Demographic Consequences of Incest Tabus: A Microsimulation Analysis

E. A. Hammel, C. K. McDaniel, K. W. Wachter

The cultural regulation of sexuality through rules about incest and exogamy has long been regarded as one of the most important achievements of humankind, distinguishing us unequivocally from related species (*1*). Explanations of the causes of such rules abound. Aberle *et al.* (*2*) identify six general types of explanation, including four in which incest tabus are said to confer advantages on the societies employing them:

Summary. Theories of incest tabus usually stress the psychosocial advantages of marriage regulation. But marriage regulation may produce delays in mating and thus loss of fertility to a population. Computer microsimulation experiments measure the amount of fertility that must be achieved outside a normatively specified marriage system in order to keep population constant. This amount varies directly with scope of tabu and inversely with population size. For populations of hundreds it is negligible, but for populations of dozens it can be very great. In the latter, flexibility of marital arrangements may permit maintenance of fertility without repeated revision of rules of marriage.

1) Incest tabus prevent genetically deleterious inbreeding with close relatives.

2) The socialization of children depends on distinguishing familial and nonfamilial roles. Incest tabus separate these roles.

3) Sexual competition within small groups is disruptive. Incest tabus facilitate internal group order.

4) Incest tabus force outmarriage and hence the political alliances between groups that are the basis for larger social units.

Incest tabus may, however, confer a disadvantage more basic and obvious than any of these postulated advantages, a demographic cost incurred through restrictions on available mates. Individuals barred from certain choices of mates may have to wait longer to marry, and thus the group to which they belong may lose some of its potential fertility. Analysis of this demographic cost is easier than analysis of the advantage theories. First, it is tied directly to reproductive success, so that it is not necessary to forge elaborate logical chains to fit its effects into the framework of ordinary evolutionary argument. Second, it is subject to sharp enough definition to be modeled and measured. We attempt this process here.

The authors, all at the University of California, Berkeley 94720, are, respectively, professor of anthropology and demography, research assistant in anthropology, and associate professor of demography and statistics.

The larger we measure the demographic cost to be, the greater the burden on advantage theories such as those listed. The broader the class of populations where the cost is measured to be high, the more our attention ought to shift from advantages toward possible compensatory behavior accompanying tabus.

The effect of marriage regulation on chances of finding mates has been addressed by Hammel (*3*) in an analysis of marriage section systems, by Hammel and Hutchinson (*4*) through computer microsimulation, and by Morgan (*5*) and MacCluer and Dyke (*6*) using similar simulation techniques. These simulation studies all examine the effect of incest regulations on population change as a consequence of tabu. With the exception of Morgan's analysis, all indicate that population viability is adversely affected by incest tabus, and that this effect is stronger the smaller the population and the more severe the tabu (*7*).

In a fundamental way, however, these simulation studies all ask the wrong question. Population viability as measured in them is a poor indicator of the effect of incest prohibitions for at least two reasons. First, people faced with a scarcity of spouses created by some cultural rule may create another rule or find some other means of offsetting the effects of the first rule. Second, there is the more direct analytical problem that these studies all involve a positive feedback between (i) the effect of a tabu in diminishing population and (ii) the enhancement of the tabu's effect in small populations. This confounds the effects of the critical variables, severity of tabu and population size.

A Refined Simulation Approach

To avoid these difficulties we developed a different simulation experiment design. Rather than measure the effect of a tabu by allowing it to alter and thus confound itself with population size, we simulate nearly stationary populations and measure the fertility these populations would have to realize outside of normal marriage in order to remain stationary. The required levels of alternative fertility (AF) can be determined in a straightforward manner: The same input fertility rates are used for married and for unmarried women. The size and growth of a population are thus unaffected by the marital status of its members. The proportion of births that consists of births to unmarried women is the alternative fertility proportion (AFP), that is, the proportion of fertility that must be realized outside of normal marriage to keep the population stationary. Marriage rates are set high, so that in the absence of cultural or demographic impediments to marriage the AFP will approach zero. As the difficulties of finding a spouse increase, the chance that a woman will have a child before or between marriages increases, and so does the AFP.

Care must be taken in interpreting this AFP measure. It might be interpreted as illegitimate fertility, but it need not be only that. It could be alternative fertility achieved through any kind of marital or sexual arrangement not explicitly permitted in the modeling. To allow an initially uncomplicated evaluation of the problem, we take endogamous monogamy as "normal marriage" in our simulations. Thus any possible means of realizing fertility outside of endogamous monogamy—exogamy, polygamy, promiscuity—would be a potential mechanism for realizing the AF levels required. We consider the AFP only as an indication of the pressure for social change, if such

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occurs, or for demographic change if no social change occurs. We suggest that the pattern of our conclusions holds for any base level of marital arrangements taken as normal marriage.

Using this measure, we ask three questions about the sociodemographic impacts of incest tabus: First, does imposition of a tabu make a large difference in AFP? Second, how does AFP depend on population size? Third, do different kinds of tabus have different kinds of effects on AFP, or are the effects of different tabus sufficiently regular to permit generalization?

Assumptions in the Simulation

The computer simulation for this exploration employs recent revisions of the SOCSIM microsimulation programs (*8*). Simulations were conducted at each of the following levels of incest tabu: 0, no prohibition; 1, prohibition within the nuclear family; 2, prohibition on first cousins and any nearer kin; 3, prohibition on second cousins and any nearer kin (*9*). At each level of prohibition, 200 runs were done with starting population of 50, 100 with starting population of 100, and 100 with starting population of 300. Thus, 1600 runs in all were initiated; 1503 survived the 200-year simulation period and are included in our analysis.

Fertility and mortality rates were high, to approximate the demographic behavior of the populations in which sexual regulation might be thought to have emerged originally or to have been important. Mortality rates were taken from Weiss (*10*, table MT22.5-50). Weiss's table is based on a standard infant and juvenile mortality curve scaled to give a survivorship to age 15 of 50 percent of all live births and on a mortality schedule for ages 15 to 55 giving expectation of life at age 15 of 22.5 more years. Fertility schedules were based on Henry's estimates of natural fertility scaled to achieve an annual population increase of 5 per 10,000 (*11*). The minimum interbirth interval was set at 24 months provided that the last-born child did not die before 2 years of age. Marriage rates for widowed persons were identical to those for never-married persons. A wide range of age differences in married pairs was permitted, the central tendency being husbands 5 years older than their wives. These loose constraints on age differences allowed high rates of early marriage and remarriage (*12*). No divorce was permitted. All these factors make for a conservative estimate of the AFP, although we expect some degree of AFP even without an incest tabu in some demographic circumstances because of random fluctuations in mate availability.

Our rates are meant to model the demographic situation we think many anthropologists have in mind when considering the origin of marriage regulations or in analyzing societies where these have marked effects. No choice of rates can please all potential theoretical interests. Since we possess little precise information on the demography of such groups, any selection of rates can be at best a modestly educated guess.

Each individual simulation within a size category (50, 100, 300) and prohibition level (0, 1, 2, 3) began with the same starting population, one having an age structure appropriate to the anticipated rate of growth. Each run proceeded 100 years in order to build up genealogical depth sufficient for reckoning prohibited relationships. At year 101, a count was begun of births to single and to married women. This count was kept until year 200, when the simulation stopped. Runs that did not survive until year 200 were not included in the results. The children of unmarried females had fathers assigned at random so that each child would have a full set of ancestors through whom kinship could be traced for observance of incest tabus. (If this had not been done, the effect of the bilateral incest tabus would have been halved for children of unmarried women, a negative feedback that could have masked the consequences of tabus.)

The demographic outcomes of the simulations are summarized in Table 1. They are very close to the expectations of the input rates and our notions regarding populations in which sexual regulation might have emerged or have been important.

The Impact of Incest Tabus

We state first our three main substantive conclusions and then present the evidence and arguments which lead us to them.

First, in some cases the impact of incest tabus is enormous, involving as much as two-thirds of all the fertility of a population. This finding underwrites the importance of considering "demographic cost" in any theory of incest.

Second, the pressure exerted by tabus tapers quickly as population size increases, more quickly than the authors who have examined these questions by look-

Table 1. Realized demographic rates.

Incest level	Population size at start	Female life expectation (years) at age		Net reproduction rate	Total fertility rate	Mean age of mothers at birth of:		Brides' mean age at first marriage	Interbirth interval	Annual population growth rate	
		0	15			All children	First child			Mean	S.D.
0	50	20.1	22.4	1.03	7.12	28.3	21.2	18.4	2.83	−.00038	.00045
0	50	20.0	22.1	1.01	7.02	28.2	21.1	18.3	2.18	.00002	.00034
0	100	20.1	22.3	1.00	6.99	28.3	21.0	18.1	2.84	−.00043	.00029
0	300	20.1	22.2	1.01	7.00	28.3	21.0	17.8	2.81	−.00002	.00018
1	50	20.2	22.4	1.01	7.01	28.2	21.1	18.5	2.84	−.00090	.00047
1	50	20.1	22.3	1.01	7.01	28.2	21.1	18.4	2.85	.00022	.00036
1	100	20.1	22.3	1.02	7.07	28.3	21.0	18.0	2.83	.00022	.00026
1	300	20.1	22.2	1.01	7.04	28.3	21.0	17.8	2.81	.00022	.00015
2	50	19.9	22.1	1.00	7.06	28.2	21.2	18.5	2.84	−.00110	.00049
2	50	20.1	22.2	1.01	7.02	28.3	21.2	18.5	2.85	.00055	.00040
2	100	20.0	22.2	1.01	7.00	28.3	21.0	18.1	2.83	−.00057	.00029
2	300	20.1	22.3	1.01	7.04	28.3	21.0	17.8	2.82	.00002	.00018
3	50	20.0	22.3	0.99	6.85	28.3	21.4	19.6	2.88	−.00177	.00429
3	50	20.1	22.3	0.99	6.92	28.3	21.3	19.6	2.88	−.00061	.00035
3	100	20.1	22.4	1.00	7.00	28.3	21.1	18.3	2.83	−.00026	.00028
3	300	20.1	22.2	1.01	7.06	28.3	21.0	17.8	2.18	.00026	.00015

ing at population viability have suggested. For the most stringent tabu (level 3), the effect is strong only in populations below about 250; for the least stringent (level 1), only below about 50. The dependence of the AFP on population size appears to be extremely regular and can be modeled by a simple formula with an intuitive interpretation.

Third, the level of AF is regularly dependent on the level of incest tabu. Changes in the level of tabu alter only the slope of the relationship between AF and population size, not the form of that relationship. On these grounds we believe our findings to be generalizable.

In support of these conclusions we present first four plots of the raw data (Fig. 1). In each of these the weighted mean of the population sizes from five censuses (starting at year 100) at 20-year intervals during the 100-year observation period is plotted (X-axis) against AFP (Y-axis). Each plot gives the data for a different level of incest prohibition.

For populations below 200, the fraction of cases with AFP greater than one-third rises from .01 for no tabu to .03 for tabu level 1, to .05 for tabu level 2, and to .39 for tabu level 3. These figures suggest that in populations of small size, either habitually so or temporarily small because of random fluctuations, a strong incest tabu could be a major variable in the pattern of fertility.

The tapering of the AFP with population size is obvious from the absence of points in the upper right of all these plots. This relationship is summarized graphically in the curves in Fig. 1. These curves represent our best model of the relationship between AFP and population size for each level of tabu. In this model the AFP equals the sum of the proportion that a certain fixed number of people (a number that depends on the tabu level but is fixed independently of population size) bears to the whole population, plus the proportion of exposure to childbearing that women undergo before or between marriages because of random delays of marriage, even in an unconstrained marriage market. The formulaic representation of this relationship is $Y = B/X + A$, where Y is AFP, B is the fixed number mentioned above, A is the AFP for an unconstrained marriage market, and X is the weighted mean population size. The term B/X is then the contribution of the incest constraints to the AFP. We may arbitrarily take the size X at which B/X equals 5 percent as our indicator of populations where the fertility impact becomes important. (The size is halved if we take 10 percent, quartered for 20 percent.) These sizes for 5 percent contribution of B/X to AFP are 254 people for tabu level 3, 128 for level 2, and 56 for level 1, compared to a base of 38 for no tabu at all. Thus, a population must be smaller than about 250 persons for a strong tabu to depress normal fertility about 5 percent and smaller than about 50 for a mild tabu to make that much difference. Another interpretation of these population values is the sizes at which populations 1 percent smaller expect AFP's 0.05 percent higher with the same level of tabu. If population size drops 1 percent from this point, at any level of tabu, AFP must be about 0.05

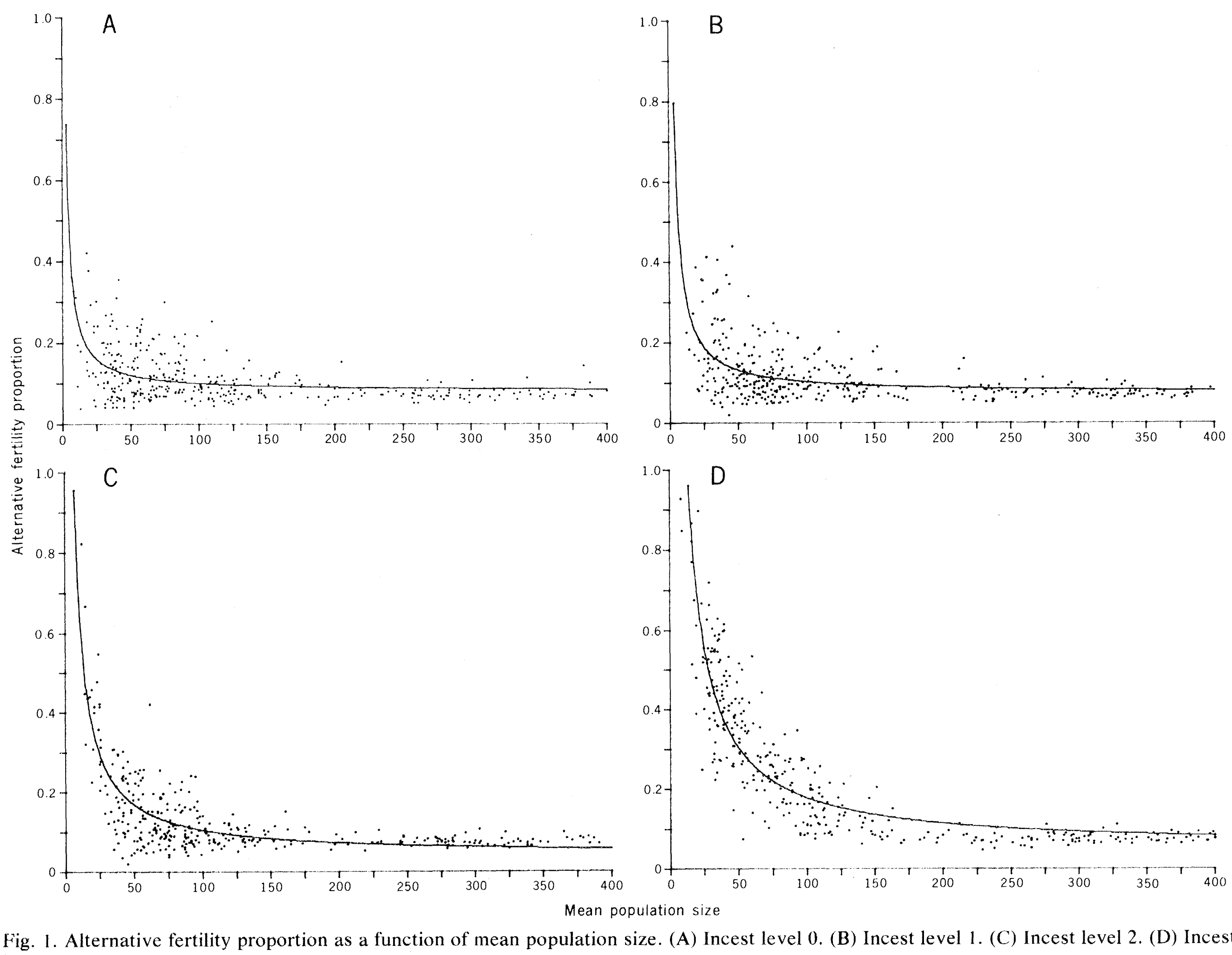

Fig. 1. Alternative fertility proportion as a function of mean population size. (A) Incest level 0. (B) Incest level 1. (C) Incest level 2. (D) Incest level 3.

percent higher to maintain population size.

That the same form of relationship between AFP and size reappears for the different tabus argues for the generalizability of our claims; this argument would be still stronger if we could elucidate a mechanism which accounts for our formula $Y = B/X + A$ and for the values of B and A that we derive empirically from our data below. The motivating idea for the form $Y = B/X + A$ is that the AFP exceeds a value A for unconstrained marriage, by the ratio between a fixed number of kin excluded by the tabu, B, and the whole population, X. A is a base level of AF and B a function of the number of kin excluded at a particular tabu level.

This interpretation of A appears viable. For a population of infinite size B/X must approach zero, so that A must constitute the minimum natural level of AFP for a given study design. We can predict a value for A from the input rates for the simulation, using a Markov model of transitions between single, married, widowed, remarried, and dead states for women. Multiplying the resulting numbers of married and unmarried women by age-specific birth rates, summing, and taking the ratio of births to unmarrieds to all births gives $A = .070$, which agrees well with the minima approached by our curves in Fig. 1.

The interpretation of B as a number of kin excluded from marriage is much less straightforward. At least four difficulties arise:

First, the number of people excluded is a complex sum. Certainly excluded are the fraction of the population of the same sex as the would-be-wed, the fraction not of marriageable age, and the fraction already married, all added to the number of persons excluded by the tabu, some of whom may be ineligible for reasons already given. Only the last of these components of B, the number of persons excluded by the tabu, seems to be fixed rather than dependent on population size.

Second, the ratio between births to married and to unmarried women occurs in a way that is not simply related to the number of years spent in the married and unmarried states. The probabilities of giving birth change with age. A woman who fails to find a husband is at a different risk of AF depending on the age at which her marriage search fails. Widows, for example, contribute quite differently to AFP than do nubile girls. A nonlinearity is introduced into the model.

Third, the loss of years lived in the married state incurred when certain marriages are prohibited is not simply related to the number of people excluded as partners. It is combinatorially possible to have every adult in a population married, even though each person was prohibited from marrying anyone in the population other than the person who became the spouse. Achievement of input marriage levels in a simulation or of desired marriage levels in the real world is dependent on the order in which matches are made.

Fourth and finally, the number of people excluded as partners is not simply related to the one thing that is reasonably easy to count, the number of kinship positions excluded by a tabu.

Having listed these problems, we note nonetheless that the values of B which we estimate from our data do in fact roughly parallel the numbers of kinship positions excluded by each tabu. If this pattern is not fortuitous, reckoning excluded persons from excluded kin positions in more refined ways might allow analytic generation of curves of the same

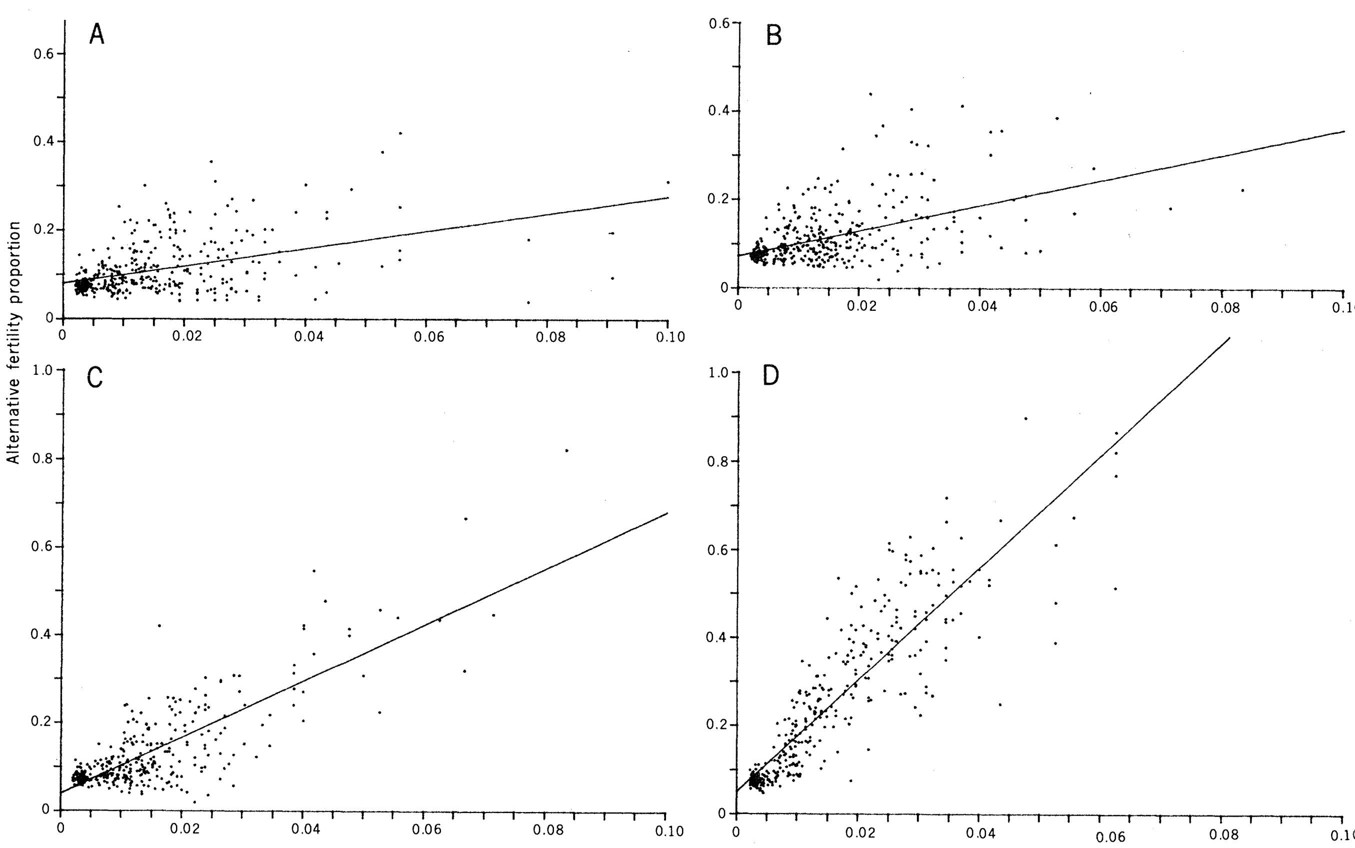

Fig. 2. Alternative fertility proportion as a function of the reciprocal of mean population size. (A) Incest level 0. (B) Incest level 1. (C) Incest level 2. (D) Incest level 3.

Table 2. Results of regression of AFP (= Y) on 1/(population size) (= $1/X$).

Incest level	N	Mean ($1/X$)	Mean (Y)	S.D. ($1/X$)	S.D. (Y)	A	B	r	r^2	t	d.f.
0	380	.0149	.1097	.0138	.0602	.0804	1.973	.45	.21	9.88	378
1	380	.0140	.1137	.0117	.0665	.0731	2.892	.51	.26	11.51	378
2	368	.0138	.1286	.0121	.0962	.0402	6.408	.80	.65	25.82	366
3	377	.0149	.2407	.0122	.1815	.0508	12.727	.88	.78	35.69	375

form appropriate for other tabus, and full interpretation of B might yet be attained.

Without a full interpretation of B, the derivation of our model and of values for A and B remains empirical. The central claim of our model is that the AFP is a linear function of the reciprocal of population size. This statement suggests plotting AFP on the Y-axis not against X but againt $1/X$ on the X-axis. Such plots for the four levels of tabu are in Fig. 2. The soundness of this family of models is reflected in the similarity among these four plots, which differ from one another in slope but not to any extent in shape. There is some flattening at the right and left of each plot, but on the whole the pattern is linear, with variability about the central line increasing toward the right, as we expect, since population size decreases in that direction and variance can be expected to be greater.

Each straight line in Fig. 2 corresponds to a hyperbola on the Fig. 1 plots. Since the transformation to $1/X$ from X has linearized our data, we may use linear regression to estimate A and B from the points in the Fig. 2 plots. It might seem appropriate to use weighted least squares rather than ordinary least squares, because the variance increases as $1/X$ increases. However, the major interest of the model occurs for lower population sizes, toward the right of the plots in Fig. 2, while for large population sizes on the left the tabus become negligible. Therefore we do not downweight the points on the right in spite of the larger variance and we use ordinary least squares to obtain estimates of A and B. The estimated values appear in Table 2.

The estimates of A, the portion of fertility always outside normal marriage, are close to one another for all four incest conditions (.080, .073, .040, and .051). Their variation is expectedly irregular and spans the .070 level predicted by the Markov model. This level also matches the mean AFP of about .070 among populations larger than 300 under all four levels of tabu.

The effect of increasing the level of tabu is reflected in the different regression coefficients (B). The estimates of B for the different tabu levels lie in regular progression (1.97, 2.89, 6.41, 12.73), showing that the enhancement of AFP grows systematically more marked the stronger the tabu. The fit of the model, as measured by the correlation coefficient r in Table 2, also improves between tabus 0 or 1 and tabus 2 or 3. All parameters are estimated with some error, of course; 95 percent confidence bands for B run 1.5 to 2.4, 2.3 to 3.4, 5.6 to 7.2, and 11.3 to 14.2 for the four tabu levels.

Because of its interaction with population size, the chief effect of the larger B values for stronger tabus is an earlier steepening of the curve connecting AFP with size as we move toward smaller sizes. Figure 3 illustrates this effect, showing the four model curves for the four tabus on a single plot. The model AFP curves are graphed against the population size itself, as in Fig. 1, rather than against the reciprocal. Here level 1 differs little from level 0, the implication being that prohibitions within the nuclear family promote alternative fertility little more than do constraints of age and sex on marriage with no tabu. That level 2 crosses below levels 0 and 1 when mean population is above 100 is probably not meaningful, since Fig. 1C shows our curve for level 2 undershooting the data points at high populations. The AFP tapers quickly at very low populations for levels 0 and 1, but more slowly for the first-cousin prohibitions at level 2 and considerably more slowly for the second-cousin prohibitions at level 3. Judged by eye, the 5 percent thresholds quoted above (where the term B/X contributes .05 to AFP) are fairly far into the flat region; the 15 percent thresholds of 13, 19, 43, and 85 for the four levels, however, indicate regions where the excess in AFP over base levels is undeniably pronounced.

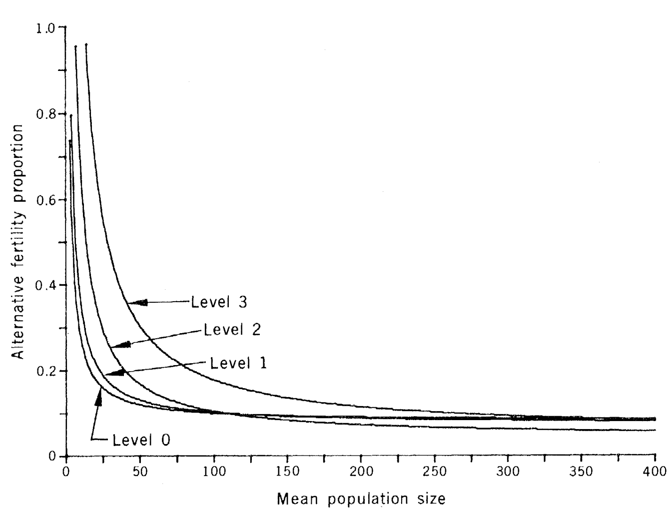

Fig. 3. Alternative fertility proportion as a function of mean population size: model curves for all incest levels.

Discussion

Our findings about the demographic costs of incest prohibitions are the consequences, worked out by the computer in meticulous detail, of theoretical specifications of population structure and dynamics and their interaction with social rules for mating and genealogical position. The modeling effort goes beyond mere assertion that costs are large or small and shows that the broad conclusions to be drawn from our analysis are entirely different for populations of different size.

We can distinguish two theaters where scripts dealing with incest might be enacted. One theater specializes in casts of hundreds, the other in casts of dozens. Each cast, of course, stands for an endogamous band with demographic and social characteristics like those in our specifications.

For the theater of the hundreds, we have shown that the demographic costs of incest prohibitions are largely negligible. Only the strong prohibition against all second cousins and nearer relatives has an impact amounting to as much as 5 percent alternative fertility (in the sense we have defined). This finding contrasts with those of earlier studies, in which tabus were found to matter for populations in the low hundreds. In the light of our measurements of alternative fertility in place of viability, we would ascribe the apparent demographic impact of tabus in these earlier analyses to the positive feedback between the effects of tabus and the effects of decreasing size built into them. In this theater our analysis would illustrate a general claim that the constraints which demography imposes on social structure are loose constraints. For populations of several hundreds, proposed advantages of incest tabus would not have to be set off against demographic difficulties from scarcity of mates, nor would systems facilitating alternative fertility be a logical concomitant of the tabus themselves.

For the theater of the dozens all our findings are reversed; at all levels of incest prohibition alternative fertility becomes important. The smallest of the 5 percent thresholds, at level 0, is 38 people. For prohibition of second cousins and closer relatives, alternative fertility reaches 18 percent for 100 people and 58 percent for two dozen people. In both theaters it is true that prohibition within the nuclear family can scarcely be distinguished from no prohibitions at all, but the impact of the stronger tabus for small populations is clear. In the theater of the dozens, advantage theories of incest have major demographic costs to overbalance or explain away, and the presence of a tabu is a prima facie case for the occurrence and importance of alternative fertility outside endogamous, monogamous marriage.

So much depends on population size that we should inquire closely what it means. In societies in which incest tabus may have emerged, localized kin groups, within which such tabus would have been most effective, might have been as small as 25 to 50 persons and thus much affected by the consequences of tabus as we have modeled them. On the other hand, it seems unlikely that such local groups would have been isolated; more likely they were members of a larger linguistic or cultural grouping, or just comembers of a set of groups in an ecological zone. How large might such an including set of groups be? Perhaps 500 persons? Perhaps 1000? Would the effect of these larger numbers, by our own arguments, reduce the consequences of imposition of sexual regulation to nothing? The question is not simple. If a congeries of local groups consisted, say, of 25 units each averaging 50 persons, thus totaling 1250, it is most unlikely that every marriageable person in every group was immediately or even periodically accessible to every other. Population density in the kinds of societies we are talking about would have been too low to permit close and continuous social contact and perhaps even too low to permit annual contact between all groups. Of course, the kinship network would be territorially dense, and imposition of tabus would eliminate more persons in neighboring than in distant groups. Looking further afield obviously solves the problem. But looking further afield means making social contacts, enlarging the socially effective population size, and this takes time—time during which fertility may be lost. We cannot provide a hypothetical cost-benefit analysis that closely models the structure of such societies because we lack the information on which to base one. But our model does give information on the consequences of socially effective population size. It is up to empirical anthropologists to determine what the socially effective populations sizes in any particular case may be (*13*).

Nevertheless we may speculate that in the history of mankind many populations must have been socially sized below 200. Pressures for expansion of mating possibilities would have been felt, and these would have been more severe at each ascending level of any existing incest tabu. Even at minimal levels of tabu continued virtue might have been its own punishment, moral inflexibility in the long run and on the average leading to extinction.

But cultures do change, and our analysis suggests that purely demographic pressures in very small populations, or these same demographic pressures combined with cultural regulation of sexuality in slightly larger populations, could in fact confer selective advantage to cultural innovation and variety. We may speculate that the array of marital customs that so titillated Victorian anthropologists was a survival mechanism in very small societies, where flexibility of response in the face of random demographic fluctuation, without major institutional overhaul, may have been important in the maintenance of social continuity. The flexibility of marital arrangements, allowing replacement of the fertility loss incurred through the prohibition of certain matings, would have permitted small populations to enjoy institutional stability and whatever advantages might accrue from incest tabus, without having to pay demographic costs that would have been fatal in the long run.

References and Notes

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3. E. A. Hammel, *Oceania* **31**, 14 (1960).
4. _____ and D. Hutchinson, in *Computer Simulation in Human Population Studies*, B. Dyke and J. W. MacCluer, Eds. (Academic Press, New York, 1973), p. 1.
5. K. Morgan, in *ibid.*, p. 15.
6. J. W. MacCluer and B. Dyke, *Soc. Biol.* **23**, 1 (1976).
7. Morgan's analysis is based on only five simulations, and the stochastic reliability of his estimate is doubtful. It seems unlikely that he allowed genealogical relationships to build to sufficient depth before observing the effects of incest tabus, so that the tabus imposed may not have had a chance to be exercised on persons known to be related, since few can have been known to be related. It is unclear whether MacCluer and Dyke (*6*) allowed sufficient buildup of genealogical relationships before observing effects, and their numerous measures of effect make interpretation more complex than the method we will propose.
8. Full details of the original simulation programs are given in the operating manual [E. A. Hammel, D. Hutchinson, K. Wachter, R. Deuel, *The SOCSIM Demographic-Sociological Microsimulation Program No. 27* (Institute of International Studies, University of California, Berkeley, 1976)] and illustrated in several substantive papers [E. A. Hammel and D. Hutchinson (*4*); E. A. Hammel, in *Demographic Anthropology: Quantitative Approaches*, E. Zubrow, Ed. (Univ. of New Mexico, Albuquerque, 1976), p. 145; E. A. Hammel and K. W. Wachter, in *Population Patterns in the Past*, R. Lee, Ed. (Academic Press, New York, 1977); K. Wachter, E. A. Hammel, T. P. R. Laslett, *Statistical Studies of Historical Social Structure* (Academic Press, New York, 1978)]. Documentation on the revisions is available from the authors.
9. "Kinship relationships" were defined genealogically. Level 1 means F,M,B,Z,S,D. Level 2 means level 1 plus FBC, MBC, FDC, MDC. Level 3 means level 2 plus FFBCC, FMBCC, . . . , MMDCC.
10. K. M. Weiss, *Am. Antiq.* **38**, 2 (1973).
11. L. Henry, *Demographie—Analyses et Modèles* (Société Encyclopédique Universelle, Paris, 1972).
12. Our "marriage rates" actually control initiation of searches for a spouse by women, not the achievement of marriages. If a woman scheduled to search for a mate in a particular month failed to find one, she remained at risk of death or having a child in that same month. If she died, of course that would be the end of it. If she had a child, that child would contribute to AFP. If she had a child, a new event would be scheduled for her at some future time, according to the probabilities of particular events appropriate to her age. If she did not have a child or die in the month in which she failed to find a spouse, she would automatically continue her search in the next month. If she failed again, she would be subject to the risks of death and of childbirth again. Thus, any woman coming of age for marriage or childbearing might have a child before being scheduled to seek a husband, because the probabilities of childbirth were the same for married as for unmarried women and were not zero. She would continue to be at risk of bearing a child, at the same rates as married women, until she was scheduled to seek a husband, and then until she found one.
13. See the interesting explorations of the topic in J. Birdsell, *Evolution* **12** (1958); N. Peterson, Ed., *Tribes and Boundaries in Australia* (Australian Institute of Aboriginal Studies, Canberra, 1976); G. King, "Cross-cultural model for the sociospatial organization of hunters-gatherers," presented at the 77th annual meeting of the American Anthropological Association, 1978.

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