EPIGAMIC AND REPRODUCTIVE BEHAVIOR OF ORANGE-CHINNED PARAKEETS IN CAPTIVITY

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In 1963 and 1964 I studied captive pairs and flocks of Orange-chinned Parakeets (*Brotogeris jugularis*) in order to provide additional information on the behavior of neotropical birds, and to learn how individuals of this gregarious species communicate with one another and with other organisms. Earlier (Power, 1966) I described aggressive and appeasement behavior, peck order, territoriality, reactions to a predator, displacement behavior, and vocalizations. The present report deals primarily with the behavior of individuals as members of pairs, with emphasis on epigamic and reproductive activities. Information on distribution and flock size in the wild, as well as materials and methods involved in this study, is given in the earlier paper.

GENERAL DIURNAL ACTIVITY

For the duration of the study, flocks ranging in size from 4 to 28 Orange-chinned Parakeets were observed at different times in a large outdoor aviary. A regular daily pattern of activity was characteristic of flocks as units; this was termed the "general activity cycle" and consisted of non-nesting birds alternately feeding and resting. The "feeding" or "active" phase of the cycle included movement from roosts to the feeding station, feeding, and movement back to roosts. The "resting" phase of the cycle was a period of minimum movement from place to place, and included stretching, self-preening, ruffling of the body feathers and other aspects of feather care, mutual preening and attentiveness between mates, and periods of sleep and seemingly complete inactivity. Alternating periods of feeding and rest were most noticeable in the morning hours, during which about four periods of activity were discernible (fig. 1), while in the afternoon the activities were performed more by individuals and pairs rather than by the flock as a unit.

Feeding was often accompanied by squawks and other vocalizations, and, since many individuals were brought into a relatively small area by their simultaneous attraction to food, there were marked increases in agonistic encounters. After feeding, the greater part of the flock moved to the uppermost perches of the aviary, and usually separated into pairs. Mates tended to stay near one another during feeding, but their mutual association was more marked during the resting phase. The tendency toward pair behavior at this time seemed strongest in flocks of relatively few members (four) and of second-year or older birds. With first-year birds I observed as many roosting singly as there were pairs, plus occasional groups of three to five or more individuals. During the resting phase the tendency toward mutual preening in first-year birds was noticeably less than in adults. An active period of self-preening and mutual preening lasted from about 5 to 30 minutes, and rather passive and sporadic preening and rest often lasted for as long as an hour thereafter.

Eugene Eisenmann (personal communication) reported that in Panamá the parakeets were social and were usually seen feeding in groups composed of pairs and occasionally trios. Unless the situation was exceptionally favorable, feeding groups usually were not large; four to six birds were commonplace, and sometimes only a single pair was seen.

As the sun was setting the birds began to congregate for the night in the uppermost perches of the aviary. At this time there was an increase in agonistic encounters

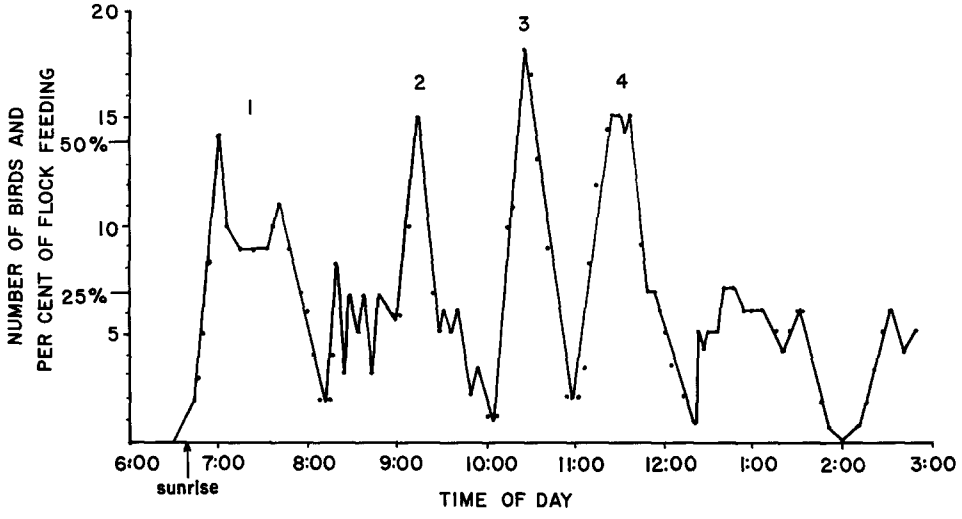

Figure 1. Morning and early-afternoon cycles of feeding and rest (on 18 January 1964). Each point represents the number of birds and the per cent of the flock feeding, recorded at about five-minute intervals.

and a conspicuous increase in vocalizations associated with aggression and annoyance (fig. 2). The initiation of roosting activity appeared to be related to decreasing light intensity, for when heavy cloud cover prevailed the birds usually went to roost several minutes to an hour before sunset. In addition, several birds housed indoors but with a full view of the setting sun would remain active if overhead lights were left on. Fully mature birds usually roosted in pairs sitting side by side, separated from other pairs by a space of a few inches to several feet. The members of any single pair usually perched with bodies touching, a characteristic also of rest periods in daylight hours. Such body contact occurs frequently in many other members of the Psittacidae, as well as in the Columbidae, but is surprisingly rare in other birds. Most birds, even many gregarious species, avoid physical contact except in fighting and copulation. If additional birds joined others already at roost (which rarely occurred without considerable commotion between the intruders and the birds on the roost), all the birds relocated themselves slightly in order to maintain appropriate distances between successive pairs. First-year birds often roosted in pairs, but it was equally common to see them roosting singly or in groups of as many as 12 birds or more. At dusk on Barro Colorado Island, Panama Canal Zone, Eisenmann observed flocks of 20 or more flying to roost, as well as actual roosting flocks of several hundred birds.

Diurnal behavior of a pair with a nest cavity. The typical pattern of diurnal behavior of an isolated pair, housed in a small cage for the duration of the study, was modified when the pair completed excavation of a nest cavity in an artificial termitarium (see Nesting in the Aviary below). The pair began daily resting and nocturnal roosting inside the cavity as soon as it was large enough to accommodate both birds. After completing the cavity the pair began activity later in the morning, spent a greater part of the day in the nest, and went to roost earlier in the evening than they did before the cavity was excavated, even though no eggs or young were present to increase the amount of time adults would ordinarily spend at the nest. Also, the

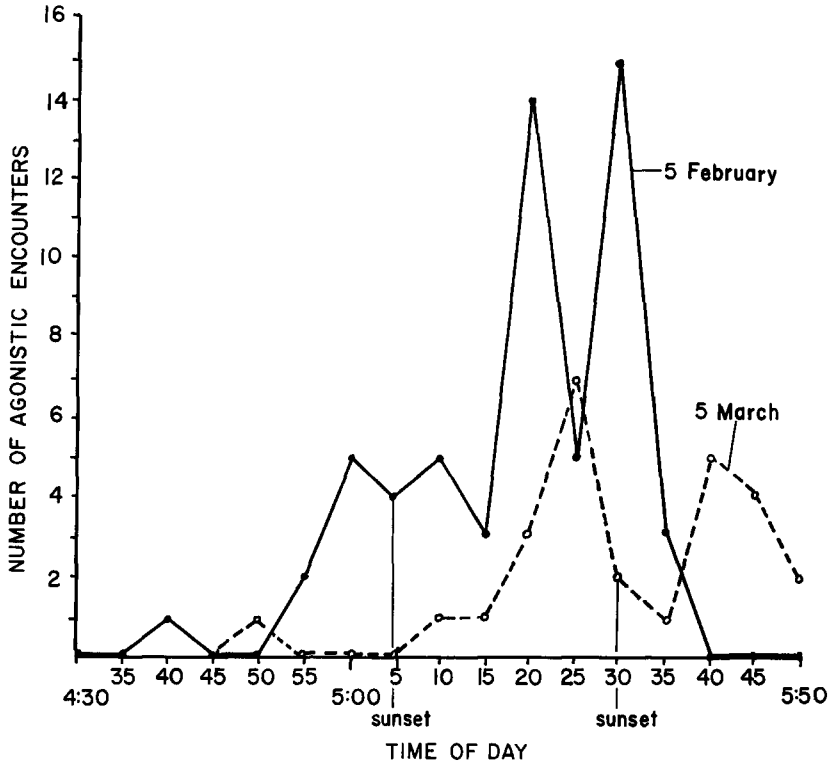

Figure 2. Agonistic behavior at the commencement of roosting on two different evenings. Each point represents the number of encounters involving threat, displacement, or both during the preceding five-minute interval.

pair arose later and roosted earlier than parakeets in a similar cage, but without a nest cavity, just a few feet away. This alteration of the daily pattern was perhaps due to the fact that the pair, being held indoors, even though situated near several large windows, was exposed to less intense early-morning and late-afternoon light than birds housed outside. More likely, however, the increase in frequency and duration of roosting was due to the proximity of the nest imposed by the captive conditions. This same pair, when placed in a room with several cages containing rather vociferous Orange-fronted Parakeets (*Aratinga canicularis*), was active a half hour to an hour earlier in the morning, went to roost about a half hour later in the evening, and stayed out of the nest cavity for greater periods of time during the day than it did when isolated from other parakeets. Orange-chinned Parakeets housed in a large outdoor aviary had available a second artificial termitarium with a prefashioned nest cavity, but did not use the cavity for roosting or for any other purpose during the summer, fall, and early-winter months.

Agonistic behavior of pairs. In aggressive encounters mates frequently acted together in driving away intruding parakeets from nests and favored perches (microterritoriality) and in attempts at mobbing or intimidating potential predators. Increased aggression presumably resulted from heightened territoriality associated with the acquisition and excavation of a nest site, and thus pair formation and the advent

of the breeding season often effected the flock social hierarchy. Two vocal duets, termed *medium-intensity* and *high-intensity antiphonal dueting*, were given by paired birds in a highly aggressive state and required a certain amount of practice until successful execution and consistently precise antiphonal timing were achieved. These topics were discussed elsewhere (Power, 1966).

FLOCK MATES AND THE PAIR BOND

The tendency for birds to roost and feed in pairs, and infrequently in trios, led to the formation of flock mates, a relatively permanent union that was maintained throughout the entire year. Such a bond presumably leads to the formation of breeding pairs in the appropriate season in the wild. Pair bonds were maintained and strengthened not only by close and relatively continual association, but by the acts of mutual preening and courtship feeding performed during the resting phase of the activity cycle.

Mutual preening was directed to the head, nape, and cloacal areas, and its effectiveness in pair-bond maintenance may have resulted from the reduction of aggressive tendencies between mates. In African lovebirds (*Agapornis*) mutual preening only of the head is indulged in by adults (Dilger, 1960). In *Aratinga canicularis* the behavior seems particularly well developed, since preening is directed to the head, wings, and tail, and apparently is necessary for peaceful relationships between mates.

Courtship feeding in its association with mutual attentiveness is similar to that in *Agapornis*, for which Dilger (1960:679–680) believes courtship feeding is not sexually motivated (*i.e.*, copulation), but is rather a means of enforcing the pair bond. The main objective of birds participating in courtship feeding is certainly not the gathering of food, since it most frequently occurred while the birds were at rest, having just fed, or at least when food was available. In courtship feeding one bird of the pair fluffs the plumage and performs a rapid and violent head-bobbing action, the peristalsis-like effect of which forces regurgitant into the mouth. The recipient does not beg to be fed, as is usually common in other cases of courtship feeding (Lack, 1940:169). The feeding bird after completion of head-bobbing, grasps the bill of its partner, so that the bills of the two birds are interlocked and at right angles, and initiates a rapid, head-jerking, or back-and-forth action, during which regurgitant is transferred to the partner. After about six head-jerks the grasp is released, and the bird that has been fed chews and swallows, while the other may begin head-bobbing anew and initiate additional feeding. Since courtship feeding occurred during periods of self and mutual attentiveness, it was often associated with stretching, bill-wiping, mutual and self-preening, and ruffling of the feathers. These may indicate ambivalent tendencies in the performing bird; however, none were frequently or consistently associated with courtship feeding, and they were not considered as actual components of this behavior. It is not certain which member of the pair performs the actual feeding, or if in fact the roles are played consistently. On the basis of observed courtship feedings that accompanied certain copulatory attempts, and on other observations, I assume that the male probably feeds the female in most cases. Courtship feeding by the female, however, is apparently not unusual in captive parrots. Dilger (1960:679–680) cites that in *Agapornis cana* and *A. taranta* females frequently feed their mates in captivity; Hardy (1963:171) reports that in captive *Aratinga canicularis* females of homosexual pairs may perform courtship feeding; and Lack (1940:176) states that courtship feeding in psittaciforms is frequently exhibited

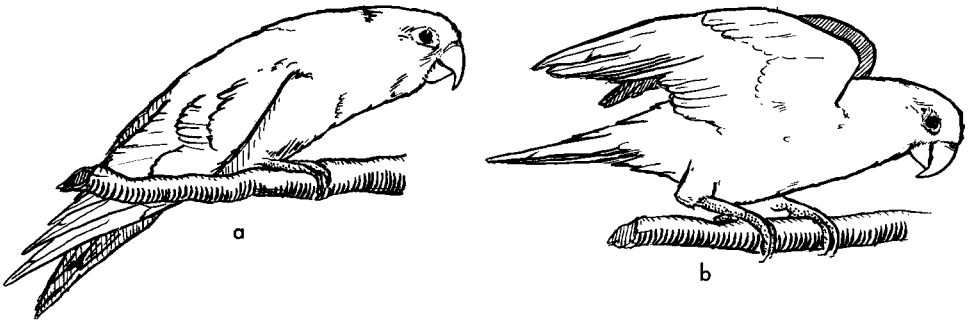

Figure 3. Wing-stretching. (a) Downward and backward extension of the wing, and (b) simultaneous stretching of both wings over the back. Position b exposes bright-yellow, smaller under-wing coverts, which may serve in intraspecific recognition.

by females when in homosexual pairs. In all of these cases, including *Brotogeris jugularis*, it is not known if the female ever feeds the male in the wild.

A rather elaborate series of actions accompanies courtship feeding in the Orange-fronted Parakeet (Hardy, 1963:171–176). Some of the components such as Head-bobbing, Bill-grasping, and Head-jerking are directly involved with the actual regurgitating and subsequent transfer of food; while others such as Head-waggling, Bill-wiping, Perch-biting, Bill-vibrating, and Pupil Flexion are of highly ambivalent character and reflect tendencies other than courtship or consummation of courtship feeding. Head-bobbing is performed to varying degrees in species of *Agapornis* (Dilger, 1960:674–675). Dilger suggests a possible direct correlation in *Agapornis* between the presence of bare or white circumorbital areas and slow Head-bobbing or few Head-bobs. It is interesting to note that in both of the white-eyed forms of *Agapornis* and in *Aratinga canicularis* (which has a yellow circumorbital area) Head-bobbing is slower than in *Brotogeris jugularis*, which has no light-colored bare areas around the eyes.

Courtship feeding in the Yellow-winged Parakeet (*Brotogeris v. versicolurus*) is similar to that in *B. jugularis*. In the former the recipient does not beg or otherwise display to be fed, and the performing bird fluffs the plumage, rapidly and violently Head-bobs, grasps the bill of the recipient, and Head-jerks in transferring regurgitant. In *B. v. versicolurus*, however, there is more frequent Wing-stretching as a prefeeding behavior than in *B. jugularis*. In Wing-stretching in both species of *Brotogeris* the flight feathers of one wing are spread while the appendage is extended downward and backward (fig. 3a). The other wing is then extended in a similar manner; often the leg is stretched backward with the wing on the same side of the body. Both wings are then stretched simultaneously, but not completely extended over the back (fig. 3b). Wing-stretching in *B. v. versicolurus* fully displays the bright yellow and white wing patches characteristic of this species, and it is perhaps significant that in all observations of Wing-stretching as a precourtship feeding behavior the wing on the side toward the recipient was extended more frequently than was the opposite wing.

It was mentioned above that during periods of rest, or immediately following feeding, adult birds usually assorted into pairs, moved to a perch in the aviary, and undertook the various activities associated with self and mutual attentiveness. It was during this time that pair bonds were apparently reinforced, partly as a result of courtship feeding and mutual preening. Wing-stretching was also frequently

performed at this time. In *B. jugularis* Wing-stretching occurred most commonly as birds were about to move from resting sites to the feeding area; such stretching seemed to be in preparation for more vigorous activity.

In *B. jugularis* stretching the wings over the back exposes the bright-yellow under-wing coverts. These are the largest bright-color areas in birds of this species, and it may be significant that the underwing coverts were exposed at times when mates were ordinarily together and mutually attentive. The marks, therefore, may be associated with intraspecific recognition. However, Wing-stretching was not noticeably ritualized, and there was no indication from its frequency that the habit was in fact more than preparation for activity. This was not the case, however, for *B. v. versicolurus*, in which the downward and backward extension of the wing clearly exposes a yellow and white color patch. On the wing all but the outer four to six primary feathers are white, more than half of the secondaries are white and tinged with yellow, and more than half of the greater wing coverts are yellow. In *B. v. versicolurus* Wing-stretching did not occur solely in preparation for activity, but was frequently and repeatedly displayed in courtship feeding. The stretching was performed by the feeding bird and usually involved the wing on the side toward the recipient. It is not certain whether stretching was a courtship display or was indicative of ambivalent tendencies in the performing bird. However, in Wing-stretching we see a habit that may be significantly associated with the distinctive, species-specific color patches. In both species of *Brotogeris* Wing-stretching occurred when mates were normally together, and in *B. v. versicolurus* Wing-stretching occurred frequently and repeatedly during times of courtship feeding and other aspects of mutual attentiveness. As indicated, the habit seems more ritualized in *B. v. versicolurus*.

In *B. jugularis* the orange chin patch, rather than the yellow under the wings, is the color mark first noticed by a human observer, and presumably by another parakeet. However, there were no indications that the chin patch was integrated in any way with the behavior of birds that had been in association with one another for some time (in this case a few months). Two experiments, one involving concealment of the orange chin patch with paint, and the other concealment of the chin patch plus the addition of a bright-yellow forehead patch, were described earlier (Power, 1966). In these experiments a member of a mated pair was removed from the aviary, disguised as described, and returned. From these experiments and other observations it seemed that the orange chin patch was not an intraspecific recognition mark for birds that had been together for several months. In addition, the chin patch was not observed to be used or to be important in any warning or threat display. This is not to say that the specific coloration is not important in intraspecific recognition in the wild. Experiments and observations indicated only that once relationships were established within a flock and between mates, the way a bird behaved (*e.g.*, normally active in its social interaction, as opposed to silent, passive, and "apprehensive" as a bird on unfamiliar territory or with unfamiliar birds) was perhaps more important in individual recognition and acceptance than specific coloration. Other experiments and observations describing these facets of pair behavior were also discussed in the earlier report.

COPULATORY AND ASSOCIATED BEHAVIOR

A nesting pair was seen on two occasions in vigorous but apparently unsuccessful attempts at copulation. The instances occurred in August and October, outside the

presumed normal breeding season. For this reason, the observed behavior may have been slightly modified from the normal or in certain respects incomplete.

In the first instance (5 August) the male sidled toward the female, placed one foot on the perch beside her and the other on her back. The female assumed a receptive posture with tail elevated and head slightly raised, and in this position cloacal contact was apparently achieved. Although the male fanned the tail feathers slightly, neither bird strongly fluffed the plumage, and no vocalizations accompanied the act. Three times while in this position the birds briefly interlocked bills and appeared to begin courtship feeding. The third attempt seemed the most successful, since it was preceded by a rapid Head-bobbing of the male, a behavior that results in regurgitant being brought into the mouth, and following bill contact the female exhibited chewing movements as if she had been fed. Courtship feeding was frequently observed during periods of intense mutual attentiveness, and I suspect that such behavior may always precede copulation in ordinary circumstances. The entire act lasted less than a minute. The birds ceased when they noticed my presence and immediately displayed intense annoyance behavior.

The second instance (24 October) was obviously incomplete since the male failed to mount the female successfully. However, an additional component of male precopulatory behavior was observed; the male fluffed the feathers and briefly stood with head up and body erect before attempting to mount the female. The latter did not assume a receptive posture, and the male did not make a second attempt.

Copulation as briefly observed in this pair of Orange-chinned Parakeets resembles copulatory behavior in *Aratinga canicularis* (Hardy, 1963:189) and *Agapornis* (Dilger, 1960:678) in the following ways: the wings are not quivered by the female during solicitation posture, the male mounts by stepping on the back of the female rather than flying to the position, and no vocalizations accompany the act. One point of contrast is that a male *Agapornis* mounts a receptive female with both feet, whereas males of *Aratinga* and *Brotogeris* place one foot on the female and the other on the perch beside her. Wing-flapping by the male also accompanies copulation in *Agapornis*.

Although I did not observe any ritualized precopulatory behavior per se, I suspect that mutual preening and courtship feeding may be exhibited in the wild and early in the nesting season. One curious component of precopulatory behavior described for *Aratinga* (Hardy, 1963:178–179) and for *Agapornis* (Dilger, 1960:674) is Switch-sidling. In Switch-sidling a male parakeet repeatedly sidles toward and away from the female of his attention, turning around on the perch as he does so. I observed this behavior in an Orange-chinned male during an annoyance situation in which my presence apparently thwarted the execution of some activity. Therefore, the primary motivation for Switch-sidling in *Brotogeris* may be ambivalence, as in the other species. But I did not observe Switch-sidling performed regularly or as a component of epigamic behavior.

NESTING IN THE WILD

In the wild, Orange-chinned Parakeets are hole nesters. Dickey and van Rossem (1938:207) reported that in El Salvador, in January and early February, pairs were seen widening and digging out natural cavities such as knot holes and shallow crevices in dead trees. From one to three pairs were noted digging at the same site, but one center-rotted stump had about 12 pairs excavating in it. This was a most unusual situation, to judge from the degree of aggressive behavior of captive pairs with nests

and the reluctance of pairs to allow other parakeets within a few feet of nests or favored perches. I doubt that 12 pairs could successfully excavate nest cavities, much less raise broods, in quarters as close as these authors suggest. No additional details of nesting are given by Dickey and van Rossem, but I am reluctant to think that in the present study the captive conditions alone were responsible for causing the observed microterritoriality of nesting pairs. Further observation in the wild during the nesting season would be decidedly useful.

Nests may also be constructed by excavation of cavities in arboreal termite nests. Over most of the range of the Orange-chinned Parakeet, however, Orange-fronted Parakeets and Green Parakeets (*Aratinga holochlora*) and several nonpsittacines are the chief users of termitaria, and may preëmpt the most desirable ones, leaving the smaller *Brotogeris* to hunt for other locations. Orange-fronted Parakeets nest almost exclusively in termitaria, and since the species is not found breeding outside the range of the termite *Eutermes* (*Nasutitermes*) *nigriceps*, Hardy (1963:182) postulates that these parrots are not able to maintain populations without the symbiotic relationship with the termites. The South American *Brotogeris versicolurus* is also reported to nest in arboreal termitaria (Seth-Smith, 1926:79). Deserted woodpecker holes are also used when available by *B. jugularis*, but often these are occupied by Ferruginous Pygmy Owls (*Glaucidium brasilianum*).

Since nest excavation in artificial termitaria was observed in captivity (see Nesting in the Aviary, below), a brief discussion of nesting in real termitaria in the wild is warranted. Excavation of nests in terrestrial and arboreal termite nests is not a rare habit, and Hindwood (1959) lists 49 species of birds that are known to do so; included are kingfishers, woodpeckers, parrots, trogons, puffbirds, a jacamar, and a cotinga. A mature termite nest is roughly globular in shape and usually attached to the trunk or limb of a tree, or rarely to a rock. The termitarium is constructed of agglutinated feces and wood debris, forming a dry and relatively hard outer layer surrounding more humid and friable inner layers. The dark-brown matrix contains a system of labyrinthine galleries, which interconnect and lead to the central chambers wherein the termite queen resides and the larvae and eggs are cared for. The entire structure is surrounded by a tan, wood-paste wrapper. If there is damage to the wrapper, hundreds of workers and soldiers move to the site and swarm over the outside of the nest where they seal the ends of the exposed galleries and repair the outer walls. So far as is known, birds always select active termitaria for nesting, for if termites are not present and constantly repairing the termitarium, it soon dries, cracks apart, and falls to the ground. Also, a dried termitarium is hard and brittle, and much more difficult for the birds to fashion a usable cavity. Once a cavity is completed, no contact between the termites and the nesting birds occurs, unless the termites are stimulated to repair further breaks in the wrapper or other extensive damage. The birds usually do not eat the insects, nor do they seem to disrupt the success of the colony in any way. One may assume that harm could come to the colony only if the termite queen were destroyed, which would probably lead to desertion of the nest or extinction of the colony.

The entrance to the parakeet nest cavity usually begins on the underside or lower half of the termitarium and consists of a short, upwardly inclined tunnel leading into the top, or near the top, of a spherical or ellipsoidal chamber within the heart of the termitarium. Since the tunnel opens downwardly, it is not in the direct rays of the sun, and as von Hagen pointed out (cited in Hardy, 1963:186), the termites may not be so greatly stimulated to fill in the tunnel as they might be if the tunnel

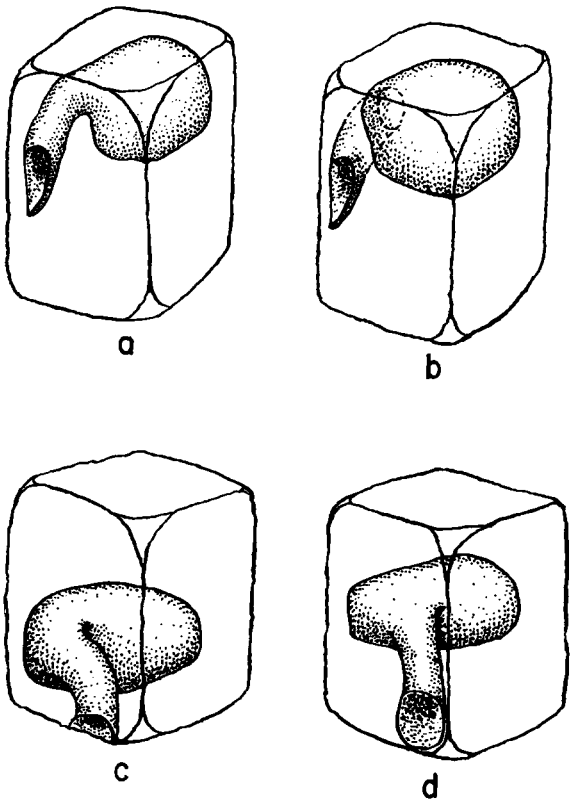

Figure 4. Artificial termitaria: (a) N-1 40 days after excavation had begun; (b) N-1 about five months after excavation had begun; (c) N-2 27 days after excavation had begun; and, (d) N-3 20 days after excavation had begun.

or break were on the upper side of the termitarium and exposed directly to sunlight. In addition, an upwardly facing entrance would be subject to various sorts of falling matter such as leaves, small twigs, and rain, which might hamper nesting activities.

Hindwood (1959) observed that in areas where abundant termitaria occurred there was a greater number of pairs and species of birds nesting in them. If this is the case, then termitaria as nest sites may be superior to holes in trees and in earthen banks. Several important reasons for the superiority of termitaria may be suggested. First, the consistency is such that it is easily excavated, yet it is strong enough to retain the shape of the tunnel and cavity and to support the weight of brooding birds and nestlings. Second, termitaria provide an environmentally stable and sheltered site in which to rear young. Within the galleries the termites maintain a nearly constant temperature and humidity, which probably helps somewhat to stabilize the temperature and humidity inside the parakeet nest chamber. Also, any cavity by its very nature would retain for a limited period of time some of the body heat of brooding birds and nestlings. Third, the young and adults when inside are invisible from the entrance and are practically inaccessible. The elevated position and rounded shape of the termitarium and the position of the passageway with relation to the nest cavity make it difficult for any but arboreal predators to reach

the eggs or young, and give the birds maximum advantage when protecting the nest from within. Fourth, the termites themselves offer protection, for if the termitarium were broken a predator would be exposed to the irritation of swarming insects. Probably snakes would be the most successful predators, and apparently the only record in the literature of predation of a bird nesting in an arboreal termitarium is a report by Gosse (1847:264) of a Yellow Boa entering a cavity and eating a brooding bird.

The interested reader is referred to von Hagen's work (1938), which presents details of the life history of the colonial and arboreal nesting termite *Eutermes (Nasutitermes)*; Hindwood (1959) offers a further discussion and list of birds nesting in the nests of social insects, as well as references regarding this phenomenon; and Hardy (1963) describes nest excavation for the Orange-fronted Parakeet.

NESTING IN THE AVIARY

In order to observe the excavation of nest cavities and subsequent nesting behavior, I provided adult Orange-chinned Parakeets with three artificial termitaria. Each termitarium was approximately 17 × 12 × 10 inches in size and was made of thick, spongy cork. The dark-brown, roughly globular, firm but pliable structures closely resembled actual termite nests.

Excavation procedure. On 11 March I attached the first of the cork termitaria (N-1) to an inside upper corner of a cage housing a male and female parakeet. Evidence of digging—a shallow depression on the face of the termitarium, located slightly above and to the left of center—was first discovered on 14 March. On 22 March the excavation site was about 2½ inches in diameter and inclined steeply upward for a distance of about 3 inches. On the days immediately following, excavation lengthened the tunnel and increased the circumference of the entrance. On 30 March I observed for the first time that an excavating bird was completely concealed from my view if it went as far into the tunnel as possible. The tunnel was approximately 7 inches long, and since the distance from the tip of the entrance to the top of the termitarium was only about 6 inches, I assumed that at about this time excavation of the nest cavity proper had begun. On 31 March the tunnel and cavity were large enough to accommodate both birds at the same time. However, it was not until one or two days later that both birds excavated simultaneously. On 4 April, 21 days after excavation commenced, the cavity was large enough to allow both birds to roost in it overnight. From this time through the remainder of the study the birds continued to roost in the cavity at night. Digging steadily decreased in April. On 23 April I removed the termitarium and sawed the top off about 2 inches below the roof. The roof portion was then fashioned into a lid that could be fastened in place over the nest cavity, yet easily removed to allow examination of the cavity. The termitarium was then placed into its original position within the cage. At that time the cavity was of the shape indicated in figure 4a.

Excavation continued after April, but it was infrequent and often directed to the outer surface of the termitarium. This random digging may have been due to the nearness of the termitarium and to the confined conditions imposed by the cage rather than to any further "interest" in shaping a nest. Eggs were not laid, but the pair continued to use the cavity as a place to roost, apparently in preference to the upper perches of the cage. By late summer the nest cavity had been gradually enlarged and was of the shape indicated in figure 4b. Sporadic and limited digging on the outside of the termitarium was noted during the fall and early-winter months.

The following year I provided the flock of 28 parakeets with two termitaria similar to the one just described. On 20 January both nests were placed high in the large outdoor aviary. The first evidence of digging was noticed on one of the nests (N-2) the next day. On 23 January there was an opening about 2½ inches in diameter and 2 inches long. By 25 January this tunnel was about 4½ inches long, and on 28 January it was long enough to conceal an excavating bird. I assume that at this time excavation of the nest chamber proper had begun. Only sporadic

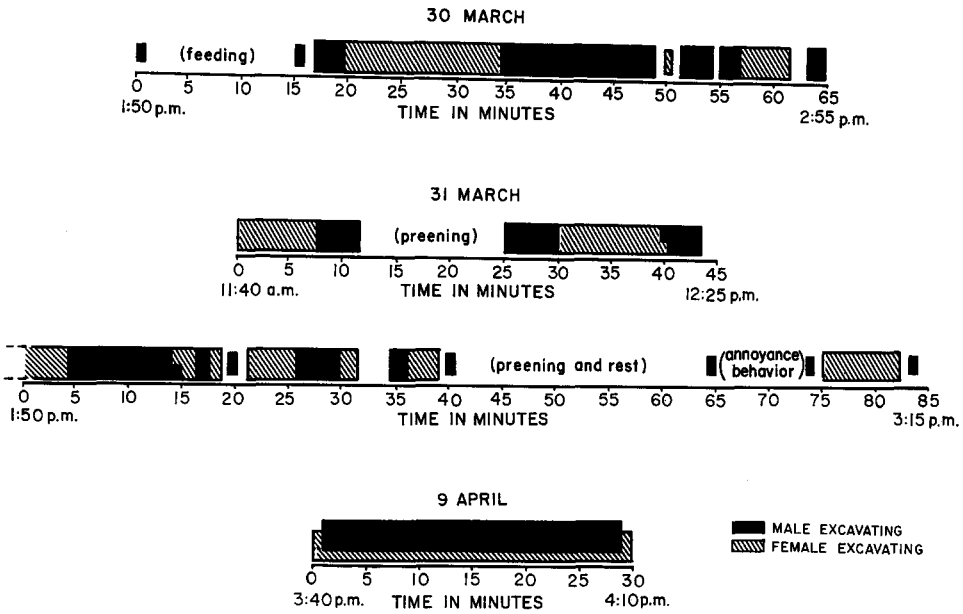

Figure 5. Records of four nest-excavation sessions showing the division of labor between male and female and the time spent digging. Areas reduced in size are abnormal (*e.g.*, excavation very brief or interrupted) and were not included in computing excavation times.

digging on the outside of the other nest (N-3) was observed until 28 January. At this time a pair began more concentrated excavation, and a shallow depression on a lower corner was first noticed. By 14 February the tunnel of N-3 was about 2½ inches in diameter and 7 inches long. On 17 February N-2 and N-3 were of the shape indicated in figures 4c and 4d.

Excavation time. Figure 5 graphically represents several typical excavation sessions and shows the sexual division of labor for each (these data are for excavation of N-1). Male and female usually took turns excavating until the site was large enough to accommodate both birds digging simultaneously. For all sessions observed, the total excavation time was divided almost equally between the birds. Uninterrupted individual excavation time varied from 1 to 30 minutes, but in most cases averaged 4 to 6 minutes. A single, uninterrupted digging session by a pair usually lasted from 10 minutes to 1 hour. In *Aratinga canicularis* both members of a pair participate in excavation, although the male performs most or all of the work until completion of the entrance and commencement of the nest chamber proper. In this species in captive pairs, Hardy (1963:185) states that "the males performed all digging until a bird could enter the tunnel and was out of sight; thereafter the females spent a few minutes (compared to several hours for the male) per day in excavation, usually relieving their mates for a short period."

Excavation behavior. The birds dug with their bills, biting off bits of material and letting it fall to the ground below or onto the nest-chamber floor. I was not able to observe how loose material was removed from the nest cavity, but probably it was pushed by the feet or some other part of the body to the top of the tunnel where it was left to fall away. I never observed material being carried out in the bill.

During a digging session both birds were attentive to that activity, and at no time did I observe one bird excavating while its mate performed an unrelated activity such as feeding or vigorous preening. Before the hole was large enough to allow both birds to dig simultaneously, one bird excavated while the other perched near the front of the excavation. After a short time the two birds would change places. On occasion a waiting bird, after a period of silence and inactivity, seemed to become "impatient" or "anxious" to dig, and paced back and forth on the

perch in front of the nest, climbed over the termitarium, frequently shifted its position near the entrance, or peered or moved part of the way into the tunnel. In a few instances a waiting male entered the tunnel and seemed to force the female to relinquish the excavation site. Quite often an individual not excavating would utter Low-intensity Squawks and "mews" that perhaps indicated ambivalence or served to keep the members of the pair in contact. As the cavity was enlarged, there was sufficient space for two birds to excavate at the same time. This seemed the most satisfactory arrangement, since the previous system of alternation of labor was abandoned, and, judging from the amount of material being removed, simultaneous digging was a more efficient method of excavation. Excavation was almost always directed toward the tunnel and nest chamber, and not until these were more or less complete did the birds dig randomly on the outside of the termitarium.

In a few places along the top of the termitarium, excavation had broken completely through to the outside. These small holes were never enlarged, and digging proceeded in an opposite direction. Light admitted by the holes may stimulate the birds to dig in another direction, thus saving the nest chamber from exposure to sun and rain. In the wild, these small holes would probably be sealed by the termites.

The ability to dig nest cavities that are always essentially the same size and pattern (an upwardly inclined tunnel leading into the top of a rounded chamber) seems to be an inherent trait in the parakeets. This pattern of excavation, however, must be flexible enough to ensure success with various sizes and shapes of termitaria. Thus a negative reaction to light while a bird is excavating would assist in shaping a cavity that fits the termitarium. Hardy (1963:186–187), in an attempt to investigate nest excavation by Orange-fronted Parakeets, provided birds with an artificial termitarium made of white "styrofoam" plastic and coated with brown vegetable dye. He found that although excavation commenced in a normal fashion, at about the time the nest chamber proper was begun the male's pattern of excavation seemed to disintegrate, and the bird thereafter widened the entrance so that it was nearly as wide as it was long. The breakdown in digging was perhaps attributable to the white coloration of the plastic, the light-reflecting and transmitting properties of which prevented the birds from creating a dark nest chamber merely by digging deep into the termitarium.

Certain psittacines, notably those of the African lovebird genus *Agapornis*, utilize material such as strips of paper, twine, and leaves to line a nest cavity (Dilger, 1960). Such material was made available to a nesting pair of Orange-chinned Parakeets, but none was used.

Egg-laying in captivity. None of the parakeets in this study laid eggs; however, successful nesting in captivity is often reported by aviculturists. Mrs. Ruby Hood of Yucaipa, California, told me that a pair of Orange-chinned Parakeets successfully bred and raised four young in an ordinary wooden nest box. Mrs. Hood lined the bottom of the nest with peat moss, but the birds promptly removed the material, apparently preferring to lay their eggs on the wooden floor. This handling of material was perhaps similar to excavation behavior, which would be necessary if the birds were to nest anywhere in the wild but in a deserted cavity or woodpecker hole. Other reports of breeding in captivity cite broods of two and three young (Hopkinson, 1926:86).

Nest sanitation. The cavity was kept relatively free of feathers and material chipped from the termitarium, except for a thin layer of fine cork particles on the cavity floor. Excrement was voided into the tunnel, resulting in a gradual accumulation of deposits along its inner side. Orange-fronted Parakeets do not befoul the entrance to the nest, indicating a possible generic difference in nest sanitation between *Aratinga* and *Brotogeris*.

Relative size of the nest cavity. Most birds that excavate their own nest cavities make them barely large enough to accommodate one adult bird and the eggs or young. This is true for some parrots, such as *Amazona finschii*, the nest cavity of which is often so small that it seems difficult that an adult bird could incubate eggs or brood young therein (Hardy, 1963:188). The Orange-chinned Parakeet constructs a relatively large nest chamber, as is the case for *Aratinga canicularis* (which constructs a cavity about 10 inches in diameter), perhaps because the matrix of the termitarium is soft, allowing easy excavation without undue expenditure of energy, and because members of the pair perform most of their duties at the nest simultaneously.

SUMMARY

This report, the second of two dealing with the behavior of Orange-chinned Parakeets (*Brotogeris jugularis*) in captivity, describes the behavior of individuals as members of pairs, with emphasis on epigamic and reproductive behavior.

General diurnal activity of a flock was primarily in alternate periods of feeding and rest. This activity cycle was most readily discernible during the morning hours. Within the flock, mates tended to stay near one another during feeding, while their mutual association was more marked during the resting phase of the activity cycle. Pairing and mutual attentiveness during the resting phase were more noticeable with second-year and older birds. During daily resting and nocturnal roosting a pair usually perched several inches to a few feet from other pairs and maintained this distance, while mates usually perched with bodies touching, a habit seen frequently in the Psittacidae and Columbidae, but rarely in other birds. An isolated pair with a nest cavity spent more time in that cavity, both at night and during the day, than at roost before they had excavated the cavity, even though no eggs or young were present. However, this may have been due to the nearness of the cavity imposed by the confined conditions.

The tendency for birds to roost and feed in pairs resulted in the formation of flock mates, a union that presumably would lead to the formation of breeding pairs during the breeding season. Pair bonds were maintained by close and relatively continual association, and by the acts of mutual preening and courtship feeding. Courtship feeding involves a rapid Head-bobbing, which brings regurgitant to the mouth (the feeding bird is probably a male in most cases), the interlocking of bills, and Head-jerking in transferring regurgitant to the recipient. Several facets of courtship feeding are compared with the behavior in *Agapornis* spp., *Aratinga canicularis*, and *Brotogeris v. versicolurus*.

Wing-stretching in the Orange-chinned Parakeet is performed in preparation for activity and is not ritualized. It exposes the characteristic yellow smaller under-wing coverts when mates are ordinarily together. In the Yellow-winged Parakeet (*B. v. versicolurus*) Wing-stretching is more ritualized, is performed extensively during courtship feeding, and exposes an extensive bright yellow and white wing patch. It is thought that Wing-stretching, in exposing species-specific color patches, and in being performed when mates are together, may serve in intraspecific recognition.

In copulation the male sidles toward the female, places one foot on her back and the other on the perch beside her. A receptive female assumes a crouched position, with head and tail slightly raised. In this position cloacal contact is achieved. A period of mutual attentiveness, including courtship feeding, probably precedes copulation. The behavior is also compared with that of *Aratinga canicularis* and *Agapornis* spp.

In the wild, Orange-chinned Parakeets nest in natural cavities in trees or excavate nest cavities in arboreal termite nests. In the aviary three nest cavities were excavated in artificial (cork) termitaria, but no eggs were laid. The male and female share equally in the excavation of a nest, digging alternately at the outset and simultaneously when the cavity is large enough to accommodate both birds. A nest consists of a short tunnel, which begins on the lower half of the outside of the termitarium, and is inclined upwardly, opening near the top of a spherical or ellipsoidal chamber in the heart of the termitarium. Much of daily resting and all of nocturnal roosting by pairs were inside the nest cavity as soon as it was large enough to ac-

commodate both birds. The birds befouled the entrance of the nest with excrement, thus differing from Orange-fronted Parakeets.

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