

## BROTHER–SISTER MARRIAGE IN ROMAN EGYPT

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**Summary.** According to official census returns from Roman Egypt (first to third centuries CE) preserved on papyrus, 23.5% of all documented marriages in the Arsinoites district in the Fayum ( $n=102$ ) were between brothers and sisters. In the second century CE, the rates were 37% in the city of Arsinoe and 18.9% in the surrounding villages. Documented pedigrees suggest a minimum mean level of inbreeding equivalent to a coefficient of inbreeding of 0.0975 in second century CE Arsinoe. Undocumented sources of inbreeding and an estimate based on the frequency of close-kin unions (corrected downwards to 30% for Arsinoe) indicate a mean coefficient of inbreeding of  $F=0.15-0.20$  in Arsinoe and of  $F=0.10-0.15$  in the villages at the end of the second century CE. These values are several times as high as any other documented levels of inbreeding. A schematic estimate of inbreeding depression in the offspring of full sibling couples indicates that fertility in these families had to be 20–50% above average to attain reproduction at replacement level. In the absence of information on the amount of genetic load in this population, this estimate may be too high.

### Introduction

Estimates of average rates of inbreeding frequently focus on breeding isolates, ranging from very small groups, such as the sect of the Samaritans, to larger ones, such as the Amish, Indian caste groups, or the inhabitants of Tristan da Cunha (for reviews, see Khat, 1989; Reddy, 1993). Such populations are usually characterised by a high incidence of marriage between first cousins and/or between uncles and nieces. So far, there has been no single study of the extent and effects of inbreeding in a population in which matings within the nuclear family (at the  $r=0.5$  level, i.e. between individuals who share 50% of their genes through common descent) are frequent. However, for at least one such population, Egypt under Roman rule (e.g. Hopkins, 1980; Goody, 1990; Shaw, 1992), quantifiable data exist that permit some rudimentary statistical analysis. There is also exclusively qualitative evidence of brother–sister and parent–child marriage from Zoroastrian Iran (Scheidel, 1996a). Other cultures are explored by Goggin & Sturtevant (1964). The Roman Egypt data are considered in the present paper.

**Table 1.** Married couples attested per census period

Period	City		Villages		Total	
	Brother–sister	Other	Brother–sister	Other	Brother–sister	Other
11–89 CE	0	1	0	2	0	3
103–187 CE	17	29	7	27	24	56
201–257 CE	0	5	0	14*	0	19
11–257 CE	17	35	7	43	24	78

\*Including 1 first-cousin marriage.

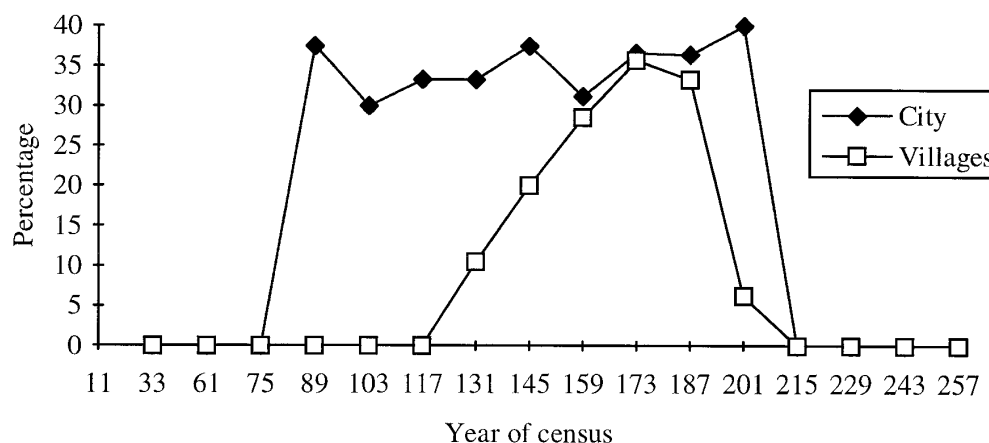
Source: Bagnall & Frier (1994).

### Data

The claim of ancient authorities that the inhabitants of Egypt, which came under Roman rule in 30 BCE, were free ‘to marry any sister of either parent or of both, not only younger but also older and of the same age’ (Philo of Alexandria, *On the Special Laws*, 3.23), is confirmed by census returns from the Roman period which survive on scraps of papyrus excavated in Egypt and now preserved and studied in collections all over the world. These census documents record the members of a given household with their name, parentage, age, and relationship within the family. They were extracted every 14 years from each head of a household in Roman Egypt to facilitate future taxation. Some 300 of these documents have been published so far, listing almost 1100 individuals (Bagnall & Frier, 1994). These records were compiled with care and have been shown to be more accurate than comparable census returns from nineteenth century Egypt or some modern developing countries. Owing to unequal chances of preservation, two-thirds of the extant texts come from a single administrative district, the Arsinoite nome in the Fayum (a fertile area around Lake Moeris to the west of present Cairo). In the Roman period, this region consisted of one city, Arsinoe, and a number of settlements technically defined as villages. The total population of the district can tentatively be put at about 90,000–120,000 people, perhaps 25,000–40,000 of whom resided in Arsinoe (cf. Rathbone, 1990). Since the other 50-odd administrative districts of Roman Egypt have yielded only a few pertinent texts, the data from the Arsinoite nome are the only ones suitable for quantification.

In that area, 20 out of 102 documented marriages (19.6%) are between full brother and sister, four are between half siblings (3.9%) and one between first cousins (1.0%) (Table 1). The occasional specification, ‘husband/wife and brother/sister of the same father and the same mother’, as well as the recorded names of the parents, leave no doubt that such couples were actually related in this manner. In this context, there is no evidence of adoption. As Table 1 shows, brother–sister unions are attested only in a limited time range covering the seven censuses of the second century CE. During that period, 30% of all attested unions are between siblings.

Since most of the extant census returns come from the second century CE, it is impossible to determine when brother–sister marriage came to be widespread in the



**Fig. 1.** Sibling couples as proportion of all couples (3-year moving average). Source: Bagnall & Frier (1994).

Arsinoites. The underlying rationale for incestuous marriage remains obscure. The data (Table 1) suggest that this practice was less common in the first half of the third century than in the second century CE ( $p < 0.1142$  for the city,  $p < 0.1236$  for the villages, z-test: the value for the total is higher,  $p < 0.0138$ , but the urban–rural split is markedly different in the two periods). However, since data from the first century CE are extremely rare, the origin of brother–sister marriage remains obscure. The apparent delay in the diffusion of such unions to the villages (Fig. 1) might indicate that, outside Arsinoe at least, brother–sister marriage was a recent phenomenon, but the pertinent sample is too small to bear much weight. Nevertheless, it will be assumed here that in the area under review, brother–sister marriage was absent or unimportant prior to the late first century CE. While this premise is almost certainly not correct (geographically unspecific literary references to that custom come from the late first century BCE and early first century CE), it will enable the establishment of minimum rates of inbreeding and inbreeding depression.

### Results and discussion

#### *Coefficients of inbreeding*

It is difficult to assess the average rate of inbreeding in the population as a whole. Reported pedigrees are normally limited to one or two generations and it is not known to what extent sibling marriage was a custom specific to some families but not to others, and to what extent it would run in families for several generations (but see below). An approximation of the minimum rate of inbreeding can be based on the attested total of individuals who are known to be inbred or who were putatively not inbred (Tables 2 and 3).

These rates are clearly too low because they fail to account for three factors: inbreeding of ancestors who remain unknown; under-documentation of first-cousin marriage, which is impossible to identify in census returns unless the parents of both

**Table 2.** Individuals of known parentage

Period	City		Villages		Total	
	Inbred	Other	Inbred	Other	Inbred	Other
11–89 CE	0	3	0	3	0	6
103–187 CE	42	58	6	37	48	95
201–257 CE	0	6	2*	13	2*	19
Not dated	0	6	0	14	0	20
<b>Total</b>	<b>42</b>	<b>73</b>	<b>8</b>	<b>67</b>	<b>50</b>	<b>140</b>

\*Offspring of first cousins.

Source: Bagnall & Frier (1994).

**Table 3.** Average coefficients of inbreeding based on known parentage\*

Period	City	Villages	Total
103–187 CE	0.0975	0.0378	0.0795
<b>Total</b>	<b>0.0848</b>	<b>0.0233</b>	<b>0.0605</b>

\*Assuming  $F=0$  for all individuals whose parents are not siblings or first cousins.

spouses still lived in the same household; and overall inbreeding resulting from less close unions. The first two of these variables are impossible to quantify. The average coefficient of inbreeding in Egypt today has been put at 0.01 (ranging from 0.009 in the cities to 0.015 in the countryside: Hafez *et al.*, 1983). It was probably higher in ancient Egypt, possibly of the order of 0.02–0.03, a surmise consistent with data from current traditionally isolated and inbred populations (cf. Cavalli-Sforza & Bodmer, 1971).

The attested frequency of sibling marriage translates into a higher estimate of the average amount of inbreeding. If in Arsinoe, 30.4% of all unions are between full siblings and 6.5% are between half siblings, and if a mean coefficient of inbreeding of 0.03 is assumed for the remaining 63.1% of the population who do not descend from sibling couples, after four generations (i.e. at the end of the second century CE) the minimum mean level of inbreeding is equivalent to a coefficient of inbreeding ( $F$ ) of 0.2243, close to the rate for offspring of full siblings. This schematic calculation is based on the unrealistic assumption that all families practise a given type of mating throughout these four generations. While this may have been true for a few families (in a papyrus text from the Arsinoites, which is not a census return, full sibling marriage continues through three successive generations: Grenfell & Hunt, 1901), for purely demographic reasons this must have been a rare occurrence (see next

paragraph). A lower average would result from the assumption that in every generation, some families discontinued brother–sister matings and others adopted this habit for the first time. In the villages, 17.6% of marriages are full sibling unions, 2.9% are between half siblings, and 79.5% are between putatively unrelated spouses. In this case, the minimum mean level of inbreeding derived from the schematic calculation is  $F=0.1394$  after four generations.

The attested rate of sibling unions of 37% in Arsinoe is almost certainly too high. In a population with very low life expectancy ( $e_0 \sim 22.5$  for females, perhaps 25 for males: Bagnall & Frier, 1994) only about 40% of all couples would have both a son and a daughter surviving to marriageable age (Hopkins, 1980; Bagnall & Frier, 1994). The scope for sibling unions was further restricted by the fact that the husband was expected to be older than his wife, an evolved mating preference that can be documented for both close-kin and non-kin unions in the census returns (Scheidel, 1995). Only about 20% of all parents would have an older son and a younger daughter who could be married to each other. Given a strong reluctance to arrange sibling marriages between an older sister and a younger brother (Scheidel, 1995), the actual frequency of brother–sister marriage was probably closer to 20% than to the purely demographic limit of 40%. This agrees well with the fact that because of the small size of the sample ( $n=46$  for 103–187 CE), the attested rate of 37% is compatible with an actual frequency of 23–51% in the free urban population as a whole ( $p < 0.05$ , z-test). The significance accorded to the birth order of potential sibling spouses favours an estimate close to the lower end of this range, in the region of 25–30%. Even this lower estimate has serious implications: if some 45% of all women in Arsinoe were married at any given time (cf. e.g. Saller, 1994) and the urban population comprised 25,000–40,000 individuals (see above), and provided that the census population is representative of the population of Arsinoe as a whole, between 1400 and 2250 out of 5600–9000 married couples in this city were full siblings. However, if only part of the population were ‘visible’ in the extant census returns, the actual number might have been significantly smaller.

With 25% full sibling and 5% half sibling unions (and a mean coefficient of inbreeding of 0.03 in the non-incestuous families), after four generations the minimum mean coefficient of inbreeding reaches 0.1885. This rate is both too low and too high: too low because an unknown number of first and second cousin marriages would have added to the mean level of inbreeding (see above); too high because, in practice, sibling marriage would have alternated with non-incestuous unions. Hence, as long as heavy inbreeding was limited to only a few generations, recourse of inbred individuals to spouses with whom they did not share common ancestors would have curbed the overall increase of the mean level of inbreeding. On the theory that these two counteracting factors would to some extent cancel each other out, the estimate that  $F \sim 0.19$  need not be wide of the mark. This rate is halfway between the values for offspring of half siblings and of full siblings, and hence extremely high. The mean level of inbreeding in the city of Arsinoe at the end of the second century CE may thus tentatively be put at  $F=0.15$ – $0.20$ , compared to  $F=0.10$ – $0.15$  in the villages. Levels such as these are up to several times as high as anything documented so far: even in the most extreme breeding isolates of today, reported estimates do not exceed 0.07 and normally remain in a range 0.03–0.05 (e.g. Reynolds & Tanner, 1983; Roberts, 1992; Reddy, 1993).

**Table 4.** Predicted rates of inbreeding depression (*i*) and child mortality in offspring of successive full sibling matings in Roman Egypt

Parents: coefficient of relationship ( <i>r</i> )	Offspring		
	Predicted <i>i</i>	Mortality up to age 10 (%)	
		Normal	Incestuous*
0.5 (first generation)	16.1	52.6	60.2
0.6 (second generation)	23.1	52.6	63.5
0.727 (third generation)	29.5	52.6	66.6

\*Calculation based on equation in Ralls *et al.* (1988), assuming that the inbred load  $B=0.7$ .

### *Inbreeding depression*

Rates of inbreeding of that order of magnitude may well have resulted in a considerable amount of inbreeding depression expressed in elevated pre-reproductive mortality and disabilities. Different methods of calculating inbreeding depression (*i*) have been discussed by Makov & Bittles (1986). Durham (1991), based on May (1979), estimates levels of *i* in several modern populations. His calculations are however vitiated by the fact that he reckons with equal rates of deleterious recessive genes in a modern western population and in arguably more inbred and much smaller endogamous communities in Israel and Nigeria, and by the application of May's equation that is rejected by Ralls, Ballou & Templeton (1988). In the present study, two different methods are used which yield very similar results: Ralls *et al.* (1988) propose the equation  $i = 1 - e^{-FB}$ , the results of which are broadly consistent with those determined by a method based on empirical data devised by Bittles & Neel (1994).

Model West Mortality Level 2 Females, an appropriate approximation of life expectancy in Roman Egypt (Bagnall & Frier, 1994), predicts a rate of survival to age 10 of 47.4% (Coale & Demeny, 1983). If the coefficient of inbreeding depression  $i = 1 - e^{-FB}$  (where  $F=0.25$  and  $B=0.7$ ), then  $i = 16.1$  (Table 4). If mortality up to age 10 is 47.4% among non-inbred offspring, the corresponding mortality rate of children of incest can be calculated as  $d_i = 100 + (i - 1)(100 - d_c)$ , where  $d_i$  and  $d_c$  represent the percentage of death in inbred and non-inbred children, respectively (cf. Durham, 1991). Hence, adding expected inbreeding depression of offspring of full sibling matings, mortality up to age 10 would rise to about 60%. After two and three generations of successive brother–sister unions, the rates would be approximately 64% and 67%, respectively (Table 4).

In non-kin couples, with life expectancy at birth of about 22.5 years, the average woman surviving to menopause must give birth to six children to attain reproduction at replacement level (Bagnall & Frier, 1994). For the sister-wives, the required numbers are 7.2, 8 and 8.9 in the first, second and third generation. While individual women would surpass even such figures, they represent very high averages. Allowing for some

'genetic death', the diminished likelihood or failure to reproduce due to physical or mental disabilities (Berry, 1981), the required rates of reproduction would have been higher still.

The crucial variable in such estimates is the average number of recessive lethals in a given population. Cavalli-Sforza & Bodmer (1971) calculate a median number of 2.2 lethal gene equivalents per individual from eighteen samples weighted towards Japanese data; Bittles & Makov (1988) present estimates for lethals ranging from 1.5 to 3.5 per individual. The most comprehensive study (38 samples), heavily biased in favour of inbred populations in India, Pakistan, Japan and Brazil (Bittles & Neel, 1994), arrives at a low average of 1.4 lethal gene equivalents per individual. This figure has been used here (Table 4). It is not inconceivable, however, that in ancient populations, the respective value was smaller still. In modern populations, by contrast, the overall level of consanguinity is now extremely low, resulting in an increasingly better preservation of recessive deleterious genes which only rarely become dominant. This may be one reason why data on nuclear family incest in western societies suggest very high rates of inbreeding depression: between one-third and one-half of all children of incest either die or suffer from severe disorders (Adams & Neel, 1967; Carter, 1967; Seemanová, 1971; Staudacher, 1974; Baird & McGillivray, 1982). This could also explain the relatively substantial negative effects of first-cousin matings in such populations (Sutter & Tabah, 1953; Bigozzi *et al.*, 1970; Fraser & Biddle, 1976). The conditions in more inbred populations are more ambiguous (for levels of inbreeding, see Freire-Maia, 1957; Freire-Maia & Elisbao, 1984; Bittles & Neel, 1994). Most of the evidence comes from first-cousin unions (Khlat, 1989; Reddy, 1993; Bittles & Neel, 1994). While it is true that in 36 out of 38 samples reviewed by Bittles & Neel (1994), mortality of offspring is higher in such unions than in non-consanguineous couples (see also, e.g. Centerwall & Centerwall, 1966; Cook & Hanslip, 1966; Chakraborty & Chakravarti, 1977; Ansari & Sinha, 1978; Reddy & Rao, 1978; Naderi, 1979; Basaran *et al.*, 1989; Reddy, 1993), the overall picture seems to be more complex. In some small and traditionally isolated communities in South India, significant effects of inbreeding depression are reportedly absent (John & Jayabal, 1971; Ghosh & Majumder, 1979; Reddy, 1983; Reddy, 1992; cf. also Lindelius, 1980) or inconsistent across age groups and areas (Rao & Inbaraj, 1979). In other cases, fertility in consanguineous couples may be above average, thereby offsetting higher neonatal mortality (Bai, John & Subramaniam, 1981; Hann, 1985; Reddy & Moddell, 1995; but cf. Reid, 1976, for depressed fertility); in one case, neonatal mortality itself has been found to be lower for first-cousin couples (Al-Awadi *et al.*, 1986). In general, there is no evidence that inbreeding increases the incidence of sterility (Cross & McKusick, 1970; Rao & Inbaraj, 1979) or the incidence of fetal death (MacCluer, 1980).

What implications this might have for an appraisal of the conditions in Roman Egypt are far from clear. Have repeated incestuous matings altered the genetic preconditions in a favourable way by reducing the genetic load? In theory, recessive lethal gene equivalents that become homozygous through incest should disappear together with their defective carriers, thereby reducing the average load for the population in question. This mechanism may have worked in the long run at low levels of inbreeding, as suggested by Sanghvi (1966, 1975), Rao & Inbaraj (1977) and Livingstone (1980). According to Morton (1993), the inbred load (B) might be reduced

by 50% through long-term preferential consanguineous marriage compared with populations that tend to avoid them. Needless to say, however, there are no comparable data on sustained brother–sister matings and the equations advanced by Sanghvi (1966, 1975) are not readily applicable to the study of nuclear family incest since they require relatively unchanging rates of  $F$ . In rare cases, intense incestuous inbreeding has yielded positive results in other mammalian species (Slatis, 1960; Templeton & Read, 1984), even though the initial cost can be forbiddingly high (Bowman & Falconer, 1960). The negative effects of very close inbreeding in mammals and birds in general are reviewed by Feldman & Christiansen (1984) and Ralls *et al.* (1988).

In practice, any reduction of deleterious recessives achieved by nuclear family incest is eradicated whenever continuous incest within the same line is interrupted; if incest resumes after interruption, the influx of new deleterious genes will produce the same initial costs as before. In order to avoid this effect, incestuous families ought to have met, without exception, two requirements: a complete absence of extramaritally conceived children and an uninterrupted supply of marriageable spouses within the nuclear family (on the significance of availability with regard to less close unions, cf. Bittles *et al.*, 1987; Reddy & Malhotra, 1991; Reddy & Moddell, 1995). However, in reality, the rate of adulterous conceptions is never zero (and normally well above that: Betzig, 1993; Baker & Bellis, 1995), and, even more importantly, since at most only 40% of all couples would have had both a son and a daughter to match, incestuous unions would, on average, have been possible only in every other generation.

Thus, even in the absence of explicit references to inbreeding depression from Roman Egypt, there is no compelling reason to assume that brother–sister marriage could have remained entirely without negative consequences for the Arsinoites. It is however possible that, due to a low incidence of lethal recessives, such effects were considerably weaker than in some western samples (see above). The census returns do not suggest lower levels of fertility or smaller numbers of children among sibling couples; in fact, if only by chance, some of the most prolific couples recorded in the census returns are full siblings (Bagnall & Frier, 1994; Scheidel, 1996a).

### Conclusion

Inbreeding rates in the city of Arsinoe at the end of the second century CE were at least two to three times as high as in the most inbred communities presently known. If brother–sister marriage was a tradition of long standing, as it may well have been, the rates were higher still but defy even tentative quantification. The effects of this practice on the pattern of fertility and mortality remain unknown: in the absence of pertinent statements and hints in the ancient sources, one can only speculate that a low frequency of deleterious recessive gene equivalents may have saved many incestuous families from extinction and thus helped to maintain that mating system for a limited time. The apparent decline of incest in the third century CE, pre-dating pervasive Christian influence and legislation (the standard explanation of its eventual disappearance), can only speculatively be linked to the aggregate impact of accumulating inbreeding depression. While many facets of this phenomenon will remain obscure, this body of documentary evidence makes Arsinoe and its hinterland the most extreme example of



inbreeding in any local population currently known. Future appraisals of the limits of inbreeding and inbreeding depression in humans, and of the evolutionary background of incest avoidance (Scheidel, 1996b), will have to take account of this unique phenomenon.

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