

NEST-RELATED ACTIVITIES OF BLACK-BILLED MAGPIES

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Black-billed Magpies (*Pica pica hudsonia*) are common and conspicuous residents in many areas of western North America. Magpies are sexually similar members of the Corvidae and are intermediate in size between other North American corvids, the crows and jays. Their predation on eggs of gamebirds and their habit of feeding on grain and other livestock forage in feedlots have led to the classification of magpies as pests over much of their range. In spite of the species' abundance and economic importance, many basic aspects of its breeding ecology and behavior are poorly or only superficially known. Linsdale (1937) reviewed the available literature on magpies and reported some personal observations, primarily on the Yellow-billed Magpie (*Pica nuttalli*), regarding ecology and behavior. Evenden (1947) commented on nest heights and location, clutch size, incubation periods, and nestling periods for several nests in Idaho. Breeding ecology of Idaho magpies was studied by Jones (1960). Available information regarding activities of magpies in relation to their prominent nests, however, remains largely speculative or anecdotal. This report concerns nest ecology and nest-associated behavior of magpies near Laramie, Wyoming.

METHODS

Field observations were made from December 1964 until December 1966. Intense observations were made during the period from March through July in 1965 and 1966. Detailed information on nesting behavior was obtained primarily in the 1966 breeding season when nests at which one or both birds were marked were observed for certain time intervals (usually 30 minutes) during various nesting stages. Portable blinds were employed, but most observations were made from a car. These observations were made at distances of over 100 yards from nests, and nesting birds were apparently not disturbed. Behavioral data were recorded in symbolic form. Ecological data concerning nest-building chronology, clutch-initiation dates, and clutch size and information regarding nest defense were obtained by visiting nest sites.

The major study area was located in timbered bottomlands of the Big Laramie River about 14 miles southwest of Laramie. Some observations were made on Sand Creek, which is three miles south of the major study area. The river area is at about 7200-foot elevation and is bordered by narrow (generally less than 100 yards wide) stands of cottonwood

(*Populus* spp.) trees and, in the wetter areas, willows (*Salix* spp.). Vegetation beyond the timber is a mosaic of irrigated hay meadows and vegetation characteristic of the cool desert. Vegetation in that part of Sand Creek studied is nearly exclusively willows bordered on either side by extensive greasewood (*Sarcobatus* spp.) flats.

Free-ranging magpies were trapped for banding and marking by means of funnel-entrance type traps. Jack-rabbit (*Lepus townsendi*) carcasses were generally used as bait. In addition to trapped birds, nestlings were banded. A total of 238 magpies were banded during the study; 137 of these were marked. Methods of marking birds followed those of Hester (1963). In brief, this procedure involved attachment of a vinyl plastic tag to the patagium of the right wing with an aluminum clip. Tags were spoon-shaped and were provided with letter-number combinations by means of vinyl plastic paint.

Trapped birds were aged by the methods of Erpino (1968). Behavioral indicators were used in sex determination in the breeding season. During courtship feeding, females alone solicited and received food. Females incubated; males did not.

The statistical analyses employed were taken from Freund (1960). The 5 per cent level of significance was used in all tests.

NEST CHARACTERISTICS

Nests examined in this study were similar in size to those studied by Linsdale (1937:83-86) and Jones (1960). Construction materials and nest-bowl lining components, however, apparently exhibit local differences. Nests in the present study consisted of a twig (cottonwood twigs on the Laramie River area and greasewood twigs on the Sand Creek area) superstructure, roughly ovoid in shape, inside of which was a chamber and nest bowl. The chamber was usually near the center of the superstructure, and thus a substantial framework of twigs surrounded the nest chamber except at the entrance. All nest bowls consisted of mud and were lined with grass, rootlets, and cattle hair. Most commonly, there was a single entrance to the nest chamber. Compass orientation of the entrance hole(s) could not be determined accurately.

Completed magpie nests were durable, and many nests persisted, some with only slight signs of decomposition, for at least four years. This durability resulted in accumulation of many nests within the study areas. Obviously, such factors as degree of exposure to wind and weather and the nature of construction

TABLE 1. Numbers of active nests in various height intervals above ground level.

Nest height, interval in feet	1965 season	1966 season	Per cent in interval
0-5.5	0	1	0.8
5.6-10.5	33	31	50.8
10.6-15.5	16	13	23.0
15.6-20.5	8	9	11.9
> 20.6	8	9	13.5
Totals	65	63	100.0

influenced the longevity of any given nest. New nests, built in the year they were first used, were characterized by fresh construction materials and the presence of fresh twigs on the ground beneath the nest.

Estimates of bowl heights of active nests were recorded during both nesting seasons (table 1). Differences in frequencies of nests in various height categories were not significant between the two years. Linsdale (1937: 76-80) noted that Black-billed Magpies usually nest near the ground in contrast to Yellow-billed Magpies, which often build nests in the tops of trees. About one half of nests used in the present study were placed more than 10 feet above the ground.

Active nests were located in both willow and cottonwood vegetation. Whether or not one of these vegetation types was preferentially used was not determined.

NEST DURABILITY

As mentioned above, magpie nests may remain at least partially intact for long periods. Several ecologic roles of nests remaining from past seasons, or nests otherwise unoccupied, were recorded. These other aspects of nest-use, in addition to the nest's invulnerability to at least some types of predators (see below), may have influenced the origin of certain characteristics of magpie nests.

Original nests. Three different situations regarding nests used in original reproductive attempts were noted: (1) in most cases an entire new nest was constructed, (2) less frequently a new bowl and superstructure were added to a pre-existing superstructure, or, rarely, (3) the bowl of an old nest was remodeled with little or no apparent alteration of the superstructure (table 2). These data are from nests where a high level of assurance existed that clutches represented original attempts. Original nests were distinguished to some extent on the basis of date of clutch initiation. More exact indicators of original nestings involving utilization of old nests were, however, nesting behaviors of pairs in various

TABLE 2. Numbers of various nest types utilized in original nesting attempts.

Year	Completely new nests	New bowl and superstructure on old superstructure	Old nests
1965	40	2	1
1966	40	5	3
Both	80	7	4

woodlots. When protracted activity was observed around old nests, and this activity occurred before oviposition in other nests in the study area, clutches laid in these nests were considered to be originals. The possibility remains, therefore, that old nests were used somewhat more extensively for original nesting attempts than is indicated herein. Tentatively, findings in the present study were in agreement with Linsdale (1937:95) who believed that magpies generally built a new nest each year.

Renesting. Seven renestings involving marked birds indicated that old nests were used in renesting attempts. These re-nests averaged about 50 yards from original nests. Other presumed re-nests also employed old nests, or as noted on three occasions during the two seasons, new nests of other magpies in which clutches had been destroyed. Re-nests were not safely distinguished by either clutch size or date of clutch initiation.

Observational data on early stages of renesting were obtained for only two pairs of magpies since most re-nests were not discovered until some time after clutch initiation. With these pairs, the bowl of an old nest was cleared and a new grass lining was added. Additions to the twig superstructure were minimal. New twigs were not noticeable on other re-nests, and, moreover, old nests used in renesting were in generally good condition. Overt sexual behavior during oviposition at re-nests was similar to that observed during oviposition in original nests. Renesting intervals, or the time from destruction of the first clutch until initial oviposition in the second nest (Sowls 1955: 132-133), averaged 13 days in five nests and did not appear to be correlated with the stage at which the original clutch was destroyed. This renesting interval was similar in length to the period of nest-bowl lining and contouring in original nesting attempts. Only single renesting attempts were recorded, and, as previously mentioned, renesting following brood destruction was rare; only one such instance was noted in 1965, and none was observed in 1966.

Since new nests were usually built each year, it is probable that nest construction normally accompanies most initial nesting attempts. Interactions between birds and their nests, as well as between mates while nest-building, may provide stimuli that enhance gonadal maturation. The use of old nests for renesting, and the nature of this use (extent of remodeling), suggests that sufficient physiological priming for production of a second clutch is incurred through participation in the terminal stages of nest-building. The adaptive significance of using old nests may be related

TABLE 3. Frequencies of observations of magpies building nests.

Date	1965 season			1966 season		
	Number of groups ^a	Number building	Per cent building	Number of groups ^a	Number building	Per cent building
16-28 February	46	0	0	51	0	0
1-15 March	55	0	0	90	3 ^b	3.3
16-31 March	52	0	0	128	19	14.8
1-15 April	136	27	19.9	108	19	17.6
16-30 April ^c	82	37	45.1	—	—	—
1-15 May ^c	65	3	4.6	—	—	—
16-31 May ^c	55	0	0	—	—	—

^a A group = a single observation of any number of birds.

^b All three instances were on 14 March.

^c Observations by late April 1966 were not comparable to same period in 1965.

to a possible element of confusion that this activity presents to potential predators. Newly constructed nests, for example, were rather conspicuous (to the author, at least) and few in number in comparison with old nests in all woodlots. One woodlot contained 40 old and eight new nests early in the 1965 season. All of the new nests were destroyed and thereby added to the population of old and unoccupied nests. One of two known renesting attempts in the woodlot produced fledged young. Thus a predator could conceivably locate and maintain surveillance on new nests with a minimum expenditure of energy and a high assurance of eventually securing prey. For a predator to visit all nests repeatedly in a particular woodlot, however, could result in a net loss of energy.

Winter roosting. During the winter months magpies were observed entering and remaining in old nests after sundown. Birds were also observed leaving old nests shortly after dawn. These observations suggested that old nests were used to some extent for night roosting. Accumulations of fecal material within the bowls of roosting nests were often extensive, probably reflecting repeated use of particular nests.

Old nests could have afforded some protection from weather and from nocturnal predators. In this context it should be mentioned that severe snowstorms and cold periods are not uncommon in this area during late April and May. Protection imparted by the nest to birds incubating eggs or brooding young in these storms may have been significant.

Use by other vertebrates. Rockwell (1909) suggested that most passerines inhabiting areas where magpies breed seek refuge in magpie nests during rain and hail storms. He further reported that various owls, hawks, and some passerines nested in unoccupied magpie nests. At least three pairs of Great Horned Owls (*Bubo virginianus*) nested in old magpie nests during both years of the present study. Two Mallards (*Anas platyrhynchos*) and one unidentified duck nested in old magpie nests in 1965. An adult female and three young raccoons (*Procyon lotor*) were located in an old nest in July 1965.

NEST-BUILDING BEHAVIOR

Chronology. Fragmentary data were obtained on early stages of nest-building. Although many observations were made during the presumed period of nest initiation, few nests were located until construction was well under way. This suggests that very little time per day was spent on construction in early stages, or that nest-building behavior was easily thwarted, for instance by the presence of the observer, during this period, or both. Birds carrying mud (in the bill), which probably represented the beginning of nest-building, were noted from late February through early April in 1965 and from late February through early March in 1966. Carrying behavior was most common approximately two weeks before intense nest-building activity in both seasons.

Intense nest-building activity, as indicated by the frequency of observations of birds building nests (table 3), was under way by mid-April in 1965 and by mid-March 1966. The latest incidents of building were recorded in early May in 1965 and in late April in 1966. Frequencies of observations of two-bird groups (presumed pairs) were highest during the peak of nest-building activity during both seasons (fig. 1). An apparent correlation existed, therefore, between building activity and the incidence of two-bird groups. Data in figure 1 also suggest that activity involving pairs was initiated earlier in 1966 than in 1965. The extended period of a high incidence of pairs later in the 1965 season may have reflected renesting activity, which was greater in 1965 than in 1966.

Diurnal variations in building intensity were recorded during both nesting seasons. In brief, while building was observed at all times of the day, it was most commonly noted from shortly after sunrise until mid-day. Activities of magpies during the afternoon primarily involved foraging. Early in the nest-building period, magpies still formed larger feeding flocks

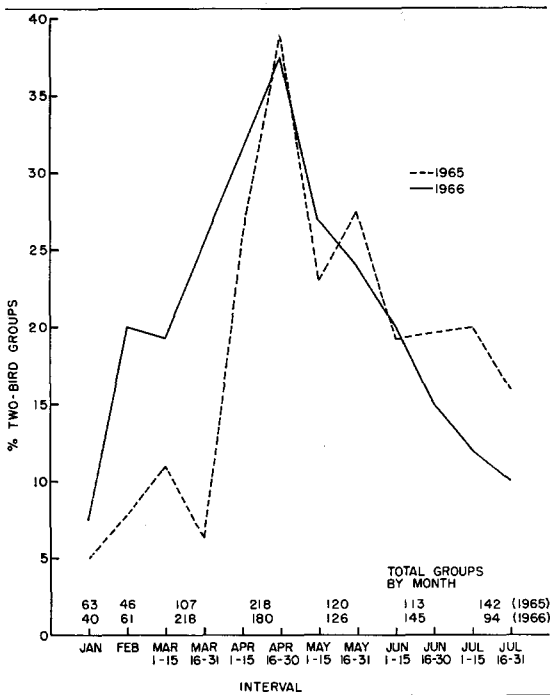


FIGURE 1. Incidence of two-bird groups plotted at half-month intervals from March through July.

characteristic of the prebreeding season in early morning. After sunrise pairs from these flocks appeared at nest sites and engaged in building. After initiation of laying, flock feeding became relatively rare. Little information on effects of weather disturbances on nest-building behavior was obtained. On at least three occasions, however, sudden snow and rainstorms temporarily halted building activity.

Stages in nest construction. Four distinct stages were evident in construction of nests. These consisted of an anchor, superstructure, mud bowl, and lining, in approximately that sequence.

Nest anchors made of mud comprised the base of the nest in early construction and formed the bottom of the mud bowl in completed nests. I found only one anchor having no evident superstructure. This consisted of mud placed in a crotch formed by branches from a larger trunk in the tree housing the incipient nest. Other nests discovered in early stages of construction were always equipped with anchors.

Sticks and twigs inserted into the anchor constituted the beginning of superstructure construction. In early stages of development these had ample bottoms and canopies but only sparse sides. The sides of the superstructure were therefore probably constructed last. Addition of twigs to the superstructure continued at decreasing intensity through the next two building stages.

When the superstructure was nearly complete, the birds began building the mud bowl of the inner chamber. In three nests mud was built up from the periphery of the now-flattened mud anchor. Addition of mud to the upper lip of the newly forming bowl

produced a deep cup within the nest chamber. Most often, the walls of this cup were attached to the inside superstructure wall. In several nests, however, the topmost edge or rim of the mud bowl was separated from the superstructure wall.

Upon completion of the mud bowl, it was lined with grass, hair, and rootlets. Two substages were identified during the period of lining. These were (1) the placement of the lining material within the bowl and (2) the shaping or contouring of this lining before oviposition. The latter stage perhaps had important behavioral-physiological consequences, as discussed below. There was no noticeable addition of material to the twig superstructure after construction of the lining.

The stages of nest construction by magpies, particularly of anchor (base) construction followed by addition of the roofed superstructure, were similar to those reported for other birds that build nonpensile roofed nests (Collias 1964). Various benefits ascribed to possession of roofed nests include protection from predation, shedding of rain, and shading from solar radiation. Results in the present study indicated no clear-cut advantages in utilization of roofed nests by magpies. Eggs and young were heavily preyed upon, the canopy was not impervious to rain or snow, and solar radiation probably did not pose a serious threat to nest contents. Several observations of attempted predation by Great Horned Owls and Common Crows (*Corvus brachyrhynchos*), however, suggested that magpie nests could not be negotiated by these species. Mammalian predators, probably raccoons, may have accounted for most observed predation. Probably owing to the protective roof and sides, incubating and brooding females were rarely caught by predators; this fact may have some significance in the evolution of magpie nests.

Unless both birds were collected while building, nests that were initiated were completed and received eggs. False nest-building, as reported by Linsdale (1937:93), was not observed.

Time required in nest construction. Few data were obtained concerning the time required for construction of the anchor and rudimentary superstructure. If the period of mud-carrying mentioned previously indicated anchor construction, perhaps slightly less than three weeks were spent in the anchor-rudimentary superstructure interval. Data from six nests indicated that an average of slightly less than nine days was required for completion of the mud bowl. An average of 14 days between the beginning of the grass lining and initial ovipositions was derived from 33 nests. The period of contouring (when noticeable amounts of lining materials were not added)

TABLE 4. Sex roles in nest-building behavior.

Nest	Total minutes observed	Number of observation periods	Number trips to nest by sex		Days from first session to initial oviposition
			Male	Female	
2C2b	366	9	40	18	31
1E1a	184	4	25	24	25
2E1c	90	3	1	1	16
1C2a	258	8	24	16	24
2D1d	247	7	7	3	12
Totals	1145	31	97	62	21.6 (ave.)

averaged 11 days (range 7–16 days) in 29 nests. It was inferred from these data that between three and four days were spent in significant addition of lining material, and that there was a period averaging 11 days before oviposition when there was little, if any, addition of material. From the foregoing information, an approximate average period of 43 days was required for completion of a nest. Information from Linsdale (1937:94) suggests that Black-billed Magpies spend five to seven weeks in nest construction.

Sex roles in building. Only members of a pair were observed building a particular nest. Communal nest-building as reported in Mexican Jays (*Aphelocoma ultramarina*) by Hardy (1961:35–36) was not noted.

Most data on sex roles in nest-building were obtained at nests varying in degree of completion from early mud-bowl construction to clutch initiation. Information derived from 1145 minutes of observation at five nests is summarized in table 4. Comparatively few building trips were recorded to nests 2E1c and 2D1d, both of which were observed largely after the peak of nest-building activity. If data for the 11 days before oviposition when little material was added to the nest are omitted, males made a total of 84 trips and females a total of 49 trips to the nest. Assuming that one male or one female trip resulted in equivalent material addition to the nest, males contributed significantly more than females to nest construction. Observations during several sessions indicated that males did, in fact, transport more material per trip than did females.

Nest components were carried to the nest and incorporated into it by both sexes. Sticks and twigs used in nest construction were gathered from the ground near the nest, broken from trees in the vicinity, or, rarely, taken from old nests. Other nest materials were collected where available near the nest.

Attentive periods during intense nest-building averaged about one minute per visit for both sexes.

Sexual behavior during nest-building. Overt sexual behavior (displays) was observed sporadically in males up to 26 days before oviposition. Intense displays, typically incomplete, began about five days before oviposition. Furthermore, as the time of clutch initiation neared, males became more attentive to females; *i.e.*, males appeared to follow females in the vicinity of the nest, and maintained close company with females while foraging. Apart from nest construction, females appeared to visit nests casually and occasionally to sit in them for short periods in the nest-contouring period. Displays by females, incomplete as in the male, were noted as early as five days before clutch initiation. The term "incomplete" means here that component consummatory acts of courtship feeding occurred in both sexes during final stages of nest-building but that terminal acts of courtship feeding (including postures and vocalizations) were not observed. The earliest known instance of culminated courtship feeding was noted on the day before the initial oviposition.

Lehrman (1961:1273–1274) noted that nest-building behavior in many birds was most intense just before ovulation and, furthermore, that the maximum rate of ovarian follicular growth occurred during nest-building. Available information on other American corvids indicates that intense nest-building activity begins about eight days before oviposition in the Clark Nutcracker (*Nucifraga columbiana*) and about five days before oviposition in the Blue Jay (*Cyanocitta cristata*), according to Mewaldt (1956) and Hardy (1961:41–42), respectively. Magpies, in contrast, stopped intense building activity some 11 days before oviposition and, moreover, showed little sexually oriented behavior until about five days before oviposition. These data suggest that final gonadal maturation occurs in the period of nest-contouring. Preliminary analyses of testes, however, showed that full spermatogenesis occurred during construction of the mud bowl (two to three weeks before clutch initiation). In contrast, one female collected

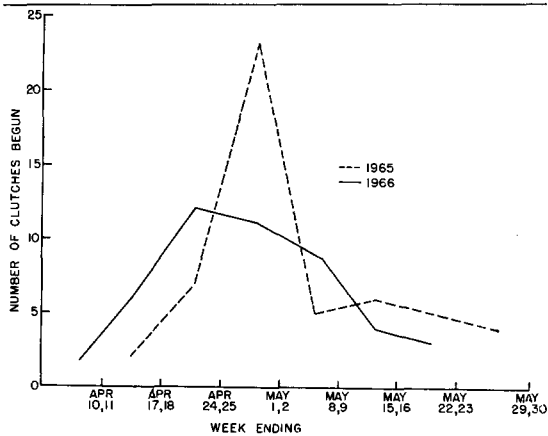


FIGURE 2. Clutch initiation dates plotted at mid-week intervals.

near the beginning of the nest-lining period had no greater macroscopic enlargement of ovarian follicles than females collected during earlier nest-building stages (Erpino, unpublished data). Social interaction with the male and perhaps visits to the nest during the period of contouring were probably involved in induction of final ovarian maturation.

Intraspecific relationships. Preliminary analyses of my data regarding social organization and ethology of magpies can be summarized as follows. Social behavior was characterized generally by toleration of conspecifics; overt aggression was not common at any time of the year. Nest-associated territoriality, by individuals, pairs, or flocks, was not evident.

Active nests in similar stages of the cycle were often close together. In 1966, for example, six simultaneously active nests were located in a woodlot about 120 yards long and 40 yards wide. Several other clusters of three to five nests were noted in both seasons, but it was unclear whether these represented a form of colonial nesting or merely chance associations.

EGG-LAYING

Chronology and phenology. Linsdale (1937: 104-105) presented data suggesting that most egg-laying occurred in April in Nye County, Nevada. Jones (1960) observed egg-laying from mid-March to late June in Idaho. Frequencies of initial ovipositions in all nests in the present study are illustrated in figure 2. These data indicate that oviposition occurred earlier in 1966 than in 1965 and support observations suggesting an earlier nesting season in 1966, as mentioned previously. The proportion of total clutches initiated in the last three weeks of April 1965 (9/48) was significantly

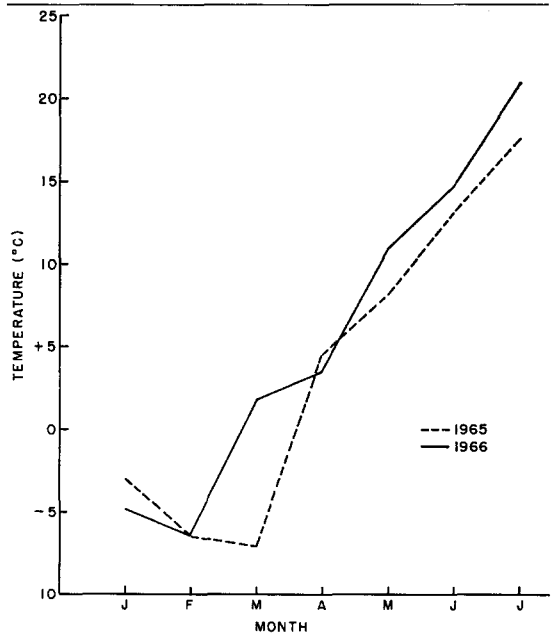


FIGURE 3. Mean monthly air temperatures in the study area for January through July.

less than the proportion initiated in the same interval in 1966 (19/46).

Exogenous stimuli that have been shown to influence timing of avian breeding include environmental temperature (Davis 1955; Marshall 1961). Temperature data for the two seasons of this investigation are presented in figure 3. Temperatures in April (the month of initial oviposition) were similar in the two years, but March (nest-building) temperatures averaged 9°C higher in 1966 than in 1965. These data suggest that higher temperatures during the prolonged building period may have permitted earlier oviposition. Conversely, low temperatures in 1965 may have delayed oviposition. Variations in temperature have been demonstrated as influencing primarily the time of ovulation itself (cf. Dane 1966), but it would appear in the present case that favorable temperatures occurring in the month before but not necessarily during ovulation influenced the timing of egg-laying. Marshall (1961) noted that published reports of temperature effects on timing of oviposition were rare during the "acceleration phase" (into which category nest-building would fall). That ovulation in magpies may not be greatly influenced by temperature was suggested when several periods of cold weather in late April 1966 did not suppress laying. Low temperatures did not inhibit gonadal development in captive House Sparrows (*Passer domesticus*), according to Kendeigh

(1941). He noted, however, that demands imposed by processes such as nest-building might require expenditure of energy in excess of that needed for gonadal maturation alone. Effects of temperature on timing of breeding may therefore be indirect.

A few data were obtained concerning the effects of the age of the female on laying chronology. In 1966 eight original clutches of adult females were begun on the average on 17 April; five original clutches of first-year females were begun on the average on 2 May. This suggests that adult females oviposited somewhat earlier than first-year females.

Clutch size. A total of 63 completed clutches was examined. In 1965, 29 clutches averaged 6.45 eggs ($sd = 1.08$), and in 1966, 34 clutches averaged 6.12 eggs ($sd = 1.60$). The difference in mean clutch size between the two seasons was not significant. The range in clutch size was three to eight, with a mode of seven for each season. Jones (1960) presented data on 285 clutches recorded in two seasons in Idaho. Analysis of these data shows an average clutch size of 6.2, although Jones reported that the average clutch size was 6.7 eggs.

Egg loss in completed clutches was noted on six occasions. Two eggs were removed in one instance, and one each in the other cases. Whether the cause of these events was removal or breakage by parent birds or by predation was not determined. Nests were visited at three- to five-day intervals in this study. Occurrence of egg loss could remain undetected when clutch size was investigated by single visits during incubation and could, therefore, be a source of error in analyses of clutch size or nesting success in magpies.

There was no evident relationship between the date of clutch initiation and clutch size. Insufficient data were obtained to permit analysis of possible influences of age of female on clutch size.

Sexual behavior during egg-laying. Courtship feeding was the most prominent activity of magpies during this period. Postural and vocal displays were complete. Courtship feeding and its ecologic and behavioral significance in other corvids have been discussed by Hardy (1961:57) and Brown (1963). Intense feeding activity is believed to stimulate the tendency to behave sexually and to maintain and strengthen the pair bond. In contrast, infrequent courtship feeding has been cited as a corollary of weak pair bonds in Mexican Jays (Brown 1963). Observations of courtship feeding in magpies suggested that both the mechanics involved in food transfer and

perhaps also functional aspects of feeding changed during the period of its occurrence (from shortly before laying, during laying, and through incubation). Twelve instances of food transfer during the laying period were noted; five occurred off the nest, seven occurred in the nest. Reception of food in the nest by females was detected by characteristic vocalizations since activity within the nest was not visible. Solicitation of feeding by females during laying was observed frequently and occurred off the nest. Display intensity and the amount of social contact between mates were great. It is probable that sexual behavior was augmented by courtship feeding during laying. Whether or not feeding activity at this time was involved in maintenance or strengthening of pair bonds, however, is questionable. It is unlikely that pair bonds, which were formed at least one month before courtship feeding activity (and may be, in fact, permanent in magpies; see Linsdale 1937:70-75), were subjected to weakening or dissolution during egg-laying.

Intense courtship feeding accompanies copulation in some corvids (Hardy 1961:58). Copulation was not observed in the present study. It is possible that copulation took place within the nest.

INCUBATION

Length. Wheelock (1904) reported an incubation period of 18 days at a single Black-billed Magpie nest in California. Information in Linsdale (1937:107) indicates an incubation period of 16 to 18 days. Evenden (1947) suggested that incubation times were from 14 to 21 days, while Jones (1960) noted an average incubation period of slightly less than 18 days for 32 nests in Idaho.

The incubation period can be defined as the time from the laying of the last egg to the hatching of the last young when all eggs in the clutch hatch (Kendeigh 1963). Accurate determination of the incubation period was not possible in the present study since (1) nests were not visited often enough during laying to allow marking of individual eggs as they were laid, (2) eggs occasionally disappeared from completed clutches and frequently a portion of the clutch did not hatch, and (3) synchrony of hatching in a given clutch varied from relatively simultaneous hatching of all eggs to hatching spread over a period of several days. "Incubation period," as used here, refers to the period from the terminal oviposition to hatching of most of the eggs. Effective incubation was, then, assumed to have begun with the laying of the

TABLE 5. Nest attentiveness during incubation.

Nest	Total sessions observed	Total minutes observed	Minutes female on nest	Per cent attentive
1D2a	4	120	100	83
2D1d	4	120	97	81
2C2b	8	240	208	87
2E1c	4	120	106	88
5D2a	3	65	60	92
1C2a	5	220	175	80
Totals	28	885	746	84

last egg. The average incubation period in 12 nests was 18.3 days ($SD = 1.16$), with a range of 16 to 20 days. Data were too few to discern relationships between clutch size and length of incubation period.

Sex roles and attentiveness. Incubation was performed by females alone; males rarely entered nests during the incubation period and then only stayed in them for short periods (usually less than one minute).

Information on nest attentiveness during incubation was obtained through observations of nests for certain time intervals (usually 30 minutes). These data are summarized in table 5. Attentiveness averaged 84 per cent of daylight hours and was not clearly related to weather conditions, time of day observed, clutch size, or stage of incubation. Females occasionally left the nest for short periods and fed or loafed, but the timing and duration of inattentive periods were influenced primarily by interactions with the male.

Sexual behavior. Courtship feeding during incubation was characterized, in general, by less vigorous display than courtship feeding during laying. Occasional bouts of intense display, however, were noted throughout the incubation period. Duration of social contacts between mates during incubation comprised less than one tenth of the total observation periods as opposed to nearly one half the total observation periods during laying. Feeding was noted 13 times; nine occurred off the nest (but within five yards of the nest) and four occurred in the nest. Social interactions between mates during incubation were therefore brief and apparently utilitarian in nature. These observations suggested that courtship feeding during incubation was related to nu-

tritional maintenance of the female during her confinement to the nest. Subjectively, male activities during courtship feeding of incubation resembled behavior involved in feeding of nestlings. Thus the possibility exists that courtship feeding in incubation constituted a priming mechanism (for the male, at least) for subsequent parental obligations.

NESTLING PERIOD

Length. The interval from hatching until fledging averaged 27.4 days ($SD = 1.71$ days) in 10 broods for which sufficient data were obtained. A range in nestling periods of 24 to 30 days was noted and was apparently not related to the number of young fledged. A period of vulnerability of eggs and young (during laying, incubation, nestling) of 50 to 55 days was thus indicated.

Sex roles and attentiveness. Females brooded nestlings for certain periods during the day. Changes in brooding behavior as related to age of nestlings are presented in table 6. These data indicate that attentiveness during the nestling period decreased as nestlings grew older and further suggest that brooding attentiveness was never as great as attentiveness during incubation of eggs. Variations in attentiveness were greatest when nestlings were 6 to 10 and 11 to 15 days old, *i.e.*, nestlings in these age classes were either brooded heavily (in cold or rainy weather) or very little. Females visited nests briefly and apparently only to feed nestlings 21 days old and older. Information on night brooding was not obtained.

Fecal sacs were removed from the nest by both parents. In 34 nests examined that contained older nestlings, only one nest chamber was heavily fouled.

Data on the contributions of the male and female in feeding nestlings are presented in table 7. When data from nest 8D2a are omitted from consideration (the female of this pair exhibited anomalous behavior consisting of persistent displacement preening and prolonged periods of loafing and tugging at her leg band during many observation sessions), an equality of male and female roles in feeding nestlings is suggested. This equal sharing

TABLE 6. Brooding attentiveness related to age of nestlings.

Age of nestlings, days	Number of nests	Total sessions observed	Total minutes observed	Minutes female on nest	Per cent attentive
1-5	5	14	435	291	67
6-10	3	8	240	90	38
11-15	4	10	300	103	34
16-20	4	9	270	29	11
21-30	3	9	270	0	0

TABLE 7. Sex roles in feeding nestlings.

Nest	Number of sessions observed	Male trips	Female trips	Per cent trips	
				Male	Female
2D1d	2	4	3	57	43
8D2a	12	37	18 ^a	67	33 ^a
1D2a	13	17	18	49	51
2C2b	9	21	15	58	42
6D1d	14	32	35	48	52
Totals	50	111	89		

^a Female exhibited aberrant behavior (see text) during most observation periods.

of feeding duties was observed during all nestling stages; even though females brooded young nestlings much of the time, they managed to make as many feeding trips as did males.

Sexual behavior. Vigorous display and courtship feeding were not observed after hatching of young. Social relationships between mates during the nestling period consisted of occasional meetings at the nest during feeding trips, participation in nest defense, and contacts while foraging away from the nest.

NEST DEFENSE

Most published accounts of interspecific nest defense in birds include descriptions of attacking, mobbing, or "scolding" behaviors that occur during nest visits by the foreign species. Intensity of nest defense as related to the stage of the seasonal cycle (building, egg-laying, incubating, nestling) is not often reported in these accounts, and available information on changes in intensity of defense associated with progression of the cycle is rare. In view of recent emphasis on interrelationships between hormones and behavior (Lehrman 1959, 1961, 1964; Guhl 1961; Beach 1964; and others), information regarding changes in intensity of nest defense during the cycle could be of potential value in the elucidation of the roles of certain pituitary and gonadal hormones in parental behavior. Insight concerning nest defense is, moreover, a basic consideration in the ethology of a species. This section reports nest-defensive behavior of magpies associated with nest visits by the author. The contents of nests were

examined during each visit; the duration of each visit was determined by the accessibility of the nest. Some individual nests were visited during all stages, but, most frequently, nests were visited during one or two stages only.

Qualitative aspects. At least until nestlings acquired the ability to vocalize in a manner similar to adults, the motivation for defensive attacks during most of the breeding season was evidently provided either by the nest itself or perhaps the nest site. If, for example, silent nestlings were moved a short distance away from the nest tree, or even a few feet beneath the nest but still in the tree, violent mobbing subsided. On two occasions, moreover, visits to nests from which eggs had been removed by predators elicited strong parental attacks. Young birds alone could elicit parental attacks only after they attained the ability to utter calls similar to those given by adult females during courtship feeding. Fledgling magpies were also strongly protected by parents for some time after leaving the nest.

Three separate categories of nest defense, subjectively differentiated on the basis of intensity of response, were noted. Weak nest defense was characterized by birds leaving the vicinity of the nest and remaining inconspicuous for the duration of the visit. Nest defense of intermediate intensity involved birds remaining within sight and hearing of the author in the general vicinity of the nest. Vigorous nest defense comprised intense mobbing with accompanying vocalizations.

Quantitative aspects. The frequencies of nest-defense classes were used as criteria for analysis of dynamics of nest defense as related

TABLE 8. Summary of nest-defense responses of magpies to nest visits.

Nesting stage	Number of nests		Number of visits		Responses ^a						Total responses		
					1965			1966					
	1965	1966	1965	1966	A	B	C	A	B	C	A	B	C
Building	23	29	64	87	3	8	53	0	4	83	3	12	136
Laying	37	26	40	30	3	14	23	1	11	18	4	25	41
Incubating	40	36	62	63	11	19	32	7	21	35	18	40	67
Nestling	27	23	61	45	35	9	17	13	9	23	48	18	40

^a A = vigorous nest defense; B = intermediate nest defense; C = weak or no nest defense.

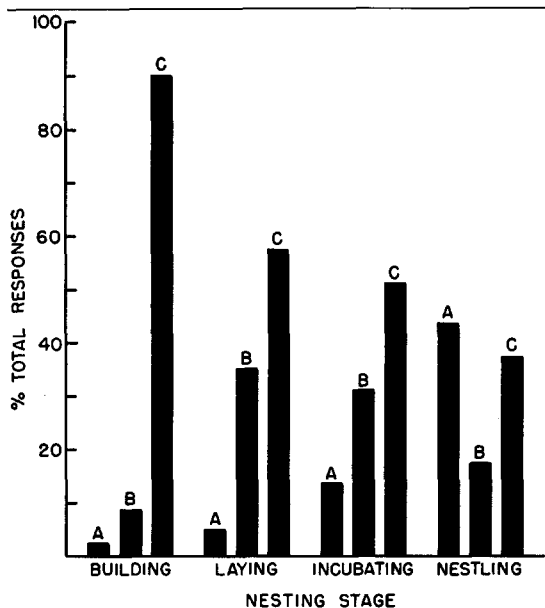


FIGURE 4. Combined percentages of nest-defense responses in relation to stage of nesting period. A = vigorous nest defense; B = nest defense of intermediate strength; C = nest defense weak or absent.

to stage in the nesting cycle (table 8). Responses listed in table 8 do not distinguish between behavior of sexes; the most vigorous reactions of one sex or the other, or both parents, were considered equivalent.

A smaller proportion of vigorous mobbing was recorded during all stages of nesting in 1966 as opposed to 1965. This reduction in intensity of nest defense was most likely a corollary of the heavy collection pressure to which nesting birds were subjected in 1966; *i.e.*, the birds were probably more wary in 1966 owing to intensive shooting in all parts of the study area. Behavioral alterations resulting from this increased wariness, however, apparently did not overshadow the more general trends in nest defense (fig. 4) that are considered here.

Data in table 8 (see also fig. 4) indicate that the most frequent response of birds building nests was departure from the area. Vigorous mobbing was elicited only three times, all at the same nest.

During egg-laying the percentage of birds that quietly left the area decreased significantly. This decrease was accompanied by a correspondingly significant increase in frequency of the intermediate type of nest defense. Vigorous nest defense was still only rarely observed.

Magpies incubating eggs exhibited a slightly (although insignificantly) increased intensity of nest defense, as suggested by the rise in

TABLE 9. Sex roles in nest defense.

Stage in cycle	Number of intermediate and vigorous responses by sex		
	Male alone	Female alone	Both parents
Building	0	0	0
Laying	1	11	6
Incubating	2	20	12
Nestling	2	16	24

frequency of vigorous mobbing responses during this period.

Nearly one half of visits to nests containing nestlings elicited strong mobbing from parent birds. This proportion of strong attacks was significantly higher than that recorded during incubation. Intermediate and weak responses showed significant decreases from frequencies of these classes observed during incubation.

Sex roles. In some instances it was possible to determine the sex of individuals exhibiting nest defense of intermediate and vigorous strength (table 9). Males alone rarely defended nests. In contrast, females alone accounted for many defensive responses during laying and incubation. Involvement of both birds in nest defense increased during the cycle and was the predominant response during the nestling stage.

Some implications of observed nest-defense patterns. The intensity of defensive activities during egg-laying and incubation periods was greater than that occurring during nest-building; maximum strength of response and minimum tolerance of intrusion were recorded during the nestling period (fig. 4). Wiens (1965) reported an increased tolerance of Common Grackles (*Quiscalus quiscula*) by Red-winged Blackbirds (*Agelaius phoeniceus*) during the nestling stage compared with other nesting stages. He attributed lessened inter-specific agonism to possible seasonal variations in aggressiveness or to a habituation of the aggressive response after repeated attacks upon subsequently harmless visitors. These observations, however, were concerned with territorial defense by Red-winged Blackbirds (and not nest defense specifically) and are probably not directly comparable to observations reported here.

Intensity or ferocity of nest defense during the incubation period has been cited as a measure of the degree of motivational tendency underlying incubation behavior or nest attentiveness (Baerends 1959). It was previously mentioned that nest attentiveness in magpies during the nestling stage was never as great as that recorded during incubation. Attentiveness averaged 84 per cent during the entire incubation period; variations in atten-

tiveness in earlier and later stages of incubation periods were insignificant. Analysis of 92 defensive responses observed during known stages of the incubation period showed no significant difference in intensity of response between the first and second halves of the incubation period. Although attentiveness decreased after hatching, the strength of nest-defense responses increased sharply. These results suggest that stimuli provided by the nest, or perhaps the nest site, and acting simultaneously with hormones influencing parental behavior, effected a stepwise increase in the strength of nest defense against intruders. Nest defense, then, is considered to have been largely unrelated to behavioral tendencies toward nest attentiveness, incubation "drive," or broodiness. That females alone accounted for many responses during laying and incubation might be cited to discount this hypothesis. It is likely, however, that female responses in these periods, particularly the incubation period, were primarily a reflection of the absence of the male, who spent much time away from the nest. Obviously, clarification of environmental, behavioral, and hormonal factors involved in attentiveness and nest defense requires further attention.

Several possibilities exist regarding the evolution of observed nest-defense patterns. That the nestling stage in magpies is characterized by vigorous parental nest defense may reflect general lack of renesting opportunity by magpies following brood destruction. If renesting after brood loss were not feasible for ecological reasons, natural selection could be expected to favor efforts to sustain the current nesting attempt when it is threatened by predation during the nestling period. Furthermore, it seems likely that the intensity of nest defense would roughly parallel the cumulative energy expended in the breeding effort up to the point of arrival of a predator. Partial support of the latter speculation is provided by work on various congeneric parrots by Dilger (1960), in which it is noted that an increase in development of mobbing within the genus was directly related to an increase in nest complexity.

SUMMARY

This paper reports field observations of aspects of nest ecology and nest-related behavior of individually marked Black-billed Magpies near Laramie, Wyoming, in 1965 and 1966.

Magpie nests consist of an ovoid twig superstructure enclosing a chamber and a mud nest bowl. There are local differences in major construction materials and bowl lining. About

one half of the active nests were more than 10 feet above the ground. There were no significant differences between the two years in the height-distribution of nests.

Completed nests are durable, and many remained essentially intact for at least four years after construction. Nests from past seasons were not frequently used for initial nesting attempts. However, in all known cases of renesting, old nests from the same or past seasons were used. Old unoccupied nests may significantly enhance nesting success by diverting the attention of predators. Old nests were also used for roosting in winter.

Magpies were never observed to attempt renesting more than once following nest destruction in a given season; the renesting interval did not appear to be related to the period of the nesting cycle in which the first attempt was interrupted.

Nest-building activity was first noted in late February in both years. Intense building activity was concentrated in mid-April in 1965 and in mid-March in 1966. Nest-building was last observed in early May in 1965 and in late April in 1966. The typical sequence of stages in nest construction is described. On the average, about 40 days were required in construction of a complete nest. Both sexes participated in building, but the male did significantly more work than the female. Maximum ovarian development was coincident with the completion ("contouring") of the nest-bowl lining. Maximum testicular development preceded this by about three weeks. It is probable that nest-building and the social interaction between members of a pair during this period has a significant role in vernal gonadal maturation, especially in the female.

No evidence of nest-related territoriality was observed. Clusters of several active nests were seen, but it is not clear that these represented a form of colonial nesting.

Egg-laying occurred earlier in 1966 than in 1967. This difference was correlated with higher air temperatures during the nest-building period in 1966. Adult females ovulated somewhat earlier than first-year females. Clutch size averaged 6.45 eggs in 1965 and 6.12 eggs in 1966. The difference is not statistically significant.

Sexual behavior including vigorous displays and courtship feeding was prominent during the egg-laying period. Courtship feeding was most common in or near the nest. Feeding of the female by the male continued through the incubation period.

The incubation period in 12 nests averaged

18.3 days. Only females incubated; attentive periods averaged 84 per cent of daylight hours.

The nestling period for 10 broods averaged 27.4 days. Attentiveness by brooding females was always less than incubation attentiveness, and decreased as the nestlings developed. Feeding duties were shared equally by the parents.

The intensity of nest defense was somewhat higher during incubation than during preceding nesting stages, and increased significantly during the nestling period.

ACKNOWLEDGMENTS

I would like to thank L. Richard Mewaldt and Kenneth L. Diem for critically reading the manuscript and offering many helpful suggestions. Information presented here was taken from a doctoral thesis done at the University of Wyoming. Much of this work was supported by a National Defense Education Act fellowship. (Present address: Department of Poultry Science, Cornell University, Ithaca, New York 14850.)

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Accepted for publication 30 June 1967.