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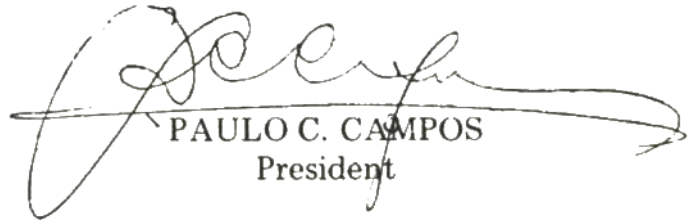
FOREWORD

The Academy was created by virtue of P.D. 1003-A of December, 1976. It was not until July 1978 though that it was established to provide a reservior of competent and technological manpower for the country.

Indeed, the creation of the Academy gives substance and meaning to the State's conviction and policy of stepping-up interest in the sciences. The Academy adequately fulfills an answer to what the future holds for erudition and scholarly work of Filipino scientists.

The National Academy of Science and Technology in celebrating its First Anniversary signified it by holding the First Annual Presentation of Papers. This, in stature necessitated the publication of the Transactions.

We hope that in putting out this publication members as well as friends of the scientific community will benefit and will be able to utilize it fully.



PAULO C. CAMPOS
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CONTENTS

GEOMETRY OF A SYSTEM OF LINEAR HOMOGENEOUS PARTIAL DIFFERENTIAL EQUATIONS

By Raymundo A. Favila

Introduction

Using a system of partial differential equations, in this paper we shall study a configuration of surfaces and congruences of lines whose elements are in a 1 — 1 correspondence. Many eminent geometers such as Wilczynski, Lane and Green had investigated the properties of a single congruence of lines but very few have studied a pair of congruences.

In this work we shall consider a pair of congruences whose generators are in 1 — 1 correspondence and which are related in a special way. We shall make use of the properties of integrable systems of differential equations and the theory of transformation to explore the intrinsic nature of the new configuration.

The Elements of the Theory of Surfaces

The concept of surface is basic in this study. Roughly speaking, a surface is a two-parameter family of points; that is, it is the locus of a point moving with two degrees of freedom. For the purposes of this study, however, these descriptions are not altogether adequate. We shall need more precise definitions.

Let the homogeneous projective coordinates (x_1, x_2, x_3, x_4) of a point in a three dimensional space be given as single-valued analytic functions of two independent variables u and v by

$$x_i = x_i(u, v), i = 1, 2, 3, 4,$$

which we write in vector notation as:

$$x = x(u, v).$$

Curves on a Surface

As u and v vary in a domain T the point generates a surface — an analytic surface. The point shall be denoted by P_x and its locus by S_x.

A curve is a one parameter family of points. If we put v = constant, c, in the parametric vector equation $x = x(u,v)$ of S_x we get a one-parameter set of points whose vector equation is

$$x = x(u, c) = f(u).$$

The locus of the point P_x is a curve which we shall call a u -curve on the surface S_x. If c varies over all possible values we obtain a family of u-curves which covers S_x.

A second family of curves is obtained if we set u = constant = c. It is the locus of P_x where

$$x = x(c, v) = g(v).$$

If c takes all possible values a second family of curves — the v-curves — is obtained.

The surface S_x is then covered by two families of curves — the u-curves and the v-curves. Thru each point P_x intersect one u-curve and one v-curve. The parameters u and v are called the curvillinear coordinates of P_x.

Let C be any curve on the surface S_x. Then it is a one parameter family of points. Therefore, each of the coordinates u and v of a point on c is expressible as a function of a parameter t; that is,

$$u = u(t), v = v(t).$$

Thus C is the locus of points P_x, where

$$x = x(u(t), v(t)),$$

as t varies over all possible values.

Consider a point P_x on C with coordinates u(t), v(t). The line P_xP_x', where $x = x(u(t), v(t))$ and $x' = \frac{\partial x}{\partial u}\frac{du}{dt} + \frac{\partial x}{\partial v}\frac{dv}{dt}$ is tangent to C at point P_x.

In the case of the u-curve and the v-curve the lines $P_xP_{x_u}$ and $P_xP_{x_v}$ are tangent lines to these curves respectively at P_x.

A differential equation of the form

$$M(u, v)du + N(u, v)\, dv = 0$$

represents a one-parameter family of curves on the surface. For, if

$$v = f(u, c), \text{ c is a variable parameter,}$$

is a general solution of the differential equation, from the vector equation $x = x(u, v)$ of S_x, we get, when v is replaced by f(u, c), the vector equation

$$x = x(u, f(c)) = g(u,c),$$

which is the vector equation of a one-parameter family of curves on S_x.

In particular, the parametric curves u = constant and v = constant are integrals of du = 0 and dv = 0 or of dudv = 0.

Tangent Plane and Osculating Plane

The plane determined by the points P_x, P_{x_u} and P_{x_v} is called the *tangent plane of S_x at P_x*.

If C is a curve on S_x thru P_x defined by

$$u = u(t), v = v(t),$$

then the plane determined by P_x, P_x' and P_x'', where

$$x' = x_u \frac{du}{dt} + x_v \frac{dv}{dt}$$

$$x'' = x_{uu} \frac{dy^2}{dt} + 2x_{uv} \frac{du}{dt}\frac{dv}{dt} + x_{vv} \frac{dv^2}{dt} + x_u \frac{d^2u}{dt^2} + x_v \frac{d^2v}{dt^2},$$

is called the *osculating plane of C at P_x*.

If at each point P_x of C on S_x, the tangent plane of S_x and the osculating plane of C *coincide*, then C is an *asymptotic curve* on S_x.

If $\bar{X}$ is any point in the tangent plane of S_x or in the osculating plane of C at P_x then

$$\begin{aligned} (\bar{X}, x, x_u, x_v) &= 0 \\ (\bar{X}, x, x', x'') &= 0 \end{aligned} \qquad (2.2)$$

are the equations of the tangent plane of S_x and the osculating plane of C respectively at P_x.

We say that a curve C on a surface S_x is an *asymptotic curve* if the tangent plane of S_x at each point of C coincides with the osculating plane of C.

Since P_x and P_x' are points in both the planes in (2.2), a necessary and sufficient condition that C is an asymptotic curve is that the point P_x'' also lies in the tangent plane.

This means that

$$(x'' \; x \; x_u \; x_v) = 0.$$

When the value of x'' given by (2.1) is substituted in this equation we get

$$L\,du^2 + 2M\,du\,dv + N\,dv^2 = 0, \qquad (2.3$$

where

$$L = (x_{uv},\ x,\ x_u,\ x_v) \qquad (2.4$$

$$M = (x_{uv},\ x,\ x_u,\ x_v)$$

$$N = (x_{uv},\ x,\ x_u, x_v).$$

The differential equation of the parametric net on S_x

$$du\ dv = 0. \qquad (2.5$$

This equation will coincide with (2.3) if, and only if

$$L = 0,\ M \neq 0,\ N = 0;$$

that is if, and only if

$$(x_{uu},\ x,\ x_u,\ x_v) = 0$$
$$(x_{vv},\ x,\ x_u,\ x_v) = 0$$
$$(x_{uv},\ x,\ x_u,\ x_v) \neq 0.$$

The first and second equation say that x_{uu} and x_{vv} are linear combinations of x, x_u and x_v, whereas the last relation says that x_{uv} is linearly independent of x, x_u and x_v. Hence we have proved that the parametric curves on S_x are asymptotics on S_x if, and only if there exist scalar functions $p(u, v)$, $q(u, v)$, $\alpha(u, v)$, $\beta(u, v)$, $\gamma(u, v)$ and $\delta(u, v)$ such that

$$x_{uu} = px + \alpha x_u + \beta x_v$$
$$x_{vv} = qx + \gamma x_u + \delta x_v \qquad (2.5)$$

and no relation of the form

$$Px_{uv} + Qx_u + Rx_v + S_x = O,$$

where P, Q, R and S are scalar functions of u and v, exists.

Thus we have shown that a surface S_x is an integral surface of a system (2.5) of second order partial differentiations when the parametric curves are the asymptotic curves on the surface. But it is not true conversely that given a system (2.5) there exists an integral surface S_x. For the existence of S_x satisfying (2.5), the system (2.5) must have to be completely integrable. The coefficients p, q, α, β, γ, δ cannot be arbitrary. They must satisfy certain conditions for integrability. These conditions arise from the demand that

$$(x_{uu})_{uv} = (x_{uu})_{vu},\ (v_{uu})_{vv} = (x_{vv})_{uu},\ (x_{vv})_{uv} = (x_{vv})_{vu}.$$

Lane proved that S_x is an integral of the system

$$\begin{aligned} x_{uu} &= px + \theta_u x_u + \beta x_v \\ x_{vv} &= qx + \delta x_u + \theta_v x_v \end{aligned} \qquad (2.6)$$

(1)

provided the following integrability conditions are satisfied:

$$\begin{aligned} \theta_{uvv} &= (\varphi\delta)_u + 2q_u + \theta_v \theta_{uv} - \beta\delta\psi \\ \theta_{uuv} &= (\varphi\beta)_v + 2p_v + \theta_u \theta_{uv} - \beta\delta\varphi \qquad (2.7) \\ p_{vv} - \theta_v p_v + \beta q_v + 2q\beta_v &= q_{u\tilde{u}} \theta_u q_u + \delta p_u + 2p\delta_u \end{aligned}$$

where

$$\varphi = (\log \beta\delta^2)_u, \quad \psi = (\log \beta^2\delta)_v \qquad (2.8)$$

When the integrability conditions (2.7) are satisfied by the coefficients of (2.6), the system is completely integrable and has four independent solutions:

$$x_i = x_i(u, v),\ i = 1, 2, 3, 4$$

which are then the coordinates of a variable point P_x the locus of which is a surface S_x.

Thus the systems (2.6) and (2.7) are differential defining an analytic surface S_x referred to its asymptotic net.

A second net of curves on the surface to which S_x may be referred is a conjugate net. In a conjugate net, the tangents of the

(1) E. P. Lane, Projective Differential Geometry of Curves and Surface, University of Chicago Press, 1932 p. 69. This book will be referred to as Lane.

curves of one family at the points of each fixed curve of the other family form a developable. If the conjugate net is taken as the reference curves on the surface S_x, then S_x is an integral of a system of the form

$$x_{uu} = ax_{vv} + bx_u + cx_v + dx \quad (1)$$

$$x_{uv} = b'x_u + c'x_v + d'x,$$

with the corresponding integrability conditions.

Congruences of Lines

A congruence of lines is a two-parameter family of lines. It is the locus of a line moving with two degrees of freedom. A congruence may be formed in several ways. For our purposes, we shall consider congruence whose generators are in 1-1 correspondence with the points of a surface.

Let S_x and S_y be two analytic surfaces whose points are in 1-1 correspondence. Then the points P_x on S_x and P_y on S_y correspond if they have the same curvillinear coordinates (u, v). The line $P_x P_y$ generates a congruence as P_x and P_y vary independently over S_x and S_y respectively, since each line $P_x P_y$ is determined by two independent parameters u and v.

Consider now two congruences $\Gamma_{xy} = (P_x P_y)$ and $\Gamma_{\bar{x}\underline{y}} = (P_{\bar{x}} P_{\underline{y}})$ determined by the pairs (S_x, S_y) and $(S_{\bar{x}}, S_{\underline{y}})$ of surfaces, whose points are in a 1-1 correspondence; that is, the points P_x, P_y, $P_{\bar{x}}$ and $P_{\underline{y}}$ have the same curvillinear coordinates (u, v). Then the generator $P_{\bar{x}} P_{\dot{y}}$ of Γ_{xy} and the generator $P_{\bar{x}} P_{\underline{y}}$ of $\Gamma_{\bar{x}\underline{y}}$ are corresponding generators of Γ_{xy} and $\Gamma_{\bar{x}\underline{y}}$.

The aim of this paper is to study this congruence correspondence. We shall start by setting up a system of partial differential equations for the congruences Γ_{xy} and $\Gamma_{\bar{x}\underline{y}}$ and deduce therefrom the properties of the new geometric configuration.

We shall assume that P_y does not lie in the tangent plane of S_x at P_x. Then $(x, x_u, x_v, y) \neq 0$. Therefore, if α and β are any vector function of u and v, there exist scalar functions A, B, C, D, A′, G′, D′, of u and v such that

$$\alpha = Ax + By + Cx_u + Dx_v$$

$$\beta = A'x + B'y + C'x_u + D\,x_v.$$

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(1) E. J. Wilczynski, Projective Differential Geometry of Curved Surfaces, I Trans. of the Am. Math. Society 8, 233-60.

Eliminating x_u and x_v in succession, we have:

$$\frac{D'\alpha - D\beta}{CD' - c'D} = \frac{AD' - A'D}{CD' - C'D}x + \frac{BD' - B'D}{CD' - C'D}y + x_u$$

$$\frac{C'\alpha - c\beta}{C'D - c'D'} = \frac{Ac' - A'C}{C'D - cD'}x + \frac{BC' - B'C}{C'D - cD'}y + x_v,$$

$$CD' - C'D \neq 0.$$

Then if we put

$$\underline{\bar{X}} = \frac{D'\alpha - D\beta}{CD' - C'D}, \quad \underline{Y} = \frac{C'\alpha - c\beta}{CD' - C'D}$$

we can write the above equations in the form

$$\begin{aligned} \underline{\bar{X}} &= x_u - lx - my \\ \underline{Y} &= x_v - l'x - m'y. \end{aligned} \tag{3.1}$$

These define the surfaces S_x and S_y. Note that if $(x, y, x_u\ x_v) \neq 0$ then

$$(\underline{\bar{x}}, \underline{y}, x, y) \neq 0.$$

Hence every vector function may be expressed as a linear combination of x, y, $\underline{\bar{x}}$ and $\underline{y}$: Therefore, the study of a pair, of congruences whose generators are in 1-1 correspondence may be based on the following system of linear homogeneous partial differential equations:

Differential Equations for Γ_{xy} *and* $\Gamma_{\underline{\bar{x}}\underline{y}}$

$$\begin{aligned} x_u &= lx + my + \underline{\bar{x}} & y_u &= ax + by + c\underline{\bar{x}} + d\underline{y} \\ x_v &= l'x + n'y + \underline{y} & y_v &= a'x + b'y + c'\underline{\bar{x}} + d'\underline{y} \\ \underline{\bar{x}}_u &= e\,x + fy + g\underline{\bar{x}} + h\,\underline{y} & \underline{y}_u &= px + qy + r\,\underline{\bar{x}} + s\underline{y} \\ \underline{\bar{x}}_v &= e'x + f'y + g'\underline{\bar{x}} + h'y & \underline{y}_v &= p'x + q'y + r'\underline{\bar{x}} + s'\underline{y} \end{aligned} \tag{3.2}$$

The scalar coefficients in the above equations are not arbitrary functions of u and v but must satisfy the following integrability conditions which are obtained by imposing the conditions $x_{uv} = x_{vu}$, $y_{uv} = y_{vu}$, etc.

Integrability Conditions

$$l'u + p + m'a = lv + e' + ma'$$

$$m'_u + q + l' m + m'b = m_v + f' + l m' + m b'$$

$$r + l' + m'c = g' + mc'$$

$$s + m'd = h' + l+md'$$

$$a'_u + a'l + ab' + c'e + d'p = a_v + al' + a'b + ce' + dp'$$

$$b'_u + a'm + c'f + d'q = b_v + am' + cf' + dq'$$

$$c'_u + a' + b'c + c'q + d'r = C_v + bc' + cg' + dr' \qquad (3.3)$$

$$d_u' + b'd + c'b + d's = d_v + bd' + ch' + ds' + a$$

$$e_u' + e'l + f'a + g'e + h'p = e_v + el' + fa' + ge' + hp'$$

$$f_u' + e'm + f'b + g'f + h'q = f_v + em' + fb' + fg' hg'$$

$$g'_u + e' + f'c + h'r = g_v + fc' + hr'$$

$$h'_u + f'd + g'h + h's = h_v + e + fd' + gh' + hs'$$

$$p'_u + p'l + q'a + r'e + s'p = p_v + pl' + qa' + re' + sp'$$

$$q'_u + p'm + q'b + r'f + s'q = q_v + pm' + qb' + rf' + sq'$$

$$r'_u + p' + q'c + r'g + s'r = r_v + qc' + rg' + sr'$$

$$s'_u + q'd + r'h = s_v + p + qd' + rh'.$$

We now introduce an additional relation between Γ_{xy} and $\Gamma_{\bar{x}\underline{y}}$.

Definition: Suppose that each generator P_xP_y of Γ_{xy} intersects an infinite number of surfaces in such a way that the tangent plane of each surface at its point of intersection with P_xP_y pass thru the corresponding line $P_{\bar{x}}P_{\underline{y}}$ of $\Gamma_{\bar{x}\underline{y}}$. Then the congruence $\Gamma_{\bar{x}\underline{y}}$ is said to be *stratifiable* with Γ_{xy}.

This definition is due to Fubini.[1]

We now raise the fundamental problem: Given a congruence Γ_{xy}, can we construct a second congruence $\Gamma_{\bar{x}\underline{y}}$ so that it shall be stratifiable with Γ_{xy}?

To answer this question, let a surface S_z, intersect the generator P_xP_y of Γ_{xy} at P_z, where, $z = x + \lambda y$, and inquire whether the function λ (u, v) can be determined so that the tangent plane of S_z at P_z will pass thru the line $P_{\bar{x}}P_{\underline{y}}$.

Let

$$(W, \bar{X}, \underline{Y}, \quad x + \lambda y) = 0$$

(1) M. S. Finikoff, Sur les congruences stratifiables, Circolo Matematica di Palermo, t. 53, p. 313. This paper will be referred to as Finikoff.

be a plane thru $\underline{\bar{X}}$, Y and $Z = x + \lambda y$. Then this will coincide with the tangent plane of S_z at P_z, where $z = x + \lambda y$ if, and only if at $W = x + \lambda y$, the following equations are satisfied:

$$(W, \underline{\bar{X}}, \underline{Y}, \; x + \lambda y) = 0$$

$$(W, \underline{\bar{X}}, \underline{Y}, \; x + \lambda y)_u = 0$$

$$(W, \underline{\bar{X}}, \underline{Y}, \; x + \lambda y)_v = 0$$

The first equation is identically satisfied. The last reduces to

$$(x + \lambda y \; , \; \underline{\bar{x}}, \; \underline{y}, \; \; x_u + \lambda y_u + \lambda_u y) = 0$$

$$(x + \lambda y \; , \; \underline{\bar{x}}, \; \underline{y}, \; \; x_v + \lambda y_v + \lambda_v y) = 0$$

which can be further simplified into

$$(x, y, \underline{\bar{x}}, y) \; [\lambda u - a\lambda^2 - (1 - b) \lambda + m] = 0$$

$$(x, y, \underline{\bar{x}}, \underline{y}) \; [v - a'\lambda^2 - (1' - b') \lambda + m'] = 0 \; ,$$

where the first four equations for x_u, x_v, y_u, y_v in (3.2) have been used. Since $(x, y, x, y) \neq 0$, we conclude that

$$\begin{aligned} \lambda_u - a \lambda^2 - (1 - b) \lambda + m &=) \; 0 \\ \lambda_v - a' \lambda^2 - (1' - b') \lambda \; + m' &= 0 \end{aligned} \qquad (3.4)$$

which are completely integrable provided the following integrability conditions are satisfied:

$$\begin{aligned} a'_u + a'(1-b) &= a_v + a(1' - b') \\ l'_u - b'_u - 2a'm &= l_v - b_v - 2am' \\ m'_u + m(l' - b') &= m_v + m' \; (1-b) \end{aligned} \qquad (3.5)$$

When these conditions (3.5) are satisfied, the equations (3.4) have an infinite number of solutions for λ. For each we get a surface S_z, $z = x + \lambda y$, whose tangent plane at P_z passes thru the line $P_x P_y$ of the congruence Γ_{xy}. In other words the generator $P_{\bar{x}} P_y$ is the axis of a pencil of planes which are tangent planes of the family $\sigma = (S_z)$ of surfaces at their points of intersection with the generator $P_x P_y$ of Γ_{xy}.

Let us note that the required congruence $\Gamma_{\underline{\bar{x}}y}$ in the fundamental problem is determined by the vector functions $\underline{\bar{x}}$ and y defined in (3.1) which in turn are determined by the functions $\bar{l}$, $1'$, m and m', which must satisfy (3.5) in order that $\Gamma_{\underline{\bar{x}}y}$ will be stratifiable with Γ_{xy}. How many such congruences $\Gamma_{\underline{\bar{x}}y}$ are there? This is answered by (3.5). Regarded as a system for the

determination of 1, 1′, m, m′ the system (3.5) consists of three operations in four unknowns. Hence there is an infinite solution for 1, 1′, m and m′. Therefore there are an infinite number of congruences $\Gamma_{\bar{x}\underline{y}}$ stratifiable with a given congruence Γ_{xy}. We have proved the following theorem:

Theorem. A given congruence Γ_{xy} determines infinitely many congruences $\Gamma_{\bar{x}\underline{y}}$ simply stratifiable with Γ_{xy}.

In the next section we shall consider the conditions under which the stratifiability relation between Γ_{xy} and $\Gamma_{\bar{x}\underline{y}}$ is symmetrical. What further conditions on the coefficients of (3.2) must be imposed so that Γ_{xy} is stratifiably with $\Gamma_{\bar{x}\underline{y}}$? Is it possible to determine a function $\mu(u, v)$ so that the tangent plane to S_z, $Z = \bar{x} + \mu \underline{y}$, at P_z shall pass thru the generator $P_x P_y$? If the answers are affirmative then Γ_{xy} and $\Gamma_{\bar{x}\underline{y}}$ are said to be *doubly* stratifiable.

Doubly Stratifiable Congruences.

To answer these questions, consider the plane determined by the points P_x, P_y and P_z. The equation of this plane is

$$(w, x, y, z) = 0,$$

This plane will coincide with the tangent plane to S_z at P_z if and only if

$$(w, x, y, Z) = 0$$

$$(w, x, y, Z)_u = 0$$

$$(w, x, y, Z)_v = 0$$

are satisfied for $W = Z - \bar{x} + \mu \underline{y}$. By an argument similar to what led us to equations (3.4) we obtain the system:

$$\begin{aligned} &\mu_u - r\mu^2 + (s - g)\mu + h = 0 \\ &\mu_u - r'\mu^2 + (s' - g')\mu + h' = 0, \end{aligned} \tag{4.1}$$

with the following conditions for integrability:

$$\begin{aligned} &r'_u + r'(g - s) = r_v + r(g' - s') \\ &g'_v - s'_u - 2r'h = g_v - s_v - 2r\,h' \\ &h'_u + h(g' - s') = h_v + h'(g - s) \end{aligned} \tag{4.2}$$

When these conditions are satisfied then (4.1) has an infinite number of solutions for μ (u, v). Therefore there are infinite number of surfaces S_z, where $Z = \bar{x} + \mu \underline{y}$. The totality of these surfaces will be denoted by $\Sigma = [S_z]$.

We now apply the foregoing theory to an important particular pair of congruences associated with a given surface. They are called the reciprocal congruences of Green.

Surfaces with Doubly Stratifiable Reciprocal Congruences

Let S_x be a surface on which the u-curve and the v-curve are the asymptotic curves on the surface. Then from (2.6), (2.7), (2.8) S_x is an integral surface of the following pair of partial differential operations:

$$\begin{aligned} y_{uu} &= \bar{\phi}\, x + \theta_u\, x_u + \beta\, x_v \\ x_{vv} &= \bar{q} x + \gamma\, x_u + \theta_v\, x_v, \\ \theta &= \log \beta\, \gamma, \end{aligned} \tag{5.1}$$

with the following integrability conditions

$$\begin{aligned} \theta_{uvv} &= (\gamma\varphi)_u + 2\bar{q}_u + \theta_v\theta_{uv} - \beta\,\gamma\,\psi \\ \theta_{uuv} &= (\beta\,\psi)_v + 2\,\bar{\phi}_v + \theta_u\theta_{uv} - \beta\,\gamma\,\psi \end{aligned} \tag{5.2}$$

$$\bar{\phi}_{vv} - \theta_v\,\bar{\phi}_v + \beta\,\bar{q}_v + 2\bar{q}\,\beta_v = \bar{q}_{uu} - \theta_u\,\bar{q}_u + \gamma\,\bar{\phi}_u + 2\bar{\phi}\gamma_u,$$

where $\varphi = (\log \beta\,\gamma^2)_u$, $\psi = (\log \beta^2\gamma)_v$. (5.3)

We pause to define some terms that will be important in subsequent discussions.

First, the concept of a developable surface; it is the locus of the tangent lines of a curve. The tangents are the generators and the curve is the edge of regression of the developable.

It can be shown that s surface S_x is a developable surface if, and only if,

$$LN - M^2 = 0\ ^{(1)}$$

where L, M, N are defined in (2.4).

Second, the generators of a congruence can be assembled into a one-parameter family of developable surfaces in two ways. The lines of a congruence are the common tangents to two surfaces, called the *focal surfaces* of the congruence. The two points at which a generator touches the *focal surfaces* are called the *focal points* of the generator, and the tangent planes are the *focal planes* of the generator[2]

(1) Lane, p. 38
(2) Ibid, p. 82

The method of obtaining these points and planes of the congruence will be indicated presently in this section.

On a surface S_x referred to the asymptotic net on the surfaces, consider a point P_x and a line 1, thru P_x but not lying in the tangent plane of S_x at P_x. Such a line may be determined by the points P_x and P_y, where

$$y = x_{uv} - \bar{a}x_u - \bar{b}x_v \tag{5.4}$$

where $\bar{a}$ and $\bar{b}$ are scalar functions of u and v. The line 1, at once determines another line 1_2 — the polar reciprocal of 1_1 with respect to the quadric of Lie at the point P_x. Referred to the tetrahedrom P_x, P_{x_u}, P_{x_v}, $P_{x_{uv}}$ the equation of this quadric is

$$2(x_2 x_3 - x_1 x_4) - (\beta\delta + \theta_{uv}) x_4^2 = 0. \tag{5.5}$$

The polar reciprocal of 1_1 is the line 1_2 which join P_ρ and P_σ where

$$\rho = x_u - \bar{b}_x, \quad \sigma = x_v - \bar{a}\,x \tag{5.6}$$

As u and v vary, 1_1 and 1_2 generate two congruences Γ_1, and Γ_2 whose generators are in 1-1 correspondence.

Let us find the focal points of the generator 1 and the developables of Γ_1. Let P_z be any point on 1_1 were

$$z = y + \lambda x.$$

Let us determine λ so that P_z will be a focal point[1] 1. Let C be a curve on S_x passing thru P_x. If as P_x varies C, generates a developable of Γ_1 and if P_z is a focal point of 1_1, then P_z will describe of curve of which 1_1, is tangent at P_z. Then

$$\frac{dz'}{dt} = z_u \frac{du}{dt} + z_v \frac{du}{dt}$$

must be a linear combination of x and y only. But we have

$$z_u = (\bar{\phi}_v - \bar{a}\,\bar{p} + \beta\,\bar{q} + \lambda u)x + (A + \lambda)x_u + (F - 2\bar{a}\,\beta + \beta\varphi)\,x_v$$

$$- (\bar{b} - \theta_u)y$$

$$z_v = (\bar{q}_u - \bar{b}\bar{q} + \delta\bar{\phi} + \lambda\, v)x + (G - 2\bar{b}\,\delta + \delta\psi)x_u + (\beta + x_v -$$

$$(\bar{a} - \theta_v)y$$

where

$$A = -\bar{a}_u - \bar{a}\bar{b} + \beta\gamma + \theta_{uv},\ F = \bar{\phi} - \bar{b}_u + \bar{b}\theta_u - \bar{b}^2 + \bar{a}\beta$$

$$B = \bar{b}_v - \bar{a}\bar{b} + \beta\gamma + \theta_{uv},\ G = \bar{q} - a_v - \bar{a}\theta_v - \bar{a}^2 + \bar{b}\beta.$$

Therefore

$$\frac{dz'}{dt} = Px + Qy + \left[(A + \lambda)\frac{du}{dt} + (G - 2\bar{b} + \gamma\varphi)\frac{dv}{dt}\right] x_u + \left[(p - 2\bar{a}\beta + \beta\varphi)\frac{du}{dt} + (\beta + \lambda)\frac{dv}{dt}\right] x_v$$

where P and Q are functions we shall have no occasion to use. Hence $\frac{dz}{dt}$ is a linear combination of x and y if, and only if

$$\begin{aligned}(A + \lambda)\,du + (G - 2\bar{b}\gamma + \gamma\psi)\,dv &= 0\\ (F - 2\bar{a}\beta + \beta\psi)du + (\beta + \lambda)\,dv &= 0\end{aligned} \qquad (5.8)$$

Eliminating du and dv from these equations, we have:

$$\begin{vmatrix} A + \lambda & F - 2\bar{a}\beta + \beta \\ F - 2\bar{a}\beta + \beta\psi & B + \lambda \end{vmatrix} = 0 \qquad (5.9)$$

or $\lambda^2 + (A + b)\lambda + AB - (F - 2\bar{a}\beta + \beta\psi)(G - 2\bar{b}\gamma + \gamma\varphi) = 0.$

If λ_1 and λ_2 are the roots of these quadratic equations then the points P_{z_1} and P_{z_2} where

$$z_1 = y + \lambda_1 x,\ z_2 = y + \lambda_2 x,$$

are the focal points of 1_1 and the surfaces S_{z_1} nd S_{z_2} are the focal surfaces of Γ_1.

If on the other hand we eliminate λ from (5.8), we obtain

$$\begin{vmatrix} du & Adu + (G - 2\bar{b}\gamma + \gamma\varphi)dv \\ dv & (F - 2\bar{a}\beta + \beta\varphi)\,du + \beta\,dv \end{vmatrix} = 0 \qquad (5.10)$$

or

$$(F - 2\bar{a}\beta + B\psi)\,du^2 - (\bar{b}_v - a_u)\,dudv - (G - 2\bar{b}\gamma + \gamma\varphi)dv^2 = 0.$$

This is the differential equation of the curves in which the developables of Γ_1 intersect S_x which will be called the Γ_1-curves.

Since the equation is quadratic, the lines of the congruence can be assembled in two ways. Hence the line 1_1 belongs to two different developables of Γ_1.

Let us similarly find the focal points and developables of Γ_2. The line 1_2 which joins $P\rho$ and $P\sigma$ has a focal point at $\xi = \rho + \mu\sigma$ if

$$\frac{d\xi}{dt} = (\rho_u + \mu_u + \mu\sigma_u)\frac{du}{dt} + (\rho_v + \mu_v\sigma + \mu\sigma_v)dv$$

is a linear combination of ρ and σ only. The values of ρ_u, ρ_v, σ_u and σ_v are given by

$$\rho_u = Fx - (\bar{b} - \theta_u)\rho + \beta\sigma, \quad \rho_v = (\bar{b}_v = + \bar{a}\,\bar{b})x - \bar{b} + x_{uv}$$

$$\sigma_u = Gx + \gamma\rho - (\bar{a} - \theta_v)\sigma, \quad \sigma_v = -(\bar{a}_u + \bar{a}\,\bar{b})x - a\rho + x_{uv}$$

Hence

$$\frac{d\xi}{dt} = P\rho + Q\sigma + [F - \mu(\bar{a}_u + \bar{a}\,\bar{b})]\,du + [-\bar{b}_v - \bar{a}\,\bar{b} + \mu G]\,dv\,x + [\mu d_u + d_v]\,x_{uv}$$

will be a linear combination of ρ and σ if, and only if

$$[F - \mu(\bar{a}_u + \bar{a}\,\bar{b})]\,du + [-\bar{b}_v - \bar{a}\,\bar{b} + \mu G]\,dv = 0$$

$$\mu\,du + dv = 0 \qquad (5.12)$$

Eliminating du and dv, from (5.12), we have:

$$\begin{vmatrix} F - \mu(\bar{a}_u + \bar{a}\,\bar{b}) & -\bar{b}_v - \bar{a}\,\bar{b} + \mu G \\ \mu & 1 \end{vmatrix} = 0 \qquad (5.13)$$

or $$F + (\bar{b}_v - \bar{a}_u)\mu - G\mu^2 = 0$$

If μ_1 and μ_2 are the roots of this quadratic then the focal points of 1_2 are $P_{\xi 1}$ and $P_{\xi 2}$ where,

$$\xi_1 = \rho + \mu_1\sigma, \quad \xi_2 = \rho + \mu_2\sigma$$

and the loci of $P_{\xi 1}$ and $P_{\xi 2}$ are the focal surfaces of $\Gamma 2$.

Eliminating μ, from (5.12) we have

$$F\,du - (\bar{b}_v + \bar{a}\,\bar{b})dv - (\bar{a}_u + \bar{a}\,\bar{b})\,du + G\,dv = 0 \qquad (5.14)$$

$$dv \qquad\qquad du$$

or

$$F\,du^2 - (\bar{b}_v - \bar{a}u)\,dudv - G\,dv^2 = 0.$$

This is the differential equation of the curves in which the developables of Γ_2 cut the surface S_x. Since the equation is quadratic the developables of Γ_2 can be assembled in two ways.

We now raise a number of questions. Is it possible for Γ_1 and Γ_2 to be doubly stratifiable? What kind of surfaces sustain reciprocal congruences that are doubly stratifiable? What kind of reciprocal congruences, with respect to a surface, are doubly stratifiable?

To answer these questions let us first set up the system (3.2) for the pair Γ_1 and Γ_2. Here ρ and σ will replace $\bar{x}$ and y in (3.2).

The Equations for Γ_1 and Γ_2

$$x_u = lx + my + \rho \qquad y_u = ax + by + c\,\rho + d\sigma$$

$$x_v = l'x + m'y + \sigma \qquad y_v = a'x + b'y + c'\rho + d'\sigma$$

$$\rho_u = ex + fy + g\rho + h\sigma \qquad \sigma_u = px + qy + r\,\rho + s\sigma$$

$$\rho_v = e'x + f'y + g'\rho + h'\sigma \qquad \sigma_v = p'x + q'y + r'\,\rho + s'\sigma$$

where

$$a = \bar{p}_v + \beta\bar{q} + \bar{b}\,\theta_{uv} + \bar{b}\gamma\beta - \bar{a}\,\bar{b}^2 - \bar{a}_u\bar{b} + \bar{a}\,\beta_v + \bar{a}\,\beta\theta_v - \bar{a}\beta - \bar{a}b_u - \bar{a}\,\bar{b}^2$$

$$a' = \bar{q}_u + \bar{p}\,\gamma + \bar{b}\gamma_u + \bar{b}\,\gamma\,\theta_u - \bar{b}^2\gamma + \bar{a}\,\bar{b}\,\theta_v - \bar{a}^2\,\bar{b}$$

$$b = \theta_u - \bar{b},\ c = \theta_{uv} + \beta\gamma - \bar{a}\,\bar{b} - \bar{a}_u,\ d = \bar{p} + \beta_v + \beta\theta_v - \bar{a}\beta - b_u + \bar{b}\,\theta_u - \bar{b}^2$$

$$b' = \theta_v - \bar{a},\ c' = \bar{q} + \gamma_u + \gamma\theta_u - \bar{b}\gamma + \bar{a}\,\theta_v - a^2,\ d' = \theta_{uv} + \beta\gamma - \bar{b}_v - \bar{a}\,\bar{b}$$

$$l = \bar{b},\ m = 0,\ 1' = \bar{a},\ m' = 0$$

$$e = F = \bar{p} + \theta_u\bar{b} + \bar{a}\beta - \bar{b}_u - \bar{b}_2,\ f = 0,\ g = \theta_u - \bar{b},\ h = \beta$$

$$e' = \bar{a}\,\bar{b} - \bar{b}_v,\ f' = 1,\ g' = \bar{a},\ h' = 0$$

$$p = \bar{a}\ \bar{b} - \bar{a}_u,\ q = 1,\ r = 0,\ s = \bar{b}$$

$$p' = G = \bar{q} - \bar{a}_v + \bar{b}\gamma - \bar{a}^2 + \bar{a}\ \beta_v,\ q' = 0,\ r' = \gamma,\ s' = \theta_v - a$$

Imposing conditions (3.5) and (4.2) for double stratifiability we get:

$$\begin{aligned} a'_u + a'(2\bar{b} - \theta_u) &= a_v + a(2\bar{a} - \theta_v) \\ \bar{a}_u - \bar{b}_v &= 0 \\ \beta_v &= \beta(2\bar{a} - \theta_v) \\ \gamma_u &= \gamma(2\bar{b} - \theta_u) \\ \bar{a}_u + \bar{b}_v &= \beta\gamma + \theta_{uv} \end{aligned} \tag{5.15}$$

From the third and fourth of these equations, we obtain

$$\begin{aligned} \bar{a} &= \frac{\beta_v + \theta_{uv}}{2\beta} = \frac{\psi}{2} \\ \bar{b} &= \frac{\gamma_u + \theta_{uv}}{2\gamma} = \frac{\psi}{2} \end{aligned} \tag{5.16}$$

From (5.16) it follows that 1_1 and 1_2 are the directrices of Wilczynski and the congruences Γ_1 and Γ_2 are the directrix congruences of Wilczynski.

Inspection of (5.10), (5.14), the second equation of (5.15) and (5.16) shows that the developables of Γ_1 and Γ_2 correspond to the same conjugate net

$$F\ du^2 - G\ dv^2 = 0 \tag{5.17}$$

on S_x.

From the second and last equation of (5.16), we obtain

$$\bar{a}_u = \frac{\beta\gamma + \theta_{uv}}{2}$$

$$\bar{b}_v = \frac{\beta\gamma + \theta_{uv}}{2}$$

But from (5.16) we have

$$\bar{a}_u = \frac{1}{2}\left(\frac{\beta_v + \beta\theta_v}{\beta}\right)_u = \frac{1}{2}[(\log\beta)_{vu} + \theta_{vu}]$$

$$\bar{b}_v = \frac{1}{2}\left(\frac{\gamma u + \gamma\theta_u}{\gamma}\right)_v = \frac{1}{2}[(\log\gamma)_{uv} + \theta_{uv}].$$

Hence $(\log\beta)_{uv} + \theta_{uv} = \beta\gamma + \theta_{uv}$

$(\log\gamma)_{uv} + \theta_{uv} = \beta\gamma + \theta_{uv}$.

Consequently,

$$\frac{\partial_2}{\partial u \partial v}(\log \beta) = \beta\gamma$$
$$\frac{\partial^2}{\partial u \partial v}(\log \gamma) = \beta\gamma \tag{5.18}$$

Therefore,

$$\frac{\partial^2}{\partial u \partial v}\left(\log \frac{\beta}{\gamma}\right) = 0 \tag{5.19}$$

Equations (5.18) state that the asymptotic tangents of S_X belong to two linear complexes — the osculating linear complexes of the asymptotics.

The equations of these complexes are

$$2w_{23} - \varphi w_{42} - \psi w_{34} = 0$$
$$2w_{14} - \varphi w_{42} + \varphi w_{34} = \theta \tag{5.20}$$

They form a pencil of complexes whose directrix congruences are Γ_1 and Γ_2.

Consider the most general transformation which leaves the form of equations (5.1) invariant, namely

$$x = c\bar{x}, \quad \bar{u} = \lambda(u), \quad \bar{v} = \mu(v), \quad c \text{ const} \tag{5.21}$$

where $\lambda(u)$ is a function of u alone and $\mu(v)$, a function of v alone.

Then the new coefficients of (5.1) are given by

$$P = \frac{\bar{p}}{\lambda'^2(u)}, \quad Q = \frac{\bar{q}}{\mu^2(v)}$$
$$\beta = \beta \frac{\mu'(v)}{\lambda'^2(u)}, \quad \gamma = \frac{\gamma \lambda'(u)}{\mu'^2(v)}$$
$$\theta = \theta - \log \lambda'(u)\ \mu'(v).$$

It is also easy to show that $\theta = \log \bar{\beta}\,\bar{\gamma}$.

$$\frac{\beta}{\gamma} = \frac{V(v)}{U(u)} \tag{5.22}$$

where U(u) is an arbitrary function of u alone and V(v) is an arbitrary function of v alone. Let us choose $\lambda(u)$ and $\mu(v)$ so that

$$\frac{\bar{\beta}}{\bar{\gamma}} = 1.$$

To do this, we note that,

$$\frac{\bar{\beta}}{\bar{\delta}} = \frac{\mu'^3(v)}{\lambda'^3(u)} \cdot \frac{\beta}{\delta} = \frac{\mu'^3(v)}{\lambda'^3(v)} \cdot \frac{U(u)}{V(v)}$$

Hence $\frac{\bar{\beta}}{\bar{\delta}} = 1$ if we choose $\lambda(u)$ and $\mu(v)$ so that

$$\lambda'^3(u)\ U(u) = k$$

$$\mu^{3\prime}(v)\ V(v) = k$$

where $k \neq 0$ may be taken equal to 1. Then we may choose

$$\lambda(u) = \frac{du}{\sqrt{U(u)}}, \quad \mu(v) = \frac{dv}{\sqrt[3]{V(v)}}$$

For this choice of $\lambda(u)$ and $\mu(v)$, the transformation (5.21) transforms the ratio $\frac{\beta}{\delta}$ into

$$\frac{\bar{\beta}}{\bar{\delta}} = 1.$$

Assuming that this transformation has been carried out we then have a system (5.1) in which $\beta = Y$ and (5.18) becomes

$$\frac{\partial(\log \beta)}{\partial u \partial v} = \beta^2 \tag{5.22}$$

the general solution of which is

$$\beta = \frac{\sqrt{U'v'}}{(U + V)} \tag{5.23}$$

where $U(u)$ and $V(v)$ are arbitrary functions of u alone and v alone respectively. Substituting $\beta = Y = \frac{\sqrt{U'V'}}{U+V}$ in the integrability conditions (5.2) and solving for $\bar{p}$ and $\bar{q}$, we get

$$\bar{p} = \frac{3}{2}\left(\frac{\sqrt{U'V'}}{U+V}\right)_v - \frac{3}{4}\left(\frac{U'}{U+V}\right)_v + A(u)$$

$$\bar{q} = -\frac{3}{2}\left(\frac{\sqrt{U'V'}}{U+V}\right)_u - \frac{3}{4}\left(\frac{V'}{U+V}\right)_u + 3(v)$$

where A (u) and B (v) are arbitrary functions.

By (5.16), (5.23) and (5.24) the functions β, $\bar{p}$, $\bar{q}$, $\bar{a}$ and $\bar{b}$ have been computed to satisfy all integrability conditions (5.15)

except the first. These five functions β, $\bar{p}$, $\bar{q}$, $\bar{a}$ and $\bar{b}$ depend on four arbitrary functions U(u), V(v), A(u) and B(v). If these four arbitrary functions are now chosen so that the two remaining conditions — the last equation of (5.2) and the first equation of (5.15) — are satisfied, then the five functions β, $\bar{p}$, $\bar{q}$, $\bar{a}$ and $\bar{b}$ determine a surface S_x which sustain a doubly stratifiable pair of reciprocal congruences Γ_1 and Γ_2. Since there are four functions to be chosen and only two equations to satisfy, the choice of the arbitrary set U(u), V(v), A(u), B(v) can, clearly, be made in an infinite number of ways.

We now recapitulate the foregoing results in the following theorem.

Theorem. There is an infinite number of surfaces which sustain a pair of doubly stratifiable reciprocal congruences. These congruences are the directrix congruences of Wilczynski whose developables correspond on the surface to the same conjugate net. The asymptotic tangents of the surface belong to the linear complexes which give rise to the directrix congruences of Wilczynski.

We now consider a particular solution $\beta = \dfrac{1}{u+v}$ of (5.22) which leads to an interesting result.

6. *The solution* $\beta = \gamma = \dfrac{1}{u+v}$

The particular solution

$$\beta = \frac{1}{u+v} \tag{6.1}$$

of the equation

$$\frac{\partial^2 (\log \beta)}{\partial_u \, \partial_v} = \beta^2$$

gives $\bar{p} = \bar{q} = \dfrac{9}{4}\beta^2$

$$\bar{a} = \bar{b} = \frac{3}{2}\beta . \tag{6.2}$$

The equations (5.1) and (5.14) of the developables Γ_1 and Γ_2 are satisfied identically. Hence the developables are indeterminate.

The line l_1 of Γ_1 is now determined by the points P_x and P_y where

$$y = x_{uv} + \left(\frac{3}{2}\beta\right) x_u + \left(\frac{3}{2}\beta\right) x_v$$

The point P_z, where

$$z = y + (\frac{3}{4}\beta^2)x = (\frac{3}{4}\beta^2)x + (\frac{3}{2}\beta)x_u + (\frac{3}{2}\beta)x_v + x_{uv},$$

lies on 1_1; its coordinates, referred to the tetrahedron

$(P_x, P_{xu}, P_{xv}, P_{x_{uv}})$,

are:

$$kx_1 = \frac{3}{4}\beta^2,\ kx_2 = \frac{3}{2}\beta,\ kx_3 = \frac{3}{2}\beta,\ kx_4 = 1. \quad (6.3)$$

The line 1_2 of Γ_2 is determined by P_ρ and P_σ, where

$$\rho = x_u + (\frac{3}{2}\beta)x,\ \sigma = x_v + (\frac{3}{2}\beta)x.$$

Referred to the same tetrahedron, the coordinates of P_ρ and P_σ are

$$(\frac{3}{2}\beta, 1, 0, 0),\ (\frac{3}{2}\beta, 0, 1, 0).$$

Obviously P_ρ and P_σ lie in the plane π whose equation is:

$$\pi:\ x_1 - (\frac{3\beta}{2})x_2 - (\frac{3\beta}{2})x_3 + (\frac{15\beta^2}{4})x_4 = 0. \quad (6.4)$$

Therefore the line l_2 also lies in this plane whose coordinates are

$$k\xi_1 = 1,\ k\xi_2 = \frac{-3\beta}{2},\ k\xi_3 = \frac{-3\beta}{2},\ k\xi_4 = \frac{15\beta^2}{4}. \quad (6.5)$$

From (6.3) it follows that P_z lies in the plane π; that is 1_1 pierces the plane π at P_z. This makes π and P_z united in position.

If in (6.3) we eliminate k and β homogeneously, we have

$$3x_1x_4 - x_2x_3 = 0 \quad (6.6)$$

which is quadric.

Similarly, from (6.5) we obtain

$$3\,\xi_1\,\xi_4 - 5\,\xi_2\,\xi_3 = 0 \quad (6.7)$$

whose point equation is

$$5x_1\,x_4 - 3x_2\,x_3 = 0 \quad (6.8)$$

which is another quadric.

Both quadrics (6.6) and (6.8) contain the points P_x, P_{x_u}, P_{x_v}, $P_{x_{uv}}$ and both are non-degenerate. The properties of these quadrics will be investigated in another paper which will deal with the surfaces of the congruences.

CLINICAL OBSERVATIONS ON DENGUE HEMORRHAGIC FEVER (DHF) IN METRO MANILA (1977-1979)

By Fe del Mundo, MA, MD and Lolita Soriano, MD

Introduction

In the Philippines, dengue and dengue-like infections, including the hemorrhagic type in epidemic forms were reported from time to time since 1903. However, it was not until 1954-1958 during an alarming outbreak, that the disease caused increasing concern and attention by physicians, government health authorities and parents. In about four or five years such concern spread in neighboring countries in view of outbreaks and alarming manifestations, particularly in Thailand and Singapore.

Epidemics of different proportions and severity of this viral infection in the region and in the country have been reported since 1954. At present Dengue Hemorrhagic Fever is considered one of the major health problems of WHO Southeast Asian and Western Pacific Regions and the disease is sometimes called Philippines, Thai or Singapore Hemorrhagic Fever. In the Philippines it is popularly known, for short, as H-Fever.

A WHO Southeast Asian Regional Conference in 1964 encouraged researches on various aspects of the disease and remarkable progress has been attained, particularly in the knowledge of its pathology and pathogenesis. Whereas it was a mysterious disease in 1954 much has been accomplished, through concerted efforts towards a better understanding of this hemorrhagic viral infection.

An alarmingly large epidemic in 1966 made it possible for the authors to study clinical manifestations of serologically-proven cases of DHF as there was much confusion in the symptoms and diagnosis of the disease, resulting in a rather inaccurate reporting of cases.

After that year, the disease has been noted to be endemic in the Philippines though the incidence has remained at low levels. The next reported outbreak was 6 years later (1972). From this trend another one was expected in 1978 but this did not occur. Both incidence and mortality rates have been less.

WHO has organized a Technical Advisory Committee on DHF for the Southeast and Western Pacific Regions which periodically

***Children's Medical Center, Philippines and its Institute of Community and Family Health.**

meets to pool experiences and prepare guides. A Dengue Newsletter has been prepared by this Committee since 1975, to bring the latest information on DHF to health workers and administrators.

The present study is an observation on clinical manifestations of DHF based on serologically proven cases admitted at the Children's Medical Center in a period of 2 years (1977-1979). The findings and trends in this study were compared with those of a similar study in 1966.

Objectives

The present study was undertaken with the following purposes:

1. To observe current clinical manifestations of DHF.
2. To follow the morbidity pattern of the disease.
3. To determine changes in the prognosis and outcome of the disease.
4. To detect early manifestations and prompt recognition of the disease, particularly its serious forms.
5. To seek ways of preventing and overcoming complications.

Materials and Methods

A total of 399 dengue fever suspects admitted at the Children's Medical Center from January 1977 to April 1979 were included in the study. Epidemiologic data, clinical manifestations and the course and outcome of each patient were recorded.

In the physical examination close attention was paid to manifestations which were found significant in other countries but which were not very impressive in previous Philippine reports.

Laboratory examinations included:

Blood pressure and tourniquet test
Complete blood count or WBC
Hematocrit
Platelet count
Viral serology — paired acute and convalescent specimens.

The first four procedures were repeated as indicated. As compared to 1966, the present laboratory work-up were much less. Thus in 1966, a peripheral smear review by a hematologist, the bleeding time, coagulation time, widal reaction, the fragility test, prothrombin time and a viral culture were done for each patient.

On the whole the incidence of the disease during the period of the study was low and serious forms were rare so that there were not sufficient cases to make the findings significant or impressive. A plan to study different modalities of management of the severe forms were not possible in this group since there were only 8 such cases and one was confined in another hospital.

Age Distribution

The age distribution of the present series (102 patients) is shown in Table III. About half of the cases were in the 5 to 9 year -old groups. This is the same age period that had the highest incidence in the 1966 study.

Table III. Age Distribution of 102 Serologically Confirmed Dengue Cases Jan 1977 — April 1979

Age Group	*Number*	*Percentage*
0 — 4 years	23	22.5%
5 — 9 years	56	54.9
10 — 15 years	19	18.6
16 — 19 years	3	2.9
20 — 24 years	1	0.98

Sex Incidence

The sex incidence (Table IV) showed a slight difference in the number of male and female patients and statistical analysis gave no difference. Other reports show no significance in the sex factor.

Table IV. Sex Distribution of 102 Serologically Confirmed Cases Jan 1977 — April 1979

Sex	*Number*	*Percentage*
Males	59	57.9 %
Females	43	42.1 %
Total	102	100.00%

$X^2 = (0\text{-}E) \cdot 0.5^2 = 1.032$ less than $X^2_{0.05} = 3.84$

A chi square showed no statistically significant difference between the affected males and females.

Symptomatology

The main symptoms observed in the order of frequency are enumerated in Table V. This line-up is about the same as that of 1966. Hyperpyrexia ranging from 39 to 40°C is the first complaint and this is alarming enough to make parents consult a physician or rush to a hospital. It is also an important guide in management and early warning of a severe form. Fever persists from 4 to 11 days or an average of 6 days. Abdominal pain is a disturbing symptom which could hardly be relieved by usual measures; fortunately the duration of pain is short, with a tendency to subside in 2 to 3 days.

Table V. Symptomatology of 102 Serologically Confirmed Dengue Cases Jan 1977 — April 1979

Symptoms	*Number of Cases*	*Percentage*
Fever	102	100
Abdominal pain	42	41.2
Epistaxis	33	32.4
Cough and colds	27	26.5
Vomiting	27	26.5
Restlessness	16	15.7
Headache	12	11.8
Hematemesis/melena	12	11.8
Other bleedings	10	9.8
Anorexia	8	7.8
Convulsion	3	2.9
Joint pains	3	2.9
Dyspnea	2	1.9

Physical Examination

The physical findings are enumerated in Table VI. Again the Tourniquet Test was the most consistent finding. At times this was negative on admission which changed, in a day or two, to a positive test. Violaceous rashes on the extremities were reported in 65% of the 1966 cases and 40% in 1977-79. Gross hemorrhages like hematemesis, melena, ecchymosis and subconjunctival hemorrhages were more frequently observed in 1966 than in the 1977-79 series. Bradycardia was usually noted during convalescence This did not seem to bother the patients and in a few days the heart rate returned to normal.

Table VI. Physical Findings of 102 Serologically Confirmed Dengue Cases
Jan 1977 — April 1979

Physical Findings	*Number of Cases*	*Percentage*
Positive Tourniquet Test	95	93.1
Petechiae	52	50.9
Rashes	41	40.1
Hepatomegaly	36	35.3
Cold extremities	30	29.4
Brodycardia	22	21.5
Pleural effusion	20	19.6
Lymphadenopathy	15	14.7
Purpura acchymosis	13	12.7
Arrhythmia	4	3.9
Abdominal distension		2.9

Two manifestations deserve mention. Hepatomegaly is a significant manifestation in Thai and other reports abroad, to the extent that it is included as one of four clinical criteria in the diagnosis of the disease. In the Philippines, the incidence is 12% for 1966 and 35% in the present study. Thai reports give an incidence of 90 to 96% hepatomegaly in children and 60% in adults. An apparent increase of hepatomegaly in the recent Philippine study may to some extent be due to increasing awareness of this finding, after frequent reports on its incidence in other countries. In fact it was remarked that hepatomegaly is observed during convalescence at which time liver palpation may be overlooked.

Again pleural effusion was not mentioned in the 1966 report though noted at postmortems in some Philippine cases. In the present study it was noted in 19.6% of the patients.

Severity

The WHO criteria of severity was availed of in this study, thus:

Grade I — Fever with no constitutional symptoms, the only hemorrhagic manifestation is tourniquet test (+)

Grade II — Additional manifestations to Grade I is spontaneous bleeding in skin and/or other hemorrhages

Dengue Hemorragic Fever

Dengue Shock Syndrome

Grade III — Circulatory failure manifested by rapid weak pulse, narrow pulse pressure (20mm Hg or less) or hypotension, cold clammy skin and restlessness

Grade IV — Profound shock with undetectable blood pressure and pulse

Accordingly the study group was classified by severity as shown in Table VII.

Table VII. Severity by WHO Criteria of 102 Serologically Positive Cases

Grade	*Number of Cases*	*Percentage*
I	17	16.7%
II	58	56.9
III	20	19.6
IV	7	6.9
Total	102	100.0

Blood Examinations

The leucocyte and differential counts, platelet count and hematocrit levels of serologically confirmed dengue patients are shown in Table VIII, IX, X and XI respectively.

Table VIII. White Blood Cell Count of 99 Serologically Confirmed Dengue Cases

WBC count	*Number*	*Percentage*
1 — 5,000/cu. mm.	40	40.4
5,001 — 10,000/cu mm.	51	51.5
10,001 — 15,000/cu mm.	7	7.2
15,001 — 20,000/cu mm.	1	1

Table IX. Differential Count of 102 Serologically Confirmed Dengue Cases

Differential Count	*Number of Cases*	*Percentage*
Neutrophilia more than 70%	31	30.3
Lymphocytosis more than 50%	40	39.2
Monocytosis more than 10%	10	9.8
Normal Differential Count	18	17.6

Results

Of 399 children admitted as dengue suspects. 259 had serological studies and of this number 61% were negative. Thus a total of 102 positive cases were included in the present study group.

Table I. HI Antibody Titers of Dengue Fever Suspects (Jan 1977 — April 1979)

Dengue Fever Suspects	399
Dengue Suspects with Serologic Tests	259
Serologically positive cases	102
Paired Blood Samples	55
Single Blood Samples	47

Monthly Incidence

The distribution of cases by month during the period of study is given in Table II. A high incidence was noted between July to November each year, with a peak in September and October.

Table II. Monthly Incidence

	1977	*1978*	*1979*	*Total*
January	1	1	1	3
February	4	0	0	4
March	2	0	1	3
April	1	0	1	2
May	0	0		0
June	3	0		3
July	3	8		11
August	6	8		14
September	4	13		17
October	9	18		27
November	4	11		15
December	2	1		3

Table X. Actual Platelet Count of 90 Serologically Confirmed Dengue Cases

Platelet Count	*Number of Cases*	*Percentage*
Less than 100,000m^3	8	8.8%
100,000 — 500,000m^3	24	26.6
500,001 — 1,000,000m^3	58	64.4

Platelet count was by indirect method.

Table XI. Hematocrit Levels of 67 Serologically Confirmed Dengue cases

Hematocrit level	*Number of Cases*	*Percentage*
less than 30 Vol. %	3	4.4%
30 — 35	6	8.9
36 — 40	17	25.3
41 — 45	25	37.3
46 — 50	7	10.4
over 50 vol. %	9	13.4

It will be noted that leucopenia was observed in 92% of cases with lymphocytosis in 39%. Low platelet counts (by indirect method) were obtained in only 8.8% of 90 cases. Hematocrit levels of 36 to 45 were noted in more than half of 67 patients. Serial platelet — hematocrit determinations were not done in this study.

Management

For Grades I to III symptomatic treatment was aimed at relieving the patients and making him comfortable. They were watched closely, particularly at the transition period from hyperpyrexia to apyrexia. Important manifestations watched for were indifference, or lethargy, anxiety, restlessness, cyanosis, coldness of extremities, together with the pulse and blood pressure.

Oral fluids were encouraged but when these were taken with hesitation, and coaxing, IV fluids were given particularly during continuous hyperpyrexia and increasing anorexia, a very helpful

measure even before evidences of impending shock started to set in.

For impending (Grade III) or actual (Grade IV) shock therapy consisted of IV fluids, plasma expander, and or steroids. Blood was administered only for massive bleeding. IV bicarbonate was given for acidosis. Oxygen was administered as needed.

Outcome

Of 102 patients in this study, 20 (19.6%) manifested impending shock (Grade III) and 7 (6.9%) went into shock (Grade IV). The management of the Grade IV or 7 shock cases was as follows:

3 received IV fluids + plasma expanders and steroid
2 received IV fluid + steroids
2 received IV fluids + plasma and subsequently also blood

No comparative study was made in this group due to the small number and the patients were not strictly comparable. There was only one death.

Summary and Conclusions

In order to determine trends in the clinical manifestations of dengue hemorrhagic fever, a study was made of 102 serologically proven dengue cases among children in Metro Manila from December 1977 to April 1979.

It is evident from this and other reports that the disease has become endemic and at low levels in Metro Manila

Of 399 dengue suspects, 102 cases (39%) were serologically positive for dengue infection.

The incidence by month gave September, October and November as the peak months with 5 to 9 years as the susceptible ages. There was no sex predilection noted.

Hyperpyrexia, abdominal pain and epistaxis were early and consistent manifestations. Hepatomegaly (35%) and pleural effusions (19%) were observed more frequently than in past reports, which were 12% and 0 in a 1966 report. Bradycardia was commonly observed during convalescence.

Approximately 90% were leucopenic with lymphocytosis of more than 50% in 39% of the cases. Low platelet counts occured in 8.8% of 90 cases. Hematocrit levels of 36 to 45 were noted in more than half of 67 patients.

By WHO criteria of severity, 20 or 19.6% were classified as Grade III (impending shock) and 7 or 6.9% as Grade IV (in shock). Of 102 cases, there was only one death.

Management was mainly symptomatic and intravenous fluids was the mainstay of therapy. There were not enough cases of impending or actual shock to carry out and compare different modalities of treatment.

HI Antibody of 102 Serologically Positive Cases

A. Single Samples

Name	*Age*	*Severity*	*Titer*
J.R.	5 years	I	1:640
O.S.	10 years	I	1:640
C.S.	9 years	I	1:1280
T.V.	7 years	I	1:1280
R.V.	14 years	I	1:1280
J.G.	12 years	I	1:1280
L.S.	5 years	I	1:1280
E.C.	15 years	I	1:640
R.Q.	14 years	I	1:1280
M.B.	6 years	I	1:1280
C.D.	4 years	I	1:1280
M.D.	3 years	II	1:640
R.S.	7 years	II	1:1280
L.C.	7 years	II	1:1280
M.M.	13 years	II	1:1280
A.C.	10 years	II	1:640
P.D.	9 years	II	1:1280
J.J.	7 years	II	1:1280
M.F.	3 years	II	1:1280
M.O.	12 years	II	1:1280
M.R.	8 years	II	1:1280
F.V.	11 years	II	1:1280
E.D.	5 years	II	1:1280
W.T.	10 years	II	1:1280
C.M.	2 years	II	1:1280
J.G.	10 years	II	1:1280
J.K.	7 years	II	1:1280
R.G.	4 years	II	1:1280
G.R.	11 years	II	1:1280
Y.R.	9 years	II	1:1280
M.A.	4 years	II	1:640
A.C.	6 years	II	1:1280
A.C.	3 years	II	1:1280
J.H.	5 years	II	1:1280
R.L.	6 years	II	1:1280
P.S.	10 years	II	1:1280
R.L.	9 years	III	1:1280
V.E.	8 years	III	1:1280

M.P.	6 years	III	1:1280
M.O.	9 years	III	1:1280
G.A.	7 years	III	1:1280
L.V.	6 years	III	1:1280
M.P	9 years	IV	1:640
M.C.	4 years	IV	1:1280
G.S.	9 years	I	1:1280
R.F.	10 years	I	1:1280
A.S.	10 years	II	1:1280

B. Paired Samples

Name	*Age*	*Severity*		*Titer*
E.J.	10 years	I	1:160	1:1280
R.I.	6 years	I	1:1280	1:1280
G.A.	8 years	I	1:80	1:1280
C.Z.	9 years	I	1:1280	1:1280
M.L.	7 years	II	1:1280	1:1280
D.C.	5 years	II	1:160	1:1280
R.O.	1 year	II	1:20	1:1280
R.P.	5 years	II	1:640	1:1280
N.M.	3 years	II	1:640	1:1280
D.H.	2 years	II	1:1280	1:1280
B.C.	5 years	II	1:1280	1:1280
D.D.	6 years	II	1:1280	1:1280
Y.W.	6 years	II	1:20	1:80
N.T.	9 years	II	1:1280	1:1280
D.G.	7 years	II	1:320	1:1280
L.P.	1 years	II	1:20	1:320
C.B.	5 years	II	1:20	1:1280
E.E.	8 years	II	1:80	1:1280
M.C.	5 years	II	1:640	1:1280
J.D.	3 years	II	20	1:320
D.A.	4 years	II	20	1:1280
D.C.	13 years	II	20	1:80
J.C.	8 years	II	1:1280	1:1280
C.T.	1 year	II	20	1:80
J.M.	4 years	II	1:160	1:1280
J.V.	11 years	II	1:80	1:1280
L.M.	3 years	II	1:80	1:1280
H.S.	9 years	II	1:20	1:320
M.P.	7 years	II	1:20	1:80
J.M.	10 years	II	1:1280	1:1280
J.D.	15 years	II	1:1280	1:1280
P.V.	1 years	I	1:20	1:80
R.M.	8 years	II	1:640	1:1280
V.V.	4 years	II	1:80	1:1280
M.A.	18 years	II	1:80	1:1280
M.V.	6 years	II	1:1280	1:1280
C.S.	5 years	II	1:20	1:80
C.M.	7 years	III	1:640	1:1280
R.L.	9 years	III	1:320	1:1280

G.R.	9 years	III	1:1280	1:1280
R.P.	8 years	III	1:1280	1:1280
G.P.	5 years	III	1:1280	1:1280
C.Q.	3 years	III	1:320	1:1280
D.B.	5 years	III	1:320	1:1280
M.C.	4 years	III	20	1:160
M.L.	5 years	III	1:1280	1:1280
M.H.	4 years	III	1:1280	1:1280
C.C.	6 years	III	1:1280	1:1280
W.A.	7 years	III	1:160	1:1280
P.P.	3 years	III	1:1280	1:1280
E.M.	8 years	IV	1:20	1:320
E.Z.	7 years	IV	1:1280	1:1280
S.C.	10 years	IV	1:1280	1:1280
R.S.	8 years	IV	1:160	1:1280
J.F.	5 mos.	I	1:20	1:80

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NEW DIMENSIONS OF HEALTH OR HEALTH FOR A NEW EPOCH

By Leonard J. Duhl and Judith K. Sherven

Introduction

I would like to thank the President, NAST for honoring me with your invitation to discuss some of the new dimensions in the field of health. I consider it an honor, but I also consider it a challenge, because in many ways the problem of understanding the difficult complexities of the health field is such that I hardly know how to begin.

My journey to your country has made me acutely aware of how little we Americans know about the issues here in the Philippines, and furthermore how little we Americans know of the situation in our own country. Therefore, we can in no way presume to speak to you of health issues that are related to the Philippines except in the broadest manner.

However, before I proceed, I would like to recognize the contribution made by Dr. Judith Sherven who has joined me in writing this paper. She is deeply concerned with the issues raised, and her extensive experience has helped in giving focus to the ideas expressed.

The task today is to talk about new ways of conceptualizing the problem of the relationship between health, illness, and what is commonly known as "health care". This is raising a dangerous topic because on the surface it is full of difficulties and complexities. And yet, in our humble efforts to describe these difficulties and complexities we gradually learn that the traditional vocabulary of modern medicine and science contains few words which are appropriate to this task. So we must draw upon other fields, other conceptualizations, and other points of view.

The symptoms are familiar. No matter where you turn, expenditures for medical services are growing by leaps and bounds, due to rising individual aspirations as well as increases in costs related to the logarithmic multiplication of technological investments. Furthermore, around the world, patterns of health manpower utilization are changing dramatically. The organized medical system is being expanded on one hand by physicians' assistants, MEDEX or medical extenders, and a wide host of ancillary manpower; and on the other by the slow reincorporation of indigenous, more traditional or non-Western practices of medicine.

Problems, resulting from the blurring of distinctions between so-called "health issues" and other kinds of social issues such as crime, education, and even poverty, are beginning to have medical overtones. We may be finding an increase in the number of phenomena that are placed in the hands of the medical professional with the expectation that he or she should be responsible for coping with these difficulties.

In the so-called developed nations, as infectious diseases and some of the other basic medical conditions that have caused death are being conquered, a new collection of illnesses or medical conditions, such as aging and environmental hazards, seems to emerge and becomes important.

We find the realm of medicine extending even further as we begin to understand the implications of the changes in all our societies and how those changes are influencing the pattern of illness production. Thus, the very changes which have occurred here in the Philippines in the last thirty years — the pressures of societal change — have effected the conditions which the average physician treats. We are thus forced by the very nature of the etiology of disease to focus more and more attention on the general structure of society and how it impinges upon the human organism.

For many years we have used the words medicine or medical care interchangeably with health and health care. People have talked of "health insurance" as if the individual's ability to deal with illness medically would in fact improve the general health and wellbeing of a society; and indeed when one deals with major infectious diseases, such as the plague, smallpox, or malaria, it is true that the general wellbeing of a society can go through vast changes due to the very processes of improving the care or prevention of medical conditions.

However, as cultural aspirations rise with affluence and illnesses that are conquerable begin to disappear, we are faced with the question of what we mean by healthy living and wellbeing. The general quality of life becomes the issue, and we begin to raise such questions as what we need to do to meet the basic needs of people.

It is only recently that such august bodies as the World Bank and the United Nations have defined people's basic needs as food, clothing, and shelter; and rediscovered that these needs, accompanied by a minimum of medical care, may in fact have an important effect both on illness rates and the quality of life of any society.

And as one looks more deeply at the question of needs, one may find much to one's surprise that needs may be even more subtle, and that such things as touch, belonging, being part of social networks, of family, community, and even nation are

critically important for people's wellbeing. One soon discovers that such questions as self-esteem are central to the sense of wellbeing and to health in much the same way that one requires food and clothing and shelter.

It is here that we begin to raise questions about the meaning of wellbeing because we find that for most of us issues which are foreign to the world of medicine, nutrition, and housing such as religion, ritual, and cultural belief systems take on prime importance in our concern with illness and its care and to the maintenance or achievement of healthy living.

It is at this moment we would like to suggest that we are faced in this world with a tremendous dilemma where a variety of our people, being at different stages of personal and social development, coming from different cultures, orientations, and ways of conceiving the world's reality, end up with different definitions of health. Illness becomes the inability of the body to meet the expectations or limitations of a society or, if we are to extend this further, when the body gets out of balance with the external environment, that is, when the internal and external environments are not synthesized, we begin to get ill health.

Furthermore, when one's lifestyle or experience is incongruous with one's self image, as say during times of revolution, war, catastrophe, or even during psychotherapy, we see people out of balance with themselves, under severe stress. Often mental or physical illness or disease is a temporary or chronic attempt to regain homeostasis. The same stress may be experienced by others as a time of change and growth.

We have just opened what may appear to be a strange door, because as we talk of individual differences as well as cultural, social, and developmental ones, we are beginning to suggest that societies are full of different realities about our world. We have always experienced our societies in which the dominant and majority cultural force has determined the criteria by which we define reality. That force has indeed determined the cosmology of the society within which questions of disease, health, and illness are defined. The questions have become decidedly political, in that society after society does battle within it as various groups jockey for power to determine right and wrong, good and bad, healthy and ill. This is not to say that there are no illnesses that cross over cultures and belief systems, yet on the whole that may have become determined by social forces.

It is here that we would like to focus on the question of how we define the realities of medicine and of the health professions. The Western model, a scientific model of Descartian proportions, has determined how the body works, and in fact determines the questions of how we are to perform our medical and other

services. Science, as we have known it up to now, has focused on its biochemical systems, its infectious and allergy responses, and a whole host of other things that we associate with Western scientific medicine.

It is quite clear that this model is different from the model of the Tao, which the Chinese have espoused for many generations. This model is based on energy systems, and social and individual equilibrium; it employs treatment procedures such as acupuncture, which are foreign to the ways of Western medicine. We raise this to suggest that if one were to design a medical and health system based purely on the models of energy, one might come up, even in the world of modern science, with models that are akin to what we have called primitive belief systems. The American Indian, the Hawaiian, and other so-called "primitive" cultures around the world have talked about the connection of all beings to one another; they have posited the belief that one is one with the earth and all its beings rather than disconnected as a human from everything else. As such, these models of health allow the energy to flow and the individual becomes one with the universe by a variety of means — physical, psychological, religious, and spiritual — and thus what we have called primitive ritual has become part and parcel of the system of on-going life and indeed part and parcel of what is called treatment or medicine within that cosmology.

We have raised the question of energy models because it is a foreign reality to those of us trained in Western medicine. Yet to those of you in touch with the people of these Islands you will know that this view is an accepted part of daily life. In this connection, we would like to refer to some interesting questions about waves and energy. To do so requires that we take license and talk about a field that we know nothing about — water and land — and try to refer some of those issues to some of the issues of energy systems.

One of the most interesting properties of water is not its chemical composition or the fact that it is so prevalent a part of our environment but rather the interesting style it has, for water never seems to flow in straight lines. It is subject to the rhythms of the moon; it flows even in the deepest ocean in its own streams; its temperatures vary a few feet apart. There are eddies and currents and whirls and waves so that it is in continuous motion.

If we look from the air at pictures of the earth, especially that part of the earth where man has not had an impact, we will find that the ground and the earth are made up of the same kinds of curves and hills and sharp peaks as well, and what you see are the endless flows and processes across the land. In viewing the earth from the air, it is interesting to see how human beings have dealt

with the curves, the flow, and the rhythms of the earth and water. What we see may be described, charitably, as a sign of human need to control the environment. We have done so in order to improve our way of life. Thus our quality of life was improved by interfering with the normal patterns of energy flow — interference necessary in order to protect ourselves from the climate, from the environment, and from predators. Further, we began to find techniques both to husband our resources and to protect ourselves against the potential, harmful effects of famine.

To resort to American imagery, one can very easily imagine the Native American's view that as the civilizing or colonization process advanced from one phase to another, a switch in cosmology changed the free-flow of the human being with its total environment to a cosmology which emphasized human control of the environment. Since we are never separate from the environment — it influences our feelings and attitudes while we make our mark on it — it is no surprise that as the environment itself was conquered, the human perception of the enemy broadened from the environment to include other humans who perceived the universe as one of the scarce resources.

In the process of husbanding and protecting the resources from others, society developed techniques and beliefs which were concomitant with that behavior. Thus the behavior that resulted from this agricultural determinism led to a belief system which not only determined the behavior of individuals but also became the controlling force in the behavior of science, and to its practice of medicine and health. Thus in a competitive, growing world it was important to have a health system, or medical system, which dealt primarily with the control of death and with techniques to cope with the competitive arrangements within societies.

What we are trying to illustrate is that in a nomadic pre-agricultural society in which people were one with the environment, there was neither ownership nor land nor competition. What *was* present was a cosmology and a belief system which led to the concept of health having to do with a *balance* of energies. Health then was defined as those human behaviors and beliefs which would coexist with the natural flow of the rivers and the streams and the hills and the valleys, and consistent with the ebb and flow of the seasons, the currents, and the weather. As soon as that society emerged which needed to conquer its environment, it not only straightened out the natural energies by creating land that was cut up in straight lines, but water had to flow in straight lines in irrigation ditches, canals, and pipes. People had to not only control each other through timed schedules, law and order, and structural education, but had to learn to control

their own emotions and physical processes, i.e., toilet training, meal times. That view of controlling society led to its fragmentation and ultimately to the theoretical models which were the models of its science, its medicine, and its concept of health and wellbeing.

At the present moment a series of changes seem to be occurring in our society. On one hand it is as if the values of the so-called primitive societies are infiltrating those with which the West is preoccupied. In the West, concepts of non-rationality are beginning to enter into rational thinking. What may be surprising, however, is that suddenly we are beginning to become aware that there is rational, scientific proof of some of the processes that heretofore have been considered unscientific.

In addition to scientific proofs there are changes in moral and ethical perceptions, just as there were when the natural world began to be controlled. We now seem to be in the midst of a shift of major proportions as we face the inability to deal with current problems. As our society becomes more and more crowded and the problems of one fragmented field after another — medicine, education, city planning — began to overlap into another fragmented field, what emerges is a need for and thus the creation of a concept of systems. Systems theory thus developed as a way of managing organized complexity. The paradox, however, is that organized complexity does not behave in a purely rational manner, and thus the concept became one of living systems — ones which continually learn and thus in a state of perpetual flux. We call these inquiring systems.

Despite this trend, the crises continued to build so that each fragment overlapping into each other fragment led to further and further complexity. Consequently, instead of talking about pieces of the earthly universe, it is becoming easier to conceive of the earth as a total organism. Such a perception is being proposed in modern physics and in neuro-physiology as the holographic universe and the holographic mind. We cannot separate the Philippines from the United States, China, Japan, or the rest of the world, nor can we separate the concepts of health from politics, governance, economics, or even the price of oil. We are thus talking about a total living organism.

We could face the issue with the concept of One World (Wendell Wilkie) or of "Spaceship Earth" as enunciated by Buckminister Fuller. We then come up with the notion that we have an earth that is a whole, that the resources are limited, and that we must find ways, not of competition but of collaboration, and slowly returning to being one again with that environment which is the earth and which is the context of our lives.

We would like to turn now to the notion previously mentioned of the hologram, because the physicists, in their analyses of the various quanta, have become more and more preoccupied with studying and finding the particles which make up the atoms or matter of the universe. If the physicists discover more and more particles, some even suggest that if they search endlessly, they will find as many particles as they set out to find. Some physicists are beginning to suggest that the issue may very well be how particles are organized and that the organization of the particles is based upon the space between the particles, which they call "consciousness"; For those of us in the field of psychology, consciousness has a similar meaning in the sense that consciousness is the way we organize reality. The physicists are suggesting that the way reality is organized determines how the particles get together. They are further suggesting that if a shift of consciousness is produced by shifting the energy pattern, what we call physical reality will change. Thus reality is a reflection of our consciousness about the universe we are in.

But let us take it one step further and go way out in concepts and then return. The physicists have even suggested, following some of the concepts of Einstein, that if one would leave the present perception that we are in and move endlessly in space and in time, we would also at the same time be back to the present. There are some physicists like David Bohm that suggest therefore that the universe is indeed a hologram. A hologram is basically a notion that says that any piece has within it all of the whole.

Geneticists, in their concepts of cloning, have suggested that in each cell is the whole organism. Thus through cloning of any cell and not just the sex cell the whole can be found.

Karl Pribram, a neuro-physiologist at Stanford University, suggests that the mind is made up of cells which both perform its pragmatic function and have within it the total memory of the universe, thus each cell is a hologram of all knowledge. If we were to take this still further, one would suggest that not only the brain has this memory but all cells do as well. But the question that Pribram raises for us is that through our education and social learning we have learned one particular decoding of the hologram and by common agreement see the same thing. Thus if we were to learn a different decoding, we would see something different and that different reality would exist. Thus all realities exist.

If then we are to go back to the concept of the physicist that all space and all time would endlessly come back to the same point, if we could abolish space and time, then all knowledge would be available to us within the present point. Techniques such as meditation, or techniques by which one is in tune with the

energy of the universe through a variety of religious practices, lead to being in tune with not only the energy but to the all-knowing, which in non-medical languages has been called "God". There are experiential techniques practiced by Buddhists and Tibetan Lamas which remove space and time and thus make available to one's self knowledge from all sources. We then arrive at the possibility of behaviors which have heretofore been mysterious.

Now let us consider as a possibility for scientific study — indeed as a possible reality — such activities as psychic healing or surgery as practiced in the Philippines, reincarnation experiences which we have denied scientifically, and other phenomena which we have heretofore classified with mysticism. We thus may find that the mystic learns to decode the hologram in a different manner than the rest of us and thus has available to him knowledge that others do not have. Thus, healers may have available to them not just scientific knowledge but the ability to tune in to energy which may be able to heal. If one were to abolish space and time and one were to lose one's fear, one could possibly utilize the energy or be in tune with the energy of the universe to become healthy. This is the concept of what we have called primitive religion, but it is also the concept of people who have healed themselves or who have been healed by healers, all of which is foreign to medical practice of Western scientific medicine.

We have suggested that we are in a time of great stress and crisis and non-solution. We are at a point which Jonas Salk calls the transition from Epoch A to Epoch B. He uses quite metaphorically the sigmoid curve of the growth of bacteria on an agar plate as it shifts from one slope to another. He suggests that as part of the upward curve there develops a metabiological and philosophical system of behavior which is different than when the curve begins its second shift. The shift from Epoch A to Epoch B means a shift in the metabiological system of belief system. The dilemma that we are faced with now is the dilemma of shifting our thinking, our institutions and organizations and values to this new system.

Thomas Kuhn suggests that major scientific advance occurs with paradigm shifts, and that paradigm shifts occur at times of crises, crises which force people to look for alternative ways of conceiving reality. In the process of crisis one cannot fall back on old cosmologies because they are no longer useful, so we search for new ones.

We are now in that moment of transition from Epoch A to Epoch B. We have evolved a step in social evolution, i.e., social development or social learning. It is not that the hologram

develops new knowledge, but rather since all knowledge may be present it is that our societal learning has developed to the point where we may now decode the hologram in a better manner. In fact, what may be occurring now is that we are forcing ourselves to devise new decoding techniques to unscramble the hologram and thus to remember what is already known but has not been decoded. Thus the only secrets that exist are secrets that result from our inability to understand, to see, to conceive, or to develop a decoding technique to reach an alternative conceptual model.

Societal learning moves at different levels for different people, in different spaces, and at different times. We are thus faced in a transition period with people in different spaces moving at different speeds towards different models of what the universe is.

We are faced then with a dilemma of governance, politics, and of the battle between the different models for people. There are many now in the world who are fighting to meet their basic needs and to meet their level of self-esteem. They wish to reach the point where they feel capable enough to ask for things for themselves. We see here many of the wandering, aimless hippies of the Sixties who then were mainly interested in being high or mellow, living from the communal pot, who are now confronting their own individualism, their own desire. But these previously "loose" individuals are generally very controlling in their new identity — of themselves and others. There are still others who have reached a point where those needs are met and they then move on to new questions. It is these people who, because of their basic needs and self-esteem have been met, can move on to these alternative models.

The paradox, however, is that those who have the most and those who have the least may be at that point in time where their search for models may be in synchrony. That is, that the models of people who have what we call primitive view of the universe and those who are frustrated with the so-called advanced view are coming up with parallel and compatible views of what the universe may be. It is only those in the middle who have moved on and have started the upward spiral who feel they must follow in all the traditional steps (so that ontogeny repeats phylogeny in this group) and in so doing need to repeat the steps of their predecessors. Thus the neocolonialists who have gotten rid of the colonial masters have become more colonial than the previous masters. These people are holding on to the model that has been successful for their forebears despite the fact that at this point in time the organism known as the earth no longer is capable of dealing or being dealt with by these old models. Since the earth is one earth, we are at the moment where we can ill afford to have cosmologies which do not meet the needs of all the people.

It is clear that the problem of our society — our total earth, the United States, the Philippines, Iran, Israel, Egypt, or any place — cannot be dealt with in separation, or in fragments. It is clear that the problems of medicine cannot be dealt with separately from the problems of education and health. Indeed, as Martin Buber has said, the problems may very well be the notion of the changing concepts of what a human being is on this earth.

We would like to close by returning to the problem of medicine and health, for we have suggested that health may indeed be the synthesis of the internal and external environments. Health may be, as Rene Dubos says, the ability to use all of one's senses; if so, health then becomes the ability to move from one reality to another as is required by the problem. It is also the ability to experience all of one's feelings and perceptions invited by the situation. For the schizoprenic, his reality is real; his problem and his illness are that he cannot move from that reality to another. For us, to move from Epoch A to Epoch B, our problem is that so long as our emotional and perceptual life is stunted and rigidified in a controlling and controlled style, we will be unable to move from our own narrow survival mechanisms to living on a holographic level where options are broadly open.

We are confronted with our own emotional and perceptual styles. For those who are caught in a fight for emotional ego and personal survival, freedom to use all of one's senses feels dangerous. Not only does this style produce asthma, ulcers, migraines, but by necessity a rigid notion of reality. When one is comfortable or skilled with a broad range of experiental capabilities, internally and with others, they no longer need to exert control over reality but are free to move from one to another.

This experiental limitation, or limiting of emotional and perceptual skills, confronts ordinary individuals, families, and communities as well, When people are deskilled emotionally, they are not able to feel or express the broad range of affects available in their person. Perceptually, having confined their view of the world to that which is culturally acceptable, they must remain blind to each other and themselves as unique, paradoxical characters.

It is a challenge to us in medicine, especially, to be able to only to understand all the realities of our patients and clients but to understand the different realities and cosmologies which make up our world and to participate in the creation of a new reality and cosmology as we go through the transition from Epoch A to Epoch B. Health in our new epoch involves not only the quality of life, but the way we live and what we think as being important. That will determine what the needs of our society are. To meet

those needs addresses health and the problems and crises that lead to illness.

We thank you for allowing us to take you on a trip of the mind, a trip that extends far beyond your mind and body, beyond your brain or mind into the mind that makes up our holographic universe. We have raised these questions here in the Philippines, primarily because we believe that your problems are the problems, not just of the Philippines but of our total earth, and that the problems that are faced by us, by you, by everyone that exists on this earth are deeply interrelated.

We thank you very much for this opportunity.

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PROPERTIES OF STARCH AND PROTEIN RELATED TO EATING QUALITY OF MILLED RICE

By Bienvenido O. Juliano

Abstract

Although amylose/amylopectin ratio of starch is the major determinant of the texture of cooked rice, varietal differences are observed which are related to other starch properties. Among high (> 25&%) amylose rices, preferred varieties with softer texture of cooked rice (with an Instron food tester-Ottawa Texture Measuring System cell) tended to have soft gel consistency and intermediate gelatinization temperature. Among intermediate (20-25%) amylose rices with similar gel consistency, the variety C4-63G with softer cooked rice tended to have higher gelatinization temperature than harder cooked rice (BPI-121-407). Among low (8-20%) amylose Korean rices of low gelatinization temperature, harder cooked rice varieties tended to have harder gel consistency than softer rices. Waxy rices with soft cooked rice had lower gelatinization temperature and softer neutral gel consistency than waxy rices with hard cooked rice.

Protein content was shown to be a secondary factor affecting the stickiness and hardness of cooked rice. About 10-15% of cooked rice protein bodies representing the lipid-rich core portion were not digested by man and expelled as fecal protein particles. Cooking made the lipid more extractable but the protein less soluble. The major undigested protein had polypeptide MW of about 5000 and was present at about 10% of total protein UV absorption of raw milled rice protein. It had lower (< 2%) lysine content and higher cysteine and methionine contents than whole rice protein.

Introduction

An interdisciplinary approach called Genetic Evaluation and Utilization (GEU) program has been in operation in IRRI since the 1960s. Although grain quality can be improved by postharvest operations and processing, IRRI's basic philosophy is to incorporate or build in as much of the desirable characteristics into a rice variety. In GEU-Grain Quality, chemists strive to obtain a better understanding of heritable grain properties related to grain quality

with an end in view of developing simple, sensitive and rapid indicators of eating quality applicable to the breeding program. A big bottleneck in our research is the lack of definitive information on relative eating quality of varieties of similar amylose contents. Our Plant Breeding department maintains a Rice Quality Laboratory, which analyzes breeding lines and selections for quality characteristics. This set-up allows the Chemistry department to devote most of its time to research. The Head of the Chemistry department, however, also oversees two chemical service laboratories, the Analytical Service Laboratory for routine analysis of elements in samples of plants, soils and solutions and the Pesticide Residue Laboratory for routine analysis of pesticide residues in plants and soils.

The major constituents of milled rice are starch and protein (Table 1). Minor constituents are fat (lipids), crude fiber (dietary fiber), and crude ash and vitamins. Starch occurs as compound

Table 1. Mean composition of waxy and nonwaxy milled rice

Constituent	*Content (wt % dry basis)*	
	Waxy (glutinous)	*Nonwaxy (nonglutinous)*
Starch	~90	~90
Amylose	1-2	12-33
Amylopectin	88-89	57-78
Protein	8	8
Fat (lipids)	1	1
Nonstarch	0.9	0.4-0.6
Starch	0.1	0.4-0.6
Crude fiber	~0.5	~0.5
Dietary fiber	~1	~1
Crude ash	~0.5	~0.5

granules in the rice endosperm 3-9 μm in size. Starch, a polymer of glucose, is the major factor affecting the texture of cooked rice, mainly the ratio of linear fraction amylose to branched fraction amylopectin (1). Amylose content is measured by its characteristic blue-colored complex with iodine. Amylose classes are: waxy (glutinous) 1-2% amylose; low amylose 12-20%; intermediate 20-25%; and high 25-33%. Waxy rice is as digestible in children as nonwaxy rice (4) and differed in composition from nonwaxy rice mainly in the lipid distribution in the endosperm (Table 1). Amylose content correlates negatively with taste panel scores for tenderness, cohesiveness, gloss, and color of cooked rice (2,3) (Table 2).

Table 2. Mean properties of milled rice and scores by a laboratory taste panel of cooked rice from low amylose and high amylose pairs from three different crosses (Juliano *et al* 1972).

Property	*Low amylose lines*	*High amylose lines*
Amylose (% dry basis)	14.2	25.3
Protein (% at 14% moisture)	10.4	10.4
Final gelatinization temp. (°C)	61.5	61.5
	Trial I (Identical water: rice ratio)	
Water: rice ratio	1.8	1.8
Tenderness[a]	7.6	4.0
Cohesiveness[a]	7.3	3.4
Color[a]	2.7	1.6
Gloss[a]	8.3	4.4
	Trial II (Adjusted water: rice ratio)	
Water: rice ratio	1.6	1.8
Tenderness[a]	6.7	4.1
Cohesiveness[a]	6.6	3.5
Color[a]	1.7	1.6
Gloss	6.9	4.2

[a]Mean of duplicate assessment by a taste panel of four judges. Numerical scores of 1 to 9 were assigned, "1" representing the least expression of the property in question and '9" highest expression.

Other starch properties we routinely measure in the breeding program are final gelatinization temperature and gel consistency. Final gelatinization temperature, measured in the program by the alkali test (5), represents the temperature of hot water at which most of the starch granules lose crystallinity and start to swell irreversibly. It is classified as low 55-69.5°C, intermediate 70-74°C, and high 74.5-80°C. Gel consistency measures the softness of a milled rice gel (100 mg) in 2 ml 0.2 N KOH by actually measuring gel length in a horizontal 13- x 100-mm test tube (6). It is classified as hard 26-40 mm, medium 41-60 mm, and soft 61-100 mm.

Since gelatinization temperature is measured by the degree of disintegration of milled rice after 23 hours at 30°C in 1.7% KOH (5), the whole grain probably reflects this starch granule property. Gelatinization temperature also correlates with resistance of the starch granules to 2.2 N HCI and α-amylolysis (7,8). Resistance of starch granules to HCI corrosion was positively correlated with gelatinization temperature, and to a lesser extent, with amylose content (8). We are checking in a cooperative study whether insects and fungi can differentiate among various brown rices differing in these starch properties.

Although protein is not a primary factor affecting eating quality of rice, rice is the principal source of dietary protein in tropical Asia (9). Proteins are polymers of amino acids joined by peptide bonds. They occur in the rice endosperm in the form of single-membraned particles called protein bodies, 0.5-4.0 μm in size (10). Cooking reduced the true protein digestibility of three milled rices in rats from 100% to 89% but improved the biological value of their protein, such that net protein utilization remained practically the same in raw and cooked rice regardless of protein content (11) (Table 3). True digestibility of rice in man is also about 85% (12) and 15% of dietary protein of man fed rice was reported to be in the feces in the form of fecal protein, with eating quality of milled rice .

Table 3. Mean nutritional properties of raw and freeze-dried cooked rice of three rice samples (Eggum *et al* 1977).

Property	*Raw milled rice*	*Freeze dried cooked milled rice*
Crude protein (% N x 5.95)	8.93	9.04
Lysine (g/16 g N)	3.60	3.51
Amino acid score[a] (%)	65.5	63.8
N balance in growing rats		
True digestibility (%)	99.7	88.6
Biological value (%)	67.7	78.2
Net protein utilization (%)	67.5	69.2
Utilizable protein (%)	6.02	6.24

[a]Based on 5.5 g lysine/16 g N as 100%.

Starch as an eating quality factor

Varietal differences in eating quality are known among rices of similar amylose content (14). For example, IR5 is considered of better quality than IR8 in the Philippines. In India, IR8 and the early semidwarf rices were considered of inferior quality to traditional rices all with high amylose content (15). Glutinous or waxy varieties also differ in quality as with Japanese rice cakes (16) and waxy rices for *pinipig* (17) and *suman sa antala* (18).

We found that the poorer quality rices such as IR8 has a stiffer cooled gel in the Amylograph and less soluble starch (particularly amylopectin) in cooking water than the softer high amylose rices such as IR5 (1). We developed in 1973 a simple micro method to

differentiate among these high amylose varieties — the gel consistency test (6).

A taste panel could not readily differentiate between IR5 and IR8. We sent IR5 and IR8 samples to Instron in 1975 for measurement of stickiness and hardness of cooked rice and it sent back results which were encouraging (Table 4). We, thus, acquired an Instron Food Tester Model 1140 in 1977 and developed a modified Ottawa Texture Measuring System cell extrusion technique for hardness, and the use of the force required to lift the plunger from the platform with cooked rice sandwiched between them as a measure of stickiness (19). The use of a cooked rice mold for measuring stickiness was not very effective on low amylose rices.

Table 4. Properties and Instron data on cooked 1974 wet season IR5 and IR8 milled rice. IRRI and Instron Ltd., England, 1975.

Property	*IR5*	*IR8*
Alkali spreading value	4..0	7.0
Amylose content (% dry basis)	28.4	27.9
Gel consistency (mm)	98	36
Mean taste panel scores[a] for warm rice		
Tenderness	4.4	3.8
Cohesiveness	4.6	4.1
Hardness (OTMS cell, 100 mm/min.) (kg)	140	160
Cohesiveness (compression anvil and compression table, 50 mm/min.) (g)	286	227

[a]Mean of duplicate assessments by a taste panel of six. Scores based on a scale of 1-9 with the higher number indicating a greater intensity of the character (Juliano *et al* 1965).

When Instron data of hardness and stickiness of cooked rice were correlated with amylose content, correlations were highly significant (19) (Fig. 1). There was more spread in values for hardness than in stickiness at similar amylose values, suggesting that these secondary factors probably affect tenderness of cooked rice rather than stickiness.

Among intermediate amylose rices, C1-63G with intermediate gelatinization temperature had 1 kg softer cooked rice than low gelatinization temperature variety BPI-121 407 although they had similar soft gel consistency values. We tested eight milled rice samples last January 1979 with Prof. A. M. del Mundo of the Institute of Human Ecology, UPLB using a consumer panel in Barrio Bukal, Lemery, Batangas. We found inconsistent results

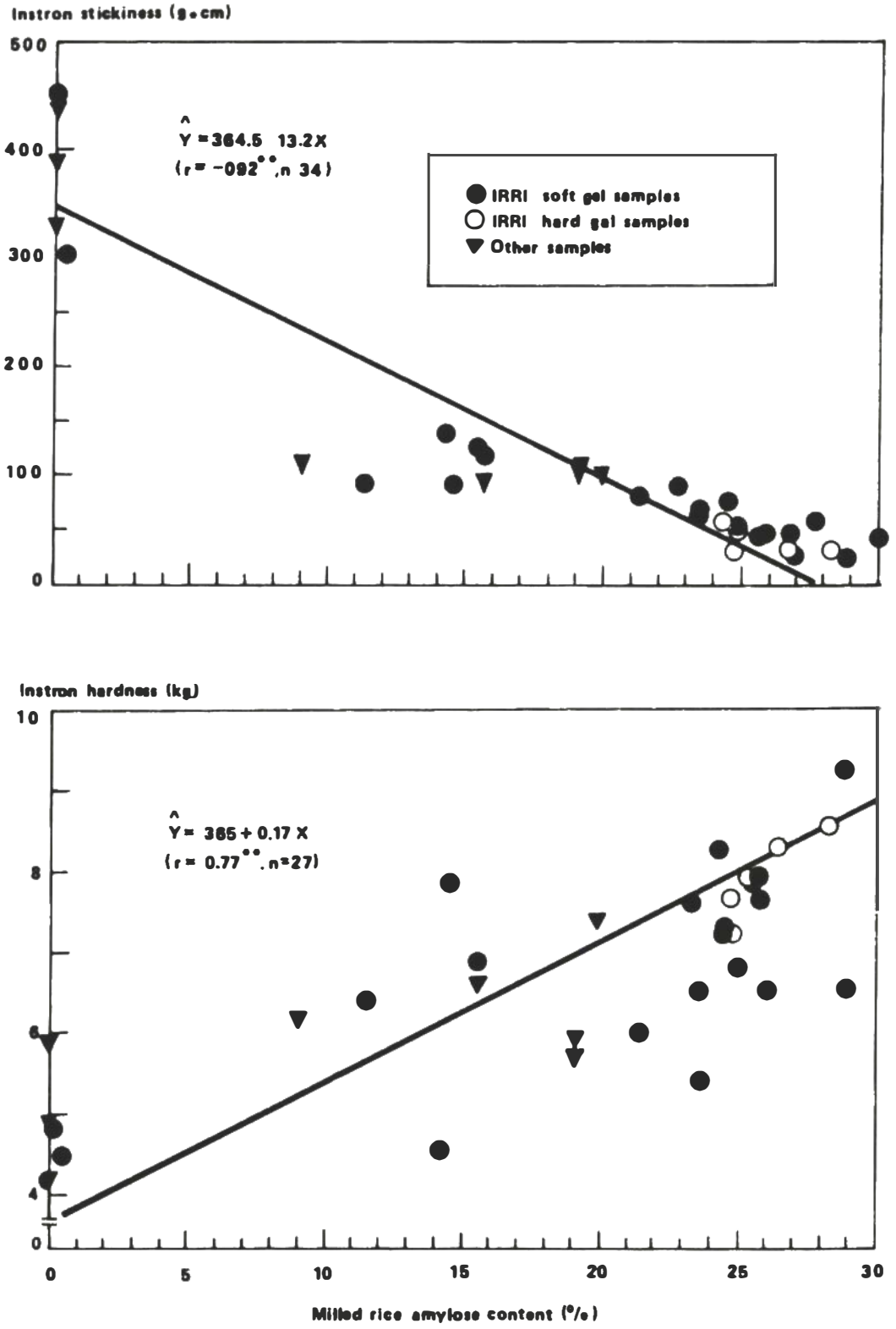

Fig. 1 Relationship between amylose content of milled rice and Instrom strickiness and hardness of rice cooked with the optinum level of water and cooled.

with BPI-121 407 and C4-63G and intermediate amylose lines derived from them (Table 5). Evidently, the panel preferred samples with minimum brokens and without a gray tinge. The results were surprising as in practice there is little price premium given to head or whole-grain rice in the country. We are repeating the test later this year using head milled rices with similar whiteness to obtain definitive results.

Among low-amylose rices, the good samples of quality differences was the first South Korean high-yielding, semi-dwarf variety, Tongil, which came from indica x japonica crossing program. Tongil was considered inferior (harder cooked rice) to traditional japonica varieties of similar amylose content and gel consistency, such as Jinheung (Table 6). We found that by increasing gel concentration from 100 mg to 120 mg/2 ml 0.2 N KOH in the gel consistency test and from 40 g to 48 g/400 g aqueous suspension in the Amylograph (19), Tongil showed harder cooled paste than Jinheung. It also showed a higher gelatinization temperature than Jinheung. Late in 1978, we tested the newer varieties from the Korean program and found them to be already similar to japonica rices in these grain properties and of improved eating quality. Egyptian low-amylose rices also differed in hardness of cooked rice (Table 5).

Table 5. Properties and preference and acceptability scores of five total milled rices used in consumer panel testing. Institute of Human Ecology, UPLB and IRRI, 1979.

Property	*IR4570-74-2*	*C4-63G (check)*	*IR9129-209-2*	*C4-63G*	*BPI-121-407*
Mean preference score[a]					
Cooked	0.247a	0.094ab	0.089ab	−0.136bc	−0.294c
Raw	0.022ab	0.178a	−0.264b	0.081ab	−0.017ab
Alkald spreading value	7.1	3.8	4.7	4.0	7.0
Amylose content (%)	24.7	23.7	21.6	24.6	23.9
Gel consistency (mm)	84	87	82	94	70
Kett Whiteness reading	40.8	43.1	37.4	40.8	38.0
Instron cooked rice					
Hardness (kg)	6.4	4.8	5.6	5.7	6.6
Stickiness (g.cm)	79	87	105	89	99

[a]Mean of 39 panelists who rated five samples each in two sets, with a common C4-63G check sample. 1st = 1.16; 2nd = 0.50; 3rd = 0; 4th = −0.50; and 5th = −1.16. Means followed by a common letter in the same line are not significantly different at the 5% level. Brokens ranged from 25-73% of total milled rice.

Table 6. Physicochemical properties of japonica and indica low amylose rices from Korea and Egypt[a], IRRI, 1978.

Variety	*Source*	*Grain type*	*Amylose content (% dry basis)*	*Gel consistency (mm)*	*Cooked rice hardness (kg)*
Jinheung	Korea	japonica	19.1	89	5.7
Akibare	Korea	japonica	17.5	90	4.6
Tongil	Korea	ind. x jap.	19.9	86	7.4
Milyang 23	Korea	ind. x jap.	19.5	92	4.7
Suweon 264	Korea	ind. x jap.	18.6	92	4.4
Giza 171	Egypt	japonica	18.4	86	5.1
Reiho	Egypt	japonica	19.6	98	5.6
IR1615-246	Egypt	indica	20.0	89	6.6
IR26-203	Egypt	indica	19.6	90	6.4

[a]All with alkali spreading value of 7.0.

Among waxy rices, those with low gelatinization temperature about 65-68°C had the softest texture of cooked processed rice products (Table 7). High gelatinization temperature rices had definitely harder cooked rice combined with harder neutral gel consistency and higher Amylograph viscosity (17,18). We had to use 200 mg flour/2 ml 0.15 N potassium acetate to obtain some degree of differentiation in gels of waxy milled rices. Among Japanese rices, very low gelatinization temperature (56-63°C) waxy rices gave inferior rice cakes to those with 65-68°C gelatinization temperature (16), although they have similar gel consistencies (20). The preferred Japanese rices have higher peak viscosity in the Amylograph (16). The secondary factors that we have found so far as indicators of eating quality among rices of similar amylose contents are summarized in Table 8.

The subject of chemical aspects of rice grain quality was reviewed in an international workshop held last October 1978 at IRRI. The proceedings of this workshop are in press. As a follow-up of this workshop, chemists are doing cooperative ring tests on five grain quality tests in order to standardize the procedures and identify sources of variation in these tests. Of particular interest is the comparison of results with various instruments measuring the texture of cooked rice.

Relationships among starch properties

Although amylose content and gelatinization temperature are independent properties of starch, not all combinations are common in the popular varieties grown in the world (Table 9). We are seeking these odd types from the IRRI world rice collection to better understand their effects on eating quality.

Table 7. Physicochemical properties of waxy rices from three countries. IRRI, 1978.

Variety or line	*Processed rice quality*	*Alkali spreading*		*Final BEPT (°C)*	*Neutral gel consistency (mm)*	*Amylograph peak visc. (B.U.)*	*Cooked rice hardness (kg)*
		1.7% KOH	*1.3% KOH*				
Philippines							
Malagkit Sungsong	good	6.4	6.0	62.5	76	440	3.5
IR29	fair	7.0	4.2	63	52	560	5.6
UPLB-Ri-1	—	6.5	4.6	64	62	400	3.3
Pampet 63	poor	2.3	2.0	77	35	870	5.9
Thailand							
Niaw San Pahtawng	good	6.8	4.8	64	94	570	4.9
RD6	good	7.0	5.0	63.5	74	450	5.9
RD4	poor	7.0	2.0	73.5	46	820	6.6
Japan							
Norin No. 1	poor	7.0	4.3	58.5	86	350	6.9
Nakatamochi	poor	7.0	4.7	63	90	350	5.9
Koganemochi	good	7.0	2.2	67.5	86	560	5.6
Hatsunemochi	good	7.0	2.8	68.5	81	595	6.0

Table 8. Summary of important secondary eating quality factors for milled rice with similar amylose content.

Amylose type and property	*Property class of milled rice*	
	Good quality (softer)	*Poor quality (harder)*
High amylose		
Gel consistency (100 mg/ 2 ml 0.2 N KOH)	soft	hard
Gelatinization temperature (° C)	intermediate	low
Amylograph peak viscosity (Brabender units)	low	high
Hot water soluble amylose (% of milled rice)	14-16	10-12
Intermediate amylose		
Gel consistency (100-110 mg/2 ml 0.2 N KOH)	soft	hard
Gelatinization temperature (° C)	intermediate?	low?
Low amylose		
Gel consistency (120 mg/ 2 ml 0.2 N KOH)	soft	hard
Amylograph peak viscosity (B.U.)	low	high
Waxy (glutinous)		
Neutral gel consistency (200 mg/2 ml 0.15 N potassium acetate)	soft	hard
Gelatinization temperature	low (65-68° C)	interm. to high; (≥70° C) very low (≤60° C)
Amylograph peak viscosity (B.U.)	intermediate	high; low

Among waxy rices, which is an ideal model system as their starch is essentially 98% amylopectin, molecular size as indexed by intrinsic viscosity and sedimentation constant tended to show a U-shaped correlation with gelatinization temperature with minimum at 65-68°C (21). Gel consistency also showed low values for low gelatinization temperature waxy rices than intermediate and high gelatinization temperature rices (20,21). Limited study on eight nonwaxy starches seemed to indicate that amylopectin

Table 9. Combination of amylose content and gelatinization temperature commonly found in cultivated rice varieties.

Amylose type	*Gelatinization temp. class*		
	Low	*Intermediate*	*High*
Waxy (0-2%)	++[a]	0[a]	+[a]
Very low (2-12%)	++	0	+
Low (12-20%)	++	0	0
Intermediate (20-25%)	+	++	0
High (25-33%)	++	++	0

[a]++ = most common; + = less common; 0 = rare.

contributes more to gel consistency than amylose (22) (Table 10). Gel viscosity correlates positively with molecular size of amylopectin also (22). Periodate oxidation indicated that the degree of branching of amylopectin is 4-5% or a mean chain length of 23-28 glucose units. Hence, molecular size was the major molecular property of amylopectin that was related to gel viscosity of both waxy and nonwaxy rices.

We are trying to recheck by gel filtration on agarose gel (Sepharose 2E) and by ultracentrifugation the molecular size of amylose and amylopectin and the intermediate fraction among high amylose rices differing in gel consistency. The fraction intermediate in properties between amylose and amylopectin has been demonstrated in corn starch and may help explain our

Table 10. Range of intrinsic viscosity and gel viscosity (160 mg/2 ml 0.2 N KOH) of amylose and amylopectin of seven nonwaxy rices (Juliano and Perdon 1975).

Property and fraction		*Viscosity*	
		Range	*Mean*
Intrinsic viscosity (ml/g)	Amylopectin	159-197	176.6
	Amylose	136-230	169.7
Gel viscosity (cps)	Starch	140-686	423.4
	Amylopectin	354-605	487.0
	Amylose	26- 73	39.6
	Reconstituted starch	148-240	210.4

difficulty in obtaining pure amylose and amylopectin from high amylose rices by the usual crystallization of amylose as the amylose-butanol complex (22).

Protein as an eating quality factor

Although we have studied in detail the major proteins of milled rice, glutelin (23,24), prolamin (25) and α-globulin, (26), and are studying the major albumin and the second major globulin, our discussion will be limited to the effect of boiling on protein digestibility. The 85% digestibility of milled rice protein in man is less than the 90% reported for wheat flour protein (12). In the mid 1960s, Dr. George Graham concluded that there was no advantage of rice over wheat in baby foods, and UNICEF dropped its project to use the overmilling fraction of milled rice (with 15% protein) as a baby food.

Dr. Y. Tanaka, who isolated and characterized the fecal protein particles (13) spent 8 months with us in 1977 and brought some of his samples for characterization. Our study since then indicated that the fraction rendered indigestible by boiling represented the core or center of the large spherical protein bodies of milled rice (10-15% of total protein and 80% of lipid) (28). Cooking evidently resulted in more protein-protein interaction resulting in reduced extractability of protein and increased extractability of the lipid (29). Fecal protein particles can be simulated by pepsin treatment of amylase-destarched milled rice (28,29).

The core portion had higher lipid content (~ 20%) than whole PB (7-9% lipids) and proportionately less protein (Table 11). Lipids had identical ratio of lipid fractions and fatty acid composition in the core and whole PB but protein showed drastically different composition (20). Core protein had lower lysine content but higher cysteine/methionine content of whole PB protein, which explains its insolubility by disulfide bond formation. (Table 9). These results explain why the net protein utilization of rice protein does not deteriorate on cooking as the protein rendered less digestible is of poorer quality than the whole protein. Digestibility alone is not a reliable indicator of protein quality. Rice protein is better retained in man than wheat protein because of its higher biological value (30).

In attempts to explain the source of this core protein, we fractionated the SDS-β-mercaptoethanol extract of milled rice and found 10% of its UV absorption on SDS-Sephadex G-75 gel filtration to correspond to the major core PB polypeptide (29) (Fig. 2). This fraction correspond to a polypeptide molecular weight of 5000. Evidently the core protein must have been synthe-

Table 11. Properties of whole and pepsin-treated (undigested) IR480-5-9 milled rice protein bodies.

Property	*Cooked whole protein bodies*	*Pepsin-treated cooked protein bodies*
Weight recovery (%)	100.0	34.5
Protein content (% N x 5.95)	79.1	62.4 (27.2%)[a]
Lipid content (%)	9.51	22.2 (80.1%)[a]
Lysine (g/16.8g N)	4.0	1.3
Cysteine (g/16.8 g N)	2.6	4.6
Methionine (g/16.8 g N)	3.1	4.8
Neutral lipid/glycolipid/ phospholipid ratio	92/5/3	92/5/3
Fatty acid composition of neutral lipids		
Palmitic (wt % of total)	32	34
Oleic (wt % of total)	24	24
Linoleic (wt % of total)	42	40

[a]Values in parenthesis are protein or lipid recoveries.

sized ahead of the rest of the outer PB proteins about 7-8 days after flowering in the presence of more lipids. It has escaped detection earlier due to its poor capacity to absorb protein stains on electrophoresis due to its small molecular size. Isolation of this polypeptide as the *S*-cyanoethyl derivative is in progress.

Other minor constituents as eating quality factors

Fig. 3 summarizes our current research program on grain quality and Fig. 4 summarizes our cooperative work with non-IRRI scientists.

We have studied lipids (1%) of milled rice as an eating quality factor. Waxy rice has more nonstarch lipids and less starch lipids than nonwaxy rice (31). These lipids are important in the gel consistency test as defatted rices all have soft gel values (29). Parboiling also makes gel consistency values softer, probably because of the lower oil content of milled parboiled rice as compared to raw milled rice.

Cell wall polysaccharides have been a popular research subject recently in view of the nutritional interest on "dietary fiber." Our studies in 1968-69 showed very little hemicellulose in milled rice (32). Cell walls are probably important in grain integrity and direction of expansion of rice grain during cooking. We reactivated our work on cell wall polysaccharides with the 4-month stay in Nov. 1978 - Feb. 1979 of Dr. B. A. Stone, Dept. of Biochemistry, LaTrobe University, Victoria, Australia.

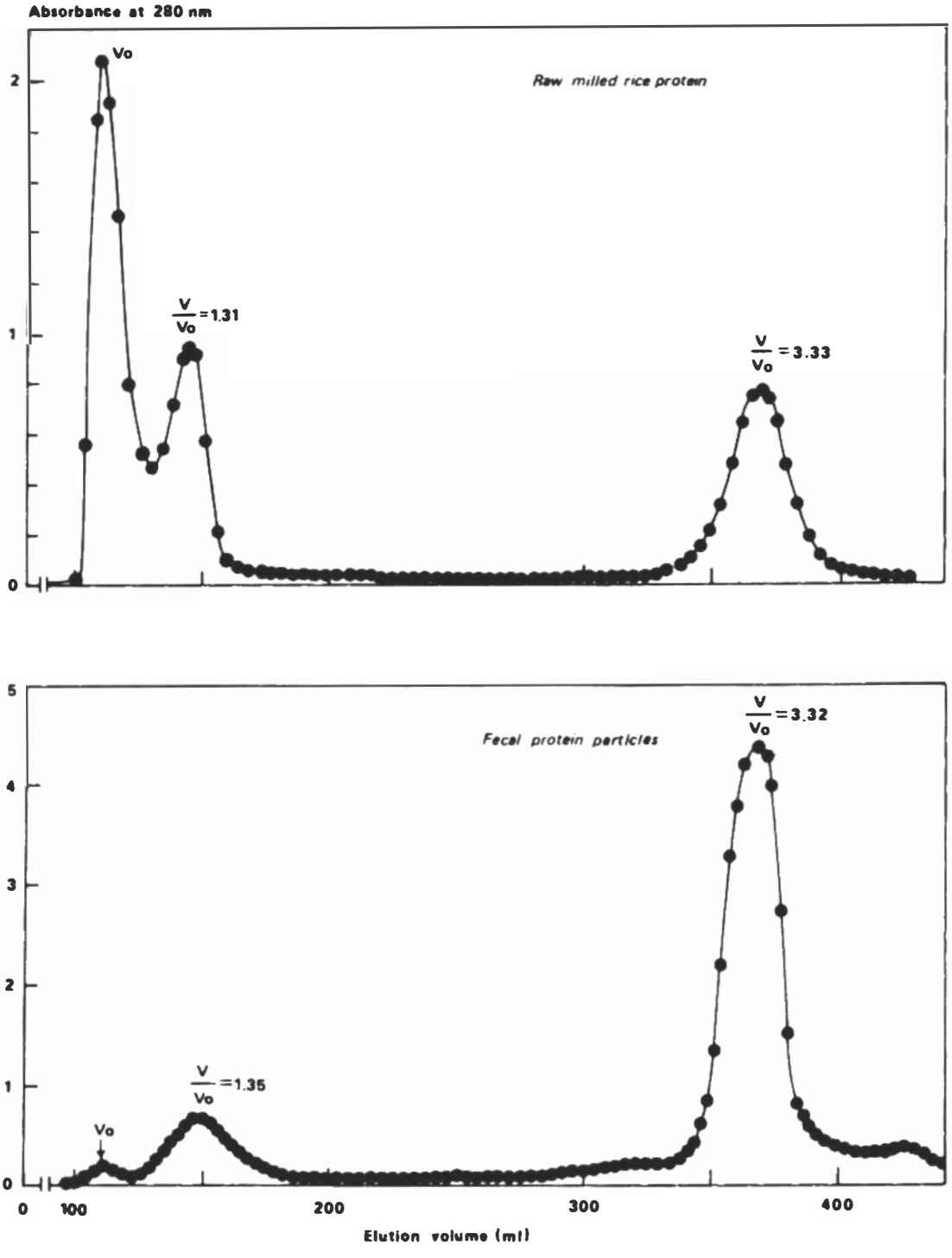

Fig. 2 SDS-Sephadex 6-75 gel filtration of total raw IR480-5-9 milled rice protein extracted by 0.5% SDS-0.6% B-mercaptoethand and of fecae protein particles from a man on an IR480-5-9 rice diet, IRRI, 1978.

4. Quality characteristics of rices grown in different countries	Researchers in 40 countries
5. International collaborative tests on rice quality methods	
a) Gel consistency	7 cooperators (5 countries)
b) Alkali test (2 methods)	9 cooperators (6 countries)
c) Amylose content (3 methods)	9 cooperators (6 countries)
d) Instrument methods for cooked rice texture (7 methods)	12 cooperators (8 countries)
6. Structural changes in developing rice grain	U.S. Grain Marketing Res. Lab., Manhattan, Kansas Mr. D. B. Bechtel
7. Lipids of starch of tropical rice	Obihiro University, Japan Dr. Y. Fujino/Mr. Y. Mano
8. Polysaccharides of intact cell walls of milled rice	LaTrobe Univ., Australia Dr. B. A. Stone

Crude ash (minerals) is also important in nutrition and may also alter the cooking characteristics of starch. The identification in the GEU program of varieties such as IR42, with tolerance to a variety content of milled rice is affected by the different soils on which IR42 can be grown without a decrease in yield.

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FERTILITY BEHAVIOR AND LABOR FORCE PARTICIPATION: A MODEL OF LEXICOGRAPHIC CHOICE

By Jose Encarnacíon, Jr.

It has been frequently observed that a smaller family size is usually associated with female employment. There is also an increasing amount of evidence that fertility rises with family income and the wife's education at relatively low levels of income and education (Encarnación, 1973, Cochrane, 1977, Hull and Hull, 1977) and only at higher levels is there the generally expected relationship that fertility falls with more education or income. Since a woman's labor force participation and her fertility are aspects of behavior of the same person (or couple), they should be explainable by a model of choice.

Section I sketches such a model; Section II cites empirical evidence and draws some implications. In particular, the model allows for a fertility decline even before a decline in mortality during the demographic transition.

I. The Model

We assume (cf. Tabbarah, 1971, Encarnación, 1973, Easterlin, 1975) that the capacity number of children a woman can bear, CK, depends positively on her educational level, E, and family income, Y:

(1) $CK = f(E, Y)$

due to better nutrition, health and medical (prenatal) care afforded by more income, and the better knowledge of good health practices and nutritional values that more education brings. We also assume that the number of child deaths in a family, CM, depends negatively on E and Y:

(2) $CM = h(E, Y)$

for reasons opposite those regarding (1). Then C, the number of (surviving) children, satisfies

(3) $C \leqslant CK - CM.$

Family income Y is[1]

(4) $Y = Y_h + t\, w\, (E)$

Where Y_h is husband's income and t w(E) is wife's income, t being her time spent on market work and w(E) her wage rate. Assuming a general-purpose commodity X with price p,

(5) $pX = Y$

is the budget constraint. We also assume that

(6) $X \geqslant g(C; E)$

is a desired minimum standards requirement that depends on family size and E, standards rising with E. In most of what follows we suppose that a couple maximizes a utility function

(7) $u(X, C, t)$

subject to (1)-(6), leaving to the end an alternative formulation. All variables are of course required to be nonnegative, satisfying natural constraints (e.g., t cannot exceed available time), and for a given couple, E and Y_h are predetermined.

Assuming that a solution to this maximization problem always exists — the no-solution case will be considered later — suppose further that

(8) $C^o = J(E, Y)$

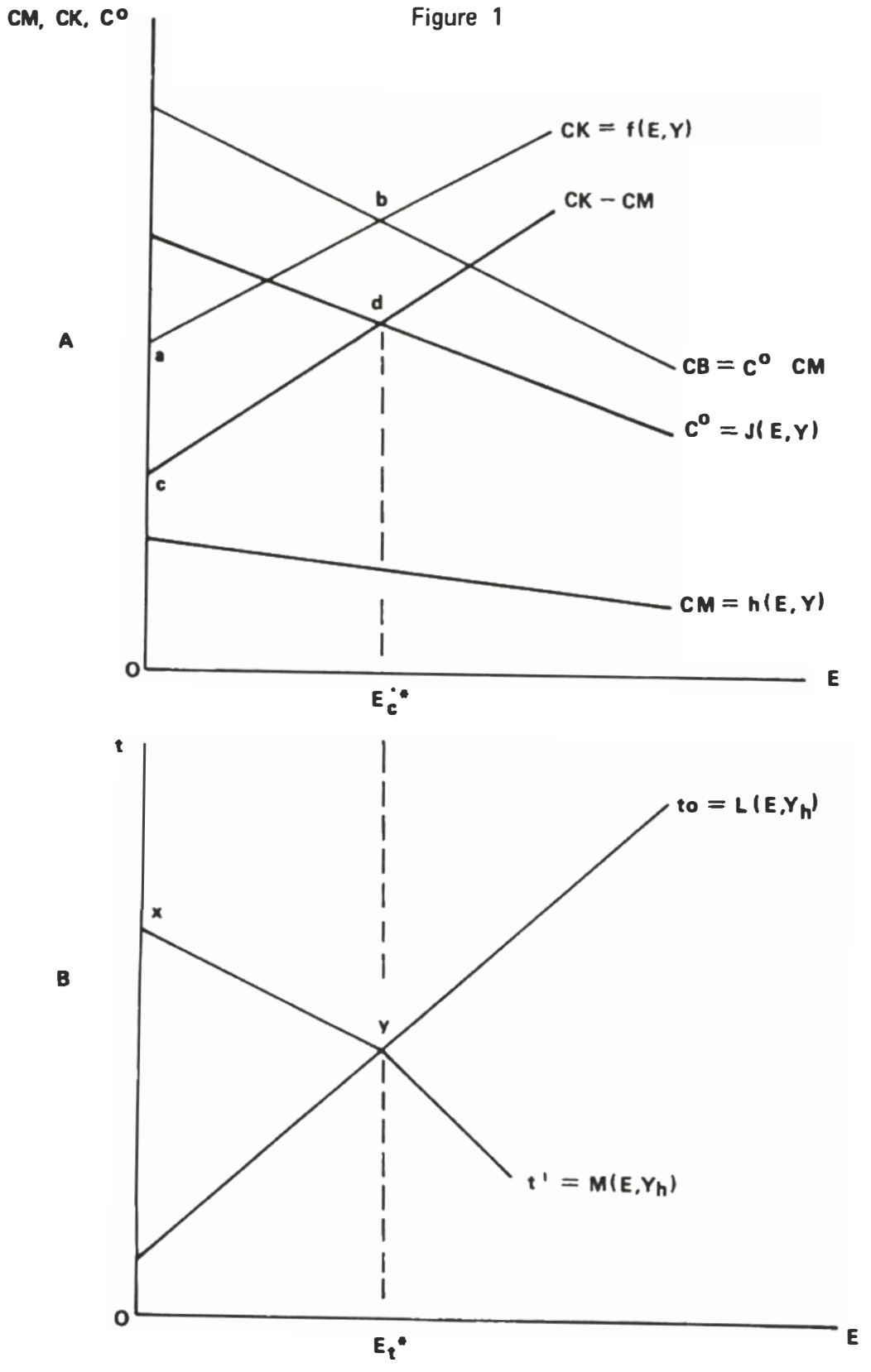
is the value of C in the solution to the same problem *without the constraint* (3). It will be useful to have a simple diagram, and for this purpose suppose that Y and E are related by $Y = k(E)$. Then we could have something like Figure IA where the CK and CM curves are drawn from (1) and (2), and the C^o curve from (8). The effect of higher E is clearly to make C^o less because of higher costs, ceteris paribus, but the correspondingly higher Y helps meet these higher costs; the C^o curve is drawn on the hypothesis that the net effect is negative.

It is reasonable to assume that a couple that would want C^o larger than CK — CM in the absence of (3) would choose C = CK — CM under (3); accordingly,

(9) $C = \min (C^o, CK - CM)$

in the solution to the original maximization problem. Thus in the diagram, what would then be observed for the number of births is

Figure 1


CM, CK, C^o
CK = f(E,Y)
CK − CM
b
d
A
a
CB = C^o CM
C^o = J(E,Y)
c
CM = h(E,Y)
O
E
E_c^*
t
to = L(E,Y_h)
x
B
y
t' = M(E,Y_h)
O
E
E_t^*

the curve abCB, and for the number of surviving children the curve cdC^{o}. Below E_c*, fertility would be higher were it not for a capacity constraint.

The case C = CK — CM is one where the couple is choosing the highest C it can have compatible with (1)-(6). E and Y are relatively low, and we would expect then that (6) is binding (i.e. the constraint is satisfied as an equality). In this case, (5) is simply a relation between C and Y, while t in (4) is just sufficient for (6) to be satisfied as an equality. Let

$$(10)\quad t' = M(E, Y_h)$$

be this value of t, and let

$$(11)\quad t^{o} = L(E, Y_h)$$

be the value of t in the solution to the maximization problem *without the constraint* (6). In order again to have a simple diagram, suppose that $Y_h = j(E)$. Figure IB is drawn on the hypothesis that t' is downward sloping and t^{o} is upward sloping, so that what would be observed for t is the curve xyt^{o}., i.e.

$$(12)\quad t = \max (t^{o}, t')$$

in the solution to the original maximization problem. There is here a parallel to the situation in Figure 1A. Below E_t*, it would be less were it not for the need to meet minimum consumption standards.

We note that the corner point y of the t' curve (which corresponds to the peak C, point d in Figure 1A) lies on the curve. For at E^{*}_{c} (where $C^{o} = CK - CM$), we have C = CK — CM so that $t = t'$ and also $C = C^{o}$ so that $t = t^{o}$ as well. Thus E_t* (where $t^{o} = t'$) equals E_c* and we may therefore speak of an education "threshold value" E* beyond which the fertility behavior as well as the labor force participation of women become qualitatively different.

Corresponding income thresholds are defined by

$$(13)\quad Y^{*} = k(E^{*})$$

$$(14)\quad Y_h^{*} = j(E^{*}).$$

E*, Y* and Y_h* are of course not invariant since they would change with shifts in the various functions that determine them.

In the foregoing we have assumed that the problem of maximizing (7) subject to (1)-(6) has a solution, and also that

such a solution satisfies (9). But income could be so low that (9) and (6) cannot both be satified. In this case we assume that (6) is dropped and (9) is maintained. (The very poor do not meet minimum consumption requirements but still have children.)

As formulated above, a couple's behavior is in effect describable in terms of lexicographical preferences; specifically, utility is a vector $U = (U_1, U_2, U_3)$ where

$$U_1 = \min(C, C^o)$$

$$U_2 = \min(X, g(C; E))$$

$$U_3 = u(X, C, t)$$

and an alternative whose utility is U is preferred to another whose utility is U' if and only if the first nonzero $U_i - U_i'$ (i = 1, 2, 3) is positive.[2] Thus the first objective is to have $C = C^o$ though in the case of below-threshold families only $C = CK - CM$ can be reached. The second objective is to attain a minimum consumption standard, though in the case of very poor families this may not be possible. Finally, U_3 is maximized over the set of alternatives with the same U_1 and the same U_2.

II. Empirical Evidence and Implications

According to the model, fertility is a nonlinear function of E and Y with a maximum at E*, Y* so that standard linear regression estimates of the relationship between fertility and education or income would yield positive, negative, or zero regression coefficients depending on the fraction of families falling below the threshold. This would explain the diverse results that Cochrane (1977) has found in her recent review of the literature. In the Philippines, an education threshold (about 6 years of schooling) and an income threshold (the minimum wage rate) are descernible from cross-section data; see eq. (A1) of the Appendix.

An estimate of t as a function of E and Y_h is given in (A2) and, as called for by the model, the same education threshold value appears. There is thus a negative correlation between labor force participation and fertility (as is apparent from Figure 1), since both below and above E*, the two move in opposite directions. But the underlying reasons are quite different for below-threshold and above-threshold women. The latter are freely optimizing, so to speak, while the former are in the labor market simply in order to meet minimum needs. This implies that ceteris paribus, below-threshold women who have more children should be working more. (A3) is in conformity with this proposition.

The model has an important implication in regard to the fertility effects of reduction in child mortality. In Figure 1A, a downward shift of the CM curve lowers the CB curve to the same extent. Families above the threshold thus match the mortality decline fully with a reduction in fertility. The CK curve remains the same, however, and families below the threshold simply have more surviving children. The net results thus depend on the proportions of families below and above the threshold. Some countries could therefore have lower mortality for decades but still have high fertility, because of the preponderance of below-threshold families; others could experience lower mortality and then lower fertility shortly after, because of a large above-threshold majority; and we also have an explanation of the case noted by Coale (1973, p. 60) of a fertility decline even before a decline in mortality. This could come about through a shift of the C^o curve or through changes in educational levels.

Finally, it is obvious from the model that fertility would rise with income rising from very low levels during the early phases of economic development. Tabbarah (1971) cites a number of studies indicating that the Western European experience had been one of rising birth rates before any decline took place and that a number of LDCs today have had birth rates indeed higher than earlier.

Acknowledgments

The author is indebted to Felice Llamas for programming assistance.

Appendix

The sample (size 3166) is from the Philippine 1968 National Demographic Survey, selected as single family nuclear-type households, the wife married once, and giving the required information. Let

AM = age of marriage of wife, in years
AGn = 1 if wife is in age-group n, 0 otherwise,
where n = 4 if age is 15-19 years
5 if age is 20-24 years
6 if age is 25-29 years
7 if age is 30-34 years
8 if age is 35-39 years
9 if age is 40-44 years

CEB = number of children born live
CS = number of children surviving
Em = 1 if wife has educational level m, 0 otherwise,
where m = 0 for one to four years of school
2 for five to seven years of school
3 for one to three years of high school
4 for high school graduate
5 for one to three years of college
6 for college graduate

T = 1 if wife is in the labor force, 0 otherwise
Y = family income, in thousand pesos
YH = husband's income, in thousand pesos
YHN = min (0, YH − 1.35)
YHY = max (0, YH − 1.35)
YN = min(0, Y − 1.5)
YX = max(0, Y − 1.5).

We have (t-values under regression coefficients):

A1) CEB = 11.3059 − 0.2877 AM − 5.7966 AG4 − 4.5855 AG5
(−29.22) (−17.95) (−33.41)

− 2.9000 AG6 − 1.2666 AG7 + 0.6365 AG9
(−27.71) (−12.17) (5.71)

+ 0.1813 E0 + 0.6532 E1 + 0.6853 E2 + 0.6263 E3
(0.78) (3.38) (3.34) (2.83)

+ 0.3625 E4 + 0.2565 E6 + 0.3036 YN
(1.55) (1.03) (3.30)

$$- 0.0054\ YX \quad (R^2 = 0.452)$$

$$\begin{aligned}(A2)\ T = {} & 0.3947 + 0.0850\ E0 - 0.0293\ El - 0.1184\ E2 \\ & \qquad (1.60) \qquad (-0.61) \qquad (-2.49) \\ & - 0.1149\ E3 - 0.0796\ E4 + 0.4161\ E6 - 0.1761\ YHN \\ & \quad (-2.23) \qquad (-1.45) \qquad (7.18) \qquad (-8.02) \\ & - 0.0045\ YHX \quad (\bar{R}^2 = 0.082) \\ & \quad (-1.75)\end{aligned}$$

Both equations show E2 as the education threshold. (A1) is 2SLS, using age-group and educational level variables, AM, YHN and YHX as predetermined. (A2) is OLS, as the explanatory variables are all predetermined. (A3) below is 2SLS, from the subsample (size 2331) of below-threshold families. It seems interesting that in all three equations, the coefficients of the above-threshold income variables are not significantly different from zero.

$$\begin{aligned}(A3)\ T = {} & 0.2280 + 0.1232\ E0 - 0.0767\ E2 - 0.1887\ YHN \\ & \qquad (4.04) \qquad (-3.44) \qquad (-7.57) \\ & - 0.0033\ YHX + 0.0282\ CS \quad (\bar{R}^2 = 0.043) \\ & \quad (-0.79) \qquad (3.55)\end{aligned}$$

NOTES

[1]Family income could be defined to include children's earnings without affecting the model's qualitative results; these are left out to avoid inessential complications.

[2]See Fishburn (1974), esp. 1450-53 on "pragmatic modifications and examples," for a review of some applications of the lexicographic principle to the description of choice.

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MANAGEMENT OF THE ENVIRONMENT

By I. E. Wallen

INTRODUCTION

Mr. President, distinguished guests, it is a great privilege for me to appear before you today. I bring greetings from the United States National Academy of Sciences, the Environmental Protection Agency and the Agency for International Development in Cairo, Egypt, where I am currently serving as an advisor to the General Organization for Industrialization of the Ministry of Industry and Petroleum.

I welcome the opportunity to talk to you about a problem recently recognized as important to the survival of man. We live in a time of tremendous upheaval in science. When I first entered the field of science fresh from World War II, the world I knew was a series of separate units of scientific effort. There was little need for international exchange because the problems appeared to be relatively small and isolated from one another. My research in water pollution was of little concern outside my home state of Oklahoma. My goal was to reduce fish kills in a few relatively inconsequential rivers that during transit through the state received pollution wastes from petroleum refineries. The bioessay techniques that I used had been developed about 2500 miles away in the state of Oregon and I obtained money for research from Washington, D. C., about 1500 miles in the other direction. My research results were published either in the state or in professional journals, conveniently recording the data as possibly of interest to a few other specialists.

All too rapidly my perspective changed. I found it desirable and established an Oklahoma Petroleum Refiners Waste Control Council, because my research was found to apply and to be supported by about fifteen different refineries. I was invited to the Western Petroleum Refiners Association and my work was determined to be of some value in the western half of the United States. Then I was made a member of a Pollution Committee of the National Fisheries Society and it was demonstrated that the principles and data collected for my research were equally applicable to other U.S. areas.

Shortly thereafter, by the mid 1950's, I was invited to share the national responsibility for the environment in Washington, D. C. and there was a required change in perspective in recognition that fresh waters empty into the ocean and that water either in

large or small volumes responds to reasonable similar physical and chemical forces. For some years, I had the privilege of sharing a move from studies of several remote oceans of the world to recognition that the studies concerned a single world ocean.

With acceptance of the existence of a single global ocean has come concern with other global interactions. Weather, population pressures, fossil fuel distribution, disease control, and distribution of natural resources can no longer be considered as internal problems to be treated by national governments. They have outgrown my 1948 mind.

It was my privilege to serve science in an area clearly demonstrating these changing scientific sensibilities, that is, during the development of U. S. President Eisenhower's Atoms for Peace program. As a research project officer, I scheduled monitoring and tracer work to study the atmospheric and oceanic distribution of reaction and fallout particles from early U. S., United Kingdom and USSR nuclear tests of atomic devices. Rates and processes of a total ocean atmosphere system could be studied and reported using radioactive isotopes as tracers.

Out of the potential for nuclear destruction of the world has come a strong interest in science management for world survival. Through the title and the text of my talk today, I want to express concern for management of the global environment. We share a universe with limited resources. There are many things which can be done to assure the continued availability of renewable resources. Each of us can take responsibility for a portion of the job to which, by virtue of employment, job assignment and interest, we can contribute.

The pattern of my career has permitted me to move rather freely to and fro across the boundaries of natural and polluted environments. I apologize for the many personal references in this talk, but I hope they will illustrate the points that I want to make. Each of us is substantially a product of our backgrounds and experiences.

I want also to present a mixture of various data that have become of concern to me from time to time. I will try to interpret some of the information into meaningful packages.

A SITUATION REPORT

It has been estimated that there are in the order of two million different kinds of biological species in the world. It is believed that these were becoming extinct at a rate of perhaps one each 100 years in past centuries. Now it has been estimated that one or more species becomes extinct each year (85 since 1900).

One of the factors in reduction of these species populations is overuse or exploitation of a resource. For many years a factory on the Eastern Shore of the United States harvested its local supply of red algae for preparation of gelatins. With increasing human populations in the area, pollution, and excessive harvest, the local supply of raw material disappeared. A new supply was found in *Eucheuma*, a red algae in the Philippines. Now most of that resource is exhausted and the factory must go to Indonesia for its raw material. One wonders when good management will replace the geographic searching.

Remarkable changes have been made in those species cultivated for human consumption during my lifetime. The cropping of rice was revolutionized here in the Philippines by work of the International Rice Research Institute. In my field of fisheries the North Pacific Salmon has been bred to produce an extraordinary improvement in growth and survival. Vegetables, flowers, and fruits of today hardly resemble those of the 1920's.

During the same time period we have discovered that fallout from northern hemisphere nuclear reactions can be found all too abundantly in the Antarctic. The world's supply of whales has become so limited that drastically reduced quotas were set for their harvest. Migratory bird populations may be greatly reduced by man's activities. Large mammals in Africa have mostly been destroyed outside of preserves. The removal of forests may have very adversely affected climates and resulted in vast increases in the sizes of deserts of the world.

In the United States and in the rest of the world a concentration of human populations in cities has followed industrialization. And industrialization has permitted survival of more individuals. But, solid waste from commercial and residential sources in the U. S. has been estimated at 130 million metric tons per year. About 70,000 different commercial chemicals are produced from a known inventory of more than 4 million different combinations of elements. Common industrial pollution problems of oxygen depletion, excess suspended solids, oil and grease, heavy metals, and toxic chemicals adversely affect 72 percent of United States water basins. About 2 to 2½ percent of the U. S. Gross National Product is spent on pollution control. Air pollution results in up to 37,000 excess deaths per year in the United States alone.

More than 220 federal data systems have been established in the U. S. to keep track of the state of the environment. Eight million tons of waste paper are recovered and recycled each year. Hazardous industrial wastes are generated in the U. S. at an annual rate of 20 million tons, and this does not include radioactive wastes and residues.

In Manila, as in most major cities of the world, clean air has become a luxury rather than a normal way of life. Five types of recognized pollutants are generally treated in setting air pollution standards: carbon monoxide, nitrogen dioxide, sulfur oxides, photochemical oxidants and total suspended particulates.

Carbon monoxide pollution mostly comes from incomplete combustion of fuel in automobiles, trucks, and other types of internal combustion engines. Traffic congestion is a strong contributing factor in pollution with carbon monoxide. Local traffic control strategies tend to reduce concentrations and effect of this pollutant, which directly interferes with the efficiency of breathing in humans.

Nitrogen dioxide and related nitrogen oxides tend to accumulate as a regional problem from combustion engine operation. These chemicals have been associated with increased incidence of respiratory infections, particularly in children. The chemicals contribute to the corrosion of electrical components and they have been found to damage the growth of plants. They are formed in fixed or mobile engines, and especially in high temperature combustion of any fossil fuel. Their abundance seems to relate to the quantity of fuel consumption.

Since most crude oil contains quantities of sulfur, the amount of sulfur dioxide and other oxides of sulfur varies with the type of refined produce used. High sulfur fuel on burning releases particulates and sulfur dioxide to produce the black smoke that is highly offensive to the eye and is believed to be harmful to health, causing respiratory and circulatory problems in man. In the presence of water vapor, sulfuric acid is formed and may harm plants and corrode surfaces of all but the most resistant material.

In the presence of nitrogen dioxide the imperfectly burned hydrocarbons in fuel react especially in light to form photochemical oxidants, including ozone. These chemicals produce respiratory irritation, particularly in asthmatic or other sensitive persons. Inefficient burning of fuels may be corrected through the use of better combustion chambers, however, the level of these pollutants continues to be of concern.

Total suspended particulates provide a useful measure of pollution, but do not identify the different effects of exposure to different chemicals. Lead particles have been demonstrated to be a hazard to health and, where possible, lead exposure is controlled. Arsenic, iron, mercury and other heavy metals are present in most natural fuels and in low concentrations can produce health problems. Although an attempt has heen made to develop controls for particles, it seems likely that in the long run it will be necessary to identify the specific metals and toxic chemicals for individual control.

Researchers have discovered that asbestos accumulation in humans may cause lung cancer, mesothelial cancer, gastrointestinal cancer and cancer of the larynx. Asbestos may reach the human body from air, food, beverages, drinking water, pharmaceutical and dental products, and other sources. Cadmium causes skin cancer in rats and possibly in man. Prostate and respiratory cancer in man have been described as a result of cadmium exposure. Certain pesticides and herbicides have been banned as probably causing liver cancers, and other adverse long-term effects. Certain geographic areas are found to contain anomalous and harmful quantities of potentially harmful metals, such as selenium.

Many other chemicals have been found to produce permanent damage to humans, even in minute quantities.

ENVIRONMENTAL ASSESSMENT

In attempting to determine the effects of new polluting activities of man on the environment, a program of environmental assessment has been developed. The Environmental Assessment is a detailed study of the consequences, both positive and negative of completion of a project or action affecting a particular piece of real estate on the Earth. Many types of projects may be undertaken, such as construction of a new factory or mine or their reconstruction, acquisition of property as a park or preserve, or installing a structure such as a breakwater for a harbor that is interposed into some portion of the natural environment. The environmental assessment is an evaluation of the effect of a land use choice as considered in comparison with other potential land use choices.

The purpose of the environmental assessment document is to provide decision makers with a comprehensive review of the reasonable foreseeable environmental effects of proposed actions and information concerning their reasonable alternatives so that fewer decisions will be made detrimental to future commitments of resources. Environmental assessments will describe the proposed action and the environment affected, including data, maps, and diagrams as necessary and relevant to any environmental issues that may arise. The goals of such an assessment is to achieve environmental benefits and reduce negative consequences of the action.

Population and growth characteristics of the affected area should be identified. The relationship of the proposed action to plans for land and resources use, policies and controls should be examined. It is essential that the sources of data used to identify, quantify, or evaluate any and all enviromental consequences will

be noted. The attention given to different environmental characteristics will vary according to the nature, scale and location of the proposed action. The assessment will be intended to identify such adverse environmental effects as water, air or noise pollution, undesirable land use patterns, damage to life systems, urban congestion, or threats to health. Alternatives should be considered in raw materials use, mining supply, and transport as well as in plant operation and wastes disposal. There should be a reasonable statement of materials use balance from the beginning to the end of the projected action.

Legal requirements have been prescribed for environmental assessments in the United States including those projects financed by such U. S. organizations as the Agency for International Development. Similar requirements have been adopted by the World Bank for its major financing in many countries.

The goal of all of this activity is to reduce pollution in the environment. There have been many attempts to set standards as levels of individual pollutants. Such standards have sometimes been viewed as allowable floors below which pollution could proceed at will. The principal industrial actions have generally been to set standards at as high levels as possible and then to relax within the safety of such numbers. I do not agree with this philosophy. There always should be a goal of zero pollution and no one should be permitted to relax short of that goal.

Recognizing that many so-called pollutants, such as lead, mercury, cadmium, etc., are natural components of the environment, it may often be necessary to live with less than zero pollution. That means to me only that most of us will *never* "relax" but will continue to move in the direction of zero pollution, perhaps without achieving it. Any standards set at less than zero become working numbers that must be subject to change as additional knowledge is gained from research and experience by the World's scientists, engineers, and factory managers.

Pollution, like any other changing process, requires continuous management. A factory may continue to be operated even though it is polluting the environment whenever the decision is made that the benefits in employment, products and profits sufficiently exceed the harm from such pollution. A portion of a forest will be used and trees will be replanted for future generations of users. Fossil fuels are used while research is intensified into the use of solar or other forms of energy as a potential replacement. Many managers must adjust their goals in an assessment of the environmental consequences of their actions.

BIOLOGICAL ENGINEERING

We have entered a period of complex management problems. In management of the environment we must become biological engineers. The American bison proved inefficient as compared to cattle in production of beef in the United States, and the bison was nearly exterminated before a few areas were set aside as preserves. Now we have sufficient sophistication in animal breeding to cross bison and cattle in order to develop even more efficient production of beef. It is important to note that the current breeding program was never envisioned by those who decided years ago to maintain an herd of American bison.

About ten years ago, while a member of the Pacific Science Board, I joined others in urging a breeding program for Philippines Milkfish patterned after the earlier U. S. success with Pacific Salmon. Before being sidetracked to other matters, I sent a specialist on artificial breeding of fishes to Manila to study the artificial propagation of Milkfish but his visit did not coincide with the natural ripening of fish eggs. However, with this procedure followed not long afterward in Taiwan and interest continues and will expand.

Some success has been achieved in the control of agricultural pests without the use of harmful pesticides. A so called "Bot fly" in the southern United States was eliminated as a serious pest through biological means. Millions of male flies were raised and sterilized before release over a large natural environment. They successfully mated with wild females (which mate only once) to the extent that eventually no young were produced and the pest disappeared.

Although unsuccessful thus far in showing practical results, a project in marine biological engineering has been approved for funding in Florida in the U. S. About fifteen years ago a group of us proposed that it would be practical to use marine animals to seal the breakwaters in harbors and present a self-maintaining resistant force to the oncoming ocean waves. Our original idea was to use coral in this way, but this use still depends on research not yet accomplished. However, a marine worm was found that produces a honeycomb-type reef more rapidly than coral in Florida, U. S. and an underwater reef has been designed which we expect will demonstrate the use of a biological breakwater to reduce the enormous loss of recreational seashore sand from the U. S. coast. In order to move from local to international application, work has begun to understand both the engineering structure and survival of the reef and the survival and breeding of the organism.

The same type of processes in biological engineering are required on a much larger scale. I want to mention two of them, endangered species and migratory animals. In both cases multinational solutions must be found to the problems. An International Convention on endangered species of wild flora and fauna came into force in 1975. Nations agreed to cooperate in stemming the tide of elimination of many discrete types of plants and animals. Although the primary beneficiary species of this action were the large mammals, it is apparent that there must be concerted action to preserve the genetic variability that has permitted living organisms to survive major climatic changes in ages past and to be expected on Earth in the future.

The migratory bird problem is also severe as only recently recognized. With increased human populations have come severe agricultural demands for new cropland to be taken ordinarily from wetlands, forests, or deserts, generally at great financial toll. Generally these actions serve to reduce the habitat available for migratory birds. In other cases, intensive hunting and trapping and in still others poisoning of food and pollution of the environment are the major factors in the reduction of populations.

Along with the increasing capability to breed captive species, the existing wetlands of the world are of enormous importance, not only for the marsh and water birds which breed locally, but for the untold millions of migratory birds which cross from southern wintering grounds to northern nesting grounds. There is an urgent need to establish a list of marshes, swamps and other wetlands and to evaluate their use. Many of the remaining wetlands are vital to the continued survival of large migratory populations.

As a problem of similar nature there have been actions to preserve whales and to control the harvest of migratory fishes such as the tuna and the salmon, both of which travel great distances; one tuna species is believed to circumnavigate much of the North Pacific Ocean during its lifetime.

Pollution is being attacked on the international front as well. An example of the most effective effort may be taken from an action plan adopted by the Mediterranean countries for that Sea. A central part of the action plan is a coordinated program for monitoring and research, including seven pilot projects:

- baseline studies and monitoring of oil and petroleum hydrocarbons in cooperation with UNEP
- monitoring and baseline studies of heavy metals, such as mercury and cadmium, in marine organisms
- studies and monitoring of chlorinated hydrocarbons, including DDT and PCB's in the fishes and other marine forms

- evaluations of the effects of pollutants on marine species and populations
- transport of pollutants along the coastal areas
- reduction of coastal pollution
- actions to combat oil spills.

A BASIS FOR ACTION

Management of the Global Environment has been given great emphasis since the 1972 Stockholm Conference and the establishment of the United Nations Environmental Program. There are notable actions in the sharing of information and practices among nations adhering to international bodies. Rather than dwell on these accomplishments, I want to embrace them, but consider what can be done on a much smaller scale; a project by project basis. I want to have you consider possible answers to the question, what can I do as an individual interested in preservation of the environment?

Much pollution results from carelessness on the part of the individual. A few people living in a large open land area can discard occasional items of trash, that is, solid wastes, without a problem. When many people live in close proximity, what was normal for an open area easily becomes a severe pollution problem. Solutions are often sought through trash removal industries paid for in the common good. These "industries of civilization" are necessary when individuals lack the space within accessible distance to remove a no longer useful item. Recycling becomes more difficult under crowded conditions. To resolve this problem, each individual must deliver trash to collection stations. In the absence of at least some individual action, there is no solution to solid wastes pollution.

Generally the solid wastes problem requires attention from many aspects. Industrial employees can assure the use of minimum packaging for a product, government employees must locate appropriate trash disposal sites and provide incentives. Housewives, children and all consumers must deliver wastes to collecting stations.

Industries must be innovative in pollution control. A break with the tradition of burning dirty coal can come with burning cleaner oil or still cleaner natural gas. Care can be exercised during the manufacture of automobiles to adjust the fuel mixture for minimum pollution, which often occurs with maximum efficiency of performance of the engine. Extra steps in removal of chemicals from wastes often are profitable based on the recovery of additional useful materials.

Until recently, brick manufacturers in Iran burned a highly polluting mixture of heavy fuel oil, coal dust, sawdust and dried animal manure. A change to natural gas as fuel not only eliminated serious pollution, but resulted in a much better brick and multiplied profitability.

Also in Iran, the local Payhan automobile manufacturer found that changing the air/fuel mixture in the combustion chamber to that appropriate for Tehran's altitude could result in a 70 percent reduction in loss of carbon monoxide and a saving of 12 to 18 percent in fuel consumption.

QUALITY OF DATA

Many management problems arise because of the lack of accuracy of data. Samples are taken at the wrong place, at the wrong time, by the use of an inadequate technique, or even for the wrong reasons. The samples may be incorrectly preserved or improperly stored. They may be examined only superficially, or with a technology that is inadequate for the purpose.

New emphasis must be given to quality control. Generally quality control means that the results of the analyses may be repeated and found to be approximately the same by the same investigator at different times or by different experienced investigators. In order to assure that data are of good quality international efforts have frequently been developed to compare results and to develop comparable procedures and standards of measurement.

Polluting materials often are very difficult to analyze and special new techniques and equipment must be produced. Because of these problems the exchange of information on methods and techniques is not only desirable, but necessary. Any manager of pollution control authorities must first resolve the issues of accuracy and reliability of data, before important decisions can be made in control of factory pollution.

HOUSEKEEPING ASPECTS

Effectively, pollution control can often be equated with good housekeeping. The managers of plants can use existing employees on cleanup assignments or provide on-site park and recreation areas, perhaps with benches and tables for use by the employees. The collection of oil and grease from leaks and process losses can often be made profitable with resale or recycling for use in soap or in alternative industries. Sedimented waste materials can at least

be used to fill low places for expansion of factory sites or in improving the natural beauty. Composted sludges often can be recycled to agricultural use. Trucks between assignments can carry trash and unusable materials to non-polluting disposal sites.

Through incentives, awards and bonus programs, managers can encourage their employees to participate in corrective actions to reduce pollution. Efficiency studies often result in important suggestions in removing pollution, sometimes at a profit.

Governmental actions may be required to assist with purchase of trash trucks, to approve a charter for a trash hauling firm, or to establish a dumping site with fence and guard at an appropriate location, perhaps for subsequent leveling and use as a filled industrial "park." Governments may need to provide training for managers or perhaps only need to supply trash vehicles.

Industry usually benefits from a program to improve housekeeping by increased labor productivity, reduction or recycling of wastes, replacement of outdated equipment of simply by enjoying an aesthetically improved environment.

REGULATION

Regulation of industry should be a last choice alternative in pollution control. Many approaches should be tried first, including private certification of products, voluntary standards, economic incentives, revised production practices, controlled trading, performance bonds, innovative technology, and direct consumer action such as petitions, product boycotts, retraining, advertising and operational and maintenance strategies.

This is particularly true because of the extraordinary problems of setting standards. The proper management of the environment must include maximum effective use for the survival of man and the earth together. Geographic areas can be set aside for industrial use while others are preserved. In vast open areas a compromised pollution standard can be greatly different from that in areas heavily populated — or rich in agricultural production.

Alternatives in environmental pollution control are generally the alternatives in biological engineering. The use of pesticides on agricultural crops must be balanced with possible destruction of wildlife and harm to human health. The harvesting of timber must be weighed against flooding in downstream areas or desertification. Oil spills must be measured against energy needs, fish production, costs of more adequate ship navigation, recreational losses, property values, and increased costs of longer shipping routes.

One ton of crude oil can cover up to 1200 hectares of sea surface. Tankers discharge a quantity of oil equal to about one percent of the cargo in washing their tanks. About one-sixth of the oil spilled into sea water will remain in solution after coastal deposition, oxidation or bacterial action (in the Mediterranean). Emergency procedures to reduce the impact of oil spills belong in the priorities of all countries.

Integrated pest management is a new term that applies to the need to reduce the overuse of pesticides. In Egypt the use of pesticides became so extreme that as many as 40 applications of pesticides were made to one crop of cotton. This type of management is an attempt to use the life cycle of a pest in reduction of its numbers. Procedures of land use, physiological selection, behavior related treatments, technological control, and release of parasites and diseases supplement the application of pesticides and herbicides.

Timber harvest in developing countries may create such management challenges as flooding, sedimentation of lakes, crop failures, the spread of diseases and declining soil fertility. The setting aside of land preserved from such exploitation should be a goal of all nations.

TRAINING

Because of the enormous variability in environmental conditions, there must always be continuous training and the exchange of ideas. The most difficult decision for management will always be to determine which problems require treatment on a priority basis. In most cases the consideration of priorities means that management will devote heavy increments of time to planning. Training or experience in planning is vital to success of environmental improvement programs.

Training may be given to potential or actual environmental managers in either engineering or in scientific fields. The manager must somehow become adept in problem recognition as well as in problem solving. A "perfect" engineering solution in production could, for example, be developed through the use of a certain chemical with properties available as a catalyst or as a part of a production process. The selected chemical may be at the same time "perfect" for the factory production need and a highly toxic menace to the health of workers. Control of pollution may become an innovative technique for non-hazardous use of the chemical, perhaps through careful handling and containment. Training should include the acquisition of skills that permit ideas

in one area to be recognized as useful in totally different relationships.

Training must be continuous and broad across many related and unrelated fields in order that such skills will appear. Such training must continue throughout the lifetime of the pollution manager, on and off the job, in and out of his country of origin.

ORGANIZING FOR THE JOB

I believe that simple solutions still exist to most problems of environmental management. I believe that there should be a small organizational structure in each nation whose responsibility extends entirely across the environmental fields, both natural and polluted. With access and full support of the Prime Minister of a nation, the chief-bureaucrat-in-charge of the environment should have equal responsibility for natural fish, wildlife and parks and for pollution control through water pollution, air pollution and environmental assessment units.

The primary goals of the head of such an organization would be to reduce pollution to its minimum practical level in continued country development and to maintain the renewable resources of native fisheries and wildfire through reserves, preserves and parks where citizens can enjoy nature. The tools of such a trade may only be garbage trucks, sewage and industrial waste treatment plants, recycled products and wastes and the powers of persuasion appropriately backed by the Prime Minister and Cabinet Ministers.

And, finally, the successful manager must be prepared to limit his field of experience and activity to focus on certain problems of great value to the country. He can easily spread his resources over an impossible area. He should accept a limited goal of accomplishment such that he can assure success of those activities underway. He must be prepared to sacrifice some important secondary objectives in order to clearly accomplish some improvements in the quality of life. He must not shift from crisis to crisis and thus never quite finish the important priorities.

With the cooperation of its citizens, any such nation will become a proud example to the world with clean air, clean waterways and a pleasant, healthful life.

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ON SPECIFICITY OF HELMINTHS

By Bogdan Czaplinski

SUMMARY

It is impossible to present in a short paper all ideas concerning specificity of helminths. For this reason, only some results of studies carried out in the Department of General Biology and Parasitology of the Medical Academy in Warsaw will be discussed.

As criteria for the determination of host specificity the following characteristics of the parasites have been studied.

1. *Extensity and intensity of natural invasion.* The majority of Hymenolepididae species parasitizing Anseriformes show narrower specificity than it was expected according to the rule of Fuhrmann (i.e., a specificity towards the order of final hosts.). In many papers and handbooks, an opinion can be found that Hymenolopididae have sometimes wide specificity not only towards the order of final host. But how can we distinguish the specific and non-specific host after having found a parasite in it especially, if the occurence of the parasite in the host is rather rare? It is proposed that a host can only be regarded as specific for a particular species of parasite if its life cycle can be completed and full development of successive generations can be assured. Consequently, we must complete our knowledge by:

2. *Experimental studies on:*

a) regularity of growth and development under comparable conditions can serve as specificity criterion on *A. anseris* but not in *D. stefariski.*

b) degree of adaptation of the parasites to hosts of different species, strains, age and sex.

c) time of development and longevity of the parasite.

3. *Topospecificity and morphological variability under natural and experimental conditions*

a) topospecificity may be helpful in the determination of the parasite species from the ecological point of view.

b) morphological variability of the most stable feature of Hymenolepididae (size and shape of the stellar hooks) and little known feature-the envelope of the oncosphera have been studied.

Conclusion

Not only the natural occurence of the parasite is important in the determination of its specificity, but experimental studies on its growth and development, topospecificity and morphological variability in hosts of different species, strains, age and sex are very useful too.

ABOUT THE AUTHORS

RAYMUNDO A. FAVILA, Academician. Ph.D. in Mathematics. From 1976 to the present, he is Professor Emeritus of Mathematics at the University of the Philippines. A consultant in Mathematics at the Centro Escolar University and at the Pamantasan ng Maynila, he is also a professorial lecturer and resource speaker in various universities, seminars and conferences. This is an indication of the specialized training he had had in Mathematics Education as well as in the use of topological method in geometry. Started out as Teaching Assistant in Mathematics at the University of California in 1937-1939, he was later to join that year at the UP Dept. of Mathematics as Instructor where he was promoted from the rungs to become Chairman in 1954 up to 1971. But this is in no way suggest a climax of of his career because in 1967 he was named Director and Dean at UP Clark Air Base where he served up to 1974. Dr. Favila has co-authored about five books in Mathematics.

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