

EFFECTS OF HUMAN DISTURBANCE ON BREEDING OF BLACK-CROWNED NIGHT HERONS

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ABSTRACT.—Visits to Black-crowned Night Heron (*Nycticorax nycticorax*) colonies just before or during laying provoked abandonment of newly constructed nests and either predation of eggs or abandonment of eggs followed by predation. Investigator disturbance caused mortality of young in some situations. Frequent disturbance also discouraged the settlement of late-nesting night herons, late clutches being more likely in colonies visited only twice than in colonies visited 10–15 times. Clutch size and fledging success of successful early nests were the same in frequently and infrequently disturbed colonies. *Received 1 September 1978, accepted 13 February 1979.*

SEVERAL experimental studies have demonstrated adverse effects of human disturbance on reproductive success of gulls (Kadlec and Drury 1968, Hunt 1972, Robert and Ralph 1975, and Gillett et al. 1975) and cormorants (Ellison and Cleary 1978). In some studies of the Ardeidae it was suspected that human visits reduced breeding success (Jenni 1969, Wolford and Boag 1971), but no control colonies were checked to verify the effect. Goering and Cherry (1971) found no difference in success of various species of heron nests visited 16 times and those visited four times. We report here on effects of initiating visits to night heron colonies early in the nesting season and we also discuss differences in colonies visited 10–15 times and those checked only twice.

STUDY AREA AND METHODS

We conducted the study in 1975 and 1976 in the St. Lawrence Estuary, on Ile Gros Pèlerin (22 ha) near Rivière du Loup, Québec, and on Ile Brûlé (8 ha), 20 km upstream. Both islands were uninhabited by people. We counted 380 night heron nests on Gros Pèlerin and 537 on Ile Brûlé in 1975. On Gros Pèlerin most night herons nested in white birch (*Betula papyrifera*) trees, whereas on Ile Brûlé most nests were in balsam fir (*Abies balsamea*) trees. Other colonial birds nesting on both islands were Great Blue Herons (*Ardea herodias*), Herring Gulls (*Larus argentatus*), and Double-crested Cormorants (*Phalacrocorax auritus*).

Disturbed colonies were treated like those subjected to a typical intensive study of breeding success. We wanted to follow the fate of eggs, so where possible colonies were first visited early in the nesting season. We checked nests every 3–5 days, the time of day varying because tide conditions determined our arrival time on islands. All nests, eggs, and young were marked. We marked eggs with a non-toxic, felt-tipped pen. We identified young by wrapping colored tape around the tarsus until they were old enough to carry leg bands. We individually marked nestlings older than 10 days with one aluminum and three colored plastic bands. These colored bands were useful in assigning young to their respective nests, because at about 18 days of age nestlings began venturing out onto surrounding branches at our approach. The colored bands were also necessary to determine fledging success for specific nests. We defined age of fledging as 28 days even though young were not yet capable of sustained flight. At 29 to 34 days of age young had quit their nests, and it was no longer feasible to locate all of them scattered high in the forest canopy. Each visit lasted 45 min to 4 h, the longer periods occurring when many young were banded and weighed. Not all night herons, however, were absent for the duration of a visit. Foliage was dense enough that not all adults left when we arrived, and by the time we reached the last nests in a colony, adults had returned to the first nests examined. Colonies were not entered on rainy days.

We established a control colony of relatively undisturbed nests on Gros Pèlerin the first year of study, and the second year we reversed the disturbed and undisturbed sites to eliminate bias introduced by

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TABLE 1. Relationship between stage of laying at time of first visit to night heron colonies and subsequent reproductive success. GP = Gros Pèlerin; IB = Ile Brûlé.

Colony	Date of first visit	Percent of nests with egg(s) on first visit	Percent of nests that became active—laying occurred	Percent of active nests failing before hatching	Percent of active nests failing after hatching	Percent of active nests yielding fledglings	Mean number of young fledged per active nest
GP ^a 1975	1 May (5) ^a	0 (18) ^b	11 (18) ^b	100	0	0	0
IB 1976	29 Apr (4)	0 (41)	44 (66)	48	31	21	0.5
GP 1976	28 Apr (5)	26 (43)	56 (64)	25	14	61	1.3
GP ^b 1975	14 May (6)	83 (36)	83 (46)	24	13	63	1.5
IB 1975	21 May (1)	95 (42)	98 (43)	17	14	69	2.1

^a Number of visits made before hatching began.

^b Total number of nests, active and inactive, examined or followed.

habituation or by differences in habitat or nesting success. On Ile Brûlé, a control was established only in the second year, the disturbed colony being the same in both years. No nests, eggs, or young were marked in any control. We checked the controls only twice, once toward the end of incubation to record clutch size and again 4 weeks later to determine number of young per nest. About 30 min were spent in a control. On both islands experimental and control colonies were 70–100 m apart, separated by dense vegetation. Our presence in the experimentals did not cause herons in the respective control to leave their nests. Goering and Cherry (1971: 303) in their study of disturbed and relatively undisturbed heronries believed that sites 70 m apart were sufficiently spaced "to prevent disturbance to one site while the other was being checked." A blind, which could be entered without disturbing the night herons, was placed near the experimental colony on Gros Pèlerin in 1976 to study egg predation.

We used standard *t*-tests to compare means of clutch size and brood size. We tested the equality of two percentages by a method based on an arcsine transformation (Sokal and Rohlf 1969: 607), which yields results similar to Chi-square without Yate's correction.

RESULTS

We found a significant correlation ($r = 0.93$, $P < 0.05$) between the percentage of nests with eggs at the time of our first visit to experimental colonies and the percentage of nests in which laying eventually occurred (Table 1). Thus visits early in nesting inhibited laying. This effect of early visits was clearly shown by our first attempt to establish a study colony on Gros Pèlerin in 1975. We checked the colony twice before laying began on about 5 May. Laying subsequently occurred in only 2 of 18 nests and by our fifth visit on 13 May all nests were empty and apparently abandoned. In contrast, the percentage of nests in which laying eventually occurred was highest (98%) in 1975 on Ile Brûlé, where we first visited the colony on 21 May, about a week before hatching began and when 95% of nests already contained eggs. As our first visit to this colony was rather late, one could argue that we overestimated the proportion of nests in which laying occurred, because nests that had failed earlier were dismantled before 21 May. Of 64 nests on both islands that failed before 18 May or never contained an egg, however, only 9% had disappeared before 24 May.

A correlation ($r = 0.91$, $P < 0.05$) was also noted between the percentage of nests with eggs on our first visit in the five colonies and the number of young finally fledged per laying attempt or per active nest (Table 1). This correlation was partially due to early visits causing egg predation or abandonment of nests with eggs, even though failure of active nests before hatching was not significantly correlated with stage of laying on our first visits ($P > 0.05$). The significant correlation between fledging success and stage of laying at time of first visits was also partly due to the nestling mortality that we caused on both islands in 1976 (noted below), mortality

TABLE 2. Clutch comparison of Black-crowned Night Herons in experimental and control colonies on Gros Pèlerin and Ile Brûlé, Québec.

	Gros Pèlerin				Ile Brûlé	
	29 May 1975		26 May 1976		25 May 1976	
	Experi- mental	Control	Experi- mental	Control	Experi- mental	Control
Number of prior visits in given year	5	0	6	0	3	0
Number of nests examined	46	37	54	53	47	72
Percent nests empty	26	16	59	38	53	18
	ns		$P < 0.05$		$P < 0.001$	
Mean clutch size of nests with eggs ^a	3.6	3.7	3.8	3.1	3.5	3.8
	ns		$P < 0.05$		ns	

^a Not all clutches necessarily complete. Also, in 1976, hatching had begun in three nests in the experimental colony on Gros Pèlerin, and in two nests in the control on Ile Brûlé. For this table, the young were considered to be eggs.

that was entirely independent of the timing of first visits. Thus the correlation between fledging success and stage of laying at first visits was somewhat fortuitous.

Experimental and control colonies were compared in late May, just before hatching, to determine if differences existed in either clutch size or proportion of empty nests (Table 2). In two of three comparisons the experimental colony contained a higher percentage of empty nests. The experimental colony not containing more empty nests than its control (Gros Pèlerin 1975) was first examined relatively late in laying, on 14 May.

Night herons remaining to nest in the experimentals incubated normal clutches, as the mean clutch size of nests with eggs in the disturbed colonies was greater than or equal to the mean clutch size in the corresponding control (Table 2). This means that in experimentals we either inhibited laying or caused loss of total clutches by predation or abandonment followed by predation.

We compared experimentals and controls again in late June just before fledging (Table 3). The proportion of empty nests was always highest in experimentals. Mean number of young per nest with nestlings older than 1 week was no different between any experimental and its control. Thus, for successful nests in the same stage of development, parents in the experimentals were rearing normal-sized broods. In both years on Gros Pèlerin, however, the controls had many late nests containing eggs or recently hatched young, whereas the respective experimentals had no such late nests (Table 3). We conclude that night herons that nested late, either because of a retarded nesting cycle or abandonment of a first nest, chose to avoid our disturbed experimental colonies on Gros Pèlerin. This effect was not seen on Ile Brûlé.

The data of Tables 1–3 clearly indicate the failure of the experimental on Ile Brûlé in 1976 (0.5 fledglings per active nest), despite very good success in this same colony the preceding year (2.1 fledglings per active nest). Therefore, there was no intrinsic reason for failure in 1976. Moreover, fledging success was good in the adjacent control in 1976, arguing against any environmental explanation for failure. We conclude that failure was partially due to initiating visits before laying began, causing inhibition of laying, abandonment of nests, and perhaps egg predation. The nest abandonment and egg predation lead to a high failure rate of active nests before hatch-

TABLE 3. Brood comparison of Black-crowned Night Herons in experimental and control colonies on Gros Pèlerin and Ile Brûlé, Québec.

	Gros Pèlerin				Ile Brûlé	
	29 June 1975		28 June 1976		27 June 1976	
	Experi- mental	Control	Experi- mental	Control	Experi- mental	Control
Number of prior visits in given year	14	1	15	1	10	1
Number of nests examined	46	64	36	42	34	55
Percent nests empty	48	27	39	19	65	13
	$P < 0.05$		$P < 0.05$		$P < 0.001$	
Percent nests with young > 1 week old	52	59	61	57	26	85
	ns		ns		$P < 0.001$	
Percent nests with eggs and/or young < 1 week old	0	14	0	24	9	2
	$P < 0.001$		$P < 0.001$		ns	
Mean brood size of nests with young > 1 week old	2.7	3.1	2.5	2.5	2.1	2.5
	ns		ns		ns	

ing (48%). The high failure rate of nests after hatching (31%) suggested that our visits also induced mortality of nestlings.

The blind on Gros Pèlerin permitted us to confirm in 1976 that night herons may abandon young after human disturbance. We observed that the parents did not return to a nest containing three 2–4-day-old young in the hour following our visit on a cold, windy day, and the nest was empty when checked a few days later. In fact, at the time of this next visit, 5 nests formerly with young were empty and a total of 25 nestlings had disappeared or were found dead, these 25 representing 73% of all nestling mortality occurring in the colony that year. We do not know if this visit caused only nest abandonment or also mortality of young by exposure.

In 69 h observation of 12 nests with eggs in the experimental on Gros Pèlerin, we saw crows (*Corvus brachyrhynchos*) take 4 eggs. One egg was removed immediately after one of our visits, and the other three were taken more than 30 min after our departure. Thus crows were the principal egg predator but rarely invaded the colony just after our visits.

DISCUSSION

Our visits to experimental colonies reduced nesting success by inhibiting laying, by increasing either nest abandonment or egg predation, and by increasing nestling mortality on Gros Pèlerin in 1976 and probably also on Ile Brûlé in 1976. The correlation between stage of laying at first visits and percentage of nests in which laying eventually occurred shows that night herons are particularly sensitive to disturbance just before and during laying. The relatively high proportion of empty nests in experimentals vs. controls before hatching supports this conclusion. Goering and Cherry (1971: 304) concluded from their study of a heronry visited four times vs. one visited 16 times that human disturbance was "not necessarily detrimental

during the later stages of reproduction." Their first visit to both heronries was late in incubation.

The late nests in the controls on Gros Pèlerin suggested that another effect of human interference is to discourage late nesters from settling in disturbed sites. This same effect was noted in a similar comparison of experimental and control colonies of Double-crested Cormorants on Gros Pèlerin (Ellison and Cleary 1978). Perhaps we found no difference in utilization of experimental vs. control sites by late nesters on Ile Brûlé because the high density of night heron nests (67 nests/ha vs. 17/ha on Gros Pèlerin) prevented a free choice of nest sites late in the season.

The comparison of experimental and control night heron colonies showed that those adult herons remaining to nest in disturbed areas incubated normal clutches and reared normal sized broods, a result also noted in the study of Double-crested Cormorants (Ellison and Cleary 1978). Thus data on clutch size in the experimentals should be valid if clutches diminished by early abandonment or predation are eliminated. Similarly, data on number of young fledged per successful nest should be representative of early nesters. If late nesters lay smaller clutches or raise fewer young than early nesters, however, data on reproductive performance of a frequently visited colony will be biased. Data from disturbed areas expressed as proportion of laying attempts that were successful, or young fledged per laying attempt, will also be biased, regardless of whether or not there are late nesters.

Only crows were seen to eat night heron eggs on Gros Pèlerin. Numerous crows were on Ile Brûlé, but we did not identify causes of predation on that island. Burger and Hahn (1977) found crows to be the principal predator of night heron eggs. Milstein et al. (1970) cite several European studies showing a correlation between corvid predation, particularly by the Eurasian Crow (*Corvus corone*), and human disturbance in heronries. In the study of Wolford and Boag (1971), Ring-billed Gulls (*Larus delawarensis*) were the most important predators of night heron eggs and nestlings.

We offer the following recommendations for minimizing effects of investigator disturbance in intensive studies of night heron reproduction. The heronry should not be visited until about a week before hatching will begin. This means that in Québec we see no way of following the fate of all eggs laid without biasing the results. Visits should not be more frequent than every 3–4 days until young are about 3 weeks old but can be more frequent thereafter. No visits should be made in any kind of inclement weather. If very accurate data on population breeding performance are required, a way should be found to record data at a distance, without entering the heronry. Pratt (1970) and Drent et al. (1964) took advantage of cliffs in their respective studies of herons and cormorants to obtain data on breeding success without human interference.

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