Reproductive studies of Cockatiels

by J.R. Millam
Department of Avian Sciences
University of California, Davis, California

My interest in studying cockatiels stems partly from the vulnerability of this large order of birds *(Psittaciformes).* For example, of the approximately 145 species of New World parrots, some 55 are threatened. Many of these species are endangered by excessive collection pressure. It is possible that a domestic breeding industry could supply pet birds at a price that would reduce the economic incentive to capture birds from the wild. However, our understanding of the captive breeding management of parrots is too incomplete to make this currently practical.

The University of California's colony of cockatiels was purchased from Aviculture Institute, Newhall, California. Early studies focused on practical questions of nutrition and basic management, e.g. Roudybush et al. (1984); Roudybush and Grau (1986). A management system evolved in which birds were maintained either in flights in a semi-enclosed aviary or in welded-wire cages (60 x 60 x 30 cm). Breeding was encouraged by attaching to the cages stainless steel nest boxes (30.5 x 20.3 x 30.5 cm) containing sterilized pine shavings. A pelleted diet was provided ad libitum in plexiglass feeders which were designed to minimize spillage. Water was continuously available from nipple drinkers. But reproduction remained problematic. On several occasions nest boxes were attached to cages as a means of encouraging egg production but the response to nest box presentation was low and unduly variable. At best, about 40% of pairs laid eggs. During this period, pairs were used which had been allowed to self-select their mates. Pairing was identified either by co-occupancy of nest boxes in large colony flights, or by "clumping" on perches. The photo-period in early breeding trials was maintained constantly at 14 hr. light: 10 hr. dark (14L:10D), because, inexplicably, preliminary work suggested this species was not influenced by changes in photo-period.

However, in 1984, C.R. Grau, Tom Roudybush and I decided to impose additional environmental cues as a means of stimulating egg production. We reasoned that because cockatiels are desert-dwelling, possibly nomadic, possibly migratory, monogamous, cavity-nesting, and granivorous, they might respond to a combination of changes in photoperiod, light intensity, misting, temperature change and increase in the plane of nutrition (Millam et al. 1988). We, therefore, designed a shotgun like cocktail of environmental cues. Over a period of ten days we increased photo-period from nine to 15 hours of light per day, light intensity from 50-250 lux to 500-1200 lux, and temperature from ambient (approximately 20°C) to 27°C. We likewise increased relative humidity by providing several hours of misting each day and the plane of nutrition by first maintaining birds on millet alone for several weeks, then switching to the pelleted diet, and finally, we provided nest boxes. The birds were already caged with self-selected mates in our standard welded-wire cages, in three decks of 12 cages per deck.

Although this trial was done without a contemporaneous control, the results were very encouraging. Within 21 days of nest box presentation, a period of time we have arbitrarily chosen for comparison purposes, about 90% of pairs were laying eggs. Eggs were removed daily for artificial incubation. Compared to earlier trials, chick hatching weight increased by nearly 1 gram, and clutch length also increased. Some pairs produced eggs every other day for two months until the end of the experiment. (There is little doubt that selection for egg number could radically change the reproductive potential of a flock in just a few generations.)

Our next study (and our first controlled study) simply asked whether nest boxes presented during short days (9L:15D) could elicit as much egg production as nest boxes plus the environmental cocktail. The results provided a clear answer. With 21 days of nest box presentation about 90% of the latter group were producing eggs, while only 17% in the short day group. The short day group was then exposed to the enhanced environment and egg production increased to expected levels.

We then began testing whether the plane of nutrition contributed anything to the response. Changing from a millet only diet during the short day period to the pelleted diet during long days made little or no difference. In subsequent trials we likewise eliminated light intensity, temperature, and by default of how bothersome it was to sanitation, misting, although the latter has not been systematically tested and this should be done. At present, we stimulate breeding simply by increasing day length from nine to 15 hours of light (hereafter termed long days) and providing nest boxes. The increase is given on the same day as nest box presentation and in a single step.

Hand vs. Parent Rearing

A second question that concerned us very much from both practical and theoretical points of view was to determine whether rearing chicks by hand had any advantages on reproductive performance as adults (Myers et al. 1988). For captive breeding this is an important question because we could envision gathering large numbers of fertile eggs for artificial incubation only to be faced with a bottleneck of how to care for the young either via assembly-line hand feeding or by using brood hens.

We addressed this question by rearing two groups of birds. One group was hatched from artificially incubated eggs and reared by hand. This consisted of keeping hatchlings in a brooder and feeding them a liquified diet. Until about 18 days of age, these chicks were visually, but not acoustically, isolated from each other as they were housed in cut-off brown paper bags to aid in practical housekeeping matters. At about seven weeks of age they were transferred as a group to colony flight cages. At about six months of age, when males typically molt into a sexually distinctive adult plumage, the genders were separated and placed in same sex flights until 18 months of age.

A second group of chicks were reared in nest boxes by their parents until about six weeks of age. These were then transferred to colony flight cages where they remained until six months of age when they, too, were separated into same sex flights. So after six months of age, we had one flight each of parent-reared males, parent-reared females, hand-reared males and hand-reared females.

At 18 months of age, these four groups were assembled into four groups of breeding pairs: in group 1, hand-reared males were paired with hand-reared females; group 2, hand-reared males with parent-reared females; 3, parent-reared males with parent-reared females and 4, parent-reared males with hand-reared females. Pairs were then transferred to experimental chambers where two breeding trials were conducted. Birds were first maintained under short day conditions for three weeks then exposed to long days and provided with nest boxes (trial 1). After the first trial the same pairs were returned to short day conditions, nest boxes were removed, and after 12 weeks, they were again provided with nest boxes and long days (trial 2).

In both trials pairs containing parent-reared males were more likely to inspect nest boxes. In trial 1, of the two groups containing parent-reared males, eight pairs inspected nest boxes whereas no nest inspection occurred in the pairs with hand-reared males. In trial 2 the numbers were ten and two, respectively.

The deficit experienced by hand-reared males in inspecting nest boxes extended to whether eggs were laid in nest boxes. Again, groups with parent-reared males, especially the group in which both sexes were parent-reared, were more likely to use nest boxes than other groups.

There are two other remarkable features of this study. First, fertility was also greatly influenced by hand-rearing, but *only* in males. Hand-reared females paired with parent-reared males produced fertile eggs, but in trial 1 only 20% of hand-reared males produced fertile eggs as opposed to 100% of parent-reared males. These results suggest that sexual imprinting is gender-specific and to some extent reversible. The implications for captive breeding schemes are obvious. The observations that males are more likely than females to imprint sexually supports current dogma in early learning although this point has been challenged by Ten Cate (1985); we may not have detected evidence of sexual imprinting in females. This interesting possibility deserves more attention.

Second, hand-reared females were more likely to lay eggs and laid more eggs but tended more often to lay them on cage floors rather than in nest boxes. This suggests that females, too, benefit from early experience in later being able to use nest boxes appropriately. Again, as with males, the incidence of using nest boxes improved in the repetition trial.

Why more pairs containing hand-reared females laid eggs is not clear. However, hand-reared female White-crowned Sparrows reared in captivity lay more eggs than wild-reared birds transferred to captivity (Baptista and Petrinovich 1986). The authors attributed this to habitat imprinting. Klinghammer (1967), however, found that hand-reared doves removed before eight days after hatching remained tame to humans but still mated with conspecifics. Thus, one possibility is that hand-reared females may have imprinted on humans. This could have reduced potential stress resulting from handling.

Hand-reared females definitely laid more eggs, but this observation is likely an artifact, secondary to the tendency to lay eggs on cage floors rather than in nest boxes. Eggs laid on cage floors were removed for artificial incubation studies. Their removal was felt to be economic and inconsequential as these very thin shelled eggs invariably crack on the wire floors and, in any event, are not well incubated by the parents. Thus the removal of these eggs likely stimulated egg production.

The conclusions to be drawn from this study have implications both for captive breeding schemes and for plans to reintroduce birds into the wild.

1) The manner in which reproductive performance is assessed depends upon the end point. If one desires egg production for artificial incubation so that chicks can be reared by foster parents, then hand-reared females are highly desirable. However, if chicks are to be parent-reared, both parents should likewise be parent-reared.

2) If chicks are to be released into the wild some care should be given as to the type of nest box in which they are reared as chicks. Habitat imprinting could possibly be used as a means of increasing the use of artificial nest boxes in reintroduction schemes. Conversely, it is possible that chicks reared in artificial nest boxes may not be as competitive in recognizing natural nest cavities as suitable nest sites.

Forced Pairing

Increasing egg production in captively bred populations by means of environmental manipulation and artificial incubation certainly may be suitable for some species. A more general question is: to what extent captive breeding is constrained by the ability of monogamous species to dissolve and form pair bonds? There are several practical questions of captive management that hinge on the plasticity of pair bonds: 1) With what efficiency can pairs be force-paired? 2) Can an already bonded pair be remated with new mates? 3) Is the success of pairing or repairing influenced by gender? age? familiarity? breeding success? 4) Can previously mated pairs be reunited? Is the former bond destroyed?

To answer questions such as these we did a study (Yamamoto et al. 1989) which began in a manner that may seem backwards in that we started with a population of pairs that were already pair-bonded by the operational definition of having had some degree of prior reproductive activity, ranging from incubating fertile eggs to "clumping." We then assembled these birds into five experimental groups: Groups 1 and 2 served as controls. They were maintained under short day conditions, without nest boxes for 12 weeks, then provided with nest boxes and photostimulated for seven weeks. They remained with their mates throughout the experiment but were moved about within the room to control for possible effects of cage movement in the other treatment groups. Group 3 pairs were randomly assigned new mates at the beginning of the short day period and spent 12 weeks with their new "short day (or wintertime)" mates. They were then reunited with their former mates at the onset of long days when nest boxes were presented. We referred to this group as the separate winter vacation group. Group 4 pairs were likewise randomly assigned new mates at the beginning of the short day period and stayed with their new mates for the duration of the experiment.

Group 5 birds were assigned new mates just at the onset of nest box presentation and photostimulation. The difference between Groups 4 and 5 addresses whether a period of time to become familiar with new mates before long days might increase reproductive activity.

We devised a method of scoring reproductive activity that assigned values according to how far each pair progressed from inspection of nest boxes (1 point), to forming nest bowls (2 points), egg laying (3 points, etc.), and finally incubating fertile eggs. Each group's score was averaged weekly. As expected, the two control groups had the highest reproductive scores, and there was no effect of moving the cages around within the room or with respect to each other. Interestingly, Group 3, that group which had spent 12 weeks of short days with new mates and were then reunited with former mates when long days began, had similar scores to control groups. If anything, their reproductive scores in the first days of the trial were higher than other groups suggesting that separating mates and then reuniting them might stimulate early reproductive activity. Absence may make the heart grow fonder. The lowest scores were attained by Group 5 in which birds were assigned new mates at the beginning of long days. Intermediate were those birds in Group 4 which had a period of 12 weeks during which to gain familiarity with their new mates. So being together, even during nonbreeding conditions, did improve later reproductive success although it was lower than in the control groups.

These results support several hypotheses regarding pair formation: 1) Self-selection of mates is important for breeding success. This is probably because a high degree of coordination and synchronization is required in species that show biparental care. But beyond this there can be immediate hazards involved if birds are force-paired. Dr. Cindy Bluhm's work (1985; Bluhm and Phillips 1981) with Canvasback Ducks showed that force-pairing resulted in the death of the male but self-selected pairs reproduced successfully. 2) Familiarity increases the probability of pair formation. This has also been observed in Zebra Finches (Caryl 1976) and ringed turtle-doves (Erickson 1973). It is widely observed, of course, that breeding success improves with experience. 3) Establishing a new mate does not destroy the old bond. This, also, has been observed in Zebra Finches and doves but it must be remembered that the pairs in our study were not acoustically isolated and in Zebra Finches acoustic cues are used to maintain existing pair bonds (Miller 1979).

Force-pairing schemes such as this may be important for genetic selection of desirable traits for producing birds for the pet bird market or for other genetic goals in release programs. In any captive breeding program it may be possible by successive repairing of mates to encourage more promiscuity in breeding.

An open question remains as to whether cockatiels are suitable as a model for psittacine research. Are the results we have obtained likely to generalize to other parrots? The answer to this is probably related to how closely other parrots resemble cockatiels either phylogenetically or ecologically. For example, and in retrospect, many of our results could have been predicted from previous work with budgerigars. For too many species, however, there isn't now enough data to attempt to answer the question. We recently compiled a brief bibliography of English, non-vet med-oriented, refereed literature (Millam 1989). We found less than 200 papers, nearly half of which dealt with budgerigars. The types of studies we are doing (see also Myers et al. 1989; Shields et al. 1989) will be most interesting when similar studies are done with representatives of other phylogenetic branches and ecological niches; work which we have begun with Orange-winged Amazons.

References

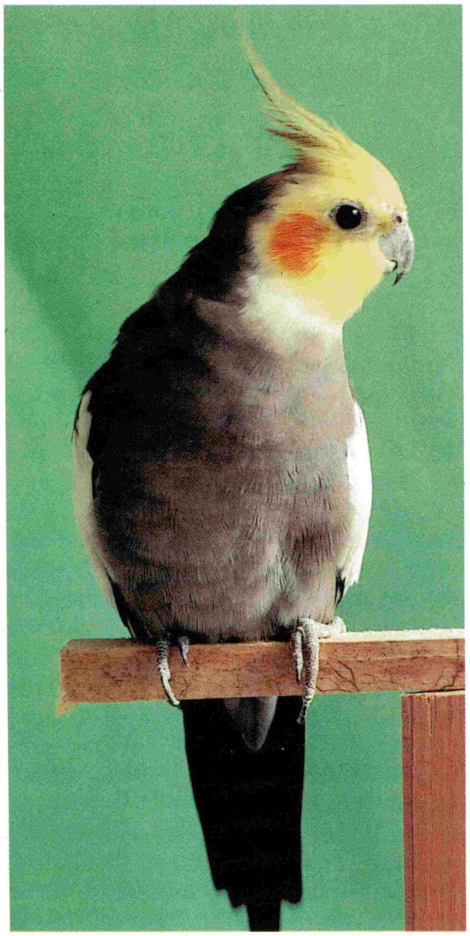
Baptista, L.F. and Petrinovich, L. 1986. Egg production in hand-raised White-crowned Sparrows. Condor 88:379-380.

Bluhm, C.K. 1985. Mate preferences and mating patterns in Canvasback Ducks *(Aytha valisineria)*. Pp. 45-56 in Avian monogamy (A. Gowaty and D.W. Mock, eds.). Ornithological Monographs 37.

Bluhm, C.K. and Phillips, R.E. 1981. Pair formation and breeding ethology of captive Canvasback Ducks *(Aytha valisineria)* at the Delta Waterfowl Research Station. Proceedings of the 1st International Birds in Captivity Symposium: 335-346.

Caryl, P.G. 1976. Sexual behavior in the Zebra Finch, *Taeniopygia guttata:* Response to familiar and novel partners. Animal Behavior 24:93-107.

Photos courtesy of author.



Normal male cockatiel

Erickson, C.J. 1973. Mate familiarity and reproductive behavior of ringed turtle doves. Auk 90:780-795.

Farner, D.S. and Serventy, D.L. 1960. The timing of reproduction in birds in the arid regions of Australia. Anatomical Records 137:354.

Klinghammer, E. 1967. Factors influencing choice of mate in altricial birds. Pp. 5-42 in Early behavior: Comparative and developmental approaches (H.W. Stevenson, Ed.). New York, Wiley.

Millam, J.R. 1989. Exotic Bird Report #9, Department of Avian Sciences, University of California, Davis. January, 1989.

Millam, J.R.; Roudybush, T.E. and Grau, C.R. 1988. Influence of environmental manipulation and nest box availability on reproductive success of captive cockatiels *(Nymphicus hollandicus).* Zoo Biology 7:25-34.

Miller, D.B. 1979. The acoustic basis of mate recognition by female Zebra Finches *(Taeniopygia guttata).* Animal Behaviour 27:376-380.

Myers, S.A.; Millam, J.R. and El Halawani, M.E. 1989. Plasma LH and prolactin levels during the reproductive cycle of the cockatiel *(Nymphicus hollandicus).* General and Comparative Endocrinology 73:85-91.

Myers, S.A.; Millam, J.R.; Roudybush, T.E. and Grau, C.R. 1989. Reproductive success of hand-reared vs. parent-reared cockatiels *(Nymphicus hollandicus).* Auk 105:536-542.

Roudybush, T.E. and Grau, C.R. 1986. Food and water interrelations and the protein requirement for growth of an altricial bird, the Cockatiel *(Nymphicus hollandicus).* Journal of Nutrition 116:552-559.

Roudybush, T.E.; Grau, C.R.; Jermin, T.; and Nearenberg, D. 1984. Pelleted and crumbled diets for cockatiels. Feedstuffs 56:18-20.

Shields, K.M.; Yamamoto, J.T. and Millam, J.R. 1989. Reproductive behavior and LH levels of cockatiels *(Nymphicus hollandicus)* associated with photostimulation, nest box presentation and degree of mate access. Hormones and Behavior 23:68-82.

Ten Cate, C. 1985. On sex differences in sexual imprinting. Animal Behaviour 33:1310-1317.

Yamamoto, J.T.; Shields, K.M.; Millam, J.R.; Roudybush, T.E. and Grau, C.R. 1989. Reproductive activity of force-paired cockatiels *(Nymphicus hollandicus).* Auk 106:86-93.

A version of this appeared in the Proceedings of the Recent Advances in Pet Bird Health and Production and Dedication of the Schubot Exotic Bird Health Center. May 25-26, 1989 at College Station, Texas. ●

Semi-enclosed aviary showing colony flights for cockatiels.