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Parental Behavior of a Bigamous Male Northern Cardinal

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ABSTRACT.—Parental behavior of a bigamous male Northern Cardinal (*Cardinalis cardinalis*) in southwestern Ohio in 1997 is described. The male was neither brighter in plumage nor larger than average. Nesting periods of the two females overlapped. The male provisioned the primary female during incubation but not the secondary female. The male delayed provisioning the secondary female's nestlings until two days after they hatched but then fed both sets of nestlings at rates typical of monogamous males. Despite initially reduced paternal care, the brood of the secondary female fledged successfully. Received 12 Mar. 1998, accepted 15 Nov. 1998.

The majority of bird species are socially monogamous (Lack 1968), the hypothesis being that ecological constraints explain the relative infrequency of polygyny in birds (Emlen and Oring 1977). At the same time, males in most species of socially monogamous birds may have the behavioral capability of becoming polygynous should ecological conditions allow multiple mates (Smith et al. 1982, Wingfield 1984). The description of infrequent cases of bigamy in socially monogamous species is relevant to any discussion of intraspecific variability in mating arrangements. The behavior of bigamous males toward two females and their offspring may provide information on the costs to females involved in such mating arrangements.

Northern Cardinals (*Cardinalis cardinalis*) are socially monogamous and sexually dichromatic; the parental behavior of bigamous males has not been previously described in detail. Here, we document bigamy and paternal care by a male Northern Cardinal observed during 20 h over a 10 day period in early June 1997.

The three cardinals, all of unknown age,

were members of a color-banded population located at Aullwood Audubon Center, 15 km northwest of Dayton, Ohio (39° 52' N, 84° 16' W) and under continuous observation since 1991. The 80 ha property is a mixture of deciduous woodlands, meadows, and prairies where cardinals are abundant. The male that became bigamous in 1997 was banded in the spring of 1996. That year he was successful over several others competing for a territory that had been occupied for several years by a male that disappeared over the 1995–1996 winter. The territory was one of the largest in the study area and among those with the most plant cover, a variable that might provide an advantage to nesting success (Conner et al. 1986, Wolfenbarger 1996; however, see Filliaiter et al. 1994). The male enlarged this territory in 1997 and it became the site of the bigamous mating.

One of the two females paired with this male in 1997 (♀ 650) was banded in 1996 on a territory adjacent to the one he occupied in 1996. This female's mate disappeared in the non-breeding season 1996–1997, as did the mate of the [bigamous] male. Female 650 remained on the same territory in 1997 and the bigamous male expanded his 1996 territory to include the area occupied by female 650. In 1997, this female was treated differently by the male from the manner in which females of monogamous males are treated by their mates (described below), and for these reasons we consider her the “secondary” female of the bigamous male. The other female (♀ 555) had been banded two years previously in an area two territories away from the bigamous male's 1996–1997 territory. She mated in 1995 but was not found in 1996; her 1995 mate retained the same territory in 1996 and mated with another female. Female 555 then reappeared in 1997 on the territory from which the bigamous male's 1996 mate had disappeared. The bigamous male treated female 555 similarly to how monogamous

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males treat their mates, and we consider her the "primary" mate of the bigamous male. We do not know which female first associated with the bigamous male in 1997.

Male cardinals provision their mates during courtship, egg-laying, and incubation (Lemon 1968; Verner and Willson 1969; Breitwisch, Banks, Donahoo, LeClair, and Schilling, unpubl. data); this is considered a form of indirect parental care (Lyon and Montgomerie 1985). We sampled provisioning behavior of the bigamous male toward both females during six 1-h observations on six days of the 12-d incubation period. The nests, located approximately 60 m apart and out of sight of each other, were monitored simultaneously during these observation periods, which included both mornings and afternoons. Neither age of eggs nor time of day influences rate of mate provisioning by male cardinals (Breitwisch, Banks, Donahoo, LeClair, and Schilling, unpubl. data). Primary female 555 began nesting a few days before secondary female 650, and the bigamous male provisioned female 555 at a similar rate ($\bar{x} = 1.00$ feeding/h) to the mean value for the monogamous population [$\bar{x} = 1.05 \pm 0.48$ (SD) feeding/h; Breitwisch, Banks, Donahoo, LeClair, and Schilling, unpubl. data]. However, female 650 received no food from the bigamous male. This is in marked contrast to a sample of 18 monogamous males in the population, all of which provisioned their mates during incubation (Breitwisch, Banks, Donahoo, LeClair, and Schilling, unpubl. data). Although the bigamous male did not provision female 650, he remained active throughout his territory and did not appear to favor the area near the nest of female 555.

Male cardinals feed nestlings at high rates, frequently surpassing the rate at which females feed nestlings (Filliater and Breitwisch 1997, Linville et al. 1998). We sampled nestling feedings by the bigamous male and the two females during 1-h samples on seven days at female 555's nest and six days at female 650's nest. Sampling periods on four of the days were coincident (see below). Observation periods included mornings and afternoons, although Filliater-Lee (1992) showed that neither male nor female feeding rate is related to time of day. The eggs of female 555 hatched three days before the eggs of female

650. The male fed the two nestlings of female 555 at a mean rate of 1.3 feeding/nestling/h, similar to the feeding rate by monogamous males ($\bar{x} = 1.1 \pm 0.53$ feeding/nestling/h; Filliater and Breitwisch 1997). Female 555 fed her nestlings at a mean rate of 0.57 feeding/nestling/h, similar to the feeding rate by females mated to monogamous males ($\bar{x} = 0.87 \pm 0.38$; Filliater and Breitwisch 1997). However, the male did not begin feeding the two nestlings of female 650 until two days after they hatched. Female 650 fed her nestlings at a mean rate of 1.0 feeding/nestling/h, similar to that of females mated to monogamous males. When the male began to feed female 650's nestlings, he fed them at a mean rate of 1.0 feeding/nestling/h, similar to the rate of feeding by monogamous males. During four days, nestlings were present in both nests and the male fed nestlings at both, roughly alternating his deliveries to the two sets of nestlings.

The fates of these two nests differed. The nestlings of the primary female were preyed upon a few days before they would have fledged, but the nestlings of the secondary female fledged successfully. We do not know whether the three adults maintained the bigamous relationship throughout the season.

We determined that the bigamous male was neither exceptionally ornamented nor notably large in body size. Using a technique described by Linville and coworkers (1998), we measured the brightness of the red breast plumage of the male and of the red underwing plumage of the two females. The bigamous male and one other male were tied as the duller in a sample of 14 males in 1997. The bigamous male was also of average body size, as measured by both tarsus and flattened wing arc (R. Breitwisch and S.U. Linville, unpubl. data). The females were both found to be at least equal to the median plumage brightness of 15 females in 1997. Primary female 555 was one score lower in brightness than secondary female 650. We lack size measurements of the two females.

Our observations suggest that there are at least potential costs for a secondary female mated to a bigamous male cardinal. Most dramatically, the bigamous male failed to provision the secondary female during incubation. A monogamous male typically provides ap-

proximately 150 feedings at the nest during the 12-d incubation period and probably supplies the female with a significant amount of food away from the nest (Breitwisch, Banks, Donahoo, LeClair, and Schilling, unpubl. data). The high rate of mate provisioning indicates that the amount of food provided may be important to the female's nutritional state, especially when considering the three or more clutches of eggs laid by a typical female in this population during a breeding season (Filliater et al. 1994). The bigamous male's behavior toward the secondary female's nestlings was not typical of monogamous males in this population. Although the male eventually began to feed the nestlings and did so at a rate typical for monogamous males, he delayed two days after these nestlings hatched before beginning to feed them.

The primary contribution of male cardinals to raising young appears to be provisioning the female, nestlings, and fledglings. Guarding and active defense against predators are of minor importance and effectiveness (Filliater et al. 1994, Nealen and Breitwisch 1997). Thus, we think it unlikely that any reduced level of these components of paternal care were a significant additional cost of bigamy to either female.

Bigamy in cardinals appears to be quite rare (see Linville and Halkin, in press). Lemon (1968) observed two cases in which he noted that the females "less tended" by the bigamous males eventually left and were probably unsuccessful (R. E. Lemon, pers. comm.). In our own studies, the instance of bigamy described here is the first witnessed in seven years of monitoring mating relationships in this population. Each of the last six years, we have observed an average of about 20 territories, suggesting that the incidence of bigamy is probably less than 5% [Verner and Willson's (1969) criterion for monogamy] and may be even less than 1%. Two other researchers have not observed bigamy in multi-year studies with a combined sample size of more than 50 pairs (G. Ritchison, pers. comm.; L. L. Wolfenbarger, pers. comm.). D. M. Scott (pers. comm.) and R. E. Lemon (1957, 1968, pers. comm.) have records of at least three bigamous males in multi-year studies of more than 50 pairs of cardinals, al-

though Scott (pers. comm.) agrees with the above estimate of less than a 5% incidence.

It has been hypothesized that staggered timing of nesting by two females mated to a bigamous male may be critical to reducing the cost of bigamy to the females (Verner 1964, Breitwisch et al. 1986, Derrickson 1989). Bigamous males should be able to apportion care more easily when nests do not overlap in time. Obviously, we cannot know if the bigamous cardinal would have provisioned the secondary female if her incubation period had not overlapped with that of the primary female. Second, with staggered nesting, a female occupied with caring for eggs or nestlings might display reduced aggression toward a second female attempting to nest (Derrickson 1989). Although female cardinals can be very aggressive toward other females (R. Breitwisch, pers. obs.), we did not witness aggression between the two females we observed.

In any case, the secondary female cardinal was successful in producing fledglings despite limited paternal care. Richmond (1978) removed male cardinals from nesting pairs and also found that females were able to raise young by themselves. We speculate, as did Richmond, that neglected females may still pay a cost in future survival from such high parental effort.

The question that remains is whether a secondary female in a bigamous relationship is making the correct decision at the time of pairing with a male or committing an error. It seems likely that there is no single answer to this question. In some monogamous species, secondary females may be able to "predict" that their young will receive paternal provisioning [e.g., Northern Shrikes, *Lanius excubitor*, and Loggerhead Shrikes, *L. ludovicianus*, (Yosef 1992)]. In others, lack of paternal provisioning may be equally predictable [e.g., Song Sparrows, *Melospiza melodia* (Smith et al. 1982), Florida Scrub Jays, *Aphelocoma c. coerulescens* (Woolfenden 1976)], or paternal provisioning may depend on degree of overlap in nesting [e.g., Northern Mockingbirds, *Mimus polyglottos* (Logan and Rulli 1981, Breitwisch et al. 1986)]. Moreover, there are other factors that may be involved in determining level of paternal care at nests of secondary females, both in species that are opportunistically bigamous and those that are typically

more polygynous. These include the degree to which an aspect of paternal care is shareable, the age and number of nestlings, and the male's confidence of paternity (Searcy and Yasukawa 1995). Explanations of such varied patterns will await additional reports on bigamous relationships in socially monogamous birds.

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