and females, ages 50-74, by community are presented in Table 5. Hypertension, as mentioned earlier, is defined as a blood pressure reading in excess of 160/95 mm Hg. The direction and significance of the prevalence rates differences between communities are presented in Table 6.

The rank order of prevalence which is set forth in Table 5 confirms the analysts from Table 3 and Figures 2-3:

- 1) There is greater prevalence in urban than in rural areas among both sexes;
- 2) prevalence is greater in the migrant urban than in the sedentary urban location;
- 3) prevalence is greater in the migrant rural than in the sedentary rural location;
- 4) the community in which migration and urban life style are combined, Davao City, has the highest prevalence rate encountered in the study.

It is noteworthy that sex differences only appear in the rural locations. In both rural Pangasinan and Davao Province, male hypertension exceeds that of females. In Davao City and Quezon City, rates for both sexes are almost identical.

Table 5. Definite Hypertensives in Four Philippine Communities: Age-Adjusted Rates by Sex for Population Ages 50-74<sup>1</sup> (per 1,000 population)

A. SEDENTARY LOCATIONS (Luzon)		<i>Rates</i>
1. Rural Pangasinan		
Male		135.9
Female		123.2
2. Quezon City		
Male		252.0
Female		256.9
B. MIGRANT LOCATIONS (Mindanao)		
1. Rural Davao Province		
Male		189.6
Female		138.8
2. Davao City		
Male		282.7
Female		294.6

<sup>1</sup>Age-adjusted to the 1975 population of the Philippines.

In Table 6, the Mantel-Haenszel relative risk formula has been computed for all pairs of locations, and the significance of differences tested. Within both sedentary (Luzon) and migrant (Mindanao) locations (Panels A-B of Table 6, the excess risk of urban over rural residents proves to be significant. Comparisons of migrant with sedentary communities (Panel C, Table 6) produce similar results: the excess risk of urban over rural residents proves, once again, to be significant. But comparisons of communities of the same type (urban vs. urban, rural vs. rural) did not yield significant results.

The final two comparisons of migrant-sedentary locations (Panel C, Table 6) are worth comment, since they represent the largest and smallest reported differences in relative-risk:

- 1) the greatest excess of hypertension risk is sustained by the residents of Davao City, the migrant urban location, compared with residents of Pangasinan, the rural sedentary location.
- 2) the smallest excess of hypertension risk is measured when the residents of Davao City, the migrant urban location, are compared with residents of Quezon City, the sedentary urban location.

The hypertension prevalence data generally confirm the conclusions reached from the examination of the blood pressure levels of persons in the 45-64 age range. The implications of Tables 3 and 6 taken together are as follows:

- 1) The urban environment is associated with both rapid elevation of blood pressure with age and excessive risk for hypertension among members



Table 6. Relative Risk for Hypertension by Sex in Four Philippine Communities for Population Ages 50-74<sup>1</sup>

	<i>Relative Risk</i>	<i>P</i>
<b>A. SEDENTARY LOCATIONS (Luzon)</b>		
<i>Urban – Rural (QC &gt; RP)</i>		
Male	1.75	.001
Female	2.07	.001
<b>B. MIGRANT LOCATIONS (Mindanao)</b>		
<i>Urban &gt; Rural (DC &gt; RD)</i>		
Male	1.52	.10
Female	2.05	.02
<b>C. MIGRANT-SEDENTARY COMPARISONS (Mindanao-Luzon)</b>		
<i>Rural &gt; Rural &gt; (RD &gt; RP)</i>		
Male	1.37	n.s.
Female	1.17	n.s.
<i>Urban &gt; Rural (QC &gt; RD)</i>		
Male	1.28	n.s.
Female	1.77	0.5
<i>Urban &gt; Rural (DC &gt; RP)</i>		
Male	2.08	.001
Female	2.40	.001
<i>Urban &gt; Urban (DC &gt; QC)</i>		
Male	1.19	n.s.
Female	1.16	n.s.

<sup>1</sup>Mantel-Haenszel relative risk formula (28). Probability by Chi-square.

RP – Rural Pangasinan  
QC – Quezon City

RD – Rural Davao  
DC – Davao City

of both sexes. This generalization holds for both sedentary and migrant urban locations.

- 2) Migration appears to interact with the urban environment to intensify the elevation of blood pressure and excessive risk for hypertension. However, differences produced by migration alone do not appear to be sufficient for statistical significance, e.g. rural Davao compared with Pangasinan.



While both modernization and adaptation are associated with elevated blood pressure and hypertension risk, the former operates independently while the latter takes auxiliary role.

### C. *Associated Variables*

The etiology of hypertension exemplifies the "linked open systems" model of explanation advocated by Cassel and his associates (29): bio-chemical, physiological, psychosocial and cultural factors are all implicated by contemporary investigators. Explanations ranging from trace minerals in the water supply to the adequacy of social support have found advocates in the recent literature (30-31).

It remains to devise a model tracing the intersystemic linkages between agents at different levels, and to test it empirically. Single factor explanations, such as obesity, still have their advocates; but they are inconsistent with current concepts of etiology. In the absence of a focusing hypothesis, however, commitment to multilevel explanation promotes "broad spectrum" data collection and interview procedures.

Among the factors generally believed to be implicated in elevated blood pressure and hypertension are age and body weight. Both were recorded for all sites in the present study. Within the two cities, a range of items including personal behavior (smoking, dietary factors) and psychosocial factors (education, occupation, social support) was also obtained and analyzed. First, the significance of weight as an explanatory factor will be examined across all four sites. Following this, age and body mass adjusted relationships between SBP and DBP and the other variables will be considered within the two cities where hypertension prevalence was found to be the greatest.

Mean heights and weights by sex for each study site are presented in Table 7 together with age-adjusted figures. All same-sex mean differences in weights between communities were significant at the .005 level with one exception: rural Davao women did not differ in weight from those in Davao City. The table supports the conclusion that both men and women tend to be heavier in urban locations. Age-adjustment increased the urban-rural differences in both sexes by decreasing the rural figures. Detailed age-specific mean heights and weights by sex and community are presented in the appendix (Tables A5-7).

The age-adjusted data by specific age group in Table 8 has been prepared to correspond to the blood pressure levels presented in Table 3. Unlike blood pressure, there is no reversal of urban-rural weight patterns with age. Men and women in the urban samples are heavier than their rural counterparts at each age level in the Table 8 sequence.

Comparison of Table 3 and Table 8 results produces some unexpected observations, however. Although blood pressure elevates with age in both sexes and all study sites (Table 3), *weight does not* (Table 9). Only in Quezon City do we find that persons in the 45-64 age groups have mean weights greater than those who are 25-44. But blood pressure and hypertension levels in Davao City are *higher* than those in Quezon City among persons 45-64 in both sexes. It seems unlikely that

Table 7. Mean Heights and Weights, Age-Adjusted and Unadjusted for Males and Females, Ages 15-74, From Four Philippine Communities: Migrant and Sedentary, Rural and Urban

	<i>Unadjusted Means</i>		<i>Age-adjusted Means<sup>1</sup></i>			
	<i>Height (Cms)</i>	<i>S.D</i>	<i>Weight (Kgs)</i>	<i>S.D</i>	<i>Height (Cms)</i>	<i>Weight (Kgs)</i>
<b>A. Sedentary</b>						
1. Rural Pangasinan						
Male						
Female						
2. Quezon City						
Male	163.32	7.02	58.46	10.49	163.37	58.18
Female	151.48	6.51	49.93	9.07	151.45	49.59
<b>B. Migrant</b>						
1. Rural Davao						
Male	159.31	7.10	52.11	8.14	158.91	51.33
Female	150.90	6.07	47.60	8.43	150.72	46.98
2. Davao City						
Male	161.66	6.41	53.78	8.91	161.70	53.78
Female	151.44	5.70	47.63	8.54	151.59	47.65

<sup>1</sup> Adjusted to the 1975 population of the Philippines

obesity will explain the prevalence of hypertension found among urban migrants to Davao City.

To assess the possible independent influence of the behavioral variables on blood pressure levels, it is necessary to control for age and body mass. For this purpose, the Quezon City and Davao City study populations were divided by sex. Each group was then separated into scale values of the nine text variables, e.g., four scale values of social support were employed. Mean SBP and DBP levels, adjusted for age and body mass index (weight/height<sup>2</sup> 10<sup>4</sup>) were then computed for each scale value of the nine variables. Tests for homogeneity of the adjusted means were calculated by analysis of covariance, using the general linear models procedure.

For any associated variable to influence the level of blood pressure in a study population, it is necessary to reject the null hypothesis that all means computed for scale values of that variable could be drawn from the same population. Results for each city and both sexes appear in Table 9, with probability values for homogeneity tests. Seven of the nine variables showed some evidence of relationship to blood pressure ( $P \leq .10$ ). However, only the physiological factors employed as controls, age and BMI, were consistently related to SBP and DBP at a high level of significance in all four groups.

Table 8. Mean Age-Adjusted Heights and Weights for Selected Age Groups, By Sex, for Four Philippine Communities: Migrant and Sedentary, Rural and Urban<sup>1</sup>

		Male		Female	
		Height (Cms)	Weight (Kgs)	Height (Cms)	Weight (Kgs)
A. Sedentary					
1. <i>Rural Pangasinan</i>					
Ages	15-24				
	25-44				
	45-64				
2. <i>Quezon City</i>					
Ages	15-24	163.77	53.51	151.10	46.73
	24-44	163.49	60.37	151.46	50.55
	45-64	163.30	62.91	151.28	53.36
B. Migrant					
1. <i>Rural Davao</i>					
Ages	15-24	157.58	48.94	150.87	45.81
	25-44	160.40	53.42	151.50	49.03
	45-64	158.83	52.31	149.75	46.54
2. <i>Davao City</i>					
Ages	15-24	161.49	50.67	151.69	44.51
	25-44	162.43	55.84	151.60	49.69
	45-64	161.06	55.49	150.93	50.24

<sup>1</sup> Age-adjusted to the Philippine population, 1975

There was little consistency across age and sex groups in either city for behavioral variables. Eight homogeneity tests were performed for each (2 BP measures x 2 sexes = 2 cities), no more than three were significant for specific variables: social support and household income. Three variables disclosed significant departures from homogeneity in only two subgroups: fat consumption, education and occupation.

Behavioral variables were more frequently associated with blood pressure levels in Quezon City than in Davao City, and were more frequently associated with female blood pressures than with male. Conventional risk factor indicators (cigaret smoking, fat consumption) appeared to be less influential than psychosocial variables (social support and income). This could be an artifact of measurement and scaling procedures.

The social support results from both cities (Table 10) represent the most frequent occurrence of statistical significance among the behavioral variables in Table 9. Inverse association of social support with blood pressure can be discerned for both sexes in Quezon City and for males in Davao City. Household income

Unadjusted Means for Systolic and Diastolic Blood Pressure, Age and Body Mass Index By  
Number of Cigarets Smoked Per Day For Davao City Males and Females

	<i>None</i>	<i>Cigarets Smoked Per Day</i>		<i>30 or more</i>
		<i>01-19</i>	<i>21-29</i>	
<b>A. Males</b>				
SBP	123.40	126.00	135.41	130.75
DBP	80.27	79.09	85.09	83.59
Age	33.08	46.82	47.05	48.71
BMI	3,320.54	3,157.03	3,369.24	3,403.31
N	617	11	22	17
<b>B. Females</b>				
SBP	117.70	117.63	144.33	—
DBP	77.21	81.63	92.67	—
Age	32.72	40.75	58.33	—
BMI	3,141.06	3,410.77	3,288.24	—
N	751	8	3	0

Age and Body Mass Adjusted Means for Systolic and Diastolic Blood Pressure By  
Number of Cigarets Smoked Per Day For Davao City Males and Females

	<i>(1)</i> <i>None</i>	<i>Cigarets Smoked Per Day</i>		<i>(4)</i> <i>30 or more</i>
		<i>(2)</i> <i>01-19</i>	<i>(3)</i> <i>21-29</i>	
<b>A. Males</b>				
SBP	123.85	122.82	129.74	124.05
DBP	80.53	77.68	81.70	79.50
<b>B. Females</b>				
SBP	117.85	110.24	124.94	—
DBP	77.30	77.15	81.51	—

*Significance levels:*

**A. Males**

The SBP comparison of Cols. 1-3, has  $P = < .05$ ; all others are n.s.

The DBP comparisons are n.s.

**B. Females**

All SBP and DBP intercolumn comparisons are n.s.

(Table 11), while displaying lesser significance, was also inversely associated with blood pressure among both sexes in Quezon City, and among women in Davao. In the Philippines, size of the extended kin group residing nearby (a measure of social support) is positively associated with social class which, in turn, reflects level of income (32-34).

**Unadjusted Means for Systolic and Diastolic Blood Pressure, Age and Body Mass Index By  
Consumption of Foods Containing Saturated Fats and Davao City Males and Females**

	<i>Level of Fat Consumption (Score Values)<sup>1</sup></i>			
	<i>0-2</i>	<i>3-4</i>	<i>5-7</i>	<i>8 or more</i>
<b>A. Males</b>				
SBP	122.87	123.08	125.30	124.90
DBP	78.5	79.78	82.14	81.71
Age	34.88	33.00	35.04	33.40
BMI	3,271.39	3,277.65	3,363.59	3,375.88
N	191	144	173	159
<b>B. Females</b>				
SBP	119.91	116.83	118.32	116.28
DBP	77.33	77.13	78.04	76.70
Age	36.46	32.08	32.60	30.85
BMI	3,081.87	3,102.73	3,201.07	3,181.59
N	172	193	210	187

<sup>1</sup>Score values refer to daily (3), weekly (2), or less frequent (1) consumption of pork/beef, eggs, butter, margarine or fried foods.

**Age and Body Mass Adjusted Means for Systolic and Diastolic Blood Pressures by Consumption  
of Foods Containing Saturated Fats and Davao City Males and Females**

	<i>Level of Fat Consumption (Score Values)</i>			
	<i>(1) 0-2</i>	<i>(2) 3-4</i>	<i>(3) 5-7</i>	<i>4 8 or more</i>
<b>A. Males</b>				
SBP	123.14	124.05	124.47	124.60
DBP	78.82	80.44	81.57	81.40
<b>B. Females</b>				
SBP	117.71	117.70	118.19	117.55
DBP	76.12	77.67	77.92	77.39

**Significance levels:**

**A. Males**

All SBP Intercolumn comparisons are n.s. The DBP comparisons of Cols. 1-3 and 1-4 have  $P = < .05$

**B. Females**

All SBP and DBP Intercolumn comparisons are n.s.

Table 9. Statistical Association of Interview Variables with Systolic and Diastolic Blood Pressures Adjusted for Age and Body Mass Index (P Values)

	<i>Davao City</i>				<i>Quezon City</i>			
	<i>SBP</i>		<i>DBP</i>		<i>SBP</i>		<i>DBP</i>	
	<i>Male</i>	<i>Female</i>	<i>Male</i>	<i>Female</i>	<i>Male</i>	<i>Female</i>	<i>Male</i>	<i>Female</i>
Age	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
Body mass Index	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
Residence in city	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Cigaret smoking	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Fat consumption	n.s.	n.s.	.06	n.s.	n.s.	n.s.	n.s.	n.s.
Social support	n.s.	n.s.	n.s.	n.s.	.005	.04	.03	n.s.
Education	n.s.	n.s.	n.s.	n.s.	n.s.	.004	n.s.	.04
Occupation	n.s.	n.s.	n.s.	n.s.	n.s.	.01	n.s.	.07
Income	n.s.	n.s.	.05	n.s.	n.s.	.0001	n.s.	.01

These variables suggest more frequent elevation of blood pressure among the lower class, but the association is based largely on significant associations from Quezon City (Table 9). In Davao, the migrant city, higher social status is more likely to result from upward social mobility. Other studies have related social mobility to an increase in levels of risk factors (35, 36). This may offset the tendency for higher social status to be associated with lower blood pressure in Davao City. At present, however, this is only a hypothesis.

### Discussion

The study undertook the comparison of blood pressures and related measurements from four Philippine communities arranged in a 2 x 2 factorial design: urban and rural, migrant and sedentary (Figure 1). It was predicted that blood pressures and hypertension levels would be (1) higher in the urban than rural communities, (2) higher in the migrant than sedentary communities.

Conclusions from intercommunity comparisons are as follows:

1. Between ages 25-44 and 45-64, elevation of blood pressure with age was always greater in urban than in rural study sites. This was true for both SBP and DBP, and for both sexes (Table 3, Figures 2-3).
2. When migrant and sedentary communities were compared (urban with urban and rural with rural), blood pressures of persons 45-64 were always higher in the migrant community. While this was true for both SBP and DBP and for both sexes, the DBP difference were more substantial (Table 3, Figures 2-3).

These conclusions from age-adjusted blood pressure levels were further tested against hypertension prevalence data:



Table 10. Mean Blood Pressure Levels Adjusted for Age and Body Mass by Level of Social Support for Males and Females in Quezon City and Davao City

A. <i>Quezon City</i>				
Level of Social Support <sup>1</sup>				
(Score Value)				
	0	1	2	3 or more
A. Males				
SBP	121.33	116.47	117.91	115.96
DBP	79.06	76.28	76.62	76.95
N	312	133	66	54
B. Females				
SBP	113.50	110.56	110.76	107.93
DBP	73.08	72.18	72.86	70.57
N	609	141	59	37
B. <i>Davao City</i>				
Level of Social Support <sup>1</sup>				
(Score Value)				
	0	1	2	3 or more
A. Males				
SBP	124.15	123.91	125.02	119.66
DBP	80.53	80.88	80.45	76.80
N	275	251	114	27
B. Females				
SBP	117.50	118.15	117.47	119.53
DBP	77.88	77.42	75.91	76.39
N	315	294	132	21

<sup>1</sup>Score values are assigned for relatives living nearby (1), for frequent visits with relatives (1), regular church attendance (1), and number of association and group memberships (1 + 05).

- Hypertension prevalence was always greater in urban than in rural study sites for both sexes (Table 5). All possible urban-rural comparison, (4) between migrant and sedentary study sites were made by computing relative risks, and were significant ( $P \geq .05$ ) for at least one sex (Table 6).
- When migrant and sedentary sites of the same type were compared (urban with urban and rural with rural), hypertension was always more prevalent in the migrant community (Table 5). However, relative risks computed for these comparisons (panel C. Table 6), failed to reach statistical significance.

Table 11. Mean Blood Pressures Adjusted for Age and Body Mass by Level of Household Income for Males and Females in Quezon City and Davao City

A. Quezon City			
	Level of Household Income		
	<i>P000-999</i>	<i>P1000-1999</i>	<i>P2000-</i>
A. Males			
SBP	120.68	120.46	117.91
DBP	78.44	78.26	77.89
N	153	191	195
B. Females			
SBP	115.43	111.20	109.61
DBP	74.18	72.20	71.67
N	322	292	205

B. Davao City			
	Level of Household Income		
	<i>P000-999</i>	<i>P1000-1999</i>	<i>P2000-</i>
A. Males			
SBP	123.26	124.85	123.78
DBP	78.66	81.08	79.93
N	147	145	77
B. Females			
SBP	120.47	117.00	116.82
DBP	77.95	77.66	75.65
N	193	168	81

The urban environment, representing modernization, appears to be sufficient to increase hypertension prevalence significantly in the Philippines without the added factor of migration. Migration, representing the dimension of adaptation to a new environment, does not seem sufficient in itself to increase hypertension prevalence significantly without the assistance of modernization, i.e., an urban environment.

Within the two urban environments, Quezon City and Davao City, age and body mass were closely associated with blood pressure differences; the behavioral variables (personal habits, socioeconomic characteristics) were less clearly associated when age and body mass were controlled. However, both social support and household income showed significant results in a minority of cases tested (Table 9). The relative lack of explanatory power encountered in psychosocial variables, constrains-



ted with physiological attributes, has been observed by Reed, McGee and Yano (37) in their recent analysis of urban Japanese data from Hawaii.

A 1978 Iranian study (38) which compared rural villagers with migrants to Teheran and indigenous urbanites from the capital city reached conclusions similar to those presented for the four Philippine communities. Among subjects of both sexes, ages 40-59, both blood pressure and hypertension prevalence were ran. Once again, urban modernization rather than migrant adaptation appears to be the influential variable.

The failure of migrant adaptation to emerge from either the Iranian or Philippine studies as a significant determinant of blood pressure and hypertension differences is not surprising. Neither study described the migration experience or differentiated between migrant and sedentary populations with precision.

The nature of the behavioral changes entailed by migration needs to be elucidated. Length of exposure to the new environment and age at migration, social status of migrants within source and destination communities should be investigated. So too, should possible persistence of rural social organization and employment among migrants in the city as well as changes in primary variables such as diet, physical activity, occupation and social support.

A-1. Systolic and Diastolic Mean Blood Pressures with Standard Deviations and Body Mass Indices by Age Groups for Males, from Rural Pangasinan and Quezon City, Philippines, 1978

		<i>R U R A L</i>				<i>BMI</i>
		<i>SBP</i>	<i>SD</i>	<i>DBP</i>	<i>SD</i>	
Male Ages:	15-19	115.09	11.57	73.74	8.63	
	20-24	120.26	12.28	77.63	8.73	
	25-29	121.14	11.11	77.91	8.65	
	30-34	121.84	11.34	78.87	9.48	
	40-44	123.63	14.47	80.65	9.80	
	45-49	125.91	16.34	75.95	11.84	
	50-54	126.63	15.28	81.63	10.20	
	55-59	128.32	17.58	81.91	11.41	
	60-64	131.96	19.30	82.63	11.48	
	65-69	136.52	21.78	84.39	12.34	
	70-74	137.75	21.50	83.38	12.30	
		<i>U R B A N</i>				<i>BMI</i>
		<i>SBP</i>	<i>SD</i>	<i>DBP</i>	<i>SD</i>	
Male Ages:	15-19	109.53	10.24	70.22	8.39	3,165
	20-24	112.92	13.34	74.66	9.60	3,389
	25-29	116.99	13.30	76.90	8.56	3,669
	30-34	115.76	13.22	77.43	9.56	3,690
	35-39	118.39	13.63	79.14	11.06	3,779
	40-44	120.94	15.57	83.26	12.59	3,622
	45-49	124.11	15.96	81.22	10.52	3,794
	50-54	125.40	18.41	82.81	12.43	3,882
	55-59	133.77	25.87	86.10	13.85	3,879
	60-64	127.11	15.88	84.68	10.96	3,878
	65-69	141.35	17.46	80.65	11.80	3,578
	70-74	161.60	26.75	89.40	14.19	3,831

A-2 Systolic and Diastolic Mean Blood Pressures with Standard Deviations and Body Mass Indices by Age Groups for Females, Rural Pangasinan and Quezon City, Philippines, 1978

		<i>R U R A L</i>				<i>BMI</i>
		<i>SBP</i>	<i>SD</i>	<i>DBP</i>	<i>SD</i>	
Female Ages:	15-19	112.33	10.93	72.78	8.47	
	20-24	114.23	11.12	71.78	9.43	
	25-29	115.93	12.39	75.71	9.69	
	30-34	116.57	13.73	75.94	10.08	
	35-39	117.11	14.96	76.77	10.84	
	40-44	120.99	16.96	79.32	10.71	
	45-49	122.68	17.88	80.13	11.39	
	50-54	123.90	18.24	80.54	11.33	

		<i>SBP</i>	<i>SD</i>	<i>R U R A L</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
		60-64	132.23	21.28	81.39	12.17
		65-69	133.29	21.41	81.99	12.33
		70-	135.28	23.30	80.75	11.74
		<i>SBP</i>	<i>SD</i>	<i>U R B A N</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
Female Ages:	15-19	103.39	9.93	68.22	8.85	3,042.9
	20-24	106.14	14.80	68.74	11.82	3,124.1
	25-29	107.72	12.74	70.90	10.48	3,243.6
	30-34	107.59	14.48	70.40	10.81	3,269.9
	35-39	110.92	12.91	73.53	8.89	3,397.3
	40-44	112.77	17.14	74.20	12.70	3,510.3
	45-49	119.38	17.13	78.15	10.71	3,624.8
	50-54	123.68	22.50	79.45	11.23	3,503.1
	55-59	128.81	19.86	79.64	10.70	3,649.3
	60-64	131.95	21.51	81.15	11.54	3,238.6
	65-69	134.92	29.73	78.00	12.97	3,377.7
	70-	137.96	20.84	75.83	11.93	3,265.4

A-3. Systolic and Diastolic Mean Blood Pressures with Standard Deviations and Mean Body Mass Indices, by Age Groups for Males, Rural Davao Province and Urban Davao City, Philippines 1978

		<i>SBP</i>	<i>SD</i>	<i>R U R A L</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
Male Ages:	15-19	111.39	11.09	75.81	10.11	2,998
	20-24	120.77	14.91	80.72	8.02	3,228
	25-29	123.15	11.40	84.02	7.81	3,341
	30-34	124.19	12.64	84.48	8.20	3,274
	35-39	125.60	14.07	85.46	10.06	3,331
	40-44	125.00	12.60	86.55	9.90	3,362
	45-49	127.92	12.60	86.55	8.83	3,344
	50-54	128.89	16.04	86.99	9.80	3,285
	55-59	129.29	14.47	87.87	8.81	3,291
	60-64	129.17	20.91	86.17	15.78	3,192
	65-69	140.62	20.39	88.75	11.75	3,090
	70-	143.83	24.97	94.50	15.98	3,041
		<i>SBP</i>	<i>SD</i>	<i>U R B A N</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
Male Ages:	15-19	112.22	11.32	72.08	9.68	2,995
	20-24	119.65	10.22	77.94	9.15	3,310

	<i>SBP</i>	<i>SD</i>	<i>R U R A L</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
25-29	123.58	10.44	80.22	10.06	3,353
30-34	125.63	10.15	88.33	9.06	3,645
35-39	125.81	11.66	82.27	11.42	3,494
40-44	126.92	19.02	83.69	14.29	3,365
45-49	129.31	19.73	86.59	13.04	3,619
50-54	130.29	19.58	84.91	14.78	3,431
55-59	134.80	20.01	87.57	13.17	3,276
60-64	142.03	26.29	91.06	17.28	3,316
65-69	138.89	22.97	87.33	13.68	3,454
70—	137.56	23.42	81.55	15.36	3,401

A-4. Systolic and Diastolic Mean Blood Pressures with Standard Deviations and Mean Body Mass Indices, by Age Groups for Males, Rural Davao Province and Urban Davao City, Philippines 1978

	<i>SBP</i>	<i>SD</i>	<i>R U R A L</i> <i>DBP</i>	<i>SD</i>	<i>BMI</i>
Female Ages:					
15-19	109.97	10.02	76.37	7.68	2,984.6
20-24	114.82	10.43	78.60	8.47	3,093.0
25-29	116.12	12.57	78.80	9.16	3,186.7
30-34	117.33	12.66	81.67	10.75	3,272.4
35-39	116.86	12.29	81.72	8.06	3,190.5
40-44	119.90	15.50	82.44	11.23	3,299.6
45-49	122.72	17.35	83.83	10.85	3,222.8
50-54	128.98	18.03	86.30	9.68	3,122.5
55-59	122.76	13.26	82.20	11.69	2,938.0
60-64	130.09	14.74	85.73	8.10	3,040.2
65-69	139.00	13.11	88.18	10.94	2,763.3
70—	131.14	24.52	83.85	13.06	2,559.9
			<i>U R B A N</i> <i>DBP</i>		
	<i>SBP</i>	<i>SD</i>		<i>SD</i>	<i>BMI</i>
Female Ages:					
15-19	106.39	9.98	76.26	9.17	2,915.6
20-24	109.28	9.73	71.03	9.03	2,950.9
25-29	111.28	12.89	73.98	10.95	3,116.7
30-34	117.16	16.11	77.15	14.28	3,261.8
35-39	121.18	16.10	80.73	12.88	3,306.0
40-44	124.20	16.77	84.54	13.08	3,607.9
45-49	129.27	24.20	84.62	15.38	3,509.4
50-54	134.78	21.83	85.62	11.79	3,397.2
55-59	139.39	33.65	88.79	19.92	3,211.3
60-64	133.71	16.96	89.52	8.02	3,245.9
65-69	141.80	23.60	90.35	14.31	2,902.3
70—	158.67	36.10	89.00	7.04	3,066.9

A-5. Mean Heights and Weights, with Standard Deviations, by Age Group, for Males and Females from Quezon City, Philippines, 1978

		<i>M A L E S</i>				
		<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
Males Ages:	15-19	163.09	8.15	51.75	9.08	122
	20-24	164.65	6.97	55.79	7.53	82
	25-29	163.49	6.31	60.00	10.91	69
	30-34	162.49	8.01	59.98	10.93	53
	35-39	164.37	5.22	62.08	9.79	44
	40-44	163.73	6.55	59.36	10.87	46
	45-49	162.55	9.11	61.63	7.63	36
	50-54	164.52	5.58	63.94	11.95	52
	55-59	161.68	5.43	62.81	9.87	30
	60-64	164.79	4.17	63.92	8.82	19
	65-69	157.99	4.14	56.54	8.20	17
	70-74	159.23	7.07	61.13	8.26	10
	Total					580
		<i>F E M A L E S</i>				
		<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
Female Ages:	15-19	151.10	6.26	45.99	7.72	175
	20-24	152.68	6.33	47.69	6.61	147
	25-29	152.10	5.18	49.36	7.41	88
	30-34	150.35	6.59	49.24	8.61	70
	35-39	151.37	8.40	51.34	9.92	74
	40-44	151.94	7.18	53.34	10.23	76
	45-49	151.93	8.08	55.01	8.63	73
	50-54	152.55	3.93	53.54	9.74	59
	55-59	150.14	5.39	54.79	10.91	42
	60-64	149.56	4.72	48.39	6.14	20
	65-69	148.17	6.95	50.17	8.68	26
	70-74	149.94	4.69	49.00	12.48	25
	Total					873

A-6. Mean Heights and Weights, with Standard Deviations, by Age Group, for Males and Females from Davao City, Philippines, 1978

		<i>M A L E S</i>				
		<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
Male Ages:	15-19	160.46	7.00	48.13	6.70	143
	20-24	162.81	6.05	53.94	7.83	98
	25-29	163.06	5.98	54.76	7.58	88
	30-34	162.24	7.08	57.34	8.90	55
	35-39	162.94	5.66	57.03	8.85	67
	40-44	160.96	6.23	54.18	7.51	36

<i>M A L E S</i>					
	<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
45-49	161.48	7.15	58.46	10.07	49
50-54	160.00	6.12	55.00	11.09	35
55-59	162.10	5.11	53.16	8.77	30
60-64	160.65	5.96	53.37	9.95	31
65-69	158.96	5.59	55.00	8.42	18
70-74	160.52	5.91	54.71	11.42	16
Total					668

<i>F E M A L E S</i>					
Female Ages:					
15-19	151.63	5.74	44.26	6.26	160
20-24	151.77	6.06	44.84	5.92	120
25-29	151.69	5.36	47.30	7.26	112
30-34	151.28	5.51	49.40	8.37	75
35-39	151.62	6.07	50.20	9.30	80
40-44	151.83	4.92	53.56	9.43	50
45-49	150.48	6.25	50.83	9.30	46
50-54	156.05	5.15	51.78	11.07	37
55-59	150.96	5.78	48.58	9.49	33
60-64	150.13	5.23	48.80	8.48	21
65-69	150.11	6.44	44.58	9.41	20
70-74	146.86	3.34	45.06	6.69	9
Total					763

A-7. Mean Heights and Weights, with Standard Deviations, by Age Group, for Males and Females from Rural Davao Provinces, Philippines, 1978

<i>M A L E S</i>					
	<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
Males Ages:					
15-19	156.47	7.72	47.03	6.93	79
20-24	159.03	7.01	51.41	8.18	81
25-29	161.22	7.54	53.95	8.19	87
30-34	160.13	6.44	52.50	7.26	103
35-39	159.96	6.30	53.35	7.83	89
40-44	159.92	7.44	53.85	7.87	98
45-49	159.60	7.43	56.48	9.08	79
50-54	159.28	7.10	52.34	8.04	65
55-59	157.61	5.75	52.03	9.00	31
60-64	158.17	4.20	50.43	6.93	23
65-69	156.50	8.23	48.50	6.69	16
70-74	158.00	7.29	48.17	8.00	12
Total					763



	<i>Height (Cms)</i>	<i>SD</i>	<i>Weight (Kgs)</i>	<i>SD</i>	<i>N</i>
<i>F E M A L E S</i>					
Female Ages: 15-19	150.73	6.36	45.03	5.87	118
20-24	151.06	5.84	46.81	5.32	149
25-29	151.82	6.24	48.45	7.54	153
30-34	150.95	6.12	49.50	8.86	133
35-39	151.38	6.16	48.42	8.65	138
40-44	151.84	5.43	50.18	9.67	122
45-49	150.57	5.69	48.56	8.07	95
50-54	151.06	5.53	47.28	8.11	53
55-59	149.90	5.58	44.03	5.83	29
60-64	146.14	6.40	44.63	9.86	22
65-69	146.82	5.45	40.73	11.61	22
70-74	145.07	6.58	37.14	5.60	14
Total					1,048

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**Santiago V. Guzman, Discussant**

Hypertension being a public health problem needs solution which is preventive in nature. One of the main thrusts in health promotion and disease prevention is an understanding of risk factors i.e., characteristics which increase morbidity and mortality of disease. One such risk factor in hypertension is migration as already discussed by Dr. Cabral.

It might be pertinent to mention at this point that studies on intercultural assessment of the effects of migration among Japanese migrants some years ago. This study involved Japanese from Hiroshima and Nagasaki and Japanese in Honolulu and Japanese in San Francisco where they evaluated the prevalence of coronary artery disease and hypertension in these three groups of population and they found that the prevalence of coronary artery disease was highest in San Francisco and intermediate in Honolulu and lowest in Japan. The same picture was true with hypertension except that they found that hypertension was related to the weight of the individual. In other words, they were able to explain the degree of rise in blood pressure in San Francisco because the population there were heavier than the population in the other areas.

On the other hand, they had a chance to evaluate the effects of acculturation; the psycho-social and cultural changes in the population and they found that the Japanese who maintained the traditional Japanese culture and associating with more Japanese in San Francisco had the same prevalence rate of coronary artery disease as those in Japan. Whereas those who were assimilated with the American way of life had a very high prevalence of coronary artery disease. In this context, the appearance of hypertension among migrants from rural to urban area may be prevented or minimized if the migrant has social support like being among relatives and friends in the new environment.



## **CLINICAL SPECTRA OF PRIMARY NEPHROTIC GLOMERULOPATHIES: A COMPARATIVE ANALYSIS BASED ON 102 BIOPSIED CHILDREN**

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### **Introduction**

Minimal change lesion (MCL) is the commonest histologic expression of primary (idiopathic) nephrosis of infancy and childhood.<sup>1-3</sup> In the absence of expertise in and facilities for kidney biopsy, it is safe to presume that a child between 1 and 16 years of age with nephrotic syndrome has MCL until proven otherwise. The International Study of Kidney Disease in Children (ISKDC), in its 1970 Collaborative Report,<sup>4</sup> calls attention to three (3) other significant morphologic changes associated with primary nephrotic syndrome. These are: (1) focal glomerular sclerosis (FGS), (2) mesangial proliferative glomerulonephritis (MesPGN) and, (3) membranoproliferative glomerulonephritis (MPGN). These lesions have been investigated extensively over the past decade and there are sufficient data to suggest that they differ from MCL in terms of overall prognosis.<sup>2,4,6-11</sup>

In the Philippines, we started a prospective series on primary nephrotic syndrome in January 1979. Since that time, 104 first kidney biopsies have been performed on 104 children, representing almost half of the total number of primary nephrotics (218) diagnosed until December 1982.

For this paper, we limit the discussion to only 102 patients. We delve into their clinical characteristics, therapeutic responses and latest disease status, summarize the clinical picture that suggests one pathology over another, and pinpoint salient details which may guide clinicians in their choice of therapeutic agents.

### **Materials and Methods**

The collective biopsy experience of three (3) hospitals for the years 1979 to 1982 was reviewed. Due to the meager number of patients with membranous



nephropathy (only 2 out of 104 patients), they were excluded from analysis. None of the remaining 102 children had evidence of a previous episode of poststreptococcal nephritis, a preexisting systemic disease, or prior exposure to physicochemical agents known to cause nephrotic syndrome. All had a minimum follow-up period of 6 months.

On the basis of predominant histologic changes, 4 groups were identified — MCL, FGS, MesPGN and MPGN. These lesions were then compared with each other as to clinical presentation, response to conventional drug therapy and eventual outcome. Important areas of dissociation were subjected to statistical analyses using the chi-square method and the students' t-test.

### Definitions

1. Steroid-responder — one who remits within four (4) weeks of steroid therapy at high daily doses (2 mg per kg/day);
2. Steroid-resistant — one who fails to remit within four (4) weeks of steroid therapy at high daily doses;
3. Frequent-relapser<sup>2</sup> — a steroid-responder who relapses at least twice within any consecutive six-month period; a drug-free interval exists between attacks;
4. Minimal change lesions (MCL)<sup>3</sup> — the glomeruli look normal under light microscopy;
5. Focal glomerular sclerosis (FGS)<sup>4,5</sup> — glomerular obsolescence, hyalinosis and/or sclerosis limited to a few glomeruli or segment of a glomerulus;
6. Mesangial proliferative glomerulonephritis (MesPGN)<sup>8,12</sup> — there is an increase in mesangial cytoplasm and/or cellularity; no thickening of the capillary walls;
7. Membranoproliferative glomerulonephritis (MPGN)<sup>10</sup> — there is both an increase in mesangial cytoplasm and/or cellularity and thickening of the capillary walls.

### Results

Table 1 depicts the case materials for this study. Primary nephrotic syndrome was due to MCL in 38% of cases, FGS in 12%, MesPGN in 24%, and MPGN in 26%.

#### Clinical Presentations (Table II)

In all four types, there was an obvious predominance of boys over girls. The average age at onset of MPGN was significantly higher than that of MCL, FGS or MesPGN ( $p, < .05$ ). MCL patients had significantly lower average diastolic blood pressures at admission when compared with patients having the other pathologic types ( $p, < .005$ ). Initial average 24-hour proteinuria was significantly higher in FGS and in MPGN in contrast to either MCL or MesPGN ( $p, < .005$ ). The former

Table 1. Pathologic Causes of Primary Childhood Nephrosis

<i>Pathology</i>	<i>No. of Patients</i>	<i>%</i>
MCL	39	38%
FGS	12	12%
MesPGN	24	24%
MPGN	27	26%
Total	102	100%

two lesions also registered higher initial average serum creatinine levels but the difference was not significant ( $p, < .20$ ). The incidence of gross or microscopic hematuria was higher in FGS (66.6%) and in MPGN (55.5%) than that in MesPGN (33.3%) and in MCL (12.5%). This finding was highly significant ( $p, < .005$ ). And so was the incidence of hypocomplementemia in MPGN (70.4% vs. 25%, 21.7% and 13.5% in FGS, MesPGN and MCL, respectively),  $p, < .005$ .

Ten (10) of 39 MCL patients (25%) presented with nephritic signs, i.e., diastolic BP  $\geq 90$  mm Hg, significant microhematuria, or serum creatinine  $\geq 1.8$  mg%, during the first weeks of the illness. These disappeared within four weeks of steroid therapy. Hypocomplementemia ( $CH_{100} < 1:40$  or  $C_3 < 50$  mg%) was detected in 5 out of 37 patients with MCL who were tested.

### Therapeutic Responses (Table III)

All patents uniformly received corticosteroids initially at 2 mg/kg/day for four weeks. MCL and MesPGN accounted for most of the initial steroid-responders (92.3% and 83.3%, respectively). Steroid-responsiveness in both lesions was very significant ( $p, < .005$ ) unlike that in FGS and in MPGN wherein steroid-resistance was the rule.

Cyclophosphamide or chlorambucil was added to the steroid regimen as indicated, at maximum total doses of 225 mg/kg and 9 mg/kg, respectively (duration of treatment, 3 to 6 months). Twenty-five (25) out of 36 MCL patients who were steroid-responsive but frequently-relapsing received either drug; all remitted for periods longer than those obtainable from solitary steroid regimes. One (1) initially steroid-resistant MCL case was lost to follow-up and was unable to undergo cytotoxic treatment but two (2) others who had such treatment remitted.

Two (2) FGS patients were initially steroid-responsive. One developed steroid-resistance in a later relapse; she was also resistant to further therapy with cyclophosphamide. The other patient (histology, focal glomerular obsolescence) always responded to steroids alone during repeat attacks. Seven (7) initially steroid-resistant FGS patients were given cytotoxic agents; all remained proteinuric post-therapy. Dipyridamole was tried in two (2) patients and a remission of 1 and 3 months while on therapy was induced.



Table 2. Clinical Presentations of Various Pathologic Lesions

Pathology	Ave. Age at Onset (Yr)	Sex Ratio	Initial Ave. Diastolic BP (MM Hg)	Initial Ave. 24-Hr Protein- uria (GM)	Initial Ave. Serum Creat- inine (MG%)	Hematuria		Low Serum Complement Level
						Gross	Microscopic	
MCL (n, 39)	6.5 (1-15)	28M : 11F	70.5 (60-120)	4.32 (1.12-10.2)	1.12 (0.6-3.0)	0	5/39	5/37
FGS (n, 12)	6.4 (2-13)	9M : 3F	77.5 (60-100)	8.07 (2.09-19.03)	1.76 (0.8-8.3)	1/12	7/12	3/12
MesPGN (n, 24)	6.9 (2-13)	17M : 7F	79.4 (50-110)	4.28 (1.06-9.99)	1.22 (0.7-2.1)	1/24	7/24	5/23
MPGN (n, 27)	8.7 (3-15)	19M : 8F	80.7 (50-100)	7.03 (1.76-27.2)	1.51 (0.7-5.6)	7/27	8/27	19/27

Table 3. Therapeutic Responses of Various Pathologic Lesions

Pathology	Initial Steroid-Sensitivity		Subsequent Therapeutic Response			
	Responsive	Resistant	Steroid-Responsive		Steroid-Resistant	
			Cytotoxic Responsive	Cytotoxic Resistant	Cytotoxic Responsive	Cytotoxic Resistant
MCL (n, 39)	36/39 (92.3%)	3/39 (7.7%)	25/25 (100.0%)	0	2/3 (66.6%)	0
FGS (n, 12)	2/12 (16.6%)	10/12 (83.4%)	1/2 (50.0%)	1/2 (50.0%)	0	7/7 (100.0%)
MesPGN (n, 24)	20/24 (83.3%)	4/24 (16.6%)	4/5 (80.0%)	1/5 (20.0%)	0	2/2 (100.0%)
MPGN (n, 27)	10/27 (37.0%)	17/27 (63.0%)	6/7 (86.0%)	1/7 (14.0%)	4/14 (29.0%)	10/14 (71.0%)

Cyclophosphamide was given to five (5) initially steroid-responsive MesPGN cases. Four (80%) remitted following therapy while one who became steroid-resistant in a later relapse failed to respond also to that agent. Two (2) of four initially steroid-resistant MesPGN patients received cyclophosphamide. Both were treatment failures: one subsequently died of end-stage renal disease (ESRD) 2 years from diagnosis and the other was lost to follow-up.

Of 10 MPGN patients who were initially steroid-responsive, seven (7) had cyclophosphamide therapy. They included one patient who later became steroid-resistant. She did not respond to cyclophosphamide but remitted with dipyridamole. The other six (6) patients responded to cyclophosphamide (remission rate, 86%). On the contrary, out of 14 MPGN patients given cyclophosphamide because of steroid-resistance, only four successfully responded. Ten (10) patients or 71% failed to respond: four were given other drugs (e.g. indomethacin) to no avail, two had no further treatment (still normofunctional), two were in chronic renal failure (CRF), one was dead and one was lost to follow-up.

#### Eventual Outcome (Table IV)

Ninety-one (91) patients were religiously followed up for an average period of 24 months (range, 6-72 mos.). Their disease duration was 39 months on the average (range, 6-120 months). Among all four lesions, MCL had the highest remission rate (97%) with or without therapy. Next was MesPGN (remission rate, 85%). Both rates were found to be significantly higher than those observed in FGS and in MPGN ( $p < .005$ ). Only one patient with MCL had proteinuria as of this reporting; he just



Table 4. Eventual Outcome of Various Pathologic Lesions After an Average Follow-up Period of 24 Months (N, 91)

<i>Pathology</i>	<i>Average Duration of Illness (Mos)</i>	<i>Average Length of Follow-up (Mos)</i>	<i>In Remission</i>	<i>Persistent Proteinuria</i>	<i>In CRF</i>	<i>Renal Death (ESRD) or Actual Death</i>
MCL (n, 35)	33.0 (6-120)	21.7 (6-60)	34 (97%)	1	0	0
FGS (n, 11)	45.0 (6-120)	18.6 (6-48)	4 (36%)	4	0	3
MesPGN (n, 20)	42.6 (6-83)	24.9 (6-60)	17 (85%)	2	0	1
MPGN (n, 25)	43.6 (14-100)	28.4 (6.72)	16 (64%)	6	2	1

relapsed. The incidence of persistent proteinuria, CRF or death was high in the non-MCL groups. FGS and MPGN registered the highest morbidity and mortality figures.

In this series, the overall mortality rate (ESRD, CRF or actual death) was 7.7% (7/91) whereas the overall remission rate with or without treatment was 78% (71/91). The rest (14.3%) had persistent disease.

### Discussion

Primary nephrotic syndrome due to MCL has the mildest clinical signs and the best long-term outlook. Initial steroid-responders are expected to respond to subsequent courses of steroids in future attacks. Those who frequently relapse enjoy longer remission periods following use of cytotoxic agents.<sup>13-15</sup> Even a few who are initially steroid resistant respond to cytotoxic therapy.<sup>16-17</sup> Notwithstanding the initial and transient nephritic features of some patients (25% in this study), therapeutic behavior with either steroids or cytotoxic agents is the same. The hypocomplementemia that is observed in 13.5% of patients presumably reflects loss of complement via the urine concomitant with heavy proteinuria rather than consumption of this protein in an immune-mediated process.

The nephrotic syndrome seen in FGS affects the same age bracket and initially presents with normal kidney function as MCL does. A distinctive finding in FGS in this and other studies,<sup>18</sup> however, is very heavy proteinuria (up to 19.03 grams in one patient) on top of a fairly high incidence of hematuria (66.6% here). Nephrotic syndrome due to FGS is usually refractory to therapy.<sup>8,19</sup> The ability of dipyridamole to induce remission in two steroid- and cytotoxic-resistant cases in

this series is a welcome observation and certainly warrants further evaluation. Futrakul<sup>20</sup> has had similar successes using that drug in FGS. It is perhaps more beneficial and less costly, in the light of the above findings, to proceed to dipyridamole therapy after resistance to steroids has been proven among FGS patients. The benefits are translated in terms of saving some children from certain death within 6-7 years from diagnosis<sup>5</sup> and circumventing many of the undesirable side effects related to cytotoxic treatment.<sup>21</sup> The long-term prognosis of the singular case of focal glomerular obsolescence is uncertain. He remits easily with steroids and his kidney function is normal. Other investigators<sup>5,8</sup> have reported similar histories.

MesPGN appears to approximate MCL in terms of age at onset of disease, degree of proteinuria, normal kidney function and infrequent occurrence of hypocomplementemia.<sup>19</sup> Unlike in MCL, however, hypertension and hematuria are notable.<sup>7,8,12</sup> Corticosteroids are capable of inducing remission in 83.3% of cases. Those who are steroid-responsive but frequently-relapsing are likewise benefited by cytotoxic agents in 80% of children so treated. These figures are comparable to those of other studies.<sup>12</sup> Also comparable is the failure of cytotoxic agents to induce remission among patients who are initially steroid-resistant.<sup>22</sup> Long-term prognosis in this disease seems to be better than that of either FGS or MPGN but no better than that of MCL.<sup>19</sup> In fact, one death recorded here is due to MesPGN.

Among the four histologic types, MPGN can easily be sorted out on the basis of the following clinical traits: (1) older age at onset; (2) higher incidence of hypertension, hematuria and very heavy proteinuria, and; (3) prevalence of hypocomplementemia. More than half of patients are initially steroid-resistant; furthermore, those who are steroid-resistant are also resistant to cytotoxic agents. It appears that only those cases who initially and continually respond to steroids are likely to have variable remission periods post-therapy with cytotoxic drugs. Even then, the remission rate in this disorder is third only to MCL and MesPGN. Nine patients have either persistent proteinuria or end-stage kidney disease. One of them is dead after 51 months of therapy-resistant nephrotic syndrome.

Our cumulative experience these past four (4) years can be viewed from a non-operative standpoint. Much as we advise kidney biopsy for all its informative benefits, many circumstances hinder its consummation in many settings in the country. In these limited situations, constant steroid-responsiveness during nephrotic attacks may be used as a relatively good prognostic gauge,<sup>2,23</sup> irrespective of the age at onset or clinical presentation. This study uniformly shows a favorable remission rate among steroid-responders in any of the four pathologic lesions. Patients who are initially steroid-resistant are more likely to have glomerular changes that augur a poor prognosis.<sup>3</sup> For the simple reason that cytotoxic drugs may also be unable to control the proteinuria, non-cytolytic preparations like dipyridamole may be tried. The alternative use of the latter may prevent infliction of iatrogenic disorders resulting from misuse of cytotoxic agents.

### Summary

102 primary nephrotic children who had kidney biopsy between January 1979 and December 1982 were studied. The histopathology was MCL in 38%, FGS in 12%, MesPGN in 24% and MPGN in 26%. MCL patients had the most benign clinical presentation. They were steroid- and/or cytotoxic-responsive, and had excellent remission rates with or without treatment. The other three pathologies were characterized by varying degrees of hematuria, hypertension and azotemia. Hypocomplementemia was most frequently observed in MPGN. MesPGN appeared to approximate the steroid- and cytotoxic-responsiveness of MCL but its prognosis seemed not as good. FGS and MPGN were associated with very heavy proteinuria and a high incidence of hematuria and steroid/cytotoxic resistance. Death and therapy-resistant proteinuria in this series were mainly attributed to these two latter lesions.

This study corroborates the findings of other investigators that initial and continual responsiveness to steroids in nephrotic syndrome is a good prognostic index. Steroid-resistant patients should have the benefit of kidney biopsy for definite diagnosis. If this is not possible, cytolytic therapy should not be tried as it can be both ineffective and hazardous.

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### Benjamin Canlas, Discussant

This is a very special paper and would like to congratulate Dr. Alfiler for having been able to collect this number of cases in the relatively short time he has been with us. Our experience with renal biopsies has been relatively recent. Dr. Alfiler and Dr. F. Alano have made renal biopsies important procedures in their management of renal disease and for this reason we have been virtually forced to familiarize ourselves with the study of renal morphology in renal disease. I, therefore, do not consider myself to be an expert in this field.

Renal biopsy as a means of guiding the clinician in the management of renal disease has been going on for the last few decades in other parts of the world. There has also been considerable advancement in the techniques utilized for evaluating morphology. This has resulted in enormous increase in our knowledge in the nature and pathogenesis of renal disease. By correlating morphology with clinical manifestations various forms of renal disease have evolved, early diagnosis is possible, institution of the correct management is arrived at, efficacy of therapy can be correctly evaluated, prognostication is more reliable, and the natural history of the disease may be provided.

There are generally acceptable classifications of glomerulopathies that various authorities in this field postulate. While nomenclature and classification may vary somewhat according to authorities concerned, most pathologists and clinicians would understand each other even when these variations are utilized. The entities enumerated in the paper of Dr. Alfiler are generally accepted and, therefore, can be made comparable with other studies abroad.

There are, however, certain shortcomings in the study of biopsies in our country. Generally, we depend on the ordinary hematoxylineosin stain in our studies often supplemented with such special stains as PAS, trichrome and sometimes silver stains. In more sophisticated countries, all four stains enumerated above are a must and in addition they utilize immunofluorescent techniques and electron microscopy. Dr. J. Zamuco, who is another pathologist delving in renal biopsies, sometimes performs immuno-flourescent methods. Since our methods of study are limited to light microscopy accuracy in diagnosis may be open to question. However, when we compare the results of Dr. Alfiler with those noted abroad, there is general correlation of the figures. We are quite confident, therefore, that inspite of the shortcomings that we have, the pathologic diagnoses made are generally accurate.

Studies such as these can give us a better insight of renal diseases in our country which can help not only in the management but probably in the prevention of these diseases. Again, let me congratulate Dr. Alfiler for his efforts in this basic investigation.



# **BIOLOGICAL SCIENCES**





## INFLUENCE OF CHROMOSOME NUMBER ON CAFFEINE INHIBITION OF DNA REPAIR I. MUTATION FREQUENCY

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### ABSTRACT

Dormant seeds of sorghum with  $2N=20$ ; mungbean,  $2N=22$ ; peanut,  $2N=40$ ; and tobacco,  $2N=48$ , were treated with sub-lethal doses of gamma radiation, post-soaked in caffeine solution and grown in field plots to maturity. Untreated seeds and seeds treated only with radiation or caffeine were used as control.

At 30 Krads, the species with high chromosome numbers gave a bigger increase in somatic mutation frequency over the radiation control than the species with low chromosome numbers. Similarly, the species with high chromosome numbers gave a bigger increase in frequency of  $M_2$  seedling mutation over the control than the species with low chromosome numbers. The possible influence of chromosome number on caffeine inhibition of DNA repair leading to a higher probability of induced mutation is discussed briefly.

### Introduction

It is now universally recognized that living cells are normally equipped with certain enzyme mechanisms that restore damaged DNA segments to their original state. Discovery of DNA repair in the early 1950's has more or less revolutionized present concepts on chromosomal aberration and gene mutation with their important applications in plant and animal breeding. Interest in the modification of DNA repair also lies in the increasing exposure of plants to mutagenic systems in the environment occurring as industrial wastes, pesticide residues, gaseous pollutants and others which could increase spontaneous mutation rates.

Enhancement of DNA lesions and consequently increased rates of mutation reportedly result when the gap-filling process in replicating DNA is inhibited by caffeine (Kihlman *et al.*, 1974; Kihlman and Kornborg, 1972) either by competing with thymine dimers for excision enzyme (Sideropoulos and Shankel, 1968), interacting with DNA rather than with repair enzymes directly (Witte and Bohme, 1972), binding with double-stranded DNA bearing short single-stranded regions (T'so and Lu, 1962; Domon and Rauth, 1969) or other related mechanisms.

A number of factors have been reported to have influenced the enhancing action of caffeine on mutagen-treated material although the mechanisms involved remain to be described. For instance, lowering the temperature of treatment

(Kihlman *et al.*, 1974) has reportedly decreased the synergistic effects of caffeine with various chemical and physical mutagens. The presence of oxygen has been found to inhibit the effects of caffeine on the repair process when applied as a post-treatment (Novick, 1956). The frequency of chromatid aberrations markedly increased when barley seeds were post-soaked in caffeine solution at the  $G_2$ -early prophase stage following radiation treatment (Yamamoto and Yamaguchi, 1969).

### Materials and Methods

Dormant seeds of sorghum (*Sorghum vulgare* Pers.) with  $2N=20$ ; mungbean (*Vigna radiata* (L.) Wilczek.),  $2N=22$ ; peanut (*Arachis hypogea* L.)  $2N=40$ ; and tobacco (*Nicotiana tabacum* L.),  $2N=48$ , were individually selected for absence of deformities, uniform color and size. They were stored in a moist dessicator for seven days to equalize the seed moisture content to 14% and set in a thin layer in plastic envelope for irradiation. Radiation treatment was made at the Gamma Cell Facility of the Philippine Atomic Research Center in Diliman, Quezon City at total doses of 15 to 60 Krads.

Soon after radiation exposure, the seeds were soaked in 0.10% solution of caffeine (1, 3, 7 Trimethyl 6 xanthine, Nutritional Biochemicals, Cleveland) for four hours at a constant temperature of  $28^{\circ}\text{C}$ . Untreated seeds from the same sources and seeds soaked only in water or caffeine solution as well as seeds treated with gamma radiation were used as control. Some of the seeds were sown on moist tissue paper in a petri dish for measurement of seedling height and the rest of the seeds were planted in field rows in a treatment-to-row plan at the Botany Experimental Garden for scoring of plants with chimera leaves at the four to six-leaf stage.

The ripe pods or panicles, as the case may be, were harvested by the row, dried at room temperature and after a few weeks of dormancy were sown in nursery rows for determination of the frequency of  $M_2$  seedling mutations. The influence of chromosome number on mutation frequency was determined only at the dose of 30 Krads due to the high degree of lethality at the higher radiation doses and treatment combinations.

### Results and Discussion

*$M_1$  somatic mutation frequency.* The frequency of  $M_1$  plants with chimera leaves after caffeine post-treatment is shown in Table 1. While caffeine post-treatment resulted in a marked increase in somatic mutation frequency in the species with high chromosome numbers over the radiation control, there was practically no increase in mutation rate in the species with low chromosome numbers. The increase in mutation rates in the species with high chromosome numbers of 16 and 17 plants per 100  $M_1$  plants over the control were higher than those of the species with low chromosome numbers by a factor of 4.0 to 8.6.

Table 1. Percent increase in frequency of  $M_1$  chimeral plants after post-irradiation caffeine treatment

(30 Krads)

Species	Chrom. No. (2N)	Gamma radiation		Radiation + Caffeine		
		Total $M_1$ plants	Chimeras per 100 $M_1$ plants	Total $M_1$ plants	Mutation per 100 $M_1$ plants	% increase
Sorghum	20	398	18.34	267	21.72	21.16
Mungbean	22	320	21.56	236	25.85	19.90
Peanut	40	336	8.33	242	25.62	207.56
Tobacco	48	354	6.77	290	23.10	241.21

The low mutagenic response of the species with high chromosome numbers when post-soaked only in water after radiation treatment probably explains in part the very marked increase in frequency of chimeral plants. This radio-tolerance exhibited by species with high numbers of chromosomes has been a subject of active investigation by earlier workers (Sparrow *et al.*, 1961; Swaminathan, 1961) who perceived a protective or "buffering" effect of high chromosome numbers against radiation damage. As somatic mutation in mutagen-treated material is essentially due to chromosomal deletions (Sparrow, 1961), the proportion of chromosomal breaks would likely be smaller in species with higher chromosome numbers than in those with lower chromosome numbers given the same radiation dose.

The data on seedling growth reduction shown in Figure 1 supports the view (Sparrow *et al.*, 1961) that the low mutagenic response of species with high diploid numbers of chromosomes is due to radio-tolerance commonly observed in this type of material. The 50% seedling growth reduction was found at a dose of approximately 27 Krads after caffeine post-treatment in species with low chromosome numbers and about 36 Krads in species with high numbers of chromosomes. A much higher radiation dosage was required to produce the same effect in species with high chromosome numbers than the species with low chromosome numbers.

At a dose of 30 Krads, seedling growth reduction after post-treatment with caffeine caused a lethality increase of only about 8% over the control in species with low chromosome numbers and about 19% over the control in the species with high chromosome numbers. As seedling growth reduction is highly correlated with chromosomal breakage (Conger and Stevenson, 1969), it is assumed that the marked increase in somatic mutation frequency in the species with high chromosome numbers is due to large scale chromosomal breakage.

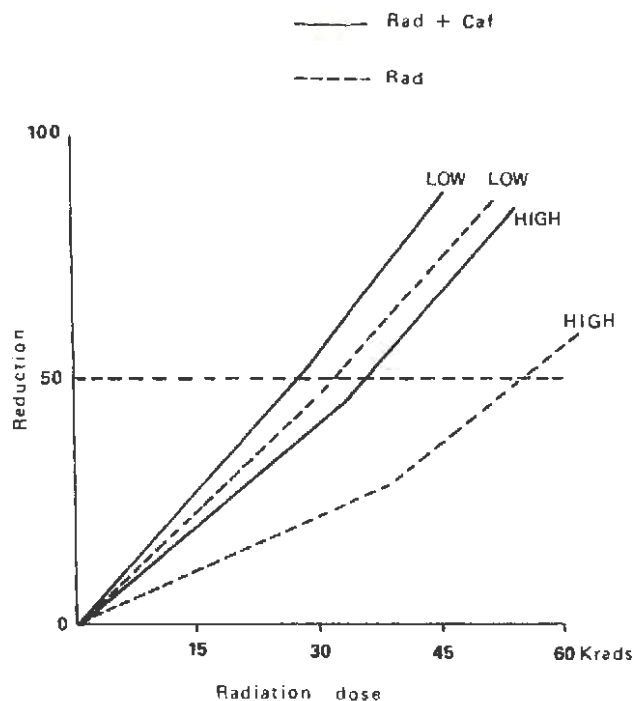


Figure 1. Mean  $M_1$  seedling growth reductions in species with low and high chromosome numbers.

*Mutagenic effects of caffeine.* When used alone, caffeine did not cause any effect both in the  $M_1$  and  $M_2$  generations. Trial tests using concentrations lower and higher than 0.10%, even when applied alone for long periods of up to 24 hours did not cause any effect on present materials. Some slight leaf damage in  $M_1$  seedling from seeds soaked for long periods at temperatures of  $32^\circ\text{C}$  –  $35^\circ\text{C}$  were also observed in the water control.

Several reports, however, are available indicating that caffeine when used alone is an inducer of point mutations and producer of chromosomal breaks (Kihlman, 1974; Ostertag and Haake, 1966; Witkin, 1958; Novick, 1956; Kihlman and Levan, 1949; Fries, 1950) in various organisms ranging from bacteriophage, bacteria and yeast to plants, *Drosophila* and mammalian cell cultures. However, Glass and Novick (1959) were able to demonstrate that the mutagenic action of caffeine requires DNA synthesis, an indication that caffeine is indeed specific for DNA (Kihlman, 1974).

It is not surprising, therefore, that the synergistic effects of caffeine with various chemical and physical mutagenic agents has attracted more interest than its use alone as a mutagen. Investigators on the potentiating effects of caffeine as a

**Table 2. Percent increase in frequency of  $M_2$  seedling mutations after post-irradiation caffeine treatment**

(30 Krads)

Species	Gamma radiation			Radiation + Caffeine		
	Chrom. No. (2N)	Total $M_2$ seedlings	Mutation per 1000 seedlings	Total $M_2$ seedlings	Mutation per 1000 seedlings	% increase
Sorghum	20	2,256	35.02	1,922	37.98	7.01
Mungbean	22	1,095	38.36	1,338	43.35	13.00
Peanut	40	612	17.97	545	44.04	245.07
Tobacco	48	1,283	14.03	1,004	39.84	183.96

post-treatment in various organisms (Yamaguchi, 1979; Thacker, 1979; Hartley-Asp and Kihlman, 1971; Sideropoulos and Shankel, 1968; Shimada and Takagi, 1967; Clarke, 1967) agree that the enhancing effect of caffeine as a post-treatment results from its inhibitory action on the repair of DNA damage, particularly the post-replication repair even in such materials as barley, bean and onion root-tips among others. This view on the nature of caffeine action has been supported by Chan *et al.*, (1979); Lehman and Kirk-Bell (1974); Buhl *et al.*, (1972) who showed that caffeine indeed inhibits post-replication repair in mutagen-treated material.

*Frequency of  $M_2$  seedling mutations.* The frequency of seedling mutations in the form of chlorophyll-deficient  $M_2$  seedlings was employed to indicate the induction of point or gene mutations, a method originally proposed by Gaul (1961) and universally adopted by plant radiation workers. As shown in Table 2, the frequency of gene mutations due to radiation alone in species with low chromosome numbers was higher than the mutation rates in the species with high chromosome numbers. This is probably due to the protective or buffering effect of high chromosome numbers previously discussed above. Thus, the increase in mutation frequency after caffeine post-treatment was markedly higher in the species with high chromosome numbers than in the low chromosome group although their mutation rates were, similar.

To induce the same effect on the genetic material, a higher dose will likely be required in cells with high chromosome numbers than in cells with few chromosomes (Sparrow *et al.*, 1961). The proportion of lesions in the genetic material will most probably be lower in cells with more chromosomes than in cells with fewer chromosomes given the same radiation dose. When the repair process is interfered with, however, as when mutagen-treated seeds are post-soaked in a solution of caffeine, the number of unrepaired lesions in cells with more chromosomes could most probably equal the number occurring in cells with low chromosome num-

bers. If each "open" or unrepaired DNA lesion becomes "fixed" as a point mutation (Kihlman *et al.*, 1974; Ahnstrom, 1974), the increase in gene mutation frequency in the species with more chromosomes will be higher than in plants with fewer chromosomes.

Chromosome number is probably related to DNA content per cell and both have been closely correlated with radiosensitivity (Underbrink *et al.*, 1968) and radiation-induced mutation rates (Abrahamson, 1973). Thus the DNA C values for the species with  $2N=22$  and  $2N=48$  of 0.60 to 2.20 pg and 10.10 to 12.50 pg per nucleus, respectively, (Bennett *et al.*, 1982) could be a good index of the induced mutation frequency in the four species. The C value of the two other plants in the present work were not available. Now in barley seeds, an average of 0.052 break is reportedly formed per  $10^6$  daltons of DNA strand per radiation dose of one kilorad (Yamaguchi, 1979). The molecular weight of chromosomes in many higher plants are probably similar to those of human chromosomes of  $32 \times 10^9$  to  $160 \times 10^9$ . If the quantity of possible DNA breaks is derived for each species and the percentage of seedling growth reduction is employed to estimate the relative quantity of unrepaired DNA lesions, a means of quantifying the protective effect of high chromosome number would have been found.

### Summary and Conclusion

The role of chromosome number on the repair-inhibiting action of caffeine on DNA lesions was investigated using species with low and high chromosome numbers.

While the species with high chromosome numbers gave a marked increase in frequency of  $M_1$  somatic mutations after caffeine post-treatment over the radiation control, the plants with low chromosome numbers did not respond similarly.

Likewise, the species with high chromosome numbers gave a marked increase in frequency of  $M_2$  gene mutations after caffeine post-irradiation treatment over the radiation control while the low chromosome number species failed to exhibit a similar increase.

These results indicate the significant influence of chromosome number on the action of caffeine. The protective or buffering effect of high chromosome number against radiation damage more or less accounts for the low mutagenic response of plants with high chromosome numbers. The lower proportion of breaks in the genetic material in species with high chromosome number than in plants with low numbers of chromosomes probably explains the radio-tolerance observed in species with large numbers of chromosomes.

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### Adoracion T. Arañez, Discussant

Changes produced by gamma rays on the DNA may be due to a direct effect in the form of molecular changes occurring in the molecule where the energy has been absorbed or indirect effects which are brought about by the chemical reactions of free radicals. Effects of ionizing radiation on the DNA of the cell is usually secondary, since most of the energy is deposited in the aqueous phase as cells contain much water. Highly reactive free radicals are formed in the radiolysis of water (Casarett, 1968).

The free radicals may convert the bases to a form with different base-pairing tendencies as the enol form of thymine and imino form of cytosine; cytosine may be converted to uracil (Lim-Sylianco, 1981). The free radicals may react with thymine producing a thymine free radical and two of such free radicals adjacent to each other may produce a dimer. The changes mentioned above may produce point mutations. Dimerization of thymine on two different strands produce interchain dimerization which may result in incomplete unwinding of the two strands during replication. As a result, the DNA strands produced are shorter and with deletions. Single strand breaks and double chain breaks are also produced by ionizing radiation (Casarett, 1968 and Lim-Sylianco, 1981) which may produce chromosomal aberrations.

The extent of changes produced by mutagens depends on the type and amount of DNA damage and the amount of repairs done on the affected DNA.

The potentiation of effects of gamma rays by post-irradiation caffeine treatment may be due to the effects of caffeine on the repair of DNA damage. The repair process affected is probably the post-replicative type rather than the excision repair, since plants lack or have very inefficient mechanisms for excision repair (Kihlman *et al.*, 1974).

The mechanism by which post-irradiation caffeine treatment may increase the mutation frequency may be similar to the action of caffeine on ultraviolet induced pyrimidine dimers given below.

Lehmann (1972) mentioned that there are gaps in daughter DNA strands when dimer-containing DNA is replicated semiconservatively. These gaps are usually filled up by post-replication repair. He presented evidence that in mouse, post-replication repair does not involve recombinational exchanges and that parental DNA does not seem to be involved in the gap-filling process. Recombinational models have been made to account for a similar gap-filling process observed in bacteria. According to Lehmann (1972) the gaps in the daughter strands opposite the pyrimidine dimers are filled in with newly synthesized DNA. It has been observed that caffeine potentiates cell killing and producing of chromosome aberrations if present during DNA synthesis period (Lehmann and Kirk-bell, 1974).

The process of filling up gaps in the daughter DNA strand may be inhibited by caffeine. Lehmann and Kirk-bell (1974) mentioned that methylated xanthines like

caffeine specifically inhibit the filling of the gaps in daughter DNA strands opposite UV-induced pyrimidine dimers in the parental strand.

There is an indication that caffeine binds most effectively to double-stranded DNA with short single-stranded regions (Kihlman, 1974). Although the inhibition produced by caffeine is reversible, the gaps in the daughter DNA strand are sealed slowly after caffeine treatment, gaps persist in the DNA for many hours and could act as focal points for production of chromosomal aberrations (Lehmann and Kirk-bell, 1974) and possibly of point mutations.

The frequency of  $M_1$  somatic mutations and  $M_2$  seedling mutations produced by gamma radiation treatment is more in sorghum and mungbean with chromosome number of 20 and 22 respectively as compared with peanut and tobacco with chromosome number of 40 and 48 respectively. However, in batches given post-irradiation caffeine treatment, the frequency of  $M_1$  somatic and  $M_2$  seedling mutations did not vary very much among the four plants studied. This is an indication that probably peanut and tobacco have better post-replication repair mechanism than sorghum and mungbean and that the post-irradiation caffeine treatment inhibited this repair mechanism. It is interesting to note that peanut and tobacco are polyploids.

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## EXPERIMENTS ON PACING UNDER FIXED-RATIO AND VARIABLE-INTERVAL SCHEDULES OF REINFORCEMENT

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### ABSTRACT

A strict version of differential reinforcement of low rates, called *pacing*, is added to a fixed-ratio schedule for the white Carneaux in a Skinner box. The experiment answers in the affirmative the question as to whether the bird can estimate the size of a ratio independently of the rate at which its pecking behavior is reinforced. The time course of its fixed-ratio behavior with pacing tends to develop longer pauses after reinforcement until the bird finally gives up responding altogether. Under a variable-interval schedule with pacing, the responding shows "breakthroughs" from pacing, signifying that the paced behavior generates an aversive condition.

### Introduction

In a previous paper,<sup>(8)</sup> a technique for the control of the free operant was described. By not reinforcing high rates, nor low rates, of responding, one has an experimental condition which we may call *pacing*, which is a very strict condition for reinforcement because, in effect, too "enthusiastic" responding as well as "sluggish" behavior will not be reinforced even if the animal is very highly motivated. It was suggested in that paper that perhaps, a pacing requirement such as was used in these experiments may generate an aversive condition in the behavior of the organism itself, so that when the pacing condition is removed, the rate of responding temporarily recovers to an "overshoot" level, a phenomenon suggestive of an "exhilarating" release from an aversive contingency imposed by an effortful task.

Since then many experiments<sup>(4, 5, 9, 14, 15)</sup> have been reported that show the effects of an effortful or aversive task on behavior. All of these researches, including those published before 1964,<sup>(1, 2, 3, 6, 7, 10, 11, 12, 13, 16)</sup> have shown the depressing or weakening of effortful or aversive contingencies on responding.

This paper reports on some experiments, which, while they were performed to resolve certain problems related to contingencies of reinforcement, are now dealt within the context of behavior under aversive conditions.

It should be noted that no investigator has so far ever reported on a pacing contingency such as the one used in these experiments, which is not a simple differential reinforcement of low rates nor of high rates.

In order to make this paper self-contained, the following descriptions as to basic experimental arrangements are taken from the previous report.

### Apparatus

Although most of the features of the experimental box, the recorder, and the programming apparatus are discussed in more detail elsewhere,<sup>(6)</sup> these will be briefly described here in order to make this account complete in itself. The pacing apparatus, however, is not described anywhere else.

*Experimental box.* This was a standard Skinner box for pigeons of the type being used in the Harvard Psychological Laboratories for the study of operant behavior. It was made from a picnic ice-box about 11" x 13" x 20". The insulation and thickness of its double walls afforded a considerable amount of sound-proofing from outside extraneous sounds. In order to further secure adequate masking of unwanted sounds, white noise was constantly delivered inside the experimental chamber.

The box was divided into two compartments by a panel. On one side was the pigeon chamber and on the other, the food magazine. The bird pecked at a plate of translucent plexiglas, which was mounted behind a circular opening in the panel about one inch in diameter at about the level of the bird's head when it was standing normally. When the bird pecked at this plate, a pair of metal contacts were separated from each other and a corresponding electrical circuit was broken. A relay operated by this circuit was used for programming the experiment and for recording. The plexiglas key was always lighted from the magazine side of the panel. When a response was reinforced, the key light went off almost simultaneously with that response and a light over the food-magazine, which was below the key, went on. For the duration of the reinforcement, which was about 3.5 secs., food was available and the magazine light was on. After 3.5 secs., food was no longer available, and the magazine light went off; at the same time, the light through the response key was turned on again.

A light of moderately low intensity was furnished by a 6-watt bulb in the bird compartment during the experiment. At the end of the experiment, this light as well as all other lights in the box were turned off, thus leaving the bird in complete darkness.

In one corner of the box was a cup where fresh water was always available.

In order to minimize grain-hunting behavior during the experiment, the cross-wire grid floor of the pigeon chamber was raised by about 1 inch from the metal bottom of the box. Any grain that might be thrown into this compartment from the food magazine was therefore completely out of reach of the bird.

Fresh air was constantly kept in circulation inside the experimental chamber by means of a motor ventilator.

*The programming apparatus and cumulative recorder.* The experiments were run through a system of switching circuits which arranged for the automatic delivery of critical stimuli and which, with timers and counters, made the programming of reinforcements possible. From the time the bird was put into the box up to the end of the experiment, there was no direct contact of any form between the experimenter and the subject. Responses as well as reinforcements were recorded through a cumulative recorder, which gave continuous records throughout the experiment.

*The pacing apparatus.* The requirement of control of rate of responding at the moment of reinforcement, for which the experimental apparatus must provide, may be satisfied by the following conditions:

- (1) Too *long* an inter-response time is not reinforced: a lower limit for rate of responding is imposed;
- (2) Too *short* an inter-response time is not to be reinforced: an upper limit for rate of responding is required; and
- (3) The animal must have emitted just before and at the moment of reinforcement an arbitrary *number* of successive responses at a rate the limits of which are set by (1) and (2) above.

The instrumentation of conditions (1) and (2) was achieved by means of two vacuum-tube timers each of which set the limits for inter-response times.

Condition (3) was met by making every pacing response step a counter which in turn determines the number of successive pacing responses that must be made before a reinforcement is delivered. If a non-pacing response is made before the full count is reached, the counter resets back to zero count and the bird has to start all over again.

*Isolation of pacing apparatus.* Since the pacing response also required that there was to be no differential external stimulus control with respect to the reinforced and non-reinforced regions of the inter-response time spectrum, it was necessary to mask all critical sounds from the timers and the counter that had to do with marking those regions off. Clicks from the timer and relays connected to it were handled by the masking noise inside the experimental chamber. The pacing counter which made an unusually loud buzz when it reset for a non-pacing response or which clicked with some intensity when a successful pacing response was made, was set up in another room some distance away from the experimental box.

## Subjects

The subjects for this studies were male White Carneaux pigeons which were about one and a half years old at the start of the experiments, and, since the life span of these birds is at least 15 years, variation in behavior due to age is ruled out.

The weights of the birds were brought down to a little below 80% of their *ad lib* weights by almost completely depriving them of food for about a week. About 2 or 3 grams of grain per day were given during this deprivation period, which was sufficient to prevent digestive disturbances that usually attend complete deprivation. After this, the daily feeding schedule was merely a matter of giving them the balance of the ration that would bring their weights up to the 80% level, as described below.

The birds were tamed before the start of the experiments in order to minimize handling effects.

All birds were trained to eat from the magazine hopper of the experimental box and to peck at the key by reinforcing progressive approximations to contact of the beak with the response key.

### Control of Other Factors

The birds were given a daily ration of a grain mixture consisting of about 40% vetch, 10% hemp seed, and 50% kaffir corn either in the experimental box or in their cages in the lofts. Their weight at the start of every experiment was always about 80% of the *ad lib* minus the ration for the day, part or all of which they worked for in the experimental chamber. Any unfed portion at the end of the experiment which was necessary to bring the weight up to the 80% level was given outside in the cages fifteen minutes after the bird was taken out of the box. This fifteen-minute delay for non-experimental feeding after the bird was taken out of the box was followed just to make sure that a relatively long period of non-responding in the experimental box was never correlated with the termination of the experiment and with a reinforcement immediately thereafter.

The room where the bird was located was lighted and darkened by an automatic switching timer which kept the light-dark cycle constant from day to day.

There were no provisions for the control of humidity, but the temperature, though variable, was kept within limits of indoor comfort for the people working in the laboratory. The performance of the White Carneaux, however, has been shown to be relatively insensitive to wide variations in humidity and temperature of the range obtaining at the laboratory.

### Some Other General Problems

*Measurements and replicates.* Data were obtained through a cumulative recorder which kept continuous records of responding as a function of time for the entire experimental session. Derivative data that were of any special interest could be obtained from this cumulative graph. Whenever a figure is given with respect to a day's performance by a single subject, it will be assumed to be typically replicated otherwise, it will be accordingly qualified.

Every experiment was run with at least two subjects, with repeated measurements taken of the performance over a period of time, usually covering both transitional developmental phases and steady states. Occasionally, an experiment was repeated on the same subject at some other value of the experimental variable, provided that the process under consideration was known to be reversible.

The results of some part of an experiment were sometimes also replicated in the study of other subjects which underwent a similar history for other purposes. Consequently, some observations that are reported for any particular experiment may apply to more than two subjects.

*Controls.* The experiments were designed so that each subject was its own control. Before any experimental variable was introduced, baselines were usually first established by stabilizing the response of the bird over some schedules the properties of which were relatively better known. The time required to get such a baseline was arbitrarily determined by the nature of the experiment and the time course of the performance. The length of the experiment could usually not be specified in advance because the deciding criterion was the appearance of certain significant changes in the responding which could not be predicted ahead of time. Different birds took different times to stabilize or to arrive at important changes in their behavior. The choice was to allow each experiment to run its course, as against the alternative experimental design in which individual difference with respect to time might be emphasized.

## Experiment A

### FIXED-RATIO SCHEDULE OF REINFORCEMENT WITH SLOW PACING

*Problem.* A bird that is placed under a fixed-ratio schedule of reinforcement invariably shows a development course of responding which progressively increases towards faster rates until a terminal value is reached. From there on, the rate is stable at that value. Studies of pigeons placed on a mixed schedule of two fixed ratios with widely disparate values, e.g. 50 and 250, indicate that they respond *as though* they were able to estimate or count approximately 50 pecks. Records under this schedule show short runs and breaks appropriate to a ratio 250. The rates of responding, however, are identical for both schedules and are taken to be at the upper limiting value for such ratio performances.

Of the various factors that may be dealt with in the investigation of this apparent ability of the bird to approximate a specified number of ratio responses is the prevailing rate of responding at the moment of reinforcement. In the above-mentioned studies, the initial rate of the bird, when it starts the ratio run, is the same as the terminal rate. If we were interested in finding out whether or not the



rate at which the bird is reinforced is the crucial factor, or the only factor, that could possibly influence its performance in other portions of the ratio curve, then a means must be found to control for the terminal rate — to prevent the so-called ratio “end effect” from developing. This can be conveniently provided for by the slow pacing of responses at the region of the curve where a reinforcement occurs. If the bird still runs at a faster rate than the reinforced rate, then the determining factor for this run cannot be the rate at which it is reinforced.

*Procedure.* Two of the subjects for this experiment were shaped up to pace at limits of 1.5 and 2.0 secs for three pacing responses. Then the birds were put on a tandem schedule consisting of a 1-min. variable-interval schedule with added pacing set at the above limiting values. For all practical purposes, these two birds may be considered to have had no history of reinforcement of inter-response times beyond the above-mentioned limits. After being stabilized on this tandem schedule, they were switched to a fixed-ratio schedule with added pacing at the same limits, but with the exception that if a bird did not perform very evenly in respect to the total ratio requirement, the number of pacing responses was reduced from three to two. This reduction was made in order to control for the size of the ratio from run to run, since the requirement of two pacing responses could be met within much less variable limits in some birds than in others. Fortunately, we had to do this with only one out of the three subjects reported in this experiment.

The ratio that was used with the added pacing requirement was calculated in the following way: The number of responses for the 1-min. variable-interval schedule with added pacing was divided by the number of reinforcements occurring for the entire experimental period. The resulting figure minus the three paced responses was then set as the fixed ratio.

Another bird which had had an extensive history of variable-interval responding was added to this experiment. It underwent a shaping up process similar to that of the above birds, the only difference being that the latter were controlled for their entire experimental history at pacing limits of 1.5 and 2.0 secs.

*Results.* Figure 1 at (A) shows the initial responding of S-106 on a fixed ratio of 35 with added pacing. The record is read as a cumulative graph where the line resets back to the zero point of the ordinate after every reinforcement. The ratio counts are relatively constant at this time. This bird never had any history of reinforcement above or below the specified pacing limits of 1.5 and 2.0 secs.

Figure 1 at (B) shows the responding of the same bird under identical experimental conditions two months later. From a relatively slow rate of about 0.6 responses per sec. in Record A, “runs” of about 2 or 3 responses per sec. have developed just before reinforcement, as indicated in Record C. These runs are well above and beyond that for which the pacing apparatus had ever reinforced the bird. The fast runs are variable in length, but the specified ratio count is pretty well approximated by many of these runs, such as in segment *x* and elsewhere. After each run, there is a tapering off to the pacing rate at which the responding is reinforced. The results for this bird are therefore positive: high rates develop which are

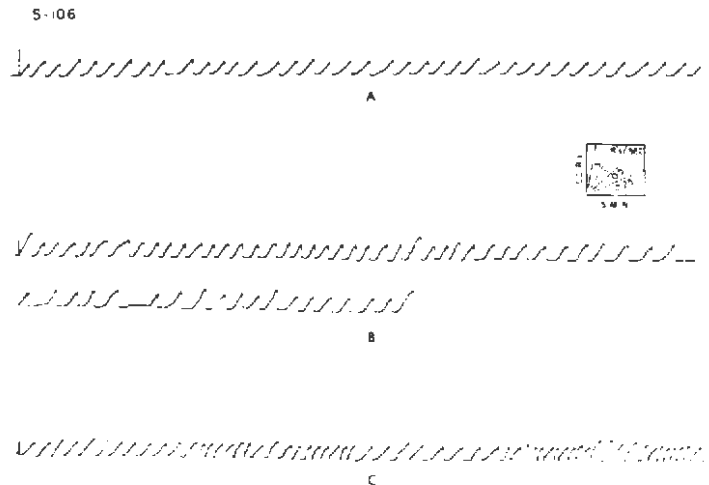


FIGURE 1

Figure 1. Showing various stages in the development of rapid "estimation runs under fixed ratio of 35 with added slow pacing for a bird without any experimental history of reinforcement at fast rates. (A) Initial fixed-ratio performance with pacing at limits 1.5" and 2.0". (B) An intermediate stage under the same condition 18 days after (A). (C) Under the same conditions 2 months after (A).

different from any that had prevailed at the moment of reinforcement during practically the entire history of the bird with respect to the response key of the experimental chamber.

Compare Records A and C in Figure 1 and note that pauses are shorter or have disappeared where the fast runs have developed. Record B is an intermediate record and was taken 18 days after A. It shows an earlier stage of the development of rapid runs.

The results for another bird, S-66, which had been previously exposed to a variable-interval schedule of reinforcement, are represented in Figure 1-X. Record A reports an entire experimental session under a fixed-ratio schedule of 40 responses with added pacing at limits 1.3 and 1.6 secs. The schedule had just been shifted from a 1-min. variable interval with added pacing. Four days afterwards, runs of approximately the size of the required ratio are already in evidence, as shown in *b* and *c* of Record B of Figure 1-X. It should be noted in this record that instead of an initial run at a fast rate followed by paced responding, the pigeon starts with a pacing rate and then bursts into a fast run at about the completion of the ratio count required by the schedule. This is shown in *a* and *d* of this same Record B (Figure 1-X). As a result, the bird's performance at this point becomes incompatible with the pacing condition. The bird executes another run approxi-

S-56

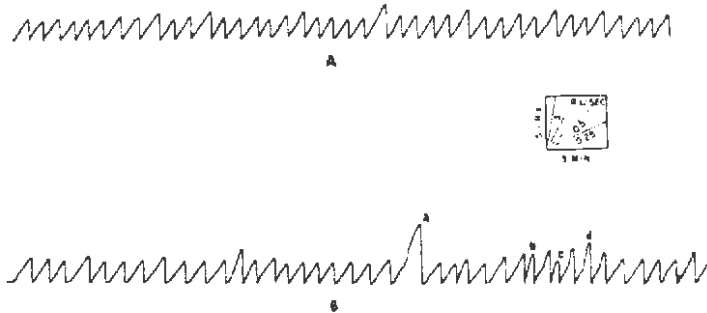


FIGURE 1-X

Figure 1-X. Showing the development of fixed-ratio "estimation" runs under moderately slow pacing conditions for a bird with an extensive history of variable-interval reinforcement. (A) Initial responding at fixed-ratio schedule of 40 with pacing at limits 1.3" and 1.6". (B) 4 days after (A). Note: how the ratio is "measured" either by a rapid run, *b* and *c*, or in terms of pacing run, *a* and *d*.

mately equal in magnitude to the required ratio value before it settles down to a pacing rate for which it gets reinforced. The absence of pauses after reinforcement in Figure 1-X at A should be noted. It is characteristic of birds that have had a prolonged history of variable-interval responding that this pause should be absent when the pacing condition which is introduced is at moderately slow rate limits.

S-105 was an exact duplicate of S-106 as to history and control conditions. Records of a typical performance are shown in Figure 2: Record A indicates a relatively even responding at about 0.6 response per sec. under a fixed ratio of 47 with added pacing. The bird had just been shifted from a 1-min. variable-interval schedule with added pacing. Then in succeeding experimental sessions, progressively longer pauses after reinforcement developed. Part of the record for the 12th day after that of Record A is shown in Figure 2 in B record. *Two days after this the bird simply ceased to respond to the key:* a very important finding!

The foregoing procedure was repeated for a fixed ratio value of 35 with added pacing and the results were similar: on the 17th day *the bird was reinforced only 8 times within a period of 5 hours.*

The procedure was again repeated at a much lower ratio of 20 with added pacing. As indicated in Figure 2 in record C, the bird was able to sustain its responding. This is a typical record of the sessions on the 7th day and thereafter.

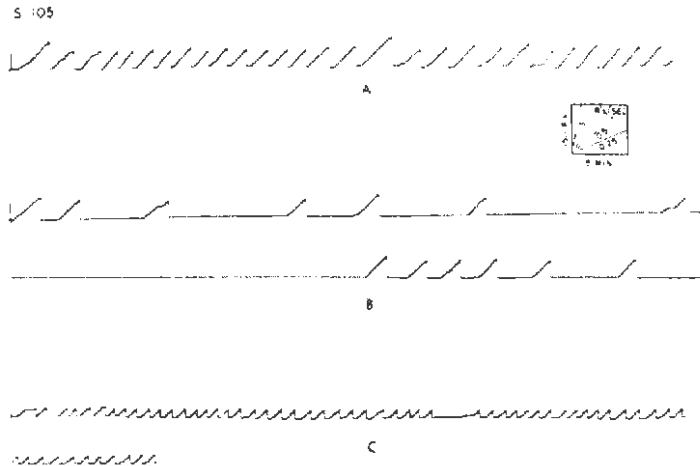


FIGURE 2

Figure 2. The development of very long pauses under a fixed-ratio schedule with slow pacing in a bird without any experimental history of reinforcement for rapid responding.

- (A) Initial responding at fixed ratio of 47 with pacing at limits 1.5" and 2.0"
- (B) 12 days afterwards under the same conditions. In 2 days more after this record, the bird ceased to respond completely.
- (C) Recovery at fixed ratio of 20. Typical performance for 7th day and afterwards.

*Discussion.* Pacing at slow rates was used as a method for assessing the role of what is happening at the time of reinforcement in relation to rapid runs in ratio responding. This method required a controlled history of reinforcement at a specified pacing rate before exposure to a ratio schedule with added pacing. Whatever may be the factors that account for the rapid runs which develop in ratio performance, this experiment demonstrates that they do not, or need not, include the rate at which the bird is reinforced. As indicated in *a* and *d*, Figure 1-X at B, however, progress towards the fixed-ratio value is itself reinforcing.

As will be seen in Experiment B, rapid runs may also occur on a variable-interval schedule with pacing whether or not a bird has had a history of reinforcement at rapid rates. Figure 5 and Figure 6 at C illustrate these rapid rates under pacing. The size of these fast runs are highly variable and may occur after a short pause or after a pacing run. The fast runs in the curves under fixed ratio, however, are distinctly of about the ratio count. The bird "estimates" the ratio under pacing and the variability of the estimate may be of responses occurring at a pacing rate rather than in rapid runs.

Since pacing behavior involves a rather well-defined topography of mediating response, a given number of pacing responses means a well-defined amount of such behavior. As mentioned earlier, the behavior we are speaking of may be regarded as a chain the only reinforced portion of which is the peck at the key. A given pacing

response which gets recorded represents a much greater amount of behavior under pacing than under, fixed-ratio reinforcement without pacing. This chain, therefore, is such as to make the ratio a strenuous requirement, possibly equivalent to a large ratio without pacing. The relatively longer pauses at the end of the ratio curves in this experiment are consistent with this view. However, the restraining factor of pacing at the moment of reinforcement may even be the most formidable element responsible for these longer pauses, since it prevents the organism from entering into a natural gradient in strengthened behavior at the moment of reinforcement, i.e. heightened rates of responding. There would in effect be two sources of the indisposition to respond after completing the ratio: an augmented effortfulness in the performance of what amounts to large ratio requirement and the aversiveness of the task in being prevented from performing at high rates at the moment of reinforcement.

The preceding paragraph applies with special force to the subjects of this experiment that had never been reinforced at rapid rates. One of these birds eventually ceased to respond at a fixed ratio of 47 with added pacing, though the topography of the pacing response was intact up to the last reinforced run.

## Experiment B

### VARIABLE-INTERVAL SCHEDULE OF REINFORCEMENT WITH PACING

*Problem.* The variable-interval schedule, with or without the added pacing condition, was used in the previous experiments as a baseline against which the effects of another variable may be assessed. Variable-interval responding could, however, be treated separately in its own right. The object of the following experiments was to investigate some of the properties of variable-interval performance under pacing conditions at slow rates.

*Procedure.* A direct comparison of variable-interval curves, with and without pacing, where the performance under both conditions develop approximately concurrently, was made by using multiple-schedule techniques. Each of the two schedules was placed under stimulus control: when the bird was on a variable-interval without pacing, the response key was illuminated white; when it was on a variable-interval schedule with pacing, the key was red. One-half of the experimental hour was under one schedule and the second half, under the other. In order to avoid any possible sequence bias in the allocation of the halves of the experimental session, the first half of the hour was assigned to a particular schedule in alternate sessions. In the intervening session it was assigned to the other schedule.

It was necessary to equate the number of reinforcements on the two schedules. This is especially important in a multiple schedule where the *change* from

one condition to the other may give an important difference simply because the density of reinforcements had changed. When there is not such a relatively rapid shift from one schedule to another as in the single-schedule technique which was used in the previous experiments, this question may not be of any significance.

Observations of the prior performance of the birds indicated that by using a 2-min. variable-interval schedule without the pacing condition for comparison against a 1-min. variable-interval schedule with pacing, we could achieve approximately the same number of reinforcements per unit time. We therefore simply ran the motor for the 1-min. variable-interval half as fast as usual in order to get a 2-min. variable-interval schedule. This procedure had the added advantage that no reinforcements in the 2-min. variable-interval schedule without pacing would come closer together than twice the shortest interval on the 1-min. variable-interval schedule. This made some provision, therefore, for the comparison and interpretation of pauses after reinforcement, because in the pacing condition no reinforcement could possibly occur unless the bird had made at least four responses, which necessarily required time.

Preceding this experiment, two birds had undergone an extensive history of variable-interval responding, under pacing conditions and without pacing. The performance of these two birds on the multiple schedule were observed for 18 hours and 11 hours respectively, until a clear-cut difference between the two schedules could be seen. Then the pacing condition was removed and the birds were allowed to run under a 2-min. variable-interval schedule for both red and white keys.

In a second part of the experiment, no use was made of a 2-min. variable-interval schedule in order to equate for number of reinforcements. The subjects were two birds reported in earlier experiments and three others that were used for some other experiments. In these cases, the birds were simply put on a 1-min. variable-interval schedule, allowed to stabilize, then put on a 1-min. variable interval with added pacing, and allowed to stabilize again.

*Results.* Record A in Figure 3 shows a typical record for one of the subjects after 18 hours of exposure to the multiple schedule described above. The first half of this graph shows responding under a 1-min. variable-interval schedule with pacing, the schedule being under control of a red response key. The bird ran at approximately 0.4 response per second with relatively long pauses after reinforcement. The second half of this record is for a 2-min. variable-interval under the control of a white key. A rapid rate of about 2.0 responses per second, which is appropriate to the straight variable-interval schedule, comes out as soon as the color of the key is changed to white. The rate then subsides to a lower rate of about 1.3 responses per second with occasional short runs at approximately the pacing rate, as at *p* and *q*. The pauses after reinforcement in this half of the record have almost disappeared or, at least, are much shorter than in the earlier pacing condition. Figure 3 at B shows the loss of stimulus control with respect to the colors of the key eight hours after the pacing condition was removed. The loss was progressive over this interval of time.

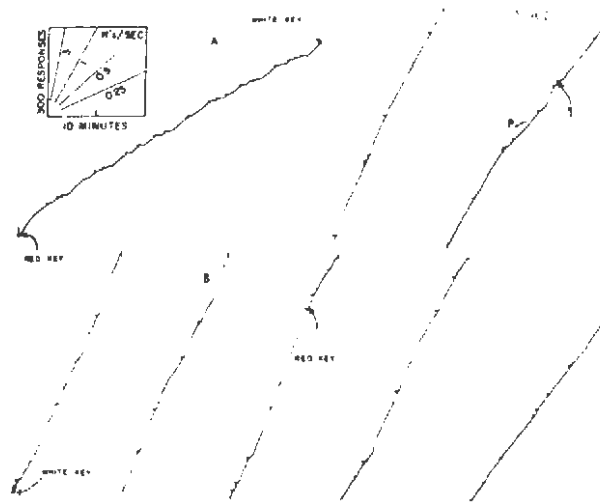


FIGURE 3

Figure 3. (A) Comparison curves for the 18th hour of a multiple schedule where the two parts of the schedule are under stimulus control: *red key* – 1-min. variable interval with pacing (limits at 2.0" and 2.5"); *white key* – 2-min. variable interval only. (B) Showing loss of stimulus control with respect to the key-colors in the multiple schedule on the 8th hour after the bird was put on a straight variable-interval schedule on both red and white.

The other bird's performance is indicated in Figure 4. Record A was taken 11 hours after the multiple schedule was started, and Record B was made 5 hours after the pacing was removed. All observations pertinent to the previous subject with respect to pauses after reinforcement, rate differences, and the occasional appearance of pacing rates under the non-pacing stimulus may also be made here. Note the runs at the pacing rate in the variable-interval schedule, as in *m* in Figure 4, Record A. and *n* in Figure 4, Record B. Before the state of the multiple-schedule in Figures 3 and 4, Record A, is reached, however, there is a relatively brief and occasional appearance of fast runs immediately after a reinforcement while under the pacing condition. This is indicated in Figure 5 in A. After these fast runs, the bird paces at a rate of about 0.5 response per second, which is somewhat higher than that at the stage where the longer pauses have made their appearance — about 0.4 response per second. A somewhat weaker version of this same phenomenon is seen in the curve for the other bird, as shown in Figure 5 in A. After a relatively short pause of about 1 or 2 seconds, there is a brief run of about 5 to 8 responses at a fast rate, after which the bird settles down to a pacing rate. This pacing rate is about 0.5 response per second and is again higher than that in Figure 3, record A, where, after a long pause, the rate is of the order of 0.4 response per second. It is left an open question at this point whether, where the pauses are short under

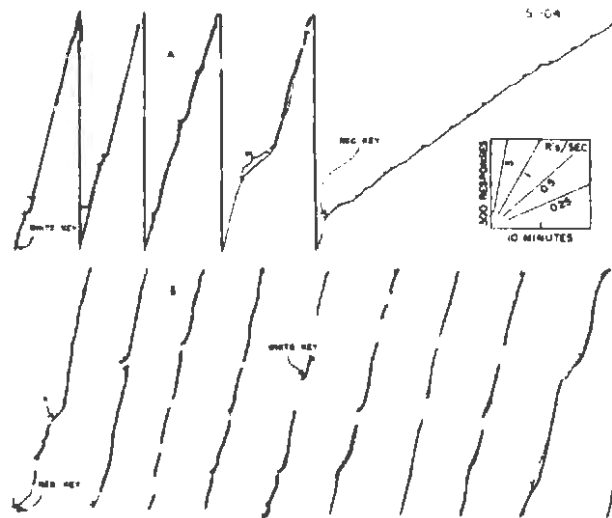


FIGURE 4

Figure 4. A set of curves for another bird, S-104, under the same experimental treatment as that of S-102 in Figure 3.

the pacing condition, the runs are inductive effects from the variable-interval part of the multiple schedule.

We may now examine the results of the single-schedule technique, where the birds were allowed to stabilize on a 1-min. variable-interval schedule with added pacing. Five subjects used earlier in this study were subjected to this procedure for some purpose or other and all gave uniform results at stable states. A typical curve is shown in Figure 6, Record B. The responding is even, the pauses after reinforcement are quite marked, and the rate is the reinforced pacing rate. S-102 and S-104, which had been exposed previously to variable-interval contingencies, where there was opportunity to develop high rates of responding, show fast runs immediately after reinforcement under an added pacing condition. Figure 6, Record A, and 6, Record C show examples of this kind of run about 5 days after the birds were first subjected to the variable-interval reinforcement schedule with added pacing.

These fast runs under a pacing condition are not confined to occasions where a short pause follows a reinforcement. They may occur while the bird has begun slow pacing — “breaking through” the paced responding, as it were. This is shown in *a* and *b* of Figure 6, Record D, for two different birds. Curiously enough S-149 for the curve in Figure 6, Record D, had never had any history of reinforcement at high rates prior to this “breaking through”.

*Discussion.* Pauses after reinforcement under a variable-interval schedule with added pacing are markedly longer than those of the control situation where the



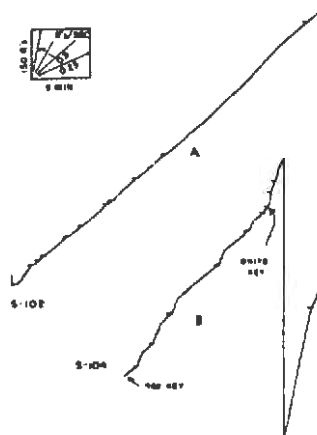


FIGURE 5

Figure 5. Showing rapid runs after a short pause following reinforcement before going down to a pacing rate, for birds under multiple-schedule procedure. (A) shows this effect only occasionally and in weak form. The stronger version is in (B) for that part of the curve on the red key.

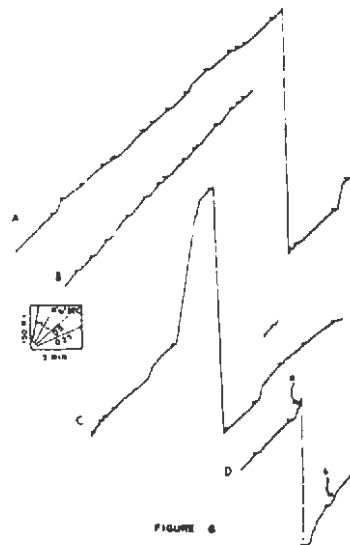


FIGURE 6

Figure 6. Variable-interval curves under slow pacing conditions obtained from different birds with the single-schedule technique. (A) and (C) show rapid runs after a short pause following reinforcement for S-102 and S-104, respectively. (B) shows a stable performance curve under 1-min. variable-interval schedule with slow pacing. Note the longer pauses. (S-149). (D) shows an example of "breaking through" at a fast rate from a pacing run (S-149).

pacing is absent. Steps were taken to rule out the possibility that such a difference might depend on the number of responses that have to be emitted before reinforcement. If, by making only one or two responses since the last reinforcement, another reinforcement occurs, as in the usual variable-interval schedule, then the bird is necessarily in a different situation in terms of this number from that in the pacing condition where the bird has to emit at least four responses before reinforcement. Since the only difference in the two parts of the multiple schedule was the pacing condition, the longer pauses in the variable interval with pacing must be due solely to this difference. The possibility of color preference is excluded by the fact that the birds on a straight variable-interval schedule alternately on red and white keys gave the same rates of responding on both colors, with identical characteristics of the curves immediately after reinforcement.

The above findings have its analogues in the preceding experiments on a fixed-ratio schedule with pacing, where the pauses are very much longer than those which hold for an equivalent straight ratio performance. The result also recalls the case of paced fixed-ratio responding at a ratio value of 47, where the bird progressively developed longer and longer breaks until it ceased to respond. These converging lines of evidence point to the possible aversive character of slow paced-behavior. Since there were no aversive stimuli in the external environment of the subject under the pacing condition, the aversive stimulus must have been the organism's own behavior.

The fact that a bird which has had no history of reinforcement at fast rates still shows rapid runs, i.e. "breaking through" the pacing, may similarly indicate that running at a preferred rate removes the organism from an aversive condition. These fast runs under a variable-interval schedule with slow pacing could not have been due to what had happened just before and at the moment of reinforcement because the rate at the moment of reinforcement was controlled at slow rates. Neither could it have been the immediate effect of a reinforcement since the run come only either after a short pause or after pacing had been started. Another possibility, of course, might lie in the pre-experimental history of the organism. But even if this were true, the argument is not in any way diminished under the circumstances.

It is significant that the presence of fast runs in fixed ratio with pacing is correlated with relatively shorter pauses or absence of pausing. In the variable-interval with pacing, fast runs are also accompanied by shorter pauses after reinforcement. Where there are no rapid runs the pauses are longer.

### Summary and Conclusions

(1) The slow pacing technique applied to the study of fixed-ratio schedules shows that rapid rates may occur in fixed-ratio responding although the bird has never had any experimental history of reinforcement at such high rates. It is in-

ferred that progress towards the fixed ratio value may be reinforcing and leads to such rapid rates as are not accounted for in terms of the usual ratio "end effect".

Furthermore, a relatively accurate estimation of the value of the ratio is found to be possible either in executing a slow pacing run or a rapid run. This "estimation" behavior of the pigeon in fixed-ratio responding, therefore, does not depend upon the rate at which it is running.

(2) The performance under a variable-interval schedule with slow pacing shows: (a) Relatively longer pauses after reinforcement than a control performance with no pacing. It was shown that these longer pauses were not due to the absence of a quick reinforcement since the last reinforced response. They are, it is suggested, due to the possible aversive character of slow-pacing behavior. (b) "Breaking through" at a rapid rate after a pacing run or, at some brief transitional stage, a rapid run after short pause, which are not explained in terms of progress towards a count as in the case of the fixed ratio with pacing.

(3) In both variable-interval and fixed-ratio schedules with pacing, fast runs are correlated with shorter pauses after reinforcement or with the absence of pauses. When there are no rapid runs after reinforcement, the pauses are relatively longer. Again, the possibility that pacing behavior has aversive properties may explain this. This also confirms (2) above.

### A BRIEF RETROSPECTIVE ON A FEATURE OF THE EXPERIMENTAL RESULTS

The foregoing experiments, while difficult of execution and instrumentation, were rather simple and straightforward in design and in answering some questions in the laboratory investigation of contingencies of reinforcement, with special reference to what is happening to the organism at the moment of reinforcement. The experiments tried to tease out the concept of "ratio end effect" and to throw some light on the capacity of the organism to estimate counts without actually counting, as part of the general problem of the organism effort at all times to maximize the results of its behavior.

However, there were results that were quite unexpected during the experiments, which were not really part of the original project. The most fundamental of these was that a slow-pacing contingency, as here defined, had repeatedly demonstrated its aversive character: when an animal is prevented running at optimum rates under the very strict conditions of pacing, even if the task be as simple as executing a ratio of less than 50 responses, the organism will develop a strong indisposition to respond. Almost like a profound extinction process seem to be set in motion, or that some aversive condition is generated in behavior of the animal itself such that the organism would rather starve than engage in paced behavior.

There are suitable analogues to this type of situation in human behavior, such

as that of an aspiring writer who has all the elementary skills for turning out a good paper but who is kept from achieving a satisfactory output because of a self-imposed criteria of excellence that makes his task extremely difficult.

There are all manner of procedures for suppressing, depressing or, in general, weakening any given behavior such as electric shock, verbal punishment, making tasks more physically effortful, and so forth, but a method that merely requires a much higher degree of precision in responding could be just as effective in knocking out the behavior. A pacing requirement is something of this method, with the added feature that a reinforcement is automatically more and more delayed if the individual manifests any behavior that denotes enthusiasm. The gradually lengthening pauses after such small ratios with the pacing requirement reminds us of profound extinction effects that go with extremely large ratios that are required for reinforcement.

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### F.G. David, Discussant

On the whole, the empirical finding in the two experiments, reported by Dr. Lagnay, included the following: A) Added to a stable, fixed ratio (FR) or reinforcement, wherein the ratio was about 35 responses per one instance of reinforcement, a pacing schedule of 1.5-2.0 responses per second induced (a) the disappearance of the ratio "end-effect", which is characterized by a rapid increase in the rate of responding just immediately before reinforcement, (b) the decrease or disappearance of the characteristic pauses just immediately after reinforcement, and (c) induced the appearance of "fast runs" or rapid rate of responding, especially at intervals where pauses would have occurred or immediately after the periods of pacing. B) Added to a high ratio of FR-47, the pacing schedule induced the disappearance of responding altogether. (Responding was restored only when the ratio was reduced to FR-20.) And C) In a tandem of two concurrent variable interval schedules of reinforcement (VI), for which the average interval per instance of reinforcement was 1.0 minute for one schedule, and 2.0 minutes for the other schedule, and in which each of the schedules was under a distinct stimulus control — red response-key for the VI-1.0 minute and white for the VI-2.0 minutes —, the pacing added to the VI-1.0 minute induced the appearance of pauses immediately after reinforcement and the over-all decrease in the response rate. Complementarily, under the VI-2.0 minutes, to which pacing was not added, there appeared a compensatory appearance to "fast runs" of responding and an over-all increase in response rate.

In consideration of the empirical finding, Dr. Lagnay raised the thought and explication that A) the addition of a pacing schedule provided a test, which showed, more obviously, that the experimental animals, or pigeons in the study, could "estimate" or "count" ratios or the passage of time; and B) the addition of the pacing schedule increased the work-demand on the animals, so much that the response-characteristic, that was required, was by itself aversive. One particular basis for this explication was the cessation of responding of the bird which was put under a demanding schedule of a high FR-47, which was coupled with a pacing schedule.

While the two experiments in the study only dealt with a small sample of five pigeons, the empirical finding appeared to be firm enough. Despite all this, one can raise certain obvious weakness of an "own-control" experimental design, especially pertaining only to a very limited sample. An "own-control" design can not account for the variance due to individual differences; more so, if the experimental subjects are not looked at as a block and nuisance factor. This objection is not a mere matter of one's being bothered about a lack of experimental-design or statistical elegance. It is pretty substantive, particularly in respect to contemporary pieces of evidence, obtained even in fairly radical "Skinnerian" laboratories, predisposed to hold a mechanistic, reductionistic view of reality, physical or behavioral and biological, that individual difference is significant even among common, experimental

animals. In this light, the singular case of the pigeon subject to the FR-47 plus a pacing schedule, the case for the explication of effortfulness or aversiveness, might just be unique to the bird in question. Of course, this objection is a matter of empirical debate, and it can be dealt with, without difficulty, by means of a replication of the case with many more pigeons, under similar regiment of experimental conditions.

And concerning the facts of "fast runs", which appeared to be tied up to the compensatory release from the pauses and pacing effects, one wonders whether or not these kinds of effects can be obtained with any type of responses. May it be that this so-called pacing effects are unique to the response of pecking in the bird? May it be that the whole matter is a case for so-called species-specific behavior? May it be that pecking follows a "tempo", such as that attributed to the effects of the related studies of Gilbert. Works by Robert Bolles and by Gilbert on species-specific responses and on "tempo" in pigeons' pecking are crucial for consideration, therefore, of the case for the effects of pacing.

Finally, one must note, especially in connection with the second experiment by Dr. Lagmay, that response-rate under a tandem of two or more concurrent schedules of variable interval has been shown quantitatively to be proportional to the rate of reinforcement. Herrnstein, a contemporary of Dr. Lagmay at the Harvard Laboratory, has worked on an elegant and well-confirmed quantitative analysis of the law of effects. The said law is expressed in a non-formidable equation. The point, in connection with the paper now under discussion anyhow, is that the effects, obtained in the experiments, need not be looked at as an admirable case for the ability of pigeons to "estimate" schedules, as they may be mere mechanical matching of probabilities. For, indeed, if the pigeons can "estimate" response requirements relative to reinforcement rate, why do they have to emit many responses at a steady rate, under the VI schedule, when all that is required is either a single response at the lapse of the average interval or a few responses in accordance with the pacing limitation? Maybe the principle of parsimony must be invoked here, that the more complex explication of "estimation" is unnecessary, inasmuch as the matter can be accounted for in terms of a simpler concept of matching probabilities, as well as of "tempo."

## **AN ASSESSMENT STUDY ON THE SEA VEGETABLE POTENTIALS IN PANAY ISLAND WITH EMPHASIS ON *CAULERPA PELTATA* VAR. *MACRODISCA***

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### **Introduction**

This paper contains a brief resume of some major results of an on-going study designed to assess the sea vegetable potentials of Panay Island with special treatment on *Caulerpa peltata* var. *macrodisca*.

The increasing need to utilize algae for human consumption or industrial purposes constitutes the bare justification for a concentration of efforts on surveys of resources and in particular, the productivity and quantitative assessment of the standing crop.

To date there has been no attempt to assess the seaweed potential in the Philippines. There is a dearth of reports along this line to be used as base-line data for future plans to assess the quantity of seaweeds specifically sea vegetables — important marine resource found in Philippine waters. There are major steps in realizing a seaweed potential in the Philippines such as:

- 1) To identify the kinds, abundance, and commercial values;
- 2) To introduce production, with sustained support by government and private sectors;
- 3) To utilize wild crops and to eventually farm certain commercial species and to sell the product with good profit for all; and
- 4) To assure a satisfactory life style to the farmer producers, whose product should continue to be valuable to the end users.

The desire to implement these steps has been the aim of an on-going project financed by the National Research Council of the Philippines. The present project, opted to limit the scope of work as to assess the sea vegetable potentials of Panay Island, Central Philippines.

### **Methodology**

Started in 1982, the NRCP project research team launched a series of surveys and sampling collections conducted in the four member-provinces of Panay Island namely, Aklan, Antique, Capiz and Iloilo. Data gathered show the presence of



several edible species of green, brown and red seaweeds otherwise known as sea vegetables. Ironically, most of these species are unknown as human food to the inhabitants in contrast to their popularity and acceptability as food by the Ilokans. Of these, the more noteworthy and popular to the island's inhabitants is *Caulerpa peltata* var. *macrodisca*, a green alga locally known as "laba-laba" (Ilongo/Hiligaynon) or "Eaba-eaba" (Aklanon).

One of the objectives of the project is to culture *C. peltata* var. *macrodisca* in experimental pond — a step towards possible mass production later.

*C. peltata* var. *macrodisca* used to abound, harvested and marketed locally from the Tinagong Dagat, New Washington, Aklan. This sea vegetable, however, disappeared mysteriously from the area in the late sixties. The people of New Washington attribute the disappearance of "laba-laba" to the wanton use of synthetic chemicals to exterminate weeds and predators from bangus and sugpo fish ponds. The disappearance coincided with the proliferation of the fishponds along the periphery of Tinagong Dagat in the sixties.

The present supply of "laba-laba" offered for sale in the market comes from Iloilo. The specific area or habitat of the sea vegetable was later traced to be the municipal waters of Estancia, following a series of snorkelling and scuba-diving in the island.

#### *Morphological and Ecological Notes*

Morphologically, *C. peltata* var. *macrodisca* is composed of prostrate creeping rhizome-like portion from which small rhizoidal structure arise on the lower side and erect branches of complex and variable form arise from the upper side. These branches bear peltate or disc-shaped branchlets/ramuli 10-12-15-mm in diameter, irregularly alternate, rarely whorled.

Wild growths of "laba-laba" in Estancia are found at depths ranging from the intertidal to 10 meters in areas of low salinity (brackish or estuarine), low pH and moderate water movement. Populations found intertidally show that reproductive structures are prominent during most part of the year, excepting the summer months from March to early June. In summer, pH, salinity and surface water temperature are relatively high and these prove to be deterrents to the plant growth. Mechanical breakage or injuries inflicted during harvest time cause death on that part of the plant. However, new shoots originating from the stolen show no marked seasonal periodicity. Large and thick growths of *C. peltata* var. *macrodisca* are noticeable during the cooler months from August until January of the following year.

Observations on wild *C. peltata* var. *macrodisca* in Estancia, Iloilo suggest that growth rates vary with season. Pulling or pruning, two common practices of harvesting labalaba, deprives the plant from regenerating any re-growth. Juvenile recruitment from asexually produced reproductive bodies was primarily within the one meter radius of the parent plant arranged irregularly.

### Mari-Culture of *C. Peltata* Var. *Macrodisca*

Few edible species under genus *Caulerpa* reaching the Manila markets come from Pangasinan and Cebu provinces. Of the two sources, Cebu appears able to supply *Caulerpa*, mostly *C. lentillifera*, rather regularly. The source of the *Caulerpa* comes from the culture ponds in Mactan Island. However, said supply of *Caulerpa* from Cebu will be greatly affected because the culture ponds are on the verge of being demolished. The Export Processing Zone Authority (EPZA) based in Mactan Island has programmed to establish an industrial complex that will eat up parcels of *Caulerpa* culture ponds in the Island.

Full implementation of the EPZA plan is anticipated to produce two adverse effects. Firstly, it will mark an end to the supply of *Caulerpa*; and secondly, it will cause socio-economic dislocation among the sea vegetable farmers dependent on *Caulerpa* for their daily sustenance. With the bleak picture of this important sea vegetable it was necessary to fish for possible remedies.

#### Projections

This situation paved the way to the timely implementation of the present NRCP financed project. The project is designed to survey, explore and inventory areas positive to *Caulerpa* and other sea vegetables. One area thought of was Panay Island found rich in sea vegetables. Of the species collected, *C. peltata* var. *macrodisca* was chosen to be test cultured. The plan is to transport stocks of wild *C. peltata* var. *macrodisca* to the experimental pond constructed in the vicinity of the National Museum Bio-Research Station (NMBRS) located at the coastal Barangay of Jawili, Tangalan, Aklan. Ecological parameters such as pH, salinity, water temperature will be monitored daily.

The success of the experimental *Caulerpa* culture is expected to produce the following impacts:

- (1) Re-introduction of *Caulerpa peltata* var. *macrodisca* to Tinagong Dagat, New Washington.
- (2) Transfer of culture technology to the local farmers.
- (3) Involvement of the local government by converting the project into another source of livelihood for the masses.
- (4) Mass-production of *C. peltata* var. *macrodisca* and selling the product to consumers in Manila and other cities. This should augment the production and supply of *Caulerpa* coming from Mactan Island.



Magdalena C. Cantoria, Discussant

Sea vegetables are popular as food among the Ilocanos and it is surprising to learn that many of these plants are unknown in other parts of the country, even to people living near the sea.

Within the last two decades or so, some of these sea vegetables which were unknown in other parts of the country, even to people living near the sea.

Within the last two decades or so, some of these sea vegetables which were unknown previously in Manila markets became available. Prior to that time, only gulaman dagat from Manila Bay was what was sold. With improved transportation facilities, it became possible to find such sea vegetables like *Caulerpa* and *Codium* in the Greater Manila area and even non-Ilocanos became familiar with "ar-arosip" and "pu-pulo". Dr. Cordero tells us that the caulerpa found in Manila markets comes from Pangasinan and Cebu.

"Laba-laba" or "eaba-eaba", which Dr. Cordero has chosen as test plant, must be a delicacy to have become popular in Panay, where sea vegetables are little appreciated as food for man. It must be popular enough to warrant its being harvested in and marketed from Tinagong Dagat, New Washington, Aklan. With the disappearance of the plant from this area in the late sixties, the supply of this sea vegetable now comes from Iloilo. This means that there is still a local demand for the plant, sufficient enough to make it worthwhile to investigate the possibility of its being cultivated.

Should the project of Dr. Cordero yield the expected outputs, it will be possible to grow laba-laba on a commercial scale in the Aklan region to meet local demands in that region and to augment the supply in the Manila market.

It appears that once the indigenous culture technology is known and firmly established on the basis of the research findings of Dr. Cordero, it will be possible to present the cultivation of laba-laba as a KKK project in Aklan. The project can be utilized for rural development, with proper government support and supervision. A future research program will be directed toward the development of an improved technology which will also include other sea vegetables so that, hopefully, the Philippines may enter the international market.

The conversion of long-established food-producing areas to industrial complexes is a common occurrence in modern society and this change can not be averted. That the caulerpa culture ponds in Mactan Island in Cebu will be sacrificed for the expansion of the Export Processing Zone Authority will probably redound to the ultimate advantage of the country in terms of helping our economy. Our leaders foresee an increase in export products and an increase in job opportunities for people in the area. To us biologists, the picture is indeed bleak. We foresee

pollution of the bodies of water around the area, including the existing caulerpa ponds, and the destructive effects on marine life in the vicinity. Our role is being defined in a way for us by Dr. Cordero and this is to find means to grow these endangered marine species in some other localities if we cannot protect them in their present natural habitat. Dr. Cordero is to be commended for doing his part and devoting his expertise to the conservation and development of our sea vegetables, one of our valuable marine resources.

## A COMPARATIVE STUDY ON THE CAGE CULTURE OF *TILAPIA NILOTICA* AND *TILAPIA NILOTICA* x *TILAPIA AUREA* HYBRID IN LAGUNA DE BAY\*

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### ABSTRACT

Fingerlings of purebred *Tilapia nilotica* and hybrid male *T. nilotica* x female *T. aurea* were stocked in net cages at 25/m<sup>2</sup> and cultured for 16 weeks, without supplemental feeding, in the Los Baños area of Laguna de Bay from November to March. The mean weights, survival rates and sex ratios of the fishes were evaluated. Results showed that the hybrid grew faster than the purebred. Survival rate and percentage male of the hybrid were also higher than those of the purebred.

### Introduction

The cage culture of tilapia has developed into a major industry in Laguna de Bay, the largest lake in the Philippines. In 1981, an estimated 1,000 hectares of small pens and cages were devoted to tilapia culture in the Lake (Pullin, 1981). The species of tilapia commonly cultured in cages is the Nile tilapia (*Tilapia nilotica*). There are reports of stunted fish growth, attributed to inbreeding depression in some cage farms (Anon., 1982).

Bautista *et al.* (1981) conducted a study on the cage culture of the hybrid male *T. aurea* x female *T. nilotica* and the reciprocal cross in Laguna de Bay. They found the hybrid of male *T. nilotica* and female *T. aurea* to have grown significantly faster than the hybrid of the reciprocal cross. The former hybrid was 94% male while the latter was 73% male.

In Central Luzon pond experiments, Abella (1982) found the hybrid of male *T. aurea* and female *T. nilotica* superior to the pureline of *T. nilotica* in terms of growth performance. Male percentages of the male *T. aurea* x female *T. nilotica* and male *T. nilotica* x female *T. aurea* hybrids were 66% and 80%, respectively.

This study was conducted at the Los Baños area of Laguna de Bay to compare the growth, survival and percentage male of *Tilapia nilotica* and the male *T. nilotica* x female *T. aurea* hybrid in cages. The study was done from November, 1982 to March, 1983.

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Table 1. Mean weight, percent survival and percent male of *Tilapia nilotica* and *Tilapia nilotica* x *Tilapia aurea* hybrid cultured in cages for 16 weeks.

Species	Mean Wt. (g)	% Survival	% Male
<i>Tilapia nilotica</i>	25.4	83	54
<i>Tilapia nilotica</i> x <i>Tilapia aurea</i>	30.8	98	66

Note: Figures are means of three replicates.

### Materials and Methods

Six net cages, each with dimensions of 2 x 2 x 2.5 m, suspended from bamboo rafts were used in the study. Mesh size of the cage net was 6 mm. The net cages were covered to prevent fish escape. When installed, the cages were about a meter above the lake substratum.

Fingerlings of *T. nilotica* and the hybrid, with mean weights of 2.0 g and 2.7 g respectively, were obtained from private hatcheries in Laguna de Bay. Each cage was stocked with 100 fingerlings (25/m<sup>2</sup>). Three cages (replicates) were stocked with *T. nilotica* and the other three with the hybrid. No supplemental feeds were given to the fishes. Sampling of fish in each cage was done every two weeks to measure mean weights. After 16 weeks of culture, survival rates and sex ratios of the fishes were determined.

### Results and Discussion

The results of the study (Table 1) showed that the hybrid tilapia had better growth than *T. nilotica*. Survival rate and percentage male of the hybrid were also higher than those of the purebred.

The superior growth of tilapia hybrids over the parent stocks has been reported by several workers. Hickling (1968) noted that all-male offspring of female *T. mossambica* and male *T. hornorum* grew faster than either parent. The growth rate of the hybrid female *T. mossambica* x male *T. nilotica* was found by Kuo (1969) to be better than that of the reciprocal hybrid. Pruginin (1967) reported that the all-male hybrid produced by crossing female *T. nilotica* and male *T. hornorum* grew 30% faster than *T. nilotica* and 40% faster than *T. hornorum*.

The faster growth of tilapia hybrids over their parent stocks may be partly explained by the higher percentage of male in the former. In most tilapia species, the male grows faster than the female. This phenomenon is believed to be genetically controlled (Fryer and Iles, 1972).

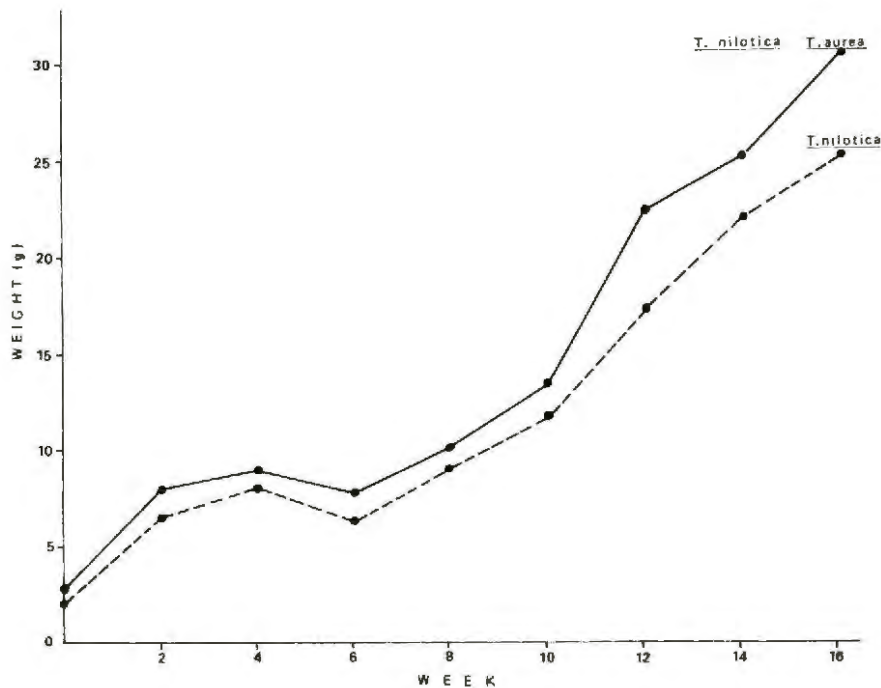


Figure 1. Growth curves of *Tilapia nilotica* and *Tilapia nilotica* x *Tilapia aurea* hybrid cultured in cages for 16 weeks.

The percentage male of the hybrid tested in this study was lower than those reported by Bautista *et al.* (1981) and Abella (1982). This discrepancy may be due to the different *T. nilotica* strains used. At least two strains of *T. nilotica* have been introduced to the Philippines. These are the Egyptian and Ghanaian strains. According to Mires (personal communication), the Ghanaian strain gives higher percentages of male in hybrid crosses than other strains. It is interesting to note, however, that in Philippine tilapia hybridization studies (Bautista *et al.*, 1981; Abella, 1982) the crossing of female *T. aurea* and male *T. nilotica* yields a higher percentage of male in the progeny than the reciprocal cross.

The generally slow growth of the experimental fishes in this study may be attributed to the cold season and low productivity of the lake during the first 10 weeks (Figure 1). Plankton production is relatively low in Laguna de Bay from November to April (Bhent, 1981). The water temperature in the Los Baños area ranged from 23.5 to 27.5°C in November to January.



### Acknowledgement

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### **Tereso A. Abella, Discussant**

We have also conducted similar studies on the evaluation of the growth performance and survival of different tilapia species/strains at the Freshwater Aquaculture Center in ponds and in cages. Most of the results of our studies here have shown the superiority of the hybrid over the purebred. This similar finding with Dr. Guerrero's study could be attributed to the hybrid vigor which has resulted to increased growth rate of the hybrid over their parents.

I am suggesting that a similar study be conducted during the warmer months of the year because temperature has a significant effect on the primary productivity of the lake which somehow have affected the total fish production in the study. This follow-up study may also determine the efficiency of the experimental fish in utilizing the predominant species of phytoplankton during this period.

Although it was observed in the study that the hybrid grew faster than the purebred it was not statistically reported whether the result was significant or not.

### **Antonio M. Bautista, Discussant**

1. Based on the result of the experiment, the bigger experimental fingerlings (hybrid) remained bigger from the start until the termination of the study. Although the initial difference is only 0.7 g., the hybrid is about 74 per cent larger than the purebred. However, it is really very difficult to get experimental animals that are uniform in size. Some workers use co-variance to analyze their data to avoid bias.

2. To produce all male hybrids, parent stocks, whether Ghanaian or Egyptian strain should be progeny tested. In progeny testing, a series of crosses between female *T. nilotica* and male *T. aurea* should be made to select those that produce all male progenies. Simultaneously, a series of reciprocal crosses are made followed by broodstock production and finally multiple spawn to validate the procedure.

3. As in our experiment on the reciprocal crosses of *T. aurea* and *T. nilotica* (1981), the higher the number of males the greater was the average weight per fish. The same result was obtained in this paper. As we all know, the males reached as high as twice the size of the female.

4. The growth rate and survival are influenced by two factors, the environment and genetic make of the fish. Slow growth rate and reduced percentage of survival could be attributed to the inbreeding depression.



# **CHEMISTRY**



## PROJECTIONS ON THE COCONUT AS A SOURCE OF LIQUID FUEL

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### ABSTRACT

Diesel fuel demand in billion nuts equivalent is  $D=24 + 1.13t$ ; coconut supply increase over present, is  $S=0.323 Nt$  ( $N$  = No. of nuts increase/palm-year). For  $N=12$ , equality of  $S=D$  is calculated to be achieved in 8.7 years and will hold for 10 years. If aim is only to take care of annual increase in demand (1.13 billion nuts), then only  $N=3.5$  is needed. To meet one-half diesel fuel demand,  $D=12+0.565t$ ;  $S=D$  in 16.5 years when  $N=4$ . Equality  $S=D$  can be maintained for 42 years.

### Introduction

It has been repeatedly demonstrated that coconut oil is a satisfactory diesel substitute (2).

This study seeks to determine, how much reliance can be placed on the supply of coconut oil as a replacement of diesel fuel. The Philippines in a normal year has a crop of about 12 billion nuts gathered from 323 million bearing coconut palms. (7) The possibility that the crop can match a growing fuel demand without increasing the number of palms, and without touching the present crop is based on the demonstrated performance of palms to yield over 150 nuts/palm-year, (4,8) in contrast to present average of only about 40. With such a fourfold performance, there is reason to expect much from the coconut as a liquid motor fuel supply. It must be recognized, however, that there are certain limitations. The palm produces nuts in bunches, about 12 in a year; the number of nuts in a bunch has an observed limit, generally about 15 (180 nuts/palm-year).

*The diesel fuel demand.* One estimate of the national diesel fuel demand was 18.2 million barrels (1981) (5) and with a growth rate of about 1.0 million barrels per year. Since coconut oil from one nut (0.147 kg) has an energy of 5.56MJ (1) and one bbl is equivalent to 6275 MJ (1.5 million Kcal) (3.6) hence,

$$1 \text{ bbl} = 1130 \text{ coconuts}$$

By the year 1984, the diesel fuel demand therefore would be  $D=1130 (21.2 + 1.0t)$  in million nuts and where  $t$  is in years or

$$D = 24 + 1.13t \text{ in billion nuts}$$

*Meeting the full diesel fuel demand.* If the present coconut palms (323 million) are to supply fuel in addition to normal usage, then the yield of nuts must

Table 1. Relation of nut increase N, to time in years when supply equal demand.

<i>N, nuts/year</i>	12	10	8	7	6
<i>t, years</i>	8.7	11.4	16.5	21.2	29.7
<i>Nt+40</i>	145	154	172	188	218

be increased correspondingly. The increase, above the present 12 billion nuts harvest, would be given by the fuel supply equation:

$$S = 0.323 \times Nt \text{ in billion nuts}$$

$$N = \text{increase in no. of nuts per palm per year}$$

$$t = \text{time in years.}$$

The diesel fuel demand estimate (starting in 1984) as given earlier is  $D=24 + 1.13t$  in billion nuts. For supply to overtake demand, S should equal D and hence:

$$0.323 Nt = 24 + 1.13t$$

$$\text{and } t = \frac{24}{(0.323 N - 1.13)} \quad (\text{Equation 1})$$

Values of N must now be supplied and can range only from 1.0 to 12, i.e. the nut bunch size (12 bunches a year) has been observed to normally not exceed 15, and present bunch size is already about 3.

Supposing now, that by intensive R and D, we will be able to increase the number of nuts per bunch by just one nut and therefore  $N=12$  nuts/palm-year.

Solving for  $t = 8.74$  years.

Coconut supply can equal coconuts needed for diesel fuel demand in 8.74 years if nut yield can be increased from present 40 nuts/palm-year, by 12 nuts per palm per year for 8.74 years. The size of increase is quite large and is probably unattainable. Smaller increments in nut yield should therefore be considered, i.e. values of N smaller than 12. Table 1, summarizes results of calculations for t when N is made to vary from 1.0 to 12, in Equation 1. Note that if R and D can increase nut yield by 8 nuts/palm-year, supply can meet diesel fuel demand in 16.5 years.

*Limit of coconut productivity.* The present bearing coconut palms appear to yield normally, a maximum of 15 nuts/bunch or 180 nuts/palm-year. Since current yield is already 40 nuts/palm-year, any nut increase can be no more than 140 nuts/palm-year or  $Nt + 40$  cannot be larger than 180. In table 1, it is seen that when  $N = 7$  (or smaller)  $Nt + 40$  is larger than 180 and thus the natural limit will be exceeded. (figure 1).

In figure 1, the demand line  $D=24 + 1.13t$  intersects the limit of supply line  $S = 0.323 (180-40)$  at  $t=18.7$  years. Beyond 18.7 years, demand outstrips supply permanently (if the 180 nut limit holds true).

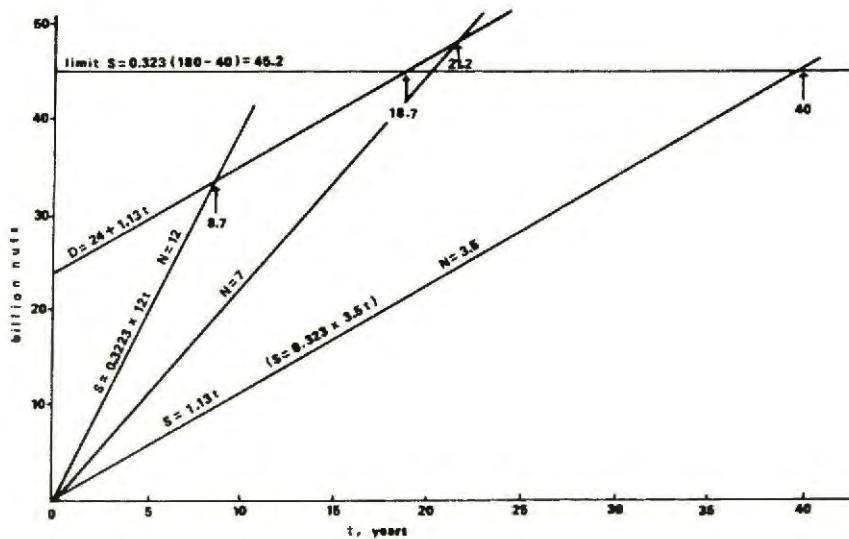


Figure 1. A projection of diesel fuel demand  $D$  and coconut supply  $S$  from 0.323 billion palms which are to increase nut yield by 12 nuts/palm-year.

*Meeting a fraction of the diesel fuel demand.* Instead of trying to meet the full diesel fuel demand, it may be more realistic to survey for possibility of satisfying only a fraction of this fuel demand, say  $3/4$ , or  $1/2$  or  $1/4$ . Calculations for  $t$  may then be made for varying assigned values of  $N$ . The working equations are:

$$\begin{aligned} \text{for } 1/4 \text{ demand, } D_{1/4} &= 6 + 0.2825 t = 0.323 N t \\ 1/2 \text{ demand, } D_{1/2} &= 12 + 0.565 t = 0.323 N t \\ 3/4 \text{ demand, } D_{3/4} &= 18 + 0.8475 t = 0.323 N t \end{aligned}$$

The calculated values of  $t$  are given in table 2. It is in this table that for  $N=4$ , the coconut palms will be able to satisfy one-half of diesel fuel demand in 16.5 years, effective for  $58.7 - 16.5 = 42$  years. (figure 2) An increase of only 2 units/palm-year ( $N=2$ ) will be enough to raise enough coconuts to meet  $1/4$  diesel fuel demand in 16.8 years and will hold good for  $138 - 16.8 = 121$  years. While the premises in this study may not hold true in the distant future, especially the projection on fuel demand, it is nevertheless shown that if given adequate  $R$  and  $D$ , our coconut forests can very well fill a good fraction of our diesel fuel needs.

*How long can coconut supply maintain equality with demand?* While full diesel fuel demand increases by 1.13 billion nuts a year, (assuming linear increase), the coconut supply is limited to a maximum of 180 nuts/palm-year, and from this



Table 2. Number of years for coconut supply to equal diesel fuel demand for full, 3/4, 1/2 and 1/4 of the demand.

<i>N</i>	<i>D</i> (1)	<i>D</i> (3/4)	<i>D</i> (1/2)	<i>D</i> (1/4)
<i>VALUES OF t</i>				
12	8.7	5.9	3.6	—
10	11.4	7.6	4.5 <sup>1</sup>	—
8	16.5	10.4	5.9	—
6	29.7	16.5	8.7	3.6
5	49.5	23.4	11.4	4.5
4	148	40.5	16.5	6.0
3	—	—	—	8.8
2	—	—	—	16.8
1	—	—	—	182

<sup>1</sup>  $1.323 Nt = 12 + 0.565t$  since  $N=10$ ,  $t=4.5$

must be subtracted 40 nuts/palm-year (devoted to current uses). The limit of supply for fuel use is therefore:

$$0.323 (180-40) = 45.2 \text{ billion nuts}$$

and therefore  $24 + 1.13t = 45.2$ ,  $t = 18.7$ . Hence, coconut supply will no longer be able to meet fully the fuel demand, beyond 18.7 years. This is shown graphically in figure 1. (The supply demand situation for one-half diesel fuel demand is described in figure 2).

*Meeting the annual diesel fuel increase.* An alternative to trying to satisfy the diesel fuel demand, is to fulfill only the annual fuel increase, which amounts to 1.13 billion nuts. Since the limit of nut production is here set at 45.2 billion nuts, therefore:

$$1.13t = 45.2 \text{ and } t = 40 \text{ years}$$

Also the rate of increase in the demand should be equal to the rate of increase of the supply and hence:

$$1.13 = 0.323 N \text{ and } N = 3.50$$

Therefore, if by R and D, we can increase nut production by 3.5 nuts/palm-year, our coconut plantations of 323 million bearing palms can take care of the annual diesel fuel increase for 40 years. Graphically this is shown in figure 1. (and in figure 2, in the case of half diesel fuel demand).

### Summary

The coconut can be a major source of diesel fuel substitute in the Philippines if R and D for increased coconut production is instituted very soon. The basis of

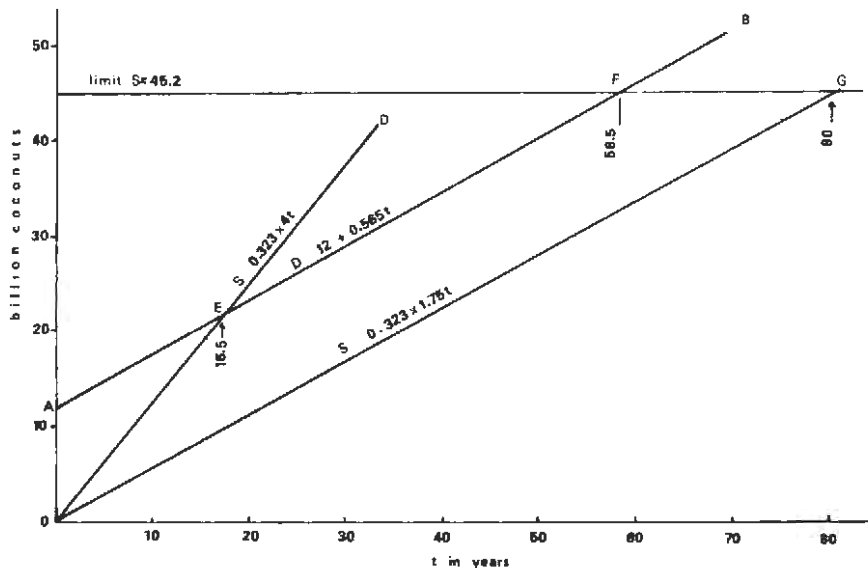


Figure 2. A projection of one-half diesel fuel ( $D\frac{1}{2}$ ) and coconut supply  $S$  from 0.323 billion palms which are to increase nut yield by 4 nuts/palm-year.

this claim is the demonstrated ability of well-cared palms to increase production from the current average of 40 nuts/palm-year to 180 nuts/palm year. Only the increase will be used for diesel fuel; the present crop size will continue to be available for domestic and export purposes.

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### Juan Quesada, Jr., Discussant

One can think up any number of arguments why Dr. Banzon's vision of a world that runs on engines powered by coconut oil is flawed.

*One*, coconut oil isn't just as yet cost-competitive with diesel fuel. It wasn't competitive when the price of crude in the spot market was \$40 a barrel, and certainly not now when there is a glut of petroleum and the price is down to something like \$29/bbl.

*Two*, coconut oil is one of our prime generators of foreign exchange, so any increase in coconut oil production must go abroad to earn dollars — or so runs official thinking in a country that is chronically starved of dollars.

*Three*, there is the issue of food versus fuel, and coconut oil as fuel is bound to lose out to coconut oil as food.

*Four*, is it realistic to say that we can double or treble the yield of our coconut farms? To talk of increased farm productivity is to talk of (1) sound farm management practices to be implemented by — who else? — the poor, semi-literate and exploited farmer or tenant; (2) motivating the absentee landlord to invest in material inputs (fertilizer, irrigation water, pesticide, etc.) and labor inputs; and (3) government policy reforms, which must consider fiscal and financial incentives, removal of structural defects that foster the backwardness of the coconut industry, and the like. All of which is tantamount to asking for the moon.

But in the end Dr. Banzon is correct.

We, who have been brought up on break-even point analysis, cost-benefit approaches, and bottom-line thinking, can ratiocinate no more or no less.

Sooner or later the world will run out of oil, but long before that time any political disturbance in the Persian Gulf may cut off our entire oil supply line from the Middle East. We get three-quarters of our crude requirements from four Arab countries. This overdependence on a few sources is anything but healthy. Our best fallback position is that which we have full control of. Against the day that our filling stations begin to dry up, we should make adequate, painstaking preparations. Increasing dramatically the yield of our coconut farms is not an overnight, or year-long, undertaking. It will take years and years and plenty of resources to reach Dr. Banzon's most modest targets.

This means long-term planning, judicious allocation of our resources, a drastic restructuring of the social organization that has impeded the progress of the coconut industry.

The coconut tree can provide food, fuel and fiber — and many more besides. And Dr. Banzon has been showing the way toward fuller industrial utilization of the coconut in his researches, papers and lectures. It can provide the building block for new industries — from organic chemicals to synthetic fibers and plastic constituents.

The trouble is that the coconut is too common, there's nothing new or novel about it, and it's too near to us to be appreciated. The fault lies not with the coconut but our vision.



## ESSENTIAL OIL OF *DIPTEROCARPUS GRANDIFLORUS* BLANCO: CHEMISTRY AND POSSIBLE SOURCE OF ENERGY\*

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### Introduction

The genus *Dipterocarpus* is of interest commercially because gurjun balsam oil is obtained from one or more of the following species: *Dipterocarpus jourdainii* Pierre; *Dipterocarpus tuberculatus* Roxb.; *Dipterocarpus costalis* Roxb.; *Dipterocarpus intricatus* Dyer; and *Dipterocarpus turbinatus* Gaertn. *D. tuberculatus* is the most common source of the oil.

The subject of this present study is *Dipterocarpus grandiflorus* Blanco. This tree, which is known locally in the Philippines as *apitong*, is reputed to be the most abundant (ca. 20%) in the commercial Philippine forests (1), Figure 1. The resin of *D. grandiflorus* is known locally as *balau*. Until now, no extensive commercial use for the oil of *D. grandiflorus* has been found. There is, however, some local use of *balau* oleoresin as an illuminant, for varnishing, and caulking boats. The wood of *D. grandiflorus* is moderately hard so it has found some use in construction and in the manufacture of medium grade furniture (2).

The object of this current study is to identify the chemical composition of the essential oil which was obtained from the water distillation of the oleoresin of *D. grandiflorus* Blanco. In addition, the use of the oil as a source of energy will be examined. The origin of the oleoresin in this study was from the wild trees found in the deep forests of the province of Leyte in the Philippines.

The oil was extracted by water distillation, the distillation method that was found to give the highest yield of oil from the oleoresin:-38-40% from the freshly collected oleoresin. It possessed a similar aroma to gurjun balsam. The color was light yellow, turning a bit dark on standing. It was insoluble in water, very soluble in common organic solvents except ethyl alcohol, very miscible with gasoline, kerosene, and diesel oil. Some physical and chemical constants of the oil were determined and are shown in Table 1. The oil was subjected to analysis using procedures that have been described in detail elsewhere (3), (4).

### Chemical Composition of the Oil

As an initial infrared spectra of the oil of *D. grandiflorus* Blanco indicated that it was mainly sesquiterpene hydrocarbon in nature, the oil was first separated into oxygenated constituents (1%) and hydrocarbons (99%) by chromatographing it over  $Al_2O_3$  (Activity II). The hydrocarbon fraction was then concentrated to

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Figure 1. *Dipterocarpus grandiflorus* Blanco (actually 40 meters high) with coconut trees in the foreground.

1.5 Gm. and this was re-chromatographed over 115 Gm. of 15%  $\text{AgNO}_3/\text{Al}_2\text{O}_3$  using gradient elution (hexane-diethyl ether-methanol). Individual fractions were concentrated on a water bath and subjected to preparative gas chromatography on a 12ft. x 0.25 in. column, packed with 10% Carbowax 20M coated on 60-80 mesh neutral and silanized Chromosorb W. All components were characterized by carefully comparing their infrared spectra with standard infrared spectra in one of the

Table 1. Physical and Chemical Constants of the Essential Oil of *Dipterocarpus Grandiflorus* Blanco

Specific gravity, $d_{30}^{30}$	0.9228
Refractive index, $n_D^{30}$	1.4930
Congeaing point	-3°C
Acid value	0.7819
Saponification value	16.35
Ester value	15.5681
Iodine value	200.45

Table 2. Constituents Previously Identified in *Dipterocarpus* Resin Oils

$\alpha$ - Gurjunene	$\gamma$ - Gurjunene
$\beta$ - Gurjene (Calarene or $\Delta^1, 10$ )	- Aristolene)
Caryophyllene	$\alpha$ - Humulene
$\beta$ - Elemene	Allo-Aromadendrene
Valencene	Cyperene
Farnesene	Capaene

author's (BML) spectral library and with previously published spectra. In addition, the whole oil was subjected to a GC-MS analysis. The results obtained from this analysis confirmed the findings of the analysis described above. Because of the quantities involved, only the hydrocarbon fraction was examined.

A survey of the literature reveals that a number of hydrocarbons have already been isolated from oils of *Dipterocarpus* species by Bisset *et al.* (5). A list of these constituents can be seen in Table 2. They also reported that two *Dipterocarpus* balsam oils of Philippine origin have been found to contain mainly sesquiterpene hydrocarbons, shown in Table 3. These same authors also compared the composition of the Philippine oil of *Dipterocarpus grandiflorus* Blanco with two further oils of Sabah origin. These results along with our findings can be seen in Table 4. As can



Table 3. Comparative Chemical Composition of Philippine *Dipterocarpus* Oils

<i>D. granicilis</i> Bl.:	$\beta$ - Caryophyllene (75%) & $\alpha$ - Humulene (25%)
<i>D. grandiflorus</i> Blanco:	$\alpha$ - Gurjunene (20%), Allo-Aromandendrene (50%) Caryophyllene (4%) & $\alpha$ - Humulene (20%)
Acc. to Bisset (1966)	

be seen, the composition of our oil is very similar to the previously published information with the exception that we have identified copaene,  $\beta$ -elemene, gennacrene D, and  $\gamma$ -gurjunene in the oil of *D. grandiflorus* for the first time. The gas chromatogram of the oil is shown in Figure 2.

### Preliminary Energy-Related Experiments

In the present age when the cost of petroleum-based fuels is continually on the rise, there has been a frantic search for substitutes for these fuels. A source of substitutes that has been in focus for the last couple of years is the plant kingdom. It has fascinated the scientists, agronomists, and industrialists because certain plants not only serve as an alternative source of energy but also ensure the renewable and, therefore, inexhaustible supply of that source.

A plant that caught our interest is *Dipterocarpus grandiflorus* Blanco the oleoresin of which might be a possible source of energy. In the Philippine hinterlands, the oleoresin is extensively used for lighting purposes. It is tightly packed at the end of a handy bamboo pole, ignited and used in the form of a torch (6). This observation was suggestive of the presence of easily combustible components in the oleoresin and gave us the notion that it might be worth examining its essential oil to find out if this oil or its constituents could serve as liquid fuels.

Among the properties that are sought for in liquid fuels, the following take precedence:

a. *Specific gravity.* A lighter fuel will have a smaller growth of penetration in the air charge but will have greater dispersion and wider cone angle. These parameters will determine the degree of efficiency of combustion of the fuel.

b. *Distilling range.* Most fuels are not pure compounds but a mixture of a large number of components, each having its own different boiling point. Hence, a fuel may start to boil at a low temperature, the lower boiling components gradually boiling away, but the temperature must be raised to keep the higher boiling components in the vapor state. For services involving rapidly fluctuating loads and speeds the more volatile fuels may provide better performance. However, best fuel economy is generally achieved from heavier types of fuels because of their higher heat content.

Table 4. Comparative Chemical Composition of the Oil of *Dipterocarpus Grandiflorus* Blanco

Compound	2 Sabah Oils*	Percentage Composition Philippine Oil*	Our Results
Copaene	—	—	0.14
$\alpha$ - Gurjunene	3 - 10	20	6.28
$\beta$ - Gurjunene	0 - 10	—	—
$\beta$ - Elemene	—	—	0.34
Caryophyllene	? - Trace	4	1.83
Allo-Aromadendrene	80 - 95	50	77.85
$\alpha$ - Humulene	? - Trace	20	2.58
Germacrene D	—	—	0.67
$\gamma$ - Gurjunene	—	—	0.43

\* Acc. to Bisset (1966)

c. *Percent volatility or evaporation rate.* Generally, in higher-speed engines, the lower the volatility, the better, since too volatile a fuel is liable to cause detonation and give rise to gassing or vaporlock problems in the fuel injection system. On the other hand, if volatility is too low a further delay period will be introduced because of the greater time taken to form a gas envelope on the outside of the sprayed droplets.

d. *Flammability.* The basic reaction involved in fuel burning is the chemical union of oxygen in the combustion air with the major fuel elements, carbon and hydrogen. When sufficient air is present, the combustion liberates large quantities of heat. Thus, fuels are hazards when subjected to ignition in locations other than the engine combustion.

e. *Viscosity.* Viscosity is an important characteristic in a diesel fuel since it affects the power to operate the pump. It has also an influence on the size of the fuel particles sprayed through the injection nozzle.

f. *Flash point.* Flash point is defined as the temperature at which vapors arising from the oil sample will ignite momentarily, or flash, on the application of a flame under specified conditions. The lower the flash point of a fuel the greater the danger of explosion and fires resulting from the ignition of the lower boiling components. Hence, the flash point is significant in determining the volatility of a combustible liquid. It can also estimate the temperature at which a fuel can be safely stored.

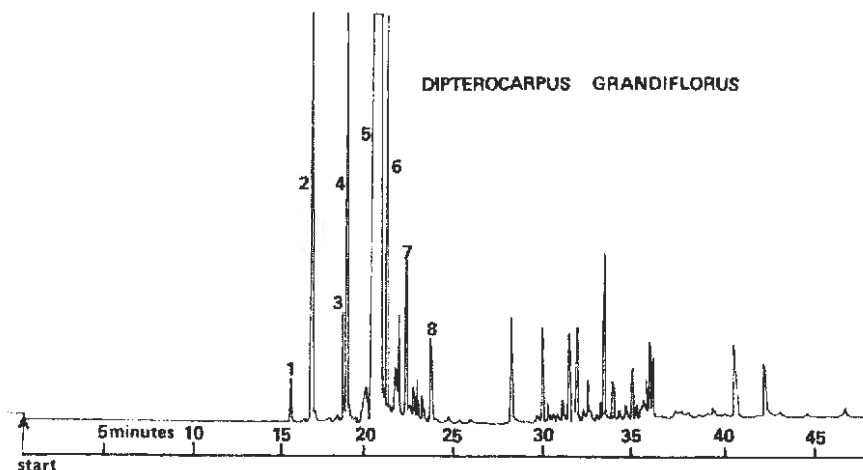


Figure 2. Gas chromatogram of the essential oil of *Diptercarpus grandiflorus* Blanco.

g. *Corrosion*. This is measured by the amount of discoloration on a mechanically cleaned strip of copper sheet when a strip of copper sheet is immersed in the fuel sample and heated under specified conditions. This will indicate if sulfur is present in a fuel. The formation of sulfur compounds during combustion can result in service corrosion of engine parts. Also, the presence of free water in the fuel is generally considered conducive to corrosion particularly of the ferrous parts of the engine.

h. *Heating value*. The heat of combustion is important as an indication of the amount of potential energy present in the fuel. It is of interest in determining the engine performance with regard to specific fuel consumption. This is measured in a bomb calorimeter and is expressed either in calories per gram Cal/Gm. or in British Thermal Unit per pound (BTU/lb).

For purpose of comparison, the oil of *D. grandiflorus*, kerosene, and a sample of commercial crude oil were examined for the afore-mentioned criteria. The results indicated that the value for *D. grandiflorus* oil compared favorably with most of the typical values for kerosene and the crude oil. The comparison is shown in Table 5.

### Comparative Energy Contents

The energy content of the essential oil of *D. grandiflorus* was measured in a Parr adiabatic automatic calorimeter. Average of the results obtained was compared with the heating values recorded in literature for a number of crude oils abroad (7). It showed that while the heating value of *D. grandiflorus* oil was a bit below those of Texas, Oklahoma, Pennsylvania, and Wyoming crude oils, it was higher than the crude oils of Kansas, Mexico, and California, as can be seen in Table 6.

Table 5. Comparative Properties of Oil of *D. Grandiflorus* Blanco, Crude Petroleum Oil, and Kerosene

	<i>Oil of D. grandiflorus</i>	<i>Crude Oil</i>	<i>Kerosene</i>
Distilling range	175-261°C	120-600°C	175-275°C
Percent volatility	19.0	17.93	99.8
Flammability (seconds) 1.5 cc.	47.6	—	45
Viscosity	4	1.3	2.4
Flash Point	110°C	66°C	42°C
Corrosion (Cu strip)	No. 1	—	No. 1
Heating Value Cal./Gm.	10,640	10,628	11,006

Table 6. Comparative Energy Contents

<i>Fuel (Crude Oil)</i>	<i>Cal/Gm.</i>	<i>BTU/lb.</i>
Mexico	10,419	18,755
California	10,506	18,910
Kansas	10,628	19,130
<i>D. GRANDIFLORUS</i>	10,640	19,148.4
Texas	10,811	19,460
Oklahoma	10,834	19,502
Pennsylvania	10,836	19,505
Wyoming	10,839	19,510

### Fractionation of the Oil

In order to have an idea which portion(s) of the essential oil of *Dipterocarpus grandiflorus* Blanco, would be of practical importance with respect to the percentage in which it is available and the heat of combustion it can generate, the oil was fractionally distilled under a reduced pressure of 67 mm. There were five fractions obtained, as shown in Table 7, all of which were mixtures as indicated by gas chromatography. Three of the fractions gave heating values that were higher than that of the whole oil. Since the oil is predominantly sesquiterpene in nature, it was

Table 7. Fractionation of the Essential Oil of *D. Grandiflorus* Blanco

Fraction	Volume (ml.)	Distilling range °C	Percent	Pressure (mm. Hg)	Cal./Gm.	BTU/lb.
1	10.8	122-144	10.8%	67	10,774	19,393
2	5.0	148-168	5.0%	67	10,347	18,624.6
3	17.4	170-180	17.4%	67	10,796	19,432.8
4	19.3	182-186	19.3%	67	10,322	18,579.6
5	27.0	187-190	27.0%	67	10,723	19,301
Residue	12.0					
Total	91.5					
Whole Oil . . .					10,640	19,148.4

likely that the high energy fractions contained the  $C_{15}H_{24}$  hydrocarbons. This formula is within the range of the molecular weights of the components comprising the hydrocarbons in the diesel fuel.

#### Blends With Diesel Oil

The essential oil of *D. grandiflorus* was found to blend thoroughly with diesel oil. For the purpose of exploring whether or not the oil can be used as supplemental to diesel oil, mixtures were prepared using varying proportions of the oil and diesel oil. The mixtures were used in preliminary tests with diesel engine. However, on account of the large volumes of blends that the engine performance tests require, this phase of our study, although ongoing and encouraging, has not yet proceeded far enough to warrant conclusive results.

#### Summary

The essential oil that was obtained by water distillation of the oleoresin of *Dipterocarpus grandiflorus* Blanco from Leyte province, Philippines, was found to contain 1% oxygenated fraction and 99% hydrocarbons, the latter mainly sesquiterpene in nature.

Aside from the sesquiterpenes that were reported by previous workers on the chemistry of Philippine *D. grandiflorus*, we have identified copaene,  $\beta$ -elemene, germacrene D, and  $\gamma$ -gurjunene in the essential oil of *D. grandiflorus* for the first time.

There were indications that the essential oil of *D. grandiflorus* might be used as a source of energy. The properties of the oil compared favorably with most of the typical values for kerosene and a commercial crude oil. The energy content,

expressed in Cal./Gm., while a bit below those of crude oils from four states of USA, was higher than those of crude oils from three other places abroad. Fractionation of the oil gave 5 fractions which were mixtures. Three of the fractions gave heating values higher than that of the whole oil. The oil blended completely with diesel oil. Engine performance tests using blends containing varying proportions of our oil and diesel oil are in progress.

Considering that the yield of oil from the oleoresin is 38-40%, and taking into account West's observation (8) that one tree produces 1 Kg. of oleoresin per day, or the equivalent of 400 cc. of oil obtainable from one tree a day, one is tempted to speculate that *D. grandiflorus* Blanco would be a promising natural source to tap for liquid fuel. In addition, this source has the advantage of surviving for a long period of time and continues its resin-producing function indefinitely.

### Acknowledgements

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### Magdalena C. Cantoria, Discussant

Many of the dipterocarps are large trees that are familiar to us as sources of lumber. Oleoresins are characteristic of the family. Some genera belonging to the family which have attracted the attention of plant chemists are *Dipterocarpus*, *Shorea*, *Dryobalanops*, and *Hopea*. Products include gurjun balsam from *Dipterocarpus turbinatus*; varnish resins from species of *Shorea*, *Hopea*, and *Dryobalanops*; and edible fat, which can be used instead of cocoa butter in chocolate manufacture, from the nuts of *Shorea macrophylla*; and Borneo camphor from *Dryobalanops aromatica*. It is interesting to note that some of our own dipterocarps have become the objects of investigation for their volatile oil content.

Dr. Norman G. Bisset, now at the Chelsea College, London, Department of Pharmacy, visited our country and other Asian countries in the 60's and eventually published the results on the investigation by his group of the volatile oils of some species of *Dipterocarpus* and their isolation and identification of several hydrocarbons. It may be gathered from the paper of Dr. Belardo that this work of his group provided the background for their own investigation of apitong. Now, 17 years later, Dr. Belardo and her co-workers have added four hydrocarbons to the list identified by Dr. Bisset and his group. This is a distinct contribution to basic science.

Dr. Belardo and her co-workers have extended their basic research studies into the properties of the volatile oil of apitong relevant to its utilization as an energy source as suggested by the presence of a large fraction of hydrocarbons in the oil. Their results show that the properties of the oil are comparable to those of kerosene and a commercial crude oil. Its energy content of 10,640 cal/g is also comparable to that of other crude oils of American origin which range from 10,419 to 10,839 cal/g.

The work of Dr. Belardo and her group now indicates studies on the physiology of the plant. Research problems that come readily to mind are the following:

1. Occurrence and distribution of the plant in the country — A proper survey will reveal the natural habitat of the plant and this will serve as a guide to the best areas where it may be grown successfully as a crop. If more trees now growing wild may be located, it will be possible to collect more samples of the oleoresin for further intensive studies.

2. Type of oleoresin-bearing structures and their location in the plant — A study of the anatomy of the tree will provide information on the type of oleoresin-bearing structures and their location in the plant. This will be helpful in devising effective methods of obtaining the oleoresin from the plant.

3. Propagation of the plant — The fastest and most efficient method of propagating the plant will have to be sought if the plant is to be developed as a crop. Generally, trees are propagated by seed, and, if this is true for apitong, then germination studies are in order.



4. Environment factors affecting the oil yield of the plant – Such factors as temperature, rainfall, altitude, and soil (physical, chemical, and microbiological properties) affect oil yield. Inorganic nutrition is also included here as part of the chemical properties of the soil. Knowledge of the extent to which the plant responds to these factors will be useful in the large-scale cultivation of the plant. It will be possible to meet the requirements of the plant for optimal growth.

5. Variation, quantitatively and qualitatively, in the oil yield with ontogenetic changes in the plant – Physiological changes in the plant as it grows and develops will result in quantitative and qualitative changes in the volatile oil yield.\* Data on these changes that occur with ontogeny will be valuable in the utilization of the volatile oil as a source of energy. The quality of the oil as an energy source may be at its peak at a particular stage of growth and development of the plant. This will determine the time of collection of the oleoresin.

6. Method of collecting the oleoresin – Trees which yield oleoresins as exudates, either naturally or as a result of injury, may be continuously tapped provided the physiology of the trees is well understood. Various methods of increasing the exudate by treatment with acids, hormones, or microorganisms will have to be tried out to determine the best method. If the tree is to be grown commercially, a continuous supply of the oleoresin has to be assured.

7. Breeding and selection for improvement of the plant as a crop – The most important factors determining yield are genetic and therefore the plants with maximum yield which are hardy, disease- and pest-resistant, and which possess other desirable characteristics will have to be selected by careful breeding and hybridization studies.

In addition to studies on the biology of the plant, other related studies may be conducted such as:

1. Feasibility studies – An insight into the cost of growing the plant and collecting the oleoresin, the quantity of oil yielded, the amount of energy generated, the cost of separating the volatile oil from the oleoresin, the performance of the oil in operating diesel engines, and other relevant details will indicate the feasibility of the actual utilization of the volatile oil of apitong as an energy source.

2. Properties and possible uses of the resin – After distilling off the volatile oil from the oleoresin, the resin is left as a residue. The physical and chemical properties of the resin may be determined and the results will be original contributions to basic science. Possible uses of the resin may be found and maximum utilization of the oleoresin will be effected.

Sufficient information on the physiology of the plant and other related aspects will provide a basis for the proper science authorities of government to recommend and support the development of our Philippine dipterocarps, starting

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\*Variations in composition of the oils as reported by Dr. Bisset and his co-workers and by Dr. Belardo's group in Table 4 could possibly be due to changes in the physiology of the plants or to the genetic make-up of the plants studied.

with apitong, as alternative sources of energy in the country. Here lies the significance of the research work of Dr. Belardo and her co-workers and for this their work may be justifiably commended.

#### Julian A. Bartzon, Discussant

The sudden increase in price of petroleum oil had posed a very serious problem to us who have very little of this commodity. Petroleum is the source of liquid motor fuel; what is affected is the motor transport industry; this means the movement of food supplies, construction materials, of trade in general, of people who have to reach their stations of work and return late to their home. Liquid petroleum fuels are needed in mechanizing agriculture; plowing and tilling, applying fertilizer and pesticides, weeding, harvesting, etc.

As is well-known alcohol (ethanol) is a good substitute as liquid motor fuel especially for gasoline engines but alcohol is expensive to produce, so far. Our raw materials for its production is not only inadequate: they are needed for food use. Hence the need to locate other sources of liquid fuels: adequate in supply and where its use will not deprive us of a food material.

Here is where the study presented by Dr. Luz Oliveros-Belardo and associates becomes of special significance. The authors find that the oil derived from the oleoresin of *D. grandiflorus*, approximates the fuel characteristics of diesel fuel as reported in Tables 5 & 6. They also find this oil to be thoroughly miscible with kerosene, gasoline and diesel fuel, which means that blends are possible. It is to be noted that complete replacement of petroleum-derived fuel may not be achieved in the near future; mixtures or blends or "extenders" (to borrow a food tech term) is all that we can hope for in the meantime. The authors of this paper as well as financial supplies are to be commended for this contribution to solve the Philippine liquid fuel problem.



## CONOTOXINS ACTING ON THE ACETYLCHOLINE RECEPTOR: A REVIEW

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### Introduction

*Conus* species are marine snails which are greatly admired for the beautiful patterns on their cone-shaped shell. At the same time, these species are notorious for their poisonous stings. Although cones usually react to disturbance by retracting into their shell, accidental stinging of humans (1, 2, 3, 4) have resulted from careless and prolonged handling of the live animal. In fact, several human fatalities have been reported over the years. Most dangerous are the fish eating or piscivorous species, particularly the larger ones such as *Conus geographus*.

Cones are basically hunters which use a well-developed venom apparatus for catching prey such as worms, other molluscs and fish (5). Two types of strategies have been observed among piscivorous *Conus* species. *C. geographus*, upon sensing a fish in the vicinity, opens up its flexible funnel-shaped rostrum or mouth like a blooming flower. As soon as the unsuspecting fish swims into the funnel, the snail stings and envelopes the fish with its rostrum. In contrast, *C. magus* and other closely related species (e.g., *C. purpurascens*, *C. achatinus*) bury themselves under the sand and entice prey by extending a brightly colored proboscis. When a fish comes to feed on the worm-like proboscis of a snail, it stings and hooks in the paralyzed fish as it emerges from the sand to engulf the fish with its distensible mouth.

The venom apparatus of cones (6) consists of a muscular venom bulb (probably acting as a pump), a long duct filled with venom, and a radula sac containing numerous hollow radula-tooth at different stages of formation. As the cone gets ready to strike, it positions one of the harpoon-shaped tooth at the end of the extensible proboscis. The highly modified tooth first acts as a hypodermic needle through which venom is injected then as a hook for pulling in the catch.

### Symptoms of *Conus* Stinging

Various symptoms have been described in stinging cases of humans. One well documented case (7) is a 28-year old man who died within 4½ hours after being pierced in the hand by a *Conus*. He complained of numbness of the hand in 5 to 6 minutes after stinging. The sensation extended upwards to the lips and mouth in a few minutes, and there was blurring of vision. Within an hour, the victim was unable to speak. He was completely paralyzed before death.

In mice, intraperitoneal injection of crude venom produce symptoms similar to those seen with many snake venoms. Death from asphyxiation occurs from a few minutes to about half an hour after injection due to paralysis of the respiratory muscles (8).

### Types of Conotoxins

The venom of *Conus* species is a complex mixture of digestive enzymes (9), quaternary ammonium compounds (6), fast-acting toxic peptides, and other components. The generic name "conotoxins" was suggested (10) for all toxic peptides isolated from *Conus* venoms, with a capital letter to indicate the species and a Roman numeral to denote the particular variant. Small Greek letters preceding the name of toxins has also been suggested as a means to indicate the physiological action.

Toxins isolated from *Conus* venom have differing physiological action with some acting on the neuromuscular system and others on the central nervous system. *Conus* species have evolved a series of neuromuscular toxins to ensure the effectiveness of venom injected to the prey. One group, the  $\omega$ -conotoxins irreversibly block nerve stimulus evoked release of transmitter at the frog neuromuscular junction (11). Another group ( $\alpha$ -conotoxins) inhibits the post-synaptic terminus of vertebrate neuromuscular junction (12, 13). A third group ( $\mu$ -conotoxins) rapidly blocks muscle action potentials in frog and mouse (14, 15). The cones are thus equipped with a set of toxins acting at three stages of impulse transmission. Although this may seem to be an "overkill", it ensures survival of the species.

### The $\alpha$ -Conotoxins

The most well-characterized of the conotoxins are of the  $\alpha$ -type. The group consists of a homologous set of small basic peptides. The amino acid sequences (12, 16) of those isolated so far are given in Fig. 1. The peptides designated by G all come from *C. geographus* and the M peptide from *C. magus*. All of them have a blocked carboxyl terminus. Conotoxins GI and GIA are essentially identical except that GIA has additional Gly. Lys at the carboxyl end. GII differs from GI only in the conservative replacement of Asn4 by histidine, Arg9 by lysine and Tyr11 by phenylalanine. MI differs from GI not only in the conservative replacement of Asn4 by His and His11 by Asn but also in the radical substitution of Glu1 (an acidic amino acid) by Arg (a basic amino acid). Obviously, there is considerable flexibility

	0	5	10	15
Conotoxin GI	Glu.Cys.Cys.Asn.Pro.Ala.Cys.Gly.Arg.His.Tyr.Ser.Cys.NH <sub>2</sub>			
Conotoxin GIA	Glu.Cys.Cys.Asn.Pro.Ala.Cys.Gly.Arg.His.Tyr.Ser.Cys.Gly.Lys.NH <sub>2</sub>			
Conotoxin GII	Glu.Cys.Cys.His.Pro.Ala.Cys.Gly.Lys.His.Phe.Ser.Cys.NH <sub>2</sub>			
Conotoxin MI	Gly.Arg.Cys.Cys.His.Pro.Ala.Cys.Gly.Lys.Asn.Tyr.Ser.Cys.NH <sub>2</sub>			
Ancestral Toxin	Gly.Arg.		Asn.	
	Cys.Cys.His.Pro.Ala.Cys.Gly.Lys.		Tyr.Ser.Cys.NH <sub>2</sub>	
	Glu.		His.	

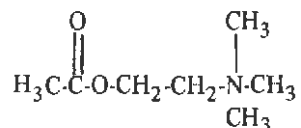
Figure 1. Amino acid sequences of  $\alpha$ -conotoxins and the proposed ancestral toxin (16).

at the amino terminus of the conotoxins. The disulphide bondings are Cys2 to Cys7, and Cys3 to Cys13 (17). Chemically synthesized conotoxins GI and MI have been demonstrated to be identical, both biochemically and pharmacologically, to the native toxins (17, 18).

Presumably, conotoxin GI and conotoxin GII arose by gene duplication and divergence within *C. geographus*. There is reason to believe that GIA arises during processing of GI from a larger precursor. Assuming that species divergence between *C. magus* and *C. geographus* occurred first before gene duplication in *C. geographus*, possibilities for the sequence of the ancestral toxin may be as shown in Fig. 1.

Physiological data (12, 13) indicate that conotoxins act at the muscle end plate region. No inhibition of either nerve or muscle action potential has been detected. McManus *et al.* (13) showed that conotoxins GI and GII compete with  $\alpha$ -bungarotoxin for binding to the acetylcholine receptor. Although MI has not been used in physiological experiments, the mode of action is presumed to be the same as the G series because of the close structural homology.

Many potent toxins similarly act by competing with acetylcholine for its receptor, without causing depolarization of the muscle membrane. So far two major classes of nicotinic Ach receptor inhibitors have been available: low molecular weight alkaloids (such as curare) and small proteins from snake venoms (e.g.,  $\alpha$ -bungarotoxin, cobratoxin, and erabutoxin). The  $\alpha$ -conotoxins comprise a third class which is intermediate in size between the small alkaloids and the snake  $\alpha$ -neurotoxins which contain 60 to 74 amino acid residues. All these toxins mimic acetylcholine which has the formula:



The onium head with its positive charge spread over the methyl cluster in an important structural feature for both muscarinic and nicotinic Ach action (19).

Correlation of activity with amino acids sequences coupled with model building suggest a conformation for  $\alpha$ -conotoxins which is analogous to the "active tip" of the short  $\alpha$ -neurotoxins of snakes (20). Both *Conus* and snake neurotoxins can undergo a conformational flip with one of the conformations being functionally equivalent to the calabash alkaloids and curare. All these  $\alpha$ -neurotoxins have a characteristic cationic pair.

It is remarkable that conotoxin MI is the most active peptide yet discovered, being about 25 times more potent than d-tubocurarine and ten times more so than  $\alpha$ -bungarotoxin on a molar basis. It is thus comparable to C-alkaloid E, whose rigid structure is assumed to be a close complimentary fit to the active site of the acetylcholine receptor protein (20).

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### **Clara Y. Lim-Sylianco, Discussant**

There is not really much to say after that very excellent presentation of Dr. Cruz. Everything was very clear. It is a very good example as to what collaboration over these years can do. It shows that one can go deep until the molecular level to investigate problems regarding our Philippine conus species. I am very much impressed with what has been accomplished until the analysis, determination of the sequence of the amino acids and some structural studies that would really give us an idea how deep one can go into the study of some of those observations that we have in our own Philippine waters. And lastly, I would like to say that Dr. Cruz must be congratulated for her continuing interest in all these aspects of conotoxin in spite of the fact that she has always been saddled with administrative and teaching responsibilities. Thank you.

### **Edgardo Gomez, Discussant**

I thought that I was going to be the most brief of the reactors but Dr. Sylianco pre-empted me from that role. You see, I am a little bit out of kilter here in the sense that this is a biochemistry paper and I am a marine biologist. The only thing we really have in common here is that I am interested in the animals that they are studying. I was going to leave all biochemistry to her to sort out. But she indicated that Dr. Cruz has presented a very clear paper so that perhaps there isn't very much need to dwell further, dig deeper into the biochemistry of this conotoxin.

What I thought I would do is just maybe make a few general remarks or observations and encourage more research along this area. Again, as a marine biologist I can't look into the biochemistry of it except perhaps to mention that in the marine environment, we have a wide variety of toxic and venomous marine animals, many of which are of interest to medicine. It is unfortunate that so few researchers in this country are looking at these substances.

I might very briefly mention a few as examples. Dr. Cruz mentioned the sea-snakes of which we have plenty in the Philippines. Among the other vertebrates, we have a number of fish including the lion fish and the scorpion fish, both of which have toxins or venoms. I am not quite sure how you differentiate between a venom and a toxin and a poison. I tend to associate toxins with the things that you ingest and venoms with those used by animals for stinging. It is very difficult sometimes to draw the line on why you say this thing is poisonous as against being venomous. I use the terms interchangeably.

Among the invertebrates, the molluscs which we are studying have been mentioned. Then you have a whole range of coelenterates such as jellyfish and corals,

all of which have some type of toxin or venom. A number of worms also are known to have some toxins. Some of you have heard of the octopus. There is a small octopus that is famous in Australia that apparently kills people every year. And many of these animals are found locally, in our own waters. Perhaps when Dr. Cruz branches out we can give her a whole array of marine organisms that she can start to look at.

Now I would just like to mention very briefly a little bit about some of the types of toxins in the marine environment. She is working on conotoxin. You also have in the puffer fish tetrodotoxins. And then you have the saxotoxins, some of which are found in bivalve molluscs and it is not very clear whether these are manufactured by the bivalves or they are concentrated by them. One of the interesting things is that some of these toxins such as the tetrodotoxins have also been found in amphibians. The question that sometimes comes to mind is how is it that two very different groups of animals have come up with the same toxins? Is it some kind of convergent evolution or do they somehow follow genetically. Are they animals related ancestrally or what? Anyway there are a lot of areas for research in this field and I think the medical applications can be very exciting.

## RECENT TRENDS IN ELECTROANALYTICAL CHEMISTRY.

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### Introduction

[In view of the heterogeneity of interests represented by the audience, I have chosen to speak in a fairly general vein, rather than discuss my very limited research area. This is also a welcome occasion to make non-electroanalytical chemists aware of some electrochemical techniques which could be useful analytical tools in their own disciplines, especially in studying processes or phenomena at electrical interfaces. Because of time constraints, only a few of the major electroanalytical techniques can be mentioned.]

Electrochemistry has to do with *controlled electrical paths* for producing chemical transformations involving a *net* electron transfer. The electrical parameters that are employed and varied to force specific electrochemical reactions are: potential or voltage (both direct current and alternating current), current, and resistance. The analytical signals or responses observed are current, charge, potential, resistance, or time-dependence of any of these signals. Resistance is often measured in the inverse form, conductance.

Electrochemical methods are generally useful for: (1) quantitative, (2) qualitative, and (3) kinetic characterizations of chemical systems. Knowledge obtained from the last two has made many irreversible reactions available for analytical applications.

The classical electroanalytical methods familiar to many are electrolysis (exhaustive), coulometry, potentiometry, amperometry, and conductimetry. In the late 1920s, J. Heyrovsky (1959 Nobel Laureate in Chemistry) invented polarography, which concerns the measurement of current resulting from an applied potential at a dropping mercury electrode (DME), a spherical microelectrode. From polarography, several *modern* methods have been born and have been loosely referred to as "polarographic methods" (strictly, they are voltammetric methods, dealing with current-potential relationships).

Polarography proved to be a very versatile analytical and thermodynamic tool. It was widely applied for 25-30 years after its invention, although involving

largely inorganic systems. The sixties saw a decline in its popularity because of the method's limitations: the DME is actually an expanding electrode (large charging currents); positive potentials are inaccessible (because of oxidation of mercury), thus excluding many oxidation reactions; the inadequate two-electrode design; and current "damping" problems which arise from oscillations due to the growth and fall of the mercury drop.

The 1970s, however, saw a "renaissance" of polarographic methods (1) and the birth of several new *transient* techniques (i.e., methods involving the application of current or potential pulses, or other signal waveforms of short duration). This revival is attributed to the advent of smaller, cheaper, and more versatile solid-state electronics (especially operational amplifiers). The three-electrode potentiostat came about, which provided precisely-controlled potentials at the working electrode. Other features of the new breed of instrumentation eliminated background current from the analytically significant faradaic current, and presented the analytical response (signal) in the form of a peak, rather than the conventional polarographic wave.

About the same time, new electrode materials (e.g., graphite, glassy carbon) started to be discovered, which extended the potential window of investigation into the anodic region, but without pronounced chemisorptive or catalytic action as in the case of platinum. New electrode designs and configurations (e.g. rotating ring-disk) also helped widen the applications (originally largely limited to the reduction of metal ions) to include many organic and biological reactions.

Present-day electroanalytical methods possess the following attractive features: (1) small volume of test solution; (2) non-exhaustive; (3) short analysis times (a few minutes); (4) high sensitivity, due to greater suppression of background; (5) improved resolving power; and (6) easy automation or computer-interfacing for laboratory control and/or data processing.

The theory for each of the techniques to be described is too mathematical; only the final, established relationship of analytical response to concentration of electroactive species will be cited. In some of the transient techniques, digital simulation has been employed to test the validity of analytical equations derived from first principles. The methods discussed below represent those used mostly in the author's research work.

## Selected Electrochemical Methods

### 1. *Potentiometry at Selective Electrodes*

The first and most widely used ion-selective electrode is the glass electrode which appeared in 1906). It consists of a special glass membrane (about 50  $\mu\text{m}$  thick), which responds to the hydronium ion in a Nernstian fashion. Measurements with ion-selective electrodes are essentially determinations of membrane potentials which themselves comprise junction potentials between electrolyte phases. The

performance of any single system is determined largely by the degree to which the species of interest can be made to dominate charge transport in part of the membrane.

Since the late sixties many different ion-selective electrodes have appeared. The latest review on this area presents a host of new electrode systems, new configurations, new reference electrodes, new routine and non-routine applications (inorganic, organic, biological, and medical), and new measurement systems including automated continuous flow types (2). The pH-sensitive electrode continues to be modified or replaced; one of these is a liquid-membrane type based on trinodecylamine as neutral carrier, which is claimed very adequate both for intracellular and extracellular hydrogen-ion activity measurements (3). Other new types of selective electrodes reported include solid-state membranes, liquid-ion exchangers, and gas-sensing and enzyme-coupled devices (2). Coated wire electrodes responsive to halo-metal complex anions (4) and chemically modified electrodes for determination of dissolved organic analytes (5) have been developed. These selective electrodes can readily be "home-made" (6, 7).

Development work concerns determination of selectivity characteristics, detection limits, temperature and response time limitations, and potential pitfalls (e.g., chemical interferences, aging, "memory effects," poisoning), prior to application to real analytical situations. Solvent effects and membrane thickness to surface ratios are some critical factors influencing non-Nernstian behavior.

## *2. DC and Pulse Polarography*

The family of polarographic techniques has again found widespread applicability since the introduction of low-cost three-electrode potentiostats and more convenient DME designs. In particular, normal pulse and differential pulse polarography have brought down the detection limits from about  $1 \times 10^{-5}$  molar for conventional (dc) polarography to at least  $1 \times 10^{-7}$  molar for the pulse modes. Enhancement in response is due to the improvement from reduced charging current contribution, since currents are sampled under potentiostatic conditions when the charging currents have decayed to the minimum value. Recent applications include trace (inorganic and organic) analyses, determination of oxidation states, detection of complexation, and acid-base chemistry. Biological and pharmaceutical applications have been especially numerous (8, 9), proving that polarography remains the most powerful electroanalytical tool today.

A new concept in dropping mercury electrodes, the static mercury drop electrode (SMDE), was introduced recently by one of the leading manufacturers of polarographs (PARC) and overcomes one formidable limitation in polarography, i.e., measurements are made at an expanding electrode. The SMDE is similar to the conventional DME; however, the electrode assembly includes a valve which allows the mercury flow to be stopped at selected time intervals to produce a stationary rather than a growing drop on the tip of the capillary. The SMDE retains all the advantages of the conventional DME (fresh surface) but avoids the problem of

obtaining data at an electrode with continuously changing area. The SMDE allows "area step" experiments to be performed, which can be considered analogous to potential step experiments. Because of the elimination of charging current from area growth terms, there is essentially no difference in detection limits between DC polarography and differential pulse polarography when using the SMDE (10). This is believed to be a very significant development and could lead to the convergence in the performance of the various polarographic techniques.

### 3. Stripping Analysis

Because of the pre-concentration step, stripping analysis is to date the most sensitive electrochemical method of analysis. It utilizes a bulk electrolysis step of a few minutes' duration to pre-concentrate (by a factor of 100-1000, or more) a substance from solution into the small volume of a mercury electrode (or onto the surface of a solid electrode). After this step, the material is redissolved ("stripped") from the electrode using some voltammetric technique (frequently linear potential sweep voltammetry).

The widest application is in the analysis of trace metals by cathodic deposition, followed by anodic stripping with a linear potential scan (anodic stripping voltammetry, ASV) or together with a differential pulse (DPASV). Mercury, platinum, gold, mercury-film on glassy carbon, etc. can serve as substrate electrodes. The technique is especially useful for the analysis of very dilute solutions, down to  $10^{-10}$  or  $10^{-11}$  molar.

Cathodic stripping voltammetric (anodic pre-concentration step) applications are slowly unfolding, e.g. analysis of Mn(II) as  $\text{MnO}_2$ , sulfide as  $\text{Ag}_2\text{S}$  (on silver electrode), etc.

A related technique but one which requires simpler instrumentation is potentiometric stripping analysis (PSA), which was introduced by Jagner *et al.* (11, 12). The same pre-concentration step is required; however, the stripping is performed chemically by an oxidizing agent (or reducing agent, in the case of anodic pre-concentration), such as oxygen,  $\text{Hg(II)}$ ,  $\text{Fe(III)}$ , etc. (13). In the reductive case, hydroquinone has been employed as stripping agent (14, 15).

In this method the analytical signal for stripping a component is proportional to the time required to redissolve that component. A theoretical analysis of the method was recently reported by Chinese workers (16).

Determinations are generally performed in stirred solutions to improve reproducibility and analytical signal levels.

There are a few problems with this technique, such as finding the suitable oxidizing or reducing agent which does not electrolyze at the potential of pre-concentration. Furthermore, the stripping process may not be entirely transport-controlled. However, good resolution and its applicability in media of low ionic strength are distinct advantages over ASV.

### 4. Voltammetry at Rotating Electrodes

One of the few convective electrode systems for which the hydrodynamic and convective-diffusion equations have been solved rigorously for the steady state

is the rotating disk electrode (RDE). It consists of a disk of the electrode material imbedded in a rod of an insulating material (e.g., glass tubing, teflon, epoxy resin, other plastics). The parameter controlled is the angular velocity of the RDE.

The Levich equation for a totally mass-transfer-limited condition predicts that the limiting current is proportional to the concentration of the electroactive species in the bulk of the solution and to the square root of the electrode rotation speed (17). The RDE has numerous applications not only for analytical determinations but also for measurement of kinetic parameters.

The rotating ring-disk electrode (RRDE) is an even more powerful tool. It consists of a disk electrode combined with a ring electrode, which is concentrically placed around the disk electrode. The current-potential characteristics of the disk electrode are unaffected by the presence of the ring. Independently of the disk (e.g. the disk at open circuit), the ring current can be measured and is related to the geometric parameters of the ring, i.e., the inner and outer radii.

RRDE experiments are usually carried out with a bipotentiostat, which allows separate adjustment of the disk potential and ring potential. However, it is possible to use an ordinary potentiostat to control the ring circuit and a simple floating power supply in the disk circuit.

Two types of experiments are frequently used at the RRDE: (a) collection experiments, where species generated at the disk are observed at the ring; and (b) shielding experiments, where the flow of bulk electroactive species to the ring is perturbed because of the reaction at the disk. The ring current is related to the disk current by the collection efficiency (in the former case) and by the shielding factor (in the latter case), both quantities being predictable from the electrode geometry (17).

The application of transients (e.g. potential step) or hydrodynamic modulation (18) have allowed the study of absorption phenomena at the disk through the currents at the ring. Monomolecular layers of Sn, Pb, Tl, and Hg have been measured on a gold RRDE and are applicable in ultra-trace analyses of these metals (19-22).

### 5. *Cyclic Voltammetry*

One very popular tool which deserves mention, not so much for its analytical utility but for the wealth of qualitative information that can be directly visualized from the current-potential curves recorded, is cyclic voltammetry. A triangular potential waveform is employed, and the resulting voltammograms are characterized by peaks. Equations to predict peak current and peak potential for both reversible and irreversible systems have been derived (23).

New systems for study would benefit from initial observations obtained from cyclic voltammetry. Different mechanisms give rise to distinct variations of peak current, peak potential, etc. with the kinetic parameters for both charge transfer and coupled chemical reactions. Diagnostic criteria for establishing mechanisms based on changes of peak potential as a function potential scan rate and concen-



tration are now known and have been utilized in numerous basic studies of electrochemical systems (24).

An interesting application of cyclic voltammetry which was reported is the *in vivo* monitoring of substances in the kidney or brain, employing a miniature carbon paste electrode (25).

## 6. *Combination Techniques*

Electrochemical detection methods are becoming very important in liquid chromatography and in continuous flow analysis (26). Ion-selective and voltammetric electrodes are frequently used. The advantage of high sensitivity continues to make electrochemical detectors popular despite the problems of providing electrodes with reproducible surface and low background current. In addition, such detectors must be compatible with the chromatographic requirement of low dead volume and fast response, and the electrochemical requirement of low resistance. The utility of the LCEC detector can be extended by derivatization of analyte molecule with electroactive reagents or by use of electrogenerated reagents.

In recent years, study of electrode processes and electrode surfaces involved other experiments to obtain information that could not be gathered in purely electrochemical measurements. One of these is absorption spectroelectrochemistry, which involves directing a light beam through the electrode surface to measure absorbance changes resulting from species produced or consumed in the electrode process. The obvious prerequisite is an optically transparent electrode (e.g. thin films of semiconductors like  $\text{SnO}_2$  or  $\text{In}_2\text{O}_3$ , or Au or Pt deposited on glass, quartz, or a plastic surface). Spectroelectrochemical methods can be especially useful for unravelling a complex sequence of charge transfers, such as in the study of redox proteins (26). Thin-layer (test solutions ca. one microliter) spectroelectrochemistry has been further combined with GC/MS to identify reaction intermediates (27).

## Instrumentation

Description of new microprocessor- or microcomputer-based electroanalytical systems comprises the largest number of publications in the field in the past few years. The objectives vary from searching for novel applications, improving the versatility of the system through software modification, to enhancing sensitivity through signal averaging. Several modules and modifications of commercial instruments were reported, e.g. a conversion module which extended the capability of a polarographic analyzer to cyclic voltammetry and derivative polarography, modification of timing sequence to improve performance, etc. (24).

Through microprocessor technology, it is possible to build a low-cost electroanalytical system with flexibility limited only by software capabilities. Enormous amounts of data may be obtained and transformations from one response to another readily performed. At the same time there can be excellent means for

detecting interferences in analytical data and possibly compensating or correcting for them. It has been suggested that instrumentation will be equivalent for the different polarographic techniques if digital approaches were routinely implemented (10).

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### Apolinar S. Loric, Discussant

Speaking as a baseball fan, I would say that Dr. Vicente has touched all the bases and made a homerun in discussing the recent trends in electroanalytical chemistry. So, what is there left to say? Well, maybe I could say something about future trends to justify my presence here.

As Dr. Vicente mentioned, practically all the "happenings" in electroanalytical chemistry for the last 30 years can be traced to a minute electrode aptly called the "dropping mercury electrode". Future trends will be largely dependent on studies on new and modified electrodes. Another metal, gallium, which is a liquid like mercury at our room temperature ( $M. P. = 30^{\circ}C$ ) during the hot months, has been considered as an electrode material and might figure prominently in future developments in the dynamic field of electroanalytical chemistry.

There is considerable interest in the chemical modification of the electrode. Coated wire electrodes and some chemically modified electrodes are already being used in ion-selective electrodes, as noted by Dr. Vicente. Chemical modification has so far been achieved by: 1) covalent attachment of functional groups; 2) adsorption of organic molecules; and 3) adherence of a polymer matrix containing a redox active component.

Chemically modified electrodes are still shrouded in mystery. They are easy to prepare, and can be *home-made* as Dr. Vicente said. This is probably why they are becoming increasingly popular. They appeal to the boy and the scientist in a man. There is, however, much controversy over the exact mechanism of their response. Some exhibit nearly Nernstian response to changes in ion concentration while others show irreproducible and drifting potentials and nobody has come up with a convincing explanation.

It is safe to say that miniaturization will underlie future developments in electroanalytical chemistry. The reason for this is the continuing effort to use very small amounts of sample which is partly fueled by the desire to economize on expensive chemicals. Another reason is the desire to use ion-selective electrodes to monitor *in vivo* important blood electrolytes.

As you may have noticed, electroanalytical chemists use down-to-earth terminology. For example, in polarography, the salt which is added to the solution in great excess, is called the *supporting* electrolyte. It gathers near the electrodes but does not react. The other electrolyte, presumably, the *star* electrolyte, is the one that reacts at the electrode, which, incidentally, is called the *working* electrode. The other electrode only acts as a reference electrode. The current that is used to charge up the electrical double layer around the *dropping* mercury electrode is called the *charging* current, of course, while the current used in the electrode reaction (which is measured in units named after Michael Faraday) is the *faradaic* current. When the potential of the working electrode obeys the Nernst equation, its behavior is termed *Nernstian*. Finally, to end this brief discussion, I'm sure you remember having heard the process of removing a deposit covering an electrode called suggestively, *stripping*.

### Amando Kapauan, Discussant

I would just like to add two very recent developments in this area of electroanalytical chemistry. One concerns a paper that is published by Dr. Vicente's old boss, Dr. Bruckenstein just recently, about two months ago, in the March issue of *Journal of Electroanalytical Chemistry* described a new kind of electrode system called the wall-tube electrode. The reason why this is very important has to do with what Dr. Vicente mentioned earlier.

One of the most powerful electrodes for the study of basic electrode reactions is the rotating disc electrode. The reason for this I won't go into, it is one of those few electrodes, in fact it is the only electrode so far up to last March in the literature, where the current is strictly proportional to the area; if you double the area, the current doubles and there are hydro-dynamic reasons for this. But if you have ever tried to make a rotating disc electrode, you will find that it is so difficult that around the world there are just a few, countable in the fingers of your hand, laboratories that are capable of turning out very good rotating disc electrode results.

Dr. Bruckenstein's paper is a mathematical study of the hydrodynamics of an electrode which is a small electrode embedded as a flat disc then polished exactly to the surface of a container's wall. The electrolyte is conducted to this electrode using a small tubing whose internal diameter is slightly bigger than the micro-electrode embedded on the wall. Under these conditions, with solution flowing from the tube into the wall (that is why it is a wall-tube electrode) the hydrodynamics is exactly the same as in the rotating disc electrode, but with the tremendous advantage that it is stationary. All you need to do is pump the solution through the tube. I expect that there will be dozens of papers in the next few years concerning the applicability of this system to basic electrode phenomena. One of the things that we ought to try our hands in because it is easy to make.

The other is the development of very cheap microprocessor systems which are all available nowadays, even in Binondo. The cheapest Apple-type computer sells for about ₱3,000.00\* This includes 64 K of memory, exact operational duplication of all Apple functions. The Apple computer has a tremendous amount of software and hardware available, compatible with it. So that I think there is no excuse for anybody who wants to fool around with microcomputers and microprocessors in terms of expenses here in this country at the present time. In fact, we are doing better than many other developed country in the world. You can't buy anything as cheaply as what is available in Binondo here. Go out there and get yourself one and start fooling around with it. It is the thing to do nowadays. Thank you very much.

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\*At printing time up to ₱7,000 because of inflation.

## LABORATORY-SCALE PRODUCTION OF CELLULOSE, GLUCOAMYLASE AND ALPHA-AMYLASE

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### ABSTRACT

The laboratory-scale production of the enzymes cellulase, glucoamylase and alpha-amylase was optimized in terms of substrate composition and concentration, inoculum size, pH and other parameters.

A local isolate of *Penicillium* was found to produce a higher cellulase activity when grown on nutrient-supplemented sugarcane bagasse compared to *Trichoderma reesei* strains QM 9414 and NRRL 11485. Batch culture of the *Penicillium* in an airlift fermenter at pH 4.5 for two days resulted in maximum activities on filter paper and carboxymethylcellulose.

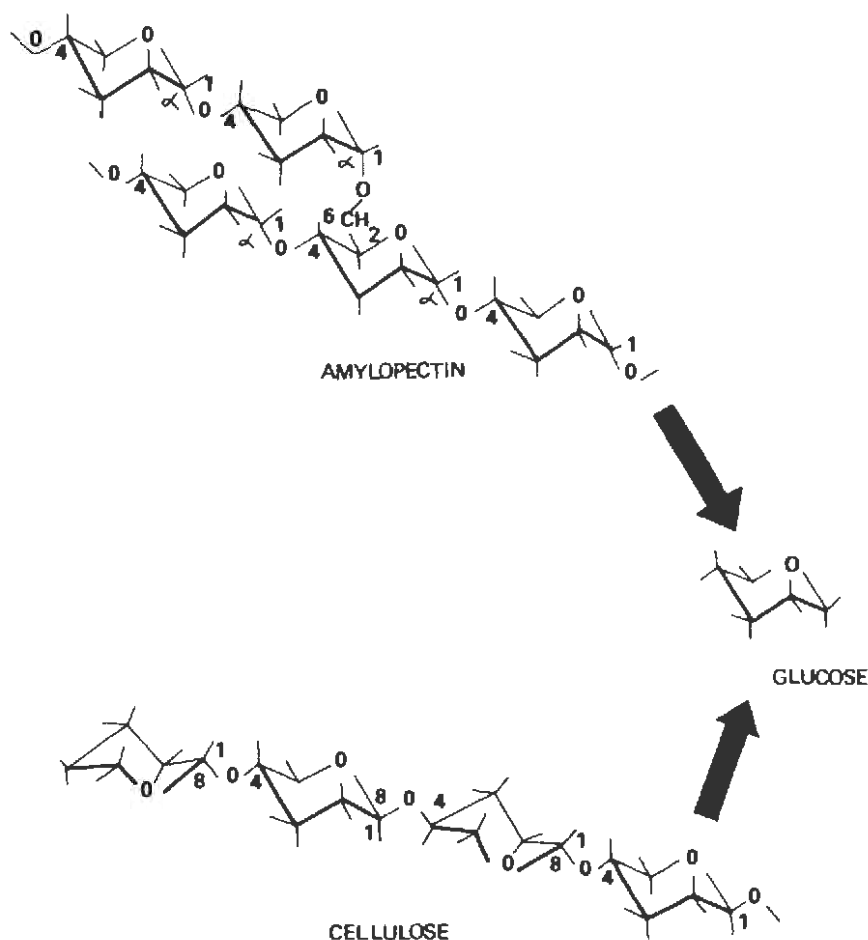
*Aspergillus awamori* NRRL 3112 produced the highest glucoamylase activity after four days of batch growth in an airlift fermenter using as substrate a mixture of cassava root flour and rice bran (1:2 weight ratio). The optimal conditions were pH 5.5, 30°C, 20% solids level of substrate and 10% inoculum size.

Alpha-amylase was produced by *Bacillus subtilis* NRRL 3411 in an airlift fermenter using as substrate a mixture of cassava root flour, rice bran, fish meal and soybean meal. After three days of fermentation the enzyme was harvested, concentrated and stabilized. Alternatively a solid enzyme powder was prepared.

### Introduction

Plant biomass, which is produced by photosynthesis, is the world's most important renewable material and energy resource. It could serve as partial substitute for fossilized biomass such as petroleum, coal and natural gas whose reserves are continually being depleted. Being dependent on land area, plant biomass production is limited and its utilization for food or fuel is governed by socio-economic and geo-political factors.

The important constituents of plant biomass are carbohydrates and lignin. Included in the former are cellulose, hemicellulose, starch and sugars. Cellulose and starch are polymers of glucose, while hemicellulose includes pentosans or polymers of pentoses (five-carbon sugars) and pentose derivatives as well as hexans or polymers of hexose (six-carbon sugars) other than glucose. On the other hand, lignin is a complex material of high molecular weight consisting of phenylpropane units linked together by a variety of bond types. Cellulose, which is usually tightly complexed with lignin and hemicellulose, is the most abundant organic substance in the world. It makes up approximately 50% of the cell wall material of wood and



Scheme 1. Chemical structures and complete hydrolytic reactions of amylopectin and cellulose.

plants and between 25 to 50% (dry basis) of wood, sugarcane bagasse, rice straw, corn cobs and other lignocellulosic materials. Starch is the primary carbohydrate in cereal grains and staple crops such as cassava and sweet potato. Approximately 25% of fresh cassava and sweet potato is starch.

The chemical structure of cellulose and starch and the reaction scheme for their complete hydrolysis into glucose, through the action of acids or enzymes, are shown in Scheme 1. Starch consists of two types of polymers, namely amylose and amylopectin. The former is a linear polysaccharide linked by  $\alpha$ -1,4 bonds while the latter, which is shown in Scheme 1, is a branched polymer containing both  $\alpha$ -1,4 and  $\alpha$ -1,6 glucosidic bonds. On the other hand, cellulose is a

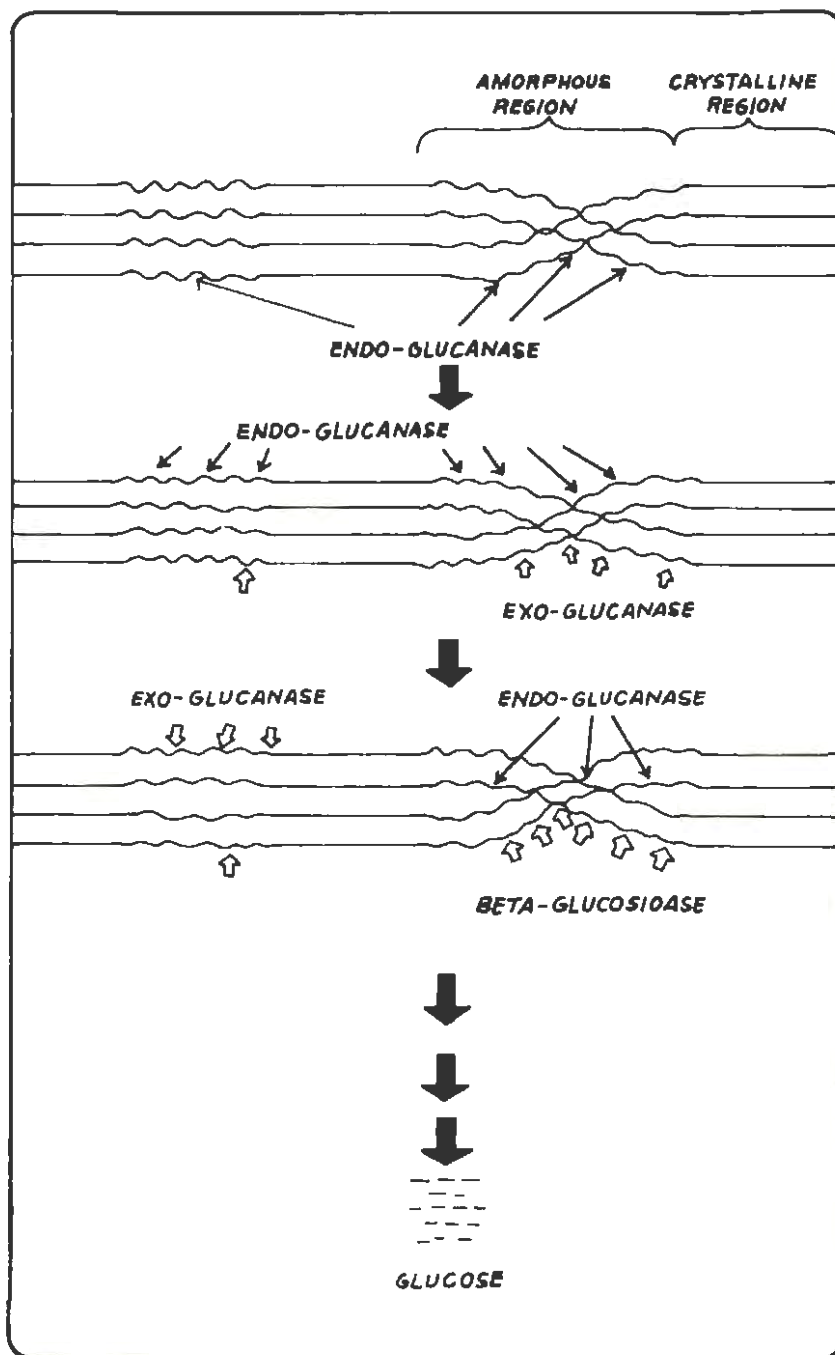


Figure 1. Enzymatic hydrolysis of cellulase (schematic).



linear polysaccharide linked by beta-1,4 glucosidic bonds (Roberts and Caserio, 1964).

The enzymatic hydrolysis of cellulose, as schematically shown in Figure 1, is generally believed to occur through the action of at least three components of the cellulase enzyme complex, namely exo beta-1,4-glucanase (or 1,4 $\beta$ -glucan cello-biohydrolase), endo beta-1,4-glucanase (or 1,4- $\beta$ -glucan glucano-hydrolase) and  $\beta$ -glucosidase. The endo-glucanase attacks the amorphous region of the cellulose fibrils by splitting internal glucosidic bonds thereby increasing the number of non-reducing ends. In turn, the exo-glucanase hydrolyzes a penultimate glucosidic bond of the exposed non-reducing ends and releases cellobiose which is further degraded to glucose by  $\beta$ -glucosidase (Fägerstam *et al.*, 1977). Detailed studies on the mechanism of action of the cellulase enzymes have been described in the proceedings of several symposia (Hajny and Reese, 1969; Wilke, 1975; Dailey *et al.*, 1975; Gaden *et al.*, 1976; Ghose, 1977; Ghose, 1981).

The enzymatic action of amylases on starch is schematically shown in Figure 2. After gelatinization or swelling in water, starch is dextrinized or converted into smaller fragments through the action of alpha-amylase and beta-amylase. The latter is an exo-glucanase and splits off maltose from the non-reducing end of starch, while the former randomly hydrolyzes an internal alpha- 1,4 glucosidic bond. The resulting dextrans are hydrolyzed by glucoamylase into glucose.

### Cellulase Production

Previous work done by the author on cellulase production dealt with semisolid cultures of several strains of the cellulolytic mold *Trichoderma viride* or *reesei*) using, as carbon substrate, mixtures of rice bran with either rice straw or rice hulls (Vilela *et al.*, 1977). Although reasonably high enzymatic activities were obtained in the culture filtrates, at least seven days of culturing were needed and the semisolid technique for enzyme production was found difficult to scale-up in later studies.

Our more recent work has concentrated on cellulase production in a locally-fabricated laboratory-scale fermenter using as substrate sugarcane bagasse or rice straw, which was supplemented with other nutrients (Bondoc, Bondoc, 1982; E.J. del Rosario and D.M. Marquez, unpublished data). An airlift fermenter, which is shown in Figure 3, was used in the fermentation studies. Aeration and agitation of the culture medium in the fermenter was simultaneously brought about by filtered air through an 'airlift effect'. The latter refers to the upward flow of the air-entrapped liquid inside the inner tube of the fermenter followed by the downward liquid flow in the outer annular region after air release such that a continuous loop motion of the liquid is obtained.

Using as substrate a mixture of NaOH-treated sugarcane bagasse and rice bran (1: 1 w/w) at 5% solids level and initial pH of 5, two strains of *Trichoderma reesei* and a local isolate of *Penicillium* (kindly given by Dr. Ireneo Dogma, Jr.) were compared in terms of cellulase production. Although slightly different initial spore

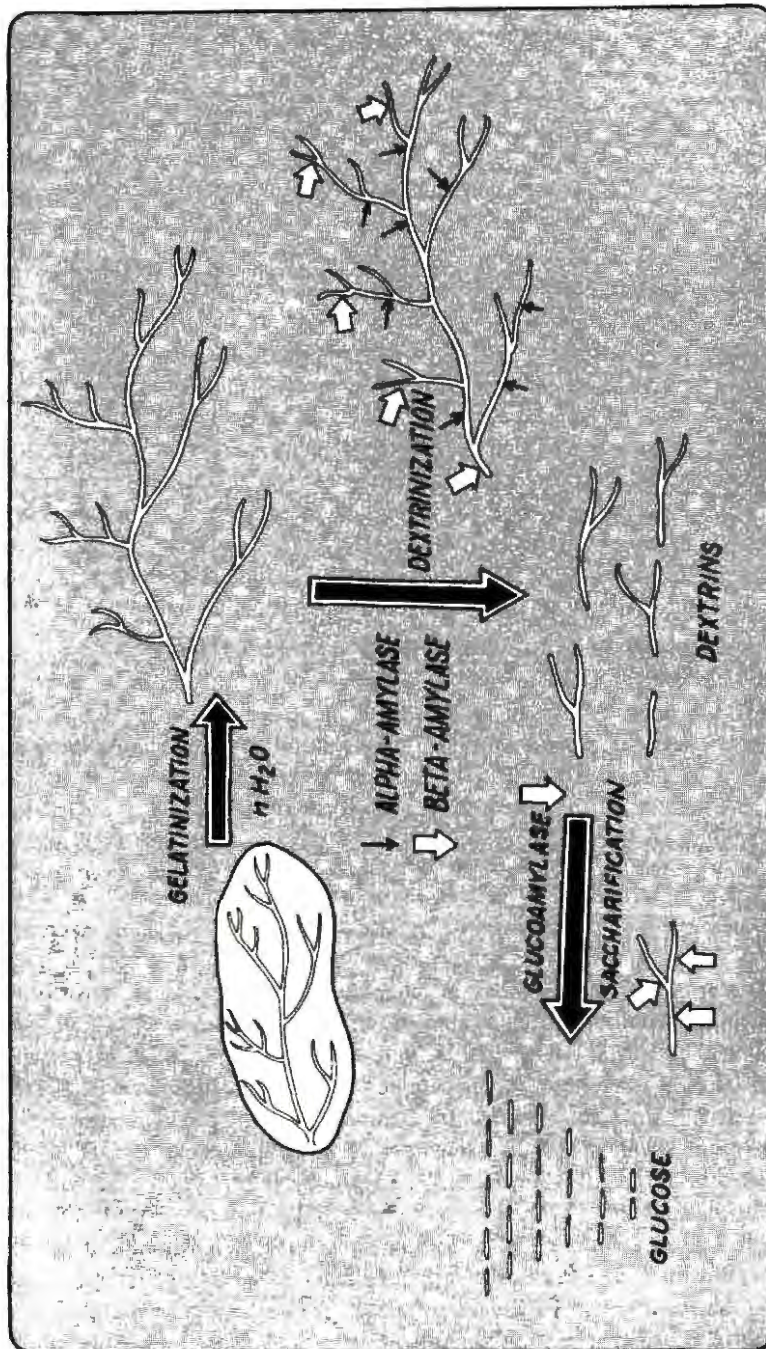


Figure 2. Enzymatic Starch Saccharification (Schematic).

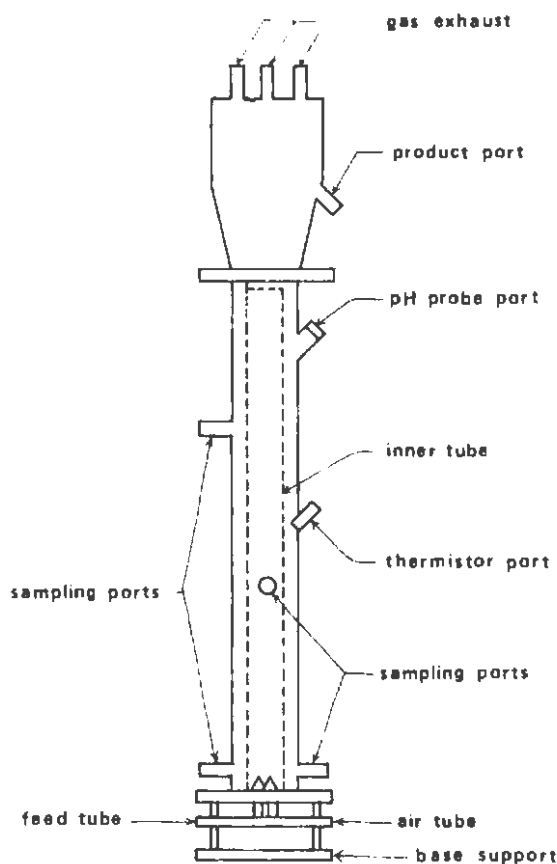


Figure 3. The airlift fermenter

concentration of the three microorganisms were used, much higher carboxymethylcellulose (CMC) volumetric activities (abbreviated as CMCVA) were obtained with *T. reesei* NRRL 11485 as shown in Figure 4. The effects of substrate composition on cellulase production by this microbial strain using either alkali-treated or untreated bagasse are summarized in Table 1. It is seen in the table that untreated bagasse is a better substrate than alkali-treated bagasse for cellulase production in terms of filter paper (FP) and CMC enzymatic activities in the fermentation medium. This result could be explained by the property of untreated bagasse to induce cellulase production by *T. reesei*; apparently, the highly resistant nature of the substrate forces the microorganism to secrete a more active enzyme for cellulose breakdown. In the case of alkali-treated bagasse, the partially delignified material is less efficient in inducing cellulase production by the microorganism.

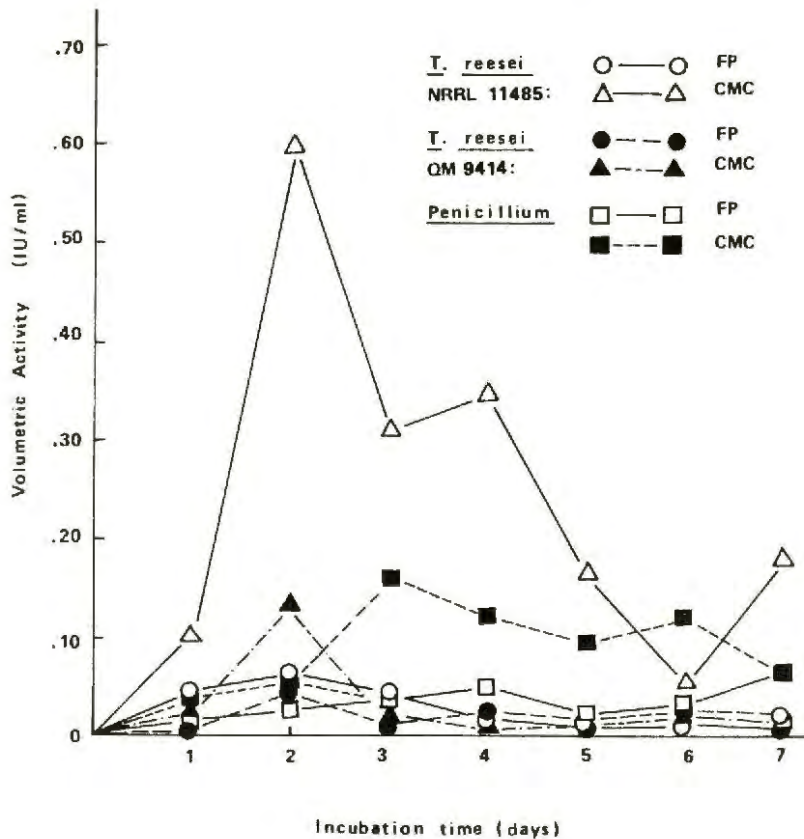


Figure 4. Volumetric activity on filter paper (FP) and carboxymethylcellulose (CMC) of culture filtrates of *T. reesei* NRRL 11485, *T. reesei* QM 9414 and *Penicillium* sp. 86.

Using untreated bagasse as carbon substrate, the production of cellulase by *T. reesei* QM 9414 was optimized in terms of substrate composition. The experimental results, which are presented in Table 2, show that the highest FP activities were obtained for a medium containing equal amounts of bagasse and rice bran while the lowest activities were observed using bagasse only. Corresponding results for the *Penicillium* isolate (Code No. 86) are given in Table 3 and show that the highest FP and CMC activities were obtained for medium E which contained untreated bagasse as carbon substrate to which were added  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{KH}_2\text{PO}_4$ , urea,  $\text{CaCl}_2$  and  $\text{MgSO}_4$ .

A summary of the FP activities and protein content of the culture medium for the three fungal strains tested is given in Table 4. It is apparent that the *Penicil-*

Table 1. Effect of substrate composition on filter paper (FP) and carboxymethylcellulose (CMC) volumetric activities of culture filtrates of *T. reesei* NRRL 11485 grown on untreated or alkali-treated bagasse\*.

Substrate Composition**	Protein Concentration %	FP Volumetric Activity IU/ml	CMC Volumetric Activity IU/ml
<i>Untreated bagasse:</i>			
Bagasse only	6.7	0.000	0.025
98: 1RB	6.9	0.008	0.041
88: 2RB	6.2	0.033	0.044
58: 5RB	4.9	0.064	0.185
Medium E	6.7	0.058	0.496
<i>Alkali-Treated bagasse:</i>			
Bagasse only	7.0	0.009	0.034
98: 1RB	6.5	0.010	0.039
88: 1RB	7.0	0.015	0.033
58: 5RB	5.5	0.036	0.132
Medium E	4.4	0.049	0.170

\*Substrate: 5% (w/v) solids; initial inoculum count- $3 \times 10^8$  spores per shake flask culture; incubation time: 2 days.

\*\*9B: 1RB (bagasse: rice bran 9: 1 w/w); 8B: 2RB (bagasse: rice bran 8:2 w/w); 5B 5RB (bagasse: rice bran 5:5 w/w); Medium E (constituents in g per 100 ml: bagasse, 5.00;  $(\text{NH}_4)_2\text{SO}_4$ , 0.14;  $\text{KH}_2\text{PO}_4$ , 0.20; urea, 0.03;  $\text{CaCl}_2$ , 0.03  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.03).

Table 2. Effect of substrate composition on filter paper (FP) and carboxymethylcellulose (CMC) volumetric activities of culture filtrates of *T. reesei* QM 94 grown on untreated bagasse\*

Substrate Composition**	Protein Concentration %	FP Volumetric Activity IU/ml	CMC Volumetric Activity IU/ml
Bagasse only	8.1	0.011	0.045
9B: 1RB	7.9	0.012	0.012
8B: 2RB	7.8	0.022	0.092
5B: 5RB	9.2	0.045	0.111
Medium	9.4	0.038	0.116

\*Substrate: 5% (w/v) solids; initial inoculum count - $3.6 \times 10^8$  spores per shake flask culture; incubation time-2 days.

\*\*Please see footnote of Table 1 for details.



Table 3. Effect of substrate composition on filter paper (FP) and carboxymethylcellulose (CMC) volumetric activities of culture filtrates of *Penicillium* sp. 86 grown on untreated bagasse\*

Substrate Composition**	Protein Concentration %	FP Volumetric Activity IU/ml	CMC Volumetric Activity IU/ml
Bagasse only	4.1	0.014	0.051
9B: 1RB	4.2	0.016	0.072
8B: 2RB	4.2	0.014	0.121
5B: 5RB	4.2	0.031	0.140
Medium	6.0	0.165	1.016

\*Substrate: 5% (w/v) solids; initial inoculum count  $8.0 \times 10^8$  spores per shake flask culture; incubation time — 4 days:

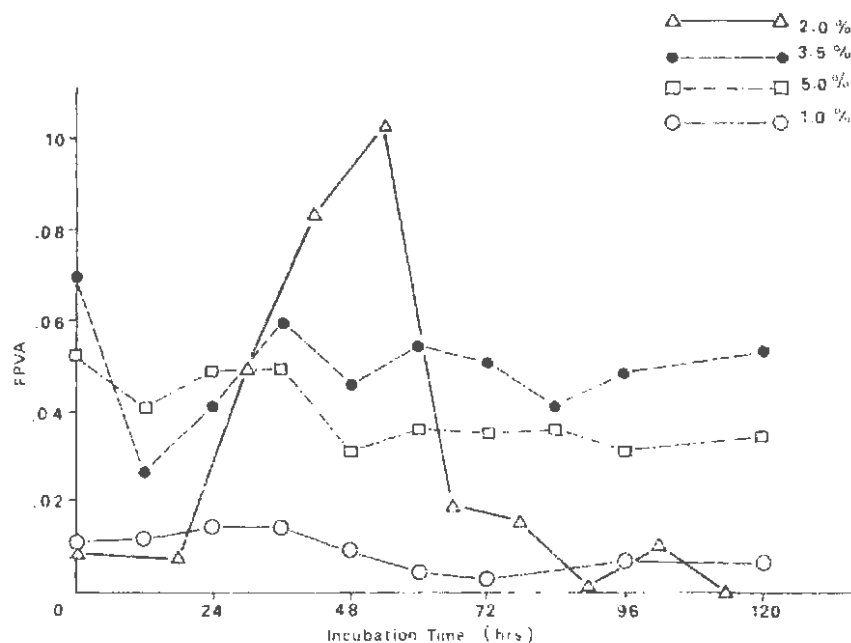
\*\*Please see footnote of Table 1 for details.

*lium* strain produced the most active cellulase among the three. A comparison of our results with those reported in literature is also relevant. For example, when *Trichoderma longibrachiatum* was grown on 0.5% NaOH-and sodium chlorite-treated bagasse, the maximum FP Volumetric activity (FPVA), FP specific activity (FPSA), CMC volumetric activity (CMCVA), CMC specific activity (CMCSA), and percentage Lowry Protein (%LP) obtained on the seventh day of fermentation were ca. 0.111 IU/ml., 0.555 IU/mg P.O. 370 IU/ml. 1.851 IU/mg P, and 2.00%, respectively (Sindhu and Sandhu, 1980). For *Aspergillus terreus* GN1 cultured on 1% alkali-treated bagasse and 600 mg cornsteep liquor/l of broth, maximum values of FPVA of 0.08 IU/ml and CMCVA of 1.00 IU/ml were obtained on the seventh day of fermentation (Garg and Neelakantan, 1982). In our study, the optimum FPVA, FPSA, CMCVA, CMCSA, and % LP obtained on the fourth day for *Penicillium* sp. 86 grown on 5% untreated bagasse and  $(\text{NH}_4)_2\text{SO}_4$  and urea as N sources were 0.165 IU/ml, 0.275 IU/mg P, 1.06 IU/ml, 1.69 IU/mg P, and 6.00%, respectively. It is evident that the cellulase activities of *Penicillium* sp. 86 are comparable if not better than those of *T. longibrachiatum* and *A. terreus*. Moreover, it is economically advantageous to utilize *Penicillium* isolate for cellulase production because it requires less incubation time and uses untreated bagasse.

The above-mentioned results were obtained in 100-ml shake-flask cultures in order to select the best microorganism and medium for scaled-up cellulase production in the 3.5-liter airlift fermenter. In turn, optimization of the airlift fermentation process was done in terms of the solids level and pH of the medium. The effect of solids level on the enzyme activity of the culture medium at various culturing times is shown in Figures 5 and 6. Maximal FP and CMC volumetric activities were obtained using a 2.0% solids level after 48 hours incubation. Results of

Table 4. Composition of Filter Paper activities and protein concentration of culture filtrates of three fungal strains.

Fungal Strain	Culture Substrate	Culture Time, days	Filter Paper Activity		Protein Concentration %
			Volumetric Activity (IU/ml)	Specific Activity (IU/mg protein)	
<i>T. reesei</i> NRRL 11485	Medium E using alkali-treated bagasse	2	0.049	0.112	4.4
<i>T. reesei</i> NRRL 11485	Untreated bagasse: rice bran (5:5)	2	0.064	0.130	4.9
<i>T. reesei</i> QM9413	Untreated bagasse: rice bran (5:5)	2	0.045	0.049	9.2
<i>Penicillium</i> sp. 86	Medium E using untreated bagasse	4	0.165	0.275	6.0

Figure 5. Plot of FPVA vs. incubation time for *Penicillium* sp. 86 grown on untreated bagasse at various solids levels tested using an airlift fermenter.

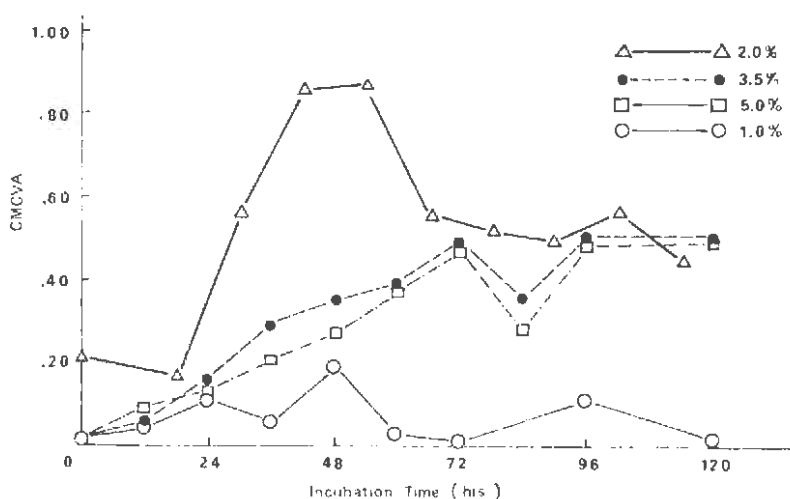


Figure 6. Plot of CMCVA vs. incubation time for *Penicillium* sp. 86 grown on untreated bagasse at various solids levels tested using an airlift fermenter.

the pH optimization studies, which are given in Figures 7 and 8, show that maximal cellulase production was achieved at pH 4.5 after 48 hours incubation using 2% untreated bagasse as carbon substrate. In summary, maximal production of cellulase was obtained by culturing *Penicillium* sp. 86 on 2% untreated sugarcane bagasse supplemented with 0.14%  $(\text{NH}_4)_2\text{SO}_4$ , 0.20%  $\text{KH}_2\text{PO}_4$ , 0.03% urea, 0.03%  $\text{CaCl}_2$  and 0.03%  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  and with the pH controlled at 4.5 and aeration at 1 vvm (volume of air per volume of fermentation medium per minute) in an airlift fermenter at room temperature (ca. 30°C).

#### Glucanase Production

The batch production of the enzyme glucanase (or amyloglucosidase) has been optimized in our laboratory using the amyolytic mold *Aspergillus awamori* NRRL 3112 (Acabal, 1983). The optimum temperature, pH, solids level, and inoculum size were determined for enzyme production in an airlift fermenter using a mixture of cassava root flour and rice bran (1:2 weight ratio) as substrate. The experimental results for the glucanase activity of the culture filtrate as a function of incubation time are presented in Figure 9. It is seen in the Figure that greater volumetric and specific activities of the enzyme were obtained at 30°C compared to 35°C.

The effect of pH on glucanase production by *A. awamori* NRRL 3112 at 30°C is shown in Figure 10. The optimal pH was found to be 5.5. A comparison of enzyme activity data at 20 and 25% solids level, which is drawn in Figure 11 shows the advantage of using the lower solids level. The results of this study are in



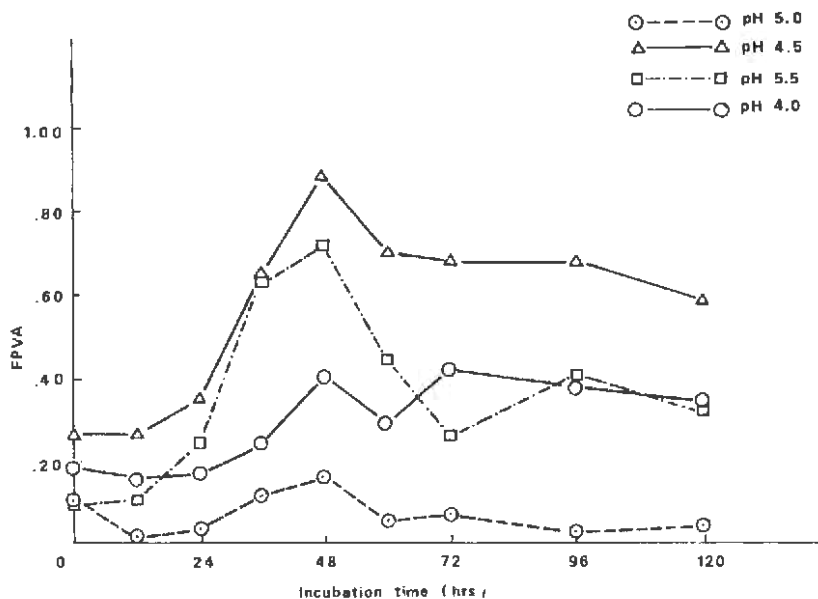


Figure 7. Plot of FPVA vs. incubation time for *Penicillium* sp. 86 grown on 2% untreated bagasse at various pH levels using an airlift fermenter.

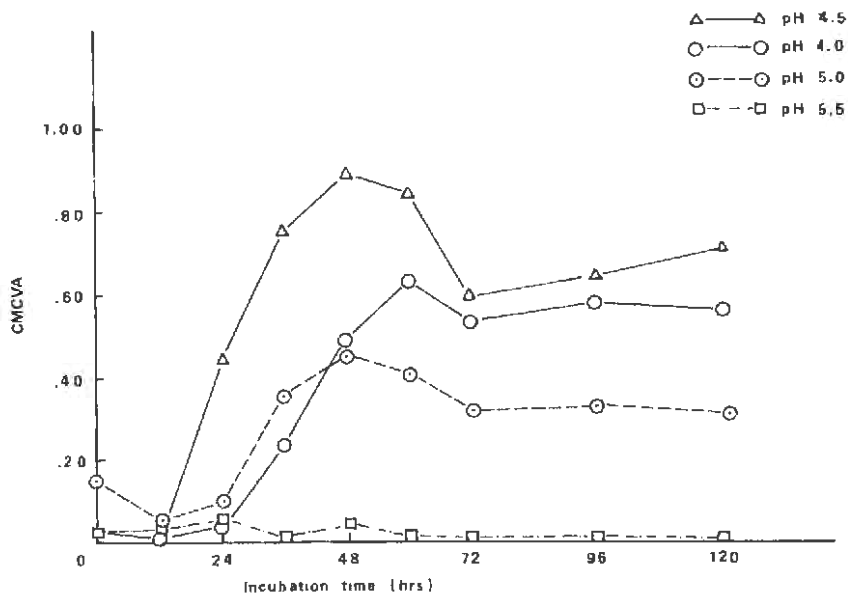


Figure 8. Plot of CMCVA vs. incubation time for *Penicillium* sp. 86 grown on 2% untreated bagasse at various pH levels using an airlift fermenter.

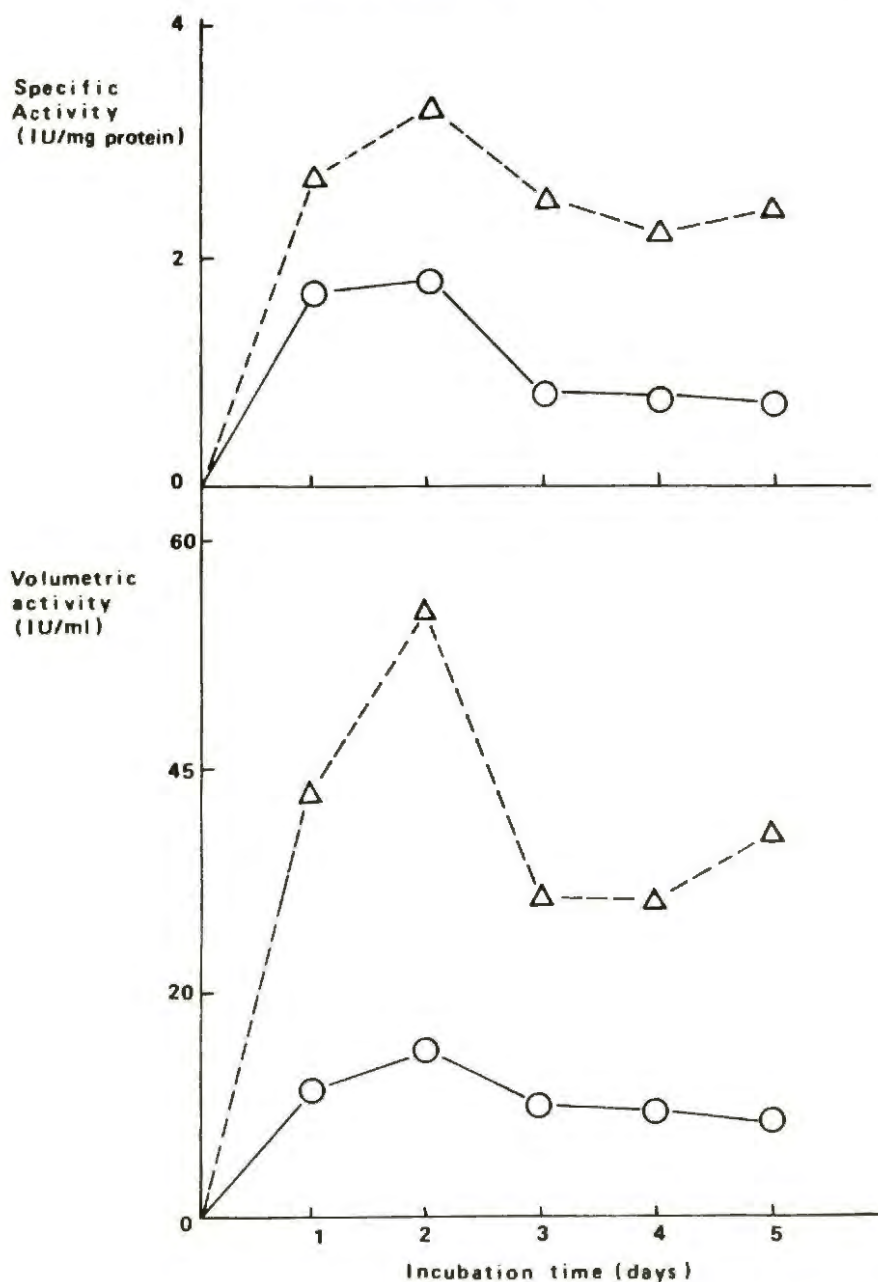


Figure 9. Volumetric and specific activities of glucoamylase produced by *A. awamori* NRRL 3112 at 30°C (Δ - Δ) and 35°C (O - O) with uncontrolled pH using 20% solids level of substrate and 10% inoculum size.

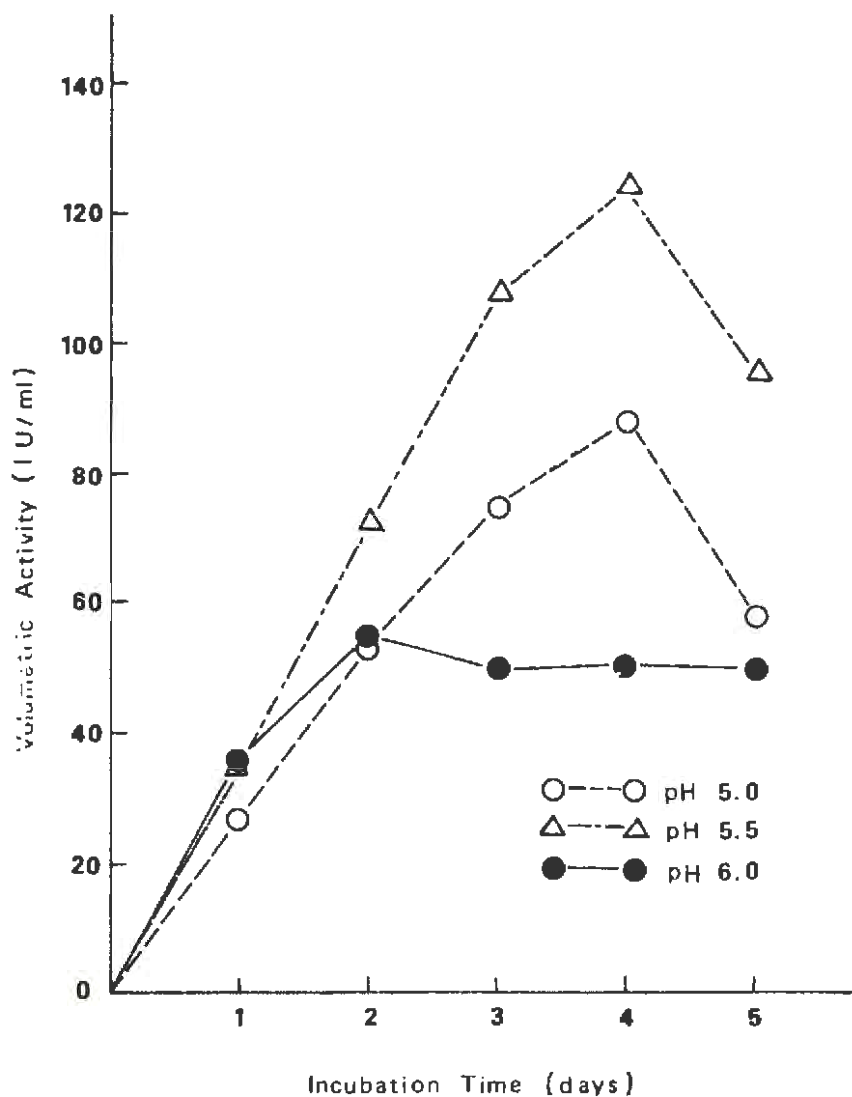


Figure 10. Volumetric activity of glucoamylase produced by *A. awamori* NRRL 3112 at 30°C as influenced by variation of pH using 20% solids level of substrate at 10% inoculum size.

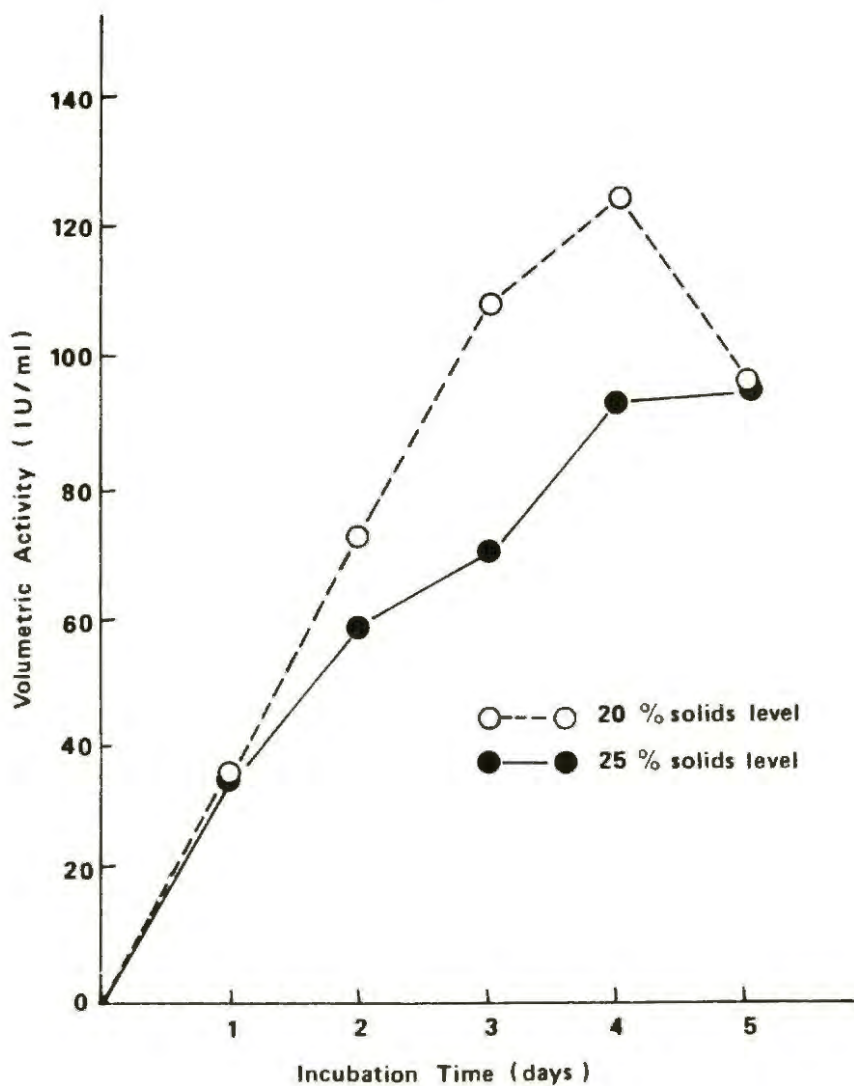


Figure 11. Volumetric activity of glucoamylase produced by *A. awamori* NRRL 3112 at 30°C and pH 5.5 as influenced by variation of solids levels of substrate using 10% inoculum size.

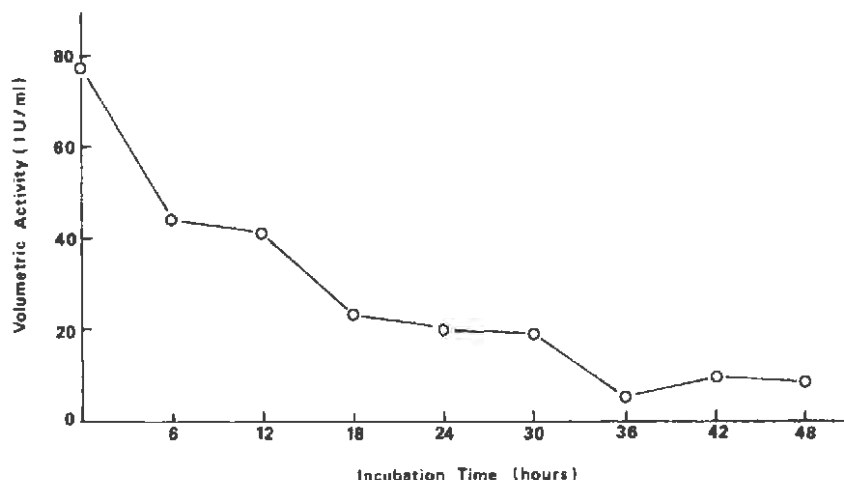


Figure 12. Volumetric activity of glucoamylase during continuous production by *A. awamori* NRRL 3112 at 30°C and pH 5.5 using 20% solids level of substrate.

agreement with those obtained by Smiley (1974) and Osorio (1981) using the same strain of mold. Furthermore, lower glucoamylase activities were obtained at 15% and 25% solids level (Smiley, 1974). Unfortunately, our studies on the effect of 10% and 20% inoculum sizes, corresponding to initial values of  $7.20 \times 10^5$  and  $1.5 \times 10^6$  spores per ml of the medium were not conclusive. Continuous-flow glucoamylase production at 30°C and pH 5.5 using 20% solids level of substrate showed a decreasing volumetric activity of the culture filtrate with time, as shown in Figure 12. The results show that the mold exhibits metabolic instability during continuous-flow culture; hence, batch enzyme production is preferable.

Partial purification data for glucoamylase using ethanol precipitation are presented in Figure 13 and Table 5. A four-fold purification of the enzyme was obtained after precipitation of the 50-80% ethanol fraction. The solid enzyme preparation had high gravimetric and specific activities which are comparable with commercial liquid glucoamylase preparations.

#### *Alpha-Amylase Production*

The enzyme alpha-amylase is required for the initial dextrinization of starch prior to saccharification by glucoamylase as shown in Figure 2. This enzyme has been produced in our laboratory in an airlift fermenter using *Bacillus subtilis* NRRL 3411. A simplified process of producing the enzyme was developed using as substrate a mixture of cassava root flour, rice bran, fish meal and soybean meal. Optimal fermentation conditions of pH, temperature, aeration rate and fermentation time were determined in order to obtain maximal yields of the enzyme. The enzyme

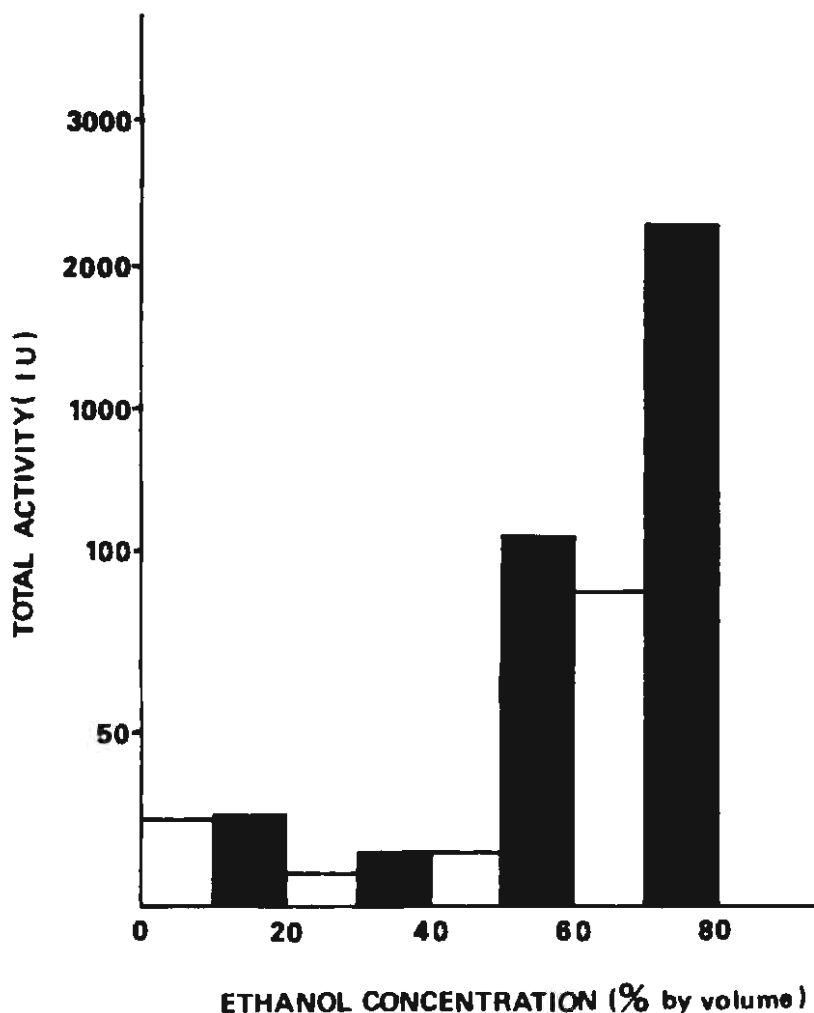


Figure 13. Total activity of glucoamylase precipitated at varying ethanol concentrations.

was then partially purified and concentrated and suitable stabilizing agents were added in order to produce stable liquid or solid enzyme preparations (E.J. del Rosario and T.V. Den, Phil. Patent Pending).

#### Acknowledgements

The author is grateful for having been awarded one of the Outstanding Young Scientist Awards in 1981. The technical data presented in this paper were based

Table 5. Comparison of laboratory and commercial preparations of glucoamylase

<i>Glucoamylase Preparation</i>	<i>Volumetric Activity (IU/ml) or Gravimetric Activity (IU/g)</i>	<i>Protein Concentration (mg/ml or mg/g)</i>	<i>Specific Activity (IU/mg protein)</i>
Crude enzyme (culture filtrate)	130	9.3	14.1
Precipitate (50-80% ethanol fraction)	3,992	69.2	57.7
SIGMA Amylo-glucosidase No. A-9268	1,443	57.7	27.9
NOVO Amylo-glucosidase 200L	6,805	171.7	39.6

primarily on the masteral theses of L. Bondoc, Jr. and A. Acabal, which were done under the author's supervision, and on collaborative research with Dr. Truong Van Den. Research support provided by BIOTECH-UPLB and F.E. Marcos Foundation, as well as the grant of VISCA-PCARRD and SEARCA Scholarships to L. Bondoc, Jr. and A. Acabal, respectively are gratefully acknowledged.

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### Lydia Joson, Discussant

The development of technology for the production of cellulolytic and amylolytic enzymes is indeed of a vital importance if the utilization of agricultural produce and wastes is to be maximized for conversion into energy, food, and chemical feedstuff. The technology for the enzymatic hydrolysis or saccharification of starches and cellulotics has long been known but its industrial application has been hindered by the high cost of enzyme production. To reduce the cost, cheaper and more efficient production methods should be developed to make the process economically viable. The UPLB group of researchers under the able leadership of Dr. del Rosario has been contributing greatly towards the development of enzyme and microbial technology in the country.

In the development of microbial process or product for industrialization, many factors come into play which should be considered:

#### 1) Raw Materials

The cost of raw materials usually constitutes about one-half to three-fourths of the cost of the product. The Philippines being a tropical agricultural country has an almost inexhaustible source of cheap raw materials. Dr. Swaminathan this morning mentioned the different methods of how agricultural residues could be processed into products of more economic value. Dr. del Rosario and his co-workers have developed a laboratory process for the production of enzymes using these same materials, which could be the basis for an industrial plant. These enzymes are necessary for the processing of large bulk of cellulotics and starchy materials into liquid biofuel, food, and chemicals.

#### 2) Microorganisms

Of course, the most important in the development of a microbiological process is the microorganism. In the studies of Dr. del Rosario *et al.*, cellulase was produced by several cellulolytic fungi. The most active, however, was a local isolate of *Penicillium* using untreated bagasse as substrate. This is very advantageous for no pre-treatment is necessary which otherwise can add to the cost of production. The same result, that is cellulase production by *Penicillium*, has been found by the group of researchers of the International Center of Cooperative Research and Development in Microbial Engineering in Japan. They found that *Penicillium purpurogenum* (Sasaki *et al.*, 1983) could also produce cellulase more active than *Trichoderma reesei*. *Trichoderma reesei*, the well-known cellulolytic fungus, is noted for its high production of a well-balanced cellulase complex required for the hydrolysis of crystalline cellulose. The enzyme system, however, is not sufficient to degrade native cellulose which the *Penicillium* of Dr. del Rosario could degrade. Other limitations of *T. reesei* enzymes are the weak beta-glucosidase activity; the need for inducers for enzyme production; the feed back inhibition of enzyme production by glucose; and its low yield. To remedy these deficiencies, strain improvement programs have been developed by two groups of researchers from the Quartermaster Laboratory of the U.S. Army Natick Research and Development and

from Rutgers University in New Jersey, as given by Dr. del Rosario. Through UV and nitrosoguanidine mutagenesis and of resistance to kabicidin, they were able to develop highly active strains. Among these are RUT NG-14 and RUT-C30 which are 5 times more active than the mutant QM 9414 (Montenecourt *et al.*, 1979); MCG 77 which can grow in glucose and other soluble substrates and produce high cellulase complex after substrate exhaustion (Gallo *et al.*, 1978); and MCG 80 which has lost its feed back inhibition to glucose and can utilize soluble substrates such as lactose and glucose (Allen and Andreotti, 1982). The proper choice of microorganism as the *Penicillium* of Dr. del Rosario is very important for the economic production of the enzyme.

### 3. Method of Propagation

There are two general methods of propagating microorganisms for the production of enzymes: solid substrate fermentation and submerged aerated process. The method of choice depends on the type of microorganism involved. Filamentous fungi because of their nature can be propagated by both methods with success, but not bacteria. As discussed by Dr. del Rosario, the submerged aerated process is easier to control and can be easily scaled up to commercial production. It is, however, more capital intensive but less labor intensive than solid substrate fermentation.

The airlift fermentor developed by Dr. del Rosario which is much cheaper than the commercial ones is indeed a positive step towards the industrial production and utilization of these enzymes in the country. I would like to add, however, that the National Institute of Science and Technology is also involved in the production of these enzymes. A systematic screening of soils for the presence of mesophilic and thermophilic cellulolytic and amylolytic bacterial fungi is being undertaken. A technology has been developed for the production of glucoamylase by solid substrate fermentation using the same organism *Aspergillus niger* NRRL 3112. Yields of about 150 IU/gram of substrate (rice bran and cassava bagasse) have been obtained. Amylase production of *Bacillus licheniformis* IFO 1220 by submerged aerated process is being undertaken.

### Priscilla C. Sanchez, Discussant

Developing countries like the Philippines would do well if they could harness nature's gift, that is the abundant renewable raw materials from plant biomass. Microbial conversions or transformations of this important resource into goods, industrial and energy products could help greatly in improving the living conditions in these countries.

The key to the bio-transformations and synthesis of new materials and compounds from plant biomass (the celluloses, starch and sugars) are the microorganisms and enzymes they produce. These biological catalysts (enzymes) hold the key to the full utilization of the abundant plant biomass around us.

Considerable advances have been made in the utilization of starches and sugars but much have to be done with cellulose which commonly abound with lignin in nature to form lignocellulose. The only useful means of utilizing lignocellulose by biological conversion is to use it in growing mushrooms.

Dr. del Rosario's work demonstrated the possibilities of the production of enzymes for industrial use. We have an abundance of raw materials for the purpose and we should proceed in the pilot production of these enzymes to test the economic feasibility. Similarly, local isolates of microorganisms must be screened. These local isolates are more adapted to our conditions hence efficiency will be much higher.

The isolates which Dr. del Rosario used (except for *Penicillium*) are standard isolates from other countries. Possibly, comparison of the efficiency of these isolates done in other countries and the result of study should have been made. This would at least give us an idea of how much more work must be done to have a full use of the technology.

Now many cellulolytic fungi have been found for commercial cellulose production such as Onozuka (Kinki Yakult Co., Ltd.) from *Trichoderma reesei* (*T. viride*) and cellulodin (Ueda Chemical, Ltd.) from *Aspergillus niger* (CANUZ). But these are not so active in the treatment of cellulose in higher temperature, and so cellulolytic thermophilic fungi could play an active role in the decomposition of cellulose at higher temperature. Application of thermophilic microorganism in degrading the abundant raw materials in the Philippines offer a solution in efficiently utilizing these materials.

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## STUDIES ON THE BIOMETHANATION OF RICE STRAW

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### ABSTRACT

The biomethanation of rice straw which was subjected to different pretreatment modes and fortified with pig manure was studied. The volume and quality of the biogas produced were monitored as well as the changes in the composition of the substrate.

The anaerobic digestion of crop residues has been posed as an option towards the utilization of these lignocellulosic residues. At present, the farmer feels that the most practical way of using this resource is to return them to the soil.

The amount of lignocellulosic crop residues generated in the Philippines annually is of significant volume and comes mainly from sugarcane bagasse, rice straw, rice husk and coconut husk. Table 1 and Table 2 show the volumes and compositions of their residues (Del Rosario, 1978).

The figures show that as of 1975, the amount of rice straw produced was 5 million tons. Thus the quantities are large and other uses for this residue must be explored.

There is not much published work on the detailed analysis of the constituents of rice straw, but a representative analysis of the proximate composition of the straw IR-8, a variety of rice, is shown in Table 3. The organic portion of rice straw, especially cellulose and hemicellulose are potential substrates for microbial action. However, lignification, silicification and the highly crystalline structure of cellulose reduce the biodegradability of rice straw. A proper understanding of the effects of these factors on the biomethanation of rice straw will allow the utilization of this crop residue in biogas production.

### Background Information

Badger and co-workers (1979) have noted that all their test crops produced twice as much biogas as did cattle manure. Further studies on the feasibility of the biomethanation of crop residues have also been conducted by Clausen and co-workers (1979). Boersma and co-workers (1981) noted the need to fortify crop residues with manure to improve the carbon: nitrogen ratio.

The nature of cellulose, in association with lignin, pectins, tannins, etc. makes it difficult for microorganisms to degrade. Gaden (1975) suggested that the degree of crystallinity and the extent of lignification of cellulosic materials determine their accessibility to hydrolytic action. The presence of silica as another

Table 1. Production estimates of some crop residue in the Philippines.

<i>Crop Residue</i>	<i>Amount Generated Million Mt/Yr.</i>	<i>Year</i>
Sugarcane bagasse	5.3	1975
Rice straw	5.0	1975
Rice hulls	1.0	1975
Coconut coir dust	2.1	1977

Source: Del Rosario (1978)

Table 2. Approximate composition of some lignocellulosic materials.

<i>Material</i>	<i>Cellulose %</i>	<i>Hemicellulose %</i>	<i>Lignin %</i>	<i>Ash %</i>
Sugarcane bagasse	40-50	20-30	18-20	4
Rice straw and rice hulls	35-45	20	20-30	15-20
Coconut coir dust	24.2	27.3	54.8	6.2

Source: Del Rosario (1978)

encrusting substance further increases the indigestibility of the cellulosic material (Han, 1975). Rice straw has an extremely high silica content of up to 16.5% of its dry matter (Han, 1975).

Thus, in order to improve the degradability of lignocellulosics, various physical and chemical pretreatment modes have been proposed (Han and Callihan, 1974; McManus and Choung, 1976; Ghedalla and Miron, 1981).

In view of the above-mentioned information, studies were conducted to determine the factors that influence the bioinethanation of rice straw.

### Materials and Methods

The experiment was conducted using the set-up in Fig. 1. Gas slides volumes were measured by water displacement and the digester bottle was shaken twice a day to allow for the mixing of the contents.

pH was monitored using pH paper moistened with the fermentation medium. Gas quality was determined using the flammability test and gas chromatographic

Table 3. Proximate composition of the rice straw from IR-8.

<i>Constituent</i>	<i>Per cent</i>
Crude Protein	3.21
Crude Fiber	28.59
Crude Fat	3.10
NFE	46.86
Total Ash	18.24
Ca	0.46
P	0.14

Source: Mohammed and Ravi, 1969.

analysis on a Shimadzu GC3B using a stainless steel column packed with 60/80 mesh activated carbon and nitrogen as carrier.

Volatile solids was determined using the standard AOAC methods and the analysis of rice straw by sequential fractionation was based on the method of Datta (1981) and shown on Fig. 2.

The fermentor slurry was prepared using chopped rice straw (5 cm) and ground rice straw (40 mesh) mixed with the starter and enough water to make up 2.1 liters final volume.

The following chemical treatments were used:

1. Sodium Hydroxide — Rice straw was soaked in 4% sodium hydroxide solution at room temperature for 4 hrs. Straw was washed until neutral with distilled water after soaking.
2. Sodium hydroxide with neutralization using hydrochloric acid. After the alkali treatment period as in 1, excess alkali was neutralized with hydrochloric acid overnight and subsequently washed with distilled water.
3. Ammonia — Rice straw was soaked in 0.1 ammonia water solution at room temperature for 20 days. Excess ammonia was washed off until neutral.
4. Hydrochloric acid — Rice straw was soaked in 0.1 N hydrochloric acid for six hours at 60°C with constant stirring and subsequently washed with distilled water until neutral.
5. Steaming — Premoistened rice straw was autoclaved at 15 psi for 1.5 hrs.
6. Coconut Coir Dust Ash Solution — Rice straw was soaked for 3 days at room temperature with coconut coir dust ash solution at varying concentrations and washed with distilled water until neutral.



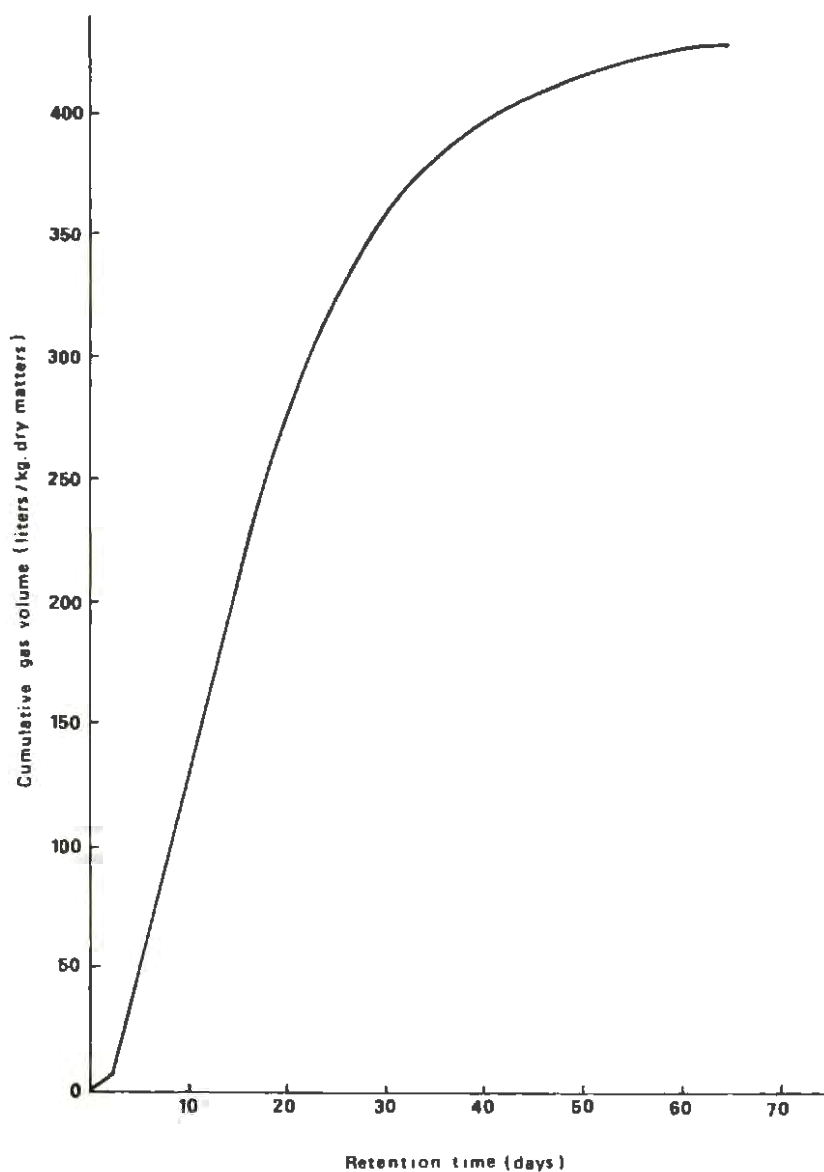


Figure 1. Typical gas production curve.

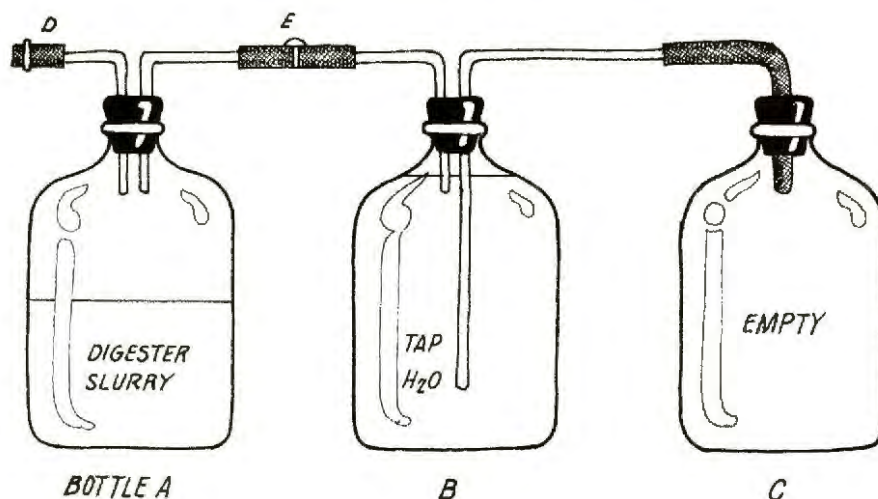


Figure 2. Biodigester set-up.

### Discussion of Results

Ground rice straw (40 mesh) proved to be a better substrate than chopped rice straw (5 cms).

The results are summarized in Tables 4-10. The different treatments had various effects in the removal of the dry matter contents of rice straw. The treatment using bases showed an average weight loss of between 33% and 39%. Negligible changes were observed with the steam treated samples. Major losses in the water soluble fractions were also observed using the base treatments. Likewise, the bases were able to extract more hemicelluloses than hydrochloric acid.

The lignin portion of the rice straw was effectively removed by the bases. The cellulose fraction seem to be the least susceptible to loss during chemical treatment.

The silica content could be lowered by about 75% using the bases.

It has been shown that after 70 days of fermentation, only 50% of the volatile solids has been converted to biogas.

Chemical treatment of rice straw before fermentation showed varying degrees of improvement except for the hydrochloric and sodium hydroxide enhanced biogas production and shortened the active growth phase, but treatment with ammonia and hydrochloric acid even slowed down gas production within the first two weeks.

Methane concentrations in the different treatments range from 49% to 75% as the fermentation progressed. Fluctuations were observed during the first 30 days, the methane levels becoming more stable after the first month. High levels of methane were observed in both the neutralized and unneutralized sodium hydro-

Table 4. Average values of % volatile solids and % ash of control and treated rice straw.

	% Volatile Solids	% Ash
Rice Straw (5 cm)	77.49	22.51
Ground Rice Straw	77.5	22.47
Treated Ground Rice Straw		
NaOH	73.95	26.05
NH <sub>3</sub>	74.82	25.18
NaOH-HCl	74.65	25.35
HCl	75.90	24.10
Steam Pressure	77.57	22.44

Table 5. Ashfree values of the different components of rice straw using fractionation method of analysis.

Treatment	% Water Solubles	% Hemi-Cellulose	% Cellulose	% Lignin
Ground Rice Straw	16.51	16.39	34.45	10.18
Treated Ground Rice Straw				
NaOH	5.76	7.04	30.95	1.63
NH <sub>3</sub>	7.50	8.55	31.04	2.31
NaOH-HCl	8.44	7.00	30.82	1.68
HCl	10.66	8.36	32.98	9.93
Steam Pressure	16.81	16.29	34.25	10.21

xide treatments from 16-32 days of fermentation giving methane levels above 70%. Both the hydrochloric acid and steam treatment did not improve gas quality compared to untreated ground rice straw and untreated chopped straw.

The flame tests showed bluish luminous color whose persistence was proportional to the rate of biogas production.

Regression analysis shows that gas production is enhanced by the levels of water solubles, hemicelluloses and cellulose contents and inhibited by lignin and alkali soluble silica contents. This confirms findings of other workers.

Preliminary results using coconut coir dust ash as an indigenous source of alkaline material shows very encouraging results with cumulative gas volumes of

Table 6. Ash analysis of treated and control rice straw after ignition at 550°C.

<i>Treatment</i>	<i>% Sand</i>	<i>% Alkali Soluble Silica</i>
Ground Rice Straw	75.07	10.15
Treated Rice Straw		
NaOH	88.90	2.63
NH <sub>3</sub>	86.45	2.83
NaOH-HCl	88.02	2.82
HCl	78.68	10.62
Steam Pressure	75.18	10.12

Table 7. Percentage of the volatile solids converted to biogas (Trial 1).

<i>Treatment</i>	<i>Day 7</i>	<i>Day 14</i>	<i>Day 21</i>	<i>Day 28</i>	<i>Day 36</i>	<i>Day 70</i>
Rice Straw	8.75	19.59	25.42	28.19	31.57	35.96
Ground Rice Straw	16.82	27.64	32.95	37.10	40.70	48.57
Treated Rice Straw						
NaOH	36.02	49.20	51.69	52.76	54.12	55.58
NH <sub>3</sub>	16.97	43.43	49.65	51.70	52.64	55.26
NaOH-HCl	29.96	48.00	51.69	53.92	54.89	57.45
HCl	5.60	13.60	22.45	33.89	39.14	45.85
Steam Pressure	22.38	30.82	35.92	37.67	40.48	46.35

400 liters at 67 days fermentation time and methane levels of up to 69% at three weeks fermentation time.

Detailed investigations are being undertaken to understand the reasons for the above-mentioned trends and observations. Likewise, a search for indigenous sources of treatment schemes is being undertaken. This is crucial for the technology to be moved to the countryside.

Table 8. Cumulative gas production (liters per kg. dry matter) for each treatment.

TREATMENT	D A Y S						
	3	6	15	21	28	36	70
Rice Straw (5 cm)	12	50	143	174	192	216	246
Ground Rice Straw (40 mesh)	53	96	200	225	254	278	332
Treated Rice Straw							
NaOH	82	164	244	252	257	264	271
NH <sub>3</sub>	19	56	230	254	265	270	283
NaOH-HCl	21	119	246	260	271	276	289
HCl	10	25	91	132	200	231	270
Steam Pressure	75	143	218	245	257	276	316

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Table 9. Concentration of the biogas produced in trial 2 (in % by volume methane)

TREATMENT	D A Y S														
	5	8	12	15	19	22	26	33	36	40	43	48	54	63	69
Ground Rice Straw	56.80	49.90	51.52	57.74	52.47	51.82	52.20	54.28	54.26	55.31	54.19	53.88	58.52	54.73	56.47
Rice Straw	60.68	54.31	53.08	58.51	55.22	49.90	49.75	51.66	55.83	51.84	52.21	53.14	60.40	56.95	56.28
Treated Rice Straw															
NaOH	49.95	48.59	47.07	50.09	64.26	74.69	73.59	70.43	60.90	58.81	58.48	57.10	56.33	57.96	65.07
NH <sub>3</sub>	50.22	47.24	50.15	55.16	70.49	63.74	65.41	63.67	62.04	59.08	59.43	56.32	58.44	60.11	59.55
NaOH-HCl	44.37	50.01	56.79	51.55	73.84	76.71	70.50	70.70	64.40	61.79	60.22	61.08	65.17	65.89	66.23
HCl	55.07	61.26	55.49	55.39	56.60	47.21	50.96	54.20	53.78	53.61	53.69	55.02	57.83	58.48	57.40
Steam Pressure	53.16	56.10	60.77	55.46	52.66	50.76	53.00	56.31	57.46	53.12	55.76	55.52	53.93	53.52	53.13

Table 10. Mean cumulative volume of gas produced and gas chromatographic analysis of pretreated rice straw.

TREATMENT	GAS VOLUME (l/kg. DRY MATTER)	GAS COMPOSITION DAYS					
		9		16		23	
		%CH <sub>4</sub>	%CO <sub>2</sub>	%CH <sub>4</sub>	%CO <sub>2</sub>	%CH <sub>4</sub>	%CO <sub>2</sub>
6% Coir Dust Ash	398	54	46	57	43	58	42
9% Coir Dust Ash	413	54	46	60	40	51	49
12% Coir Dust Ash	353	54	46	61	39	59	41
15% Coir Dust Ash	430	50	50	68	32	69	31
Control	311	56	44	51	49	64	36

**Julian A. Banzon, Discussant**

This study on biomethanation of rice straw is probably the only lengthy Philippine contribution on the subject so far. The authors have taken advantage of the much-studied caustic soda treatment of straw to increase digestibility of the straw for animal feeding.

Anaerobic digestion of waste biomass resulting in methane-rich biogas is one of the ways to meet the petroleum fuel problem. This gas serves to replace LPG in the kitchen; in N.Z., methane is separated from  $\text{CO}_2$  (as both occurs in biogas) and the  $\text{CH}_4$  is compressed and commercially used to run taxi cabs, cars and tractors. The potential purefulness of straw as a source of a very versatile fuel is thus obvious. A little over 1/2 of the biomass of the mature rice plant consists of straw, the grain comprise the remainder, hence the magnitude of the available rice straw for biomethane procedure while the experiments reported are in the laboratory stage where costs may be of secondary importance, experimenters however should keep a sharp eye on keeping procedures simple and inexpensive, if the lab results are any nearer to succeed in field trials. Water has become a very precious and scarce commodity in most any place; distilled water should be mentioned most prudently.

Some information relevant to the subject of biomethanation was discussed in an Australian-Asian Symposium on utilization of fibrous materials last May 1981 and which was held in the UPLB Campus; it appears that the authors missed this symposium.

Summing up, the authors deserve congratulation for pioneering in this area of straw utilization via biomethanation.

**Romeo V. Alicbusan, Discussant**

When the paper was submitted to me for review it is the first time that I have read such kind of work that discussed in details some studies in the bioconversion of rice straw to methane. There are some publications from other countries you can come across but these are more of a passing reference rather than a detailed report on what happens with the rice straw as it produces the biogas, how much amount is needed, what kind of pre-treatment must be done. There is no such study before and so this work is very pioneering as far as the magnitude and the nature of the research is concerned. In a way that this is going it is answering the question why rather than the how. The study, however, should be geared towards rural adaptation taking into consideration the economic situation of the people. I think the simplest way by which we can adopt the technology is to make it more practical yet efficient. It may only be 50% efficient but if easier and cheaper to make people



will accept it. I would say that maybe in the years to come when a lot of these uncertainties about rice straw conversion to methane has been resolved, the Biotech Institute will go down to the level of simplifying the procedure of methane production so that it will be highly adaptable for rural communities. Hand in hand with this development, I think engineering study must be done so that the digester could be adapted to the kind of raw material that it is going to receive. The report of Dr. Padolina is something that has look beyond the objectives. I am recommending that you study the microbiological aspect especially the anaerobes. I know that Dr. Barril studied quite extensively in Australia on this aspect and probably his expertise could be tapped. Methane generation can be done only with appropriate raw materials and the microorganisms under favorable conditions.

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