units of the reduced size (*14*). We conclude that factors correlated with the original size, such as territorial qualities and parental age, had no statistically significant influence on the difference between natural units of two or three members and units of six, seven, and eight members.

In this study, both unit size and reproductive success were correlated with vegetation on the territory and with parental age (*15*). Comparison of these and other variables revealed no significant differences between experimental and control groups of the same original size.

In summary, the positive correlation between reproductive success and the number of helpers is not the result of other variables that are correlated with unit size and reproductive success. It is caused mainly by the helpers or by an interaction of the helpers with another variable. We reject the hypothesis that helpers do more harm than good. Because helpers in this species are typically offspring of the breeder in their units (*16*), we have demonstrated, without the reservations expressed in (*7*), that helpers significantly improved the reproductive success of their parents, thereby increasing their own indirect fitness (*17*).

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References and Notes

1. This is a slight restriction of the standard usage of A. F. Skutch, *Auk* **52**, 257 (1935); *Condor* **63**, 198 (1961).
2. W. D. Hamilton, *J. Theor. Biol.* **52**, 1 (1964).
3. Increments to inclusive fitness may be divided into two types; direct effects influence offspring and other descendant relatives, while indirect effects influence nondescendant relatives and other cocarriers of the gene in question [J. L. Brown, in *Evolution of Social Behavior: Hypotheses and Empirical Tests*, H. Markl, Ed. (Verlag Chemie, Weinheim, West Germany, 1980)].
4. J. L. Brown, *Wilson Bull.* **81**, 293 (1969); *Am. Zool.* **14**, 63 (1974).
5. I. Rowley, *Emu* **64**, 251 (1965); J. Maynard Smith and M. G. Ridpath, *Am. Nat.* **106**, 47 (1972); V. Parry, *Emu* **73**, 81 (1973); G. E. Woolfenden, *Auk* **92**, 1 (1975); P. Moehlman, *Nature (London)* **277**, 382 (1979).
6. Singular breeding designates communal systems in which there is only one breeding pair in a social unit, as opposed to plural breeding, in which there are two or more.
7. J. L. Brown and R. P. Balda, *Condor* **79**, 312 (1977).
8. A. Zahavi, *Ibis* **116**, 84 (1974).
9. J. L. Brown, *ibid.* **117**, 243 (1975).
10. A. J. Gaston, *ibid.* **115**, 330 (1973); *J. Anim. Ecol.* **47**, 845 (1978).
11. Control and experimental units were treated equally. Both were lured into mist nets with tape-recorded calls; all birds were color-banded for individual recognition, weighed, measured, and released where caught. Removed birds were killed. These procedures did not cause units to leave; all units remained on their territories for at least several months.
12. This study was performed at Meandarra, Queensland, Australia, from August 1976 to August 1977. For further details on the study, see J. L. Brown, D. D. Dow, E. R. Brown, S. D. Brown, *Behav. Ecol. Sociobiol.* **4**, 43 (1978); M. S. Johnson, J. L. Brown, *ibid.* **7**, 93 (1980); J. L. Brown, *Emu* **79**, 1 (1979).
13. These groups differed in a Mann-Whitney *U* test ($U = 76$, $P < .05$, two-tailed). Observed values of F2 for control units were 0, 0, 1, 2, 2, 2, 2, 3, 3, 5, and 6 and for experimental units were 0, 0, 0, 0, 0, 1, 1, 2, and 3. Most control units had a second brood; most experimental units did not. A few control units had three successful broods; no experimental units did. Statistics were calculated by using *BMDP-77*, W. J. Dixon and M. B. Brown, Eds. (Univ. of California Press, Berkeley, 1977).
14. These two groups did not differ in a Mann-Whitney *U* test ($U = 40$, two-tailed). Observed values of F2 for natural units of two and three were 0,0,0,0,0,0,0,1, and 2.
15. J. L. Brown, E. R. Brown, S. D. Brown, in preparation.
16. In August 1977, all banded young of banded parents reared in the 1976 breeding season ($N = 45$) were still with their parents in their natal territories. The 1975 year class showed similar, but less impressive, site fidelity.
17. We limit our conclusion to the variables considered here. We intend no implications about the mechanisms of the effect of helpers on reproductive success. Specifically we do not want to imply that the increment to reproductive success arises only from the feeding of young by helpers. Helpers may also allow savings to the energy budgets of breeders by means of aid in territorial defense and antipredator behavior. For further discussions of relevant mechanisms, see J. L. Brown, *Annu. Rev. Ecol. Syst.* **9**, 123 (1978).
18. We thank R. Jamieson, E. Perry, and their families. Supported by the authors, by Public Health Service grant MH 16345, by the Australian Research Grants Committee, and by the University of Queensland.

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Reputed Band Attractiveness and Sex Manipulation in Zebra Finches

Burley's conclusions (*1*) that zebra finches (*Poephila guttata*) choose mates by their leg-band colors, that birds wearing certain colors produce more offspring than others, and that the sex ratio of the offspring depends upon the parental band colors are all unsupported by the evidence. We summarize selected objections.

(i) The study (*1*) depends upon the interpretation of unpublished (*2*) data. (ii) Band colors used were not identical with those of the unpublished study. (iii) It is unclear whether the same birds were used as in the unpublished study; zebra finches are known (*3*) to have individual preferences in mating. (iv) In either case, no history of prior nesting and mating experiences are provided, although the past experience also affects mating preferences in this species (*3*). (v) The approach criterion for sexual preference has already been established (*4*) as invalid for this species. (vi) The birds were grossly overcrowded: 60 individuals were released into an 80-m^3 aviary and at least some parents reared at least four clutches (*5*) during the study, so that density probably increased continuously. (vii) It is not reported whether renesting birds (*5*) retained the same mates. (viii) Data are not broken down by individual pairs, so individual differences in productivity of offspring are confounded with band color effects, and a direct test of mating preferences was thus ignored. (ix) At least 11 offspring were omitted because they could not be sexed by plumage (*5*) and no standard laparotomies were performed. (x) Four clutches were omitted because they were tended by a female-female pair (*5*), thus eliminating about 24 additional offspring. (xi) The very occurrence of female-female pairs (*5*) suggests behavioral pathology, and the implied infidelity casts doubt on the assignment of parentage for all offspring. (xii) The complex multivariate design with four independent variables (individual, sex, band color, and successive renesting of parent) and two dependent variables (number of male and female offspring) was invalidly analyzed with chi-square statistics. (xiii) A conservative estimate suggests that the design has more than 280 data cells, filled by only 125 data points. (xiv) Even using the χ^2 analysis, conclusions do not follow from the data. The analysis is too complicated to present here in summary, but a Xerox copy of our detailed comments may be obtained by writing J.P.H.

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References and Notes

1. N. Burley, *Science* **211**, 721 (1981).
2. Reference 6 of (*1*) cites "N. Burley, G. Krantzberg, P. Radman, in preparation. . . ."
3. K. Immelmann, in *Theoretical Advances in Behavior Genetics*, J. R. Royce and L. P. Moss, Eds. (Sijthoff and Noordhoff, Alphen aan den Rign, 1979), p. 121.
4. D. B. Miller, *Nature (London)* **280**, 389 (1979).
5. Reference 7 of (*1*): "Data on 11 'white' birds are excluded because birds with this plumage mutation cannot be accurately sexed on the basis of external appearance. Data are also excluded for one homosexual female couple (orange-blue) that raised four clutches with no apparent male assistance."

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The sex ratio of zebra finch offspring is reported by Burley (*1*) to be determined, at least in part, by the socially defined attractiveness of the parents. Such a result would be of major importance in two areas of current evolutionary theory. It would provide support for the Trivers and Willard (*2*) hypothesis concerning parental control over the sex ratio, and it would suggest another possible mechanism (*3*) for the evolution of the remarkable sexual dimorphisms in marking and form shown in many birds and some other animals. It is regrettable, therefore, that the material presented does not show a reliable relation between sex ratio of offspring and the attractiveness of the parents.

The attractiveness of the birds was manipulated by attachment of colored leg bands. The colored leg bands were classified as attractive, unattractive, or neutral (*4*), on the basis of a preference test in which individuals of each sex were allowed to perch next to variously color-banded birds, and color preference was measured by the time spent next to birds wearing a particular color. The preference test established the independent variable for the main experiment on sex ratio manipulation, so the validity of the attractiveness classification derived from that test is crucial. But the preference data are not given and the only data relevant to preference that are given—the number of offspring from the respective parental color combinations (Table 1)—seemingly deny the validity of the attractiveness manipulation. Number of offspring presumably provides a crude index of sexual attractiveness; but the neutral females produced more than half the offspring, and the unattractive males outproduced the neutral males.

Since analysis of the sex ratios of the offspring must be conditional on the attractiveness classification of the parents, and the validity of that classification is in doubt, the usefulness of further analysis is doubtful. However, some comments on the form of the analysis may be offered.

The procedure followed in (*1*) of selecting the most deviant cells of the 3 × 3 × 2 table to create a 2 × 2 table in which sex ratio is "significantly" related to parental attractiveness ignores the fact that many such 2 × 2 tables could be constructed in which the effect is not observed, let alone significant.

It is clear from the report (*1*) that offspring arrived in clutches of several birds (three or four?) and the experiment was continued long enough for each mated pair to produce several clutches. For instance, consider (Table 1) the nine offspring in the cell g-banded male, Bl-banded female which are crucial to the analysis in (*1*). We must consider how many independent events those nine offspring represent, whether it is nine or whether they arrived in clutches of two or three, possibly all to the same mated pair. The unusual sex ratio observed in that cell may be due to as few as one or two events.

Table 1. Number of offspring of each pair combination to reach maturity. Band colors were as follows: R, red; O, orange; g, light green; Bl, black; b, light blue.

Female parent	Male parent R attractive	 O neutral	 g unattractive
Bl attractive	11	8	9
O neutral	35	8	26
b unattractive	11	15	2

A better analysis of all of these factors would be based on counts of matings and the sex ratios that arise from those matings (using each pair of birds only once) in a truly free-choice situation (*5*). First, however, for this research, a valid attractiveness measure would be required. The question remains important, and Burley (*1*) has taken a suggestive and ingenious first step in addressing that question, a step without which further steps might not have been considered.

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References and Notes

1. N. Burley, *Science* **211**, 721 (1981).
2. R. L. Trivers and D. E. Willard, *ibid.* **179**, 90 (1973).
3. There are already a number of these [see R. Dawkins, *The Selfish Gene* (Oxford Univ. Press, London, 1976)].
4. The bird legs are orange.
5. Although the "birds were permitted to select mates and reproduce freely" (*1*, p. 721), the available population of mates was limited by competition, which means that many mates must have been second or even third choices. This must work both to further damage the effectiveness of the attractiveness variable and to introduce dependencies among the counts.

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A forthcoming paper (*1*) addresses points (i), (ii), (iii), and (v) raised by Immelmann *et al.* (*2*). It also includes analyses of preferences for both sequences reported in *Science* (*3*). Regarding other points raised by them (*2*): (point iv) Parental birds had no prior reproductive experience (*4*); (point vi) offspring were systematically removed at 3- to 4-week intervals to prevent overcrowding (*5*); (points vii and viii) on the basis of his own research, Immelmann (*6*) considers zebra finches to form long-term pair bonds; also, if birds changed mates during the study, interpretations would be strengthened; (ix) the 11 white offspring were about evenly distributed among pair combinations; they could not account for observed trends. (point x) The one homosexual pair raised 7, not 24, offspring. This pair bonded very early in the study, at minimum population density; (xi) a single case of homosexuality does not indicate the presence of "behavioral pathology" (*7*), especially since other birds engaged in "normal" behavior (*8*), and the colony produced many offspring. Moreover, the possibility that behavioral pathology could explain the results appears remote indeed.

At the reported stage of research, it was not feasible to monitor individual reproductive success (RS) (*9*), thereby limiting interpretation and constraining statistical analysis. For this reason, Immelmann *et al.*'s suggestions for statistical design [(xii) and (xiii)] are unrealistic. In addition, there is the crucial question of sample size required for the multivariate design they suggest; their design is not specified, but their estimate of 280 cells is quite conservative. Given within-cell variability, the sample required might well exceed 2000 offspring. Thissen and Martin's (*10*) observation that the data could have been grouped in other ways for analysis ignores the following: (i) The results of preference experiments (*1*) did allow for a priori expectations of differences in reproductive patterns of "attractive" individuals (black-banded females and red-banded males) versus "unattractive" ones (blue-banded females and green-banded males). The rationale for constructing other possible 2 × 2 tables was not evident a priori (or a posteriori). (ii) The direction of trend was uniform throughout the study (*3*). (iii) The pattern displayed by one color type (such as red-banded males) was necessarily complicated by the phenotypes of mates, which could well have acted to dilute within-sex trends in offspring production. (iv) A clutch-by-clutch, rank-order correlation between sex ratio and discrepancy in attractiveness between mates was significant (*3*), and the direction of the trend was concordant with other results: that is, the greater the discrepancy in attractiveness, the greater the bias in sex ratio in the direction of the more "attractive" mate.

Because individual RS is not known, the number of pairs of each combination cannot be determined. Minimum estimates, obtained from pairs breeding simultaneously, indicated a minimum of two to four pairs for each combination except blue-green (one pair). In all, 55 clutches were produced (*11*).

To define attractiveness in terms of RS

creates a tautology. Clearly, an independent measure is critical so that the question "what is the effect of attractiveness on RS?" can be asked, and hypotheses about function can be tested. Thissen and Martin's suggested "free-choice" design, wherein birds could interact freely, has not proved feasible because the intense intrasexual competition generated swamps the choice process. While not all aspects of this methodological problem have been worked out, we have data (*1, 12*) that attractiveness can be measured prior to pair formation without physical contact between participants.

The finding that "attractive" females are less successful reproductively than "intermediate" females is intriguing. One possible reason for this result has been discussed (*3*). Attractiveness is only one of several components affecting RS in polygynous and promiscuous species (*13*); its role in monogamous species is hardly understood. Understanding its importance requires information on the effect of attractiveness on several aspects of reproduction, including timing, frequency of breeding, eagerness to breed, the "willingness" of individuals to invest in their offspring (*14*), and the behavioral complementarity of various pair combinations.

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References and Notes

1. N. Burley *et al.*, *Anim. Behav.*, in press.
2. K. Immelmann, J. P. Hailman, J. R. Bayliss, *Science* **215**, 422 (1982).
3. N. Burley, *ibid.* **211**, 721 (1981).
4. They were denied opportunities to reproduce by isolation in unisexual groups as sexual maturity approached.
5. At the end of the 9 months for which data were reported, the population size was approximately 120, including about 20 juveniles, most of which were removed at a later date.
6. K. Immelmann, *Zool. Jb. Syst. Bd.* **90**, 1 (1962); *Australian Finches in Bush and Aviary* (Angus and Robertson, Sydney, 1974).
7. "Pseudomale" and "pseudofemale" behaviors have been described for heterosexual zebra finches by D. Morris [(*8*) and *Behaviour* **8**, 46 (1955)]. I have not previously observed homosexual pairings in zebra finches, although they do occur in low frequency in other monogamous avian species [pigeons (*Columba livia*), personal observation and W. M. Levi, *The Pigeon* (Levi, Sumter, 1974), and gulls (*Larus* spp.), J. P. Ryder, *Proceedings Colonial Waterbird Group* 1978, p. 138; ——— and P. L. Somppi, *Auk* **96**, 1 (1979)].
8. D. Morris, *Behaviour* **6**, 271 (1954).
9. Individual recognition is commonly effected by banding birds with unique color combinations. However, in this study there were at least ten birds of each color type in the aviary at any one time.
10. D. Thissen and E. Martin, *Science* **215**, 423 (1982).
11. The below average clutch size is consistent with the suggestion (*3*) that sex-ratio manipulation occurs postzygotically (and probably after hatching).
12. Unpublished data (N. Burley) indicate that preferences displayed in experiments are sex-specific. For example, males given choices among males wearing red, orange, or green bands show very different responses than females choosing among such males.
13. For example, R. A. Fisher, *The Genetical Theory of Natural Selection* (Clarendon, Oxford, 1930); G. Borgia, in *Sexual Selection and Reproductive Competition in Insects*, M. S. Blum and N. A. Blum, Eds. (Academic, New York, 1979), p. 19.
14. R. L. Trivers, in *Sexual Selection and the Descent of Man, 1871–1971*, B. Campbell, Ed. (Aldine, Chicago, 1972), p. 136.

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Cancer in Nickel-Processing Workers in New Caledonia

It appears to us that the hypothesis advanced by Langer *et al.* (*1*) is very weak and unsubstantiated when brought under close scrutiny.

1) The study by Lessard *et al.* (*2*) referred to in (*1*) does not present conclusive evidence with respect to the toxicity of nickel. As Maheux *et al.* point out (*3*), "this study [Lessard *et al.*] is by no means the final evidence that nickel (ore) dust is carcinogenic for human beings." Numerous criticisms can be made of this work, most of which were raised by the authors themselves. These include the following points: (i) There is no distinction made between primary and secondary cancers. (ii) A comparison is made between the incidence of lung cancer in New Caledonia and that in the rest of the world, which is based on data from the period 1970 to 1974 for New Caledonia and 1960 to 1964 for the rest of the world. It is known that the risk of mortality from lung cancer has risen over the years in developed countries. Between the period 1960 to 1964 and the period 1970 to 1974, the increase in the incidence was sufficient to place the European population of New Caledonia on the same level as the European population of New Zealand (where there is no nickel mining industry). (iii) The control group that was used is not representative of the population of New Caledonia and must therefore be considered with extreme caution. This group was selected from among hospital laboratory outpatients. As Maheux *et al.* admitted (*3*), "Some consequences of this, like a significant different mean age between the case group (58 years) and the comparison group (46 years) is of critical importance, even though the statistical method employed permitted to control for age." Furthermore, the proportion of smokers among the nickel workers in the control group (90 percent) is very different from what appears in our medical records (56 percent). (iv) Specificity with respect to nickel as the causative factor is missing.

2) The incidence of lung cancer in New Caledonia has remained practically unchanged over the past 10 years, although there was a considerable increase in medical monitoring and an increase in the level of nickel production from 1945 to 1975, and despite the fact that the incidence of lung cancer has increased significantly throughout the world (*4*).

3) The numbers of nasal sinus cancers, the incidence of which has been reported to be as much as 600 times higher in nickel workers according to epidemiological surveys related to "nickel smelters," have been very small thus far in New Caledonia, although nickel has been mined and smelted on the island for a century.

4) Only three cases of pleural mesothelioma were recorded in New Caledonia between 1970 and 1980 (*5, 6*), and none of these among smelter workers. In our opinion, it is not possible to conclude one way or the other about the normality or abnormality of mesothelioma occurrences in New Caledonia. If, in fact, the inhalation of asbestos fibers had been an important factor in New Caledonia, a large number of cases of asbestosis should have been observed. The results of a complete standard detection program carried out in June and July 1980 on all personnel at a mining center on the island showed no significant anomalies that could result from exposure to asbestos, notably no pleural plate, pleural thickening, or pulmonary fibrosis (*5*).

5) Ores mined in New Caledonia result from the transformation by surficial weathering of ultrabasic rocks which are more or less serpentinized. These ores correspond to soft material which surrounds hard cores of fresh rock. When serpentinized, the fresh rock contains two magnesium silicates, lizardite and chrysotile, which is fibrous. In the course of weathering, the chrysotile disappears. The newly formed magnesium silicates are predominantly a nickeliferous lizardite (plane sheets) (*7*). As a result, the fines, the part of the ore liable to produce inhalable dust, contain only small, in fact very small, amounts of chrysotile (a few hundred parts per million). Thus, the amount of fibers inhaled by nickel workers is much lower than the minimum amount established by French law and also lower than the amount currently urged as a standard (less than 0.5 fiber per cubic centimeter).

Our investigations do not lead us to support the thesis of Langer *et al.* or to suspect that the nickeliferous substances (whether associated with chrysotile or not) that are handled in New Caledonia are responsible for most of the