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Article 4

Population Trends in a Black-crowned Night-Heron Colony at Lake Calumet Wetlands

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ABSTRACT

We examined the nesting ecology of a Black-crowned Night-Heron (*Nycticorax nycticorax*) colony located at wetlands associated with Lake Calumet in south Cook County, Illinois, during the 2002 and 2003 nesting seasons. This area of southeastern Chicago has been greatly impacted by heavy industry, solid and chemical waste disposal, urbanization, and altered hydrology.

Black-crowned Night-Herons (BCNH) have nested at five known locations at Lake Calumet wetlands during 1984–2003. Emergent cover (giant reed, *Phragmites australis*) was of primary importance to this colony for nesting during that time. Cottonwoods (*Populus deltoides*) also were used for nesting from the late 1980s to mid-1990s.

During 1993–2003 the herons began arriving at the colony as early as March 10. During the two years of this study the earliest indications of nest building and courtship occurred during the first week in April; the first pairs and precopulatory displays were observed during second week of April in both years. The egg-laying period extended from April 20 to June 12 in 2002, and from April 16 to May 27/28 in 2003. Hatching occurred from mid-May to the first few days of July in 2002, and from mid-May to June 19/20 in 2003. Juvenile dispersal in 2002 occurred from mid-July through late August, and from early July through mid-August in 2003.

Reproductive parameters in BCNH nesting at the north end of Indian Ridge Marsh (IRM), the primary nesting location for this colony in both years, were typical for this species. In 2002 the "recruitment" rate (number of young/nest surviving to 15 days) of 1.74 young/pair was below the threshold of 2.0–2.1 young/nesting pair thought to be necessary to maintain BCNH populations. However, recruitment increased to 2.22 young/pair in 2003, which was among the highest previously reported. The most important cause of nest failure was poorly constructed (flat) nests which allowed the eggs to roll out into the water. Although some eggs were lost to gulls and some hatched young were taken by unknown mammalian or avian predators, predation was not an important cause of nest losses at IRM.

INTRODUCTION

The Calumet region of southwestern Lake Michigan was once a vast complex of glacial lakes, wetlands, and sand prairies. This region is now one of most heavily-industrialized in the U.S. and has been greatly impacted through industrial activities, waste disposal and discharge, urbanization, and changes to surface and groundwater hydrology. In spite of extensive habitat loss and degradation, the area remains among the most biologically diverse in the state of Illinois.

A number of wetland-dependent breeding birds of concern nest in marshes adjacent to Lake Calumet, including the state-endangered Black-crowned Night-Heron (*Nycticorax nycticorax*). One of the largest remaining breeding colonies in Illinois, this population is of considerable interest to resource professionals, environmental groups, and the conservation-minded public. Although BCNH populations have increased nationwide since banning of DDT and other persistent pesticides, Illinois has not enjoyed this recovery.

Young-of-the-year BCNH were reported in the Calumet marshes as early as 1874 (Nelson 1876–1877). Throughout much of the early part of the 20th century the Lake Calumet BCNH colony was located along the Calumet River just north of the confluence with the Grand Calumet River (Landing 1986). The BCNH have nested at wetlands adjacent to Lake Calumet since the Thomas J. O'Brien Lock and Dam went into operation in the late 1960s. The number of BCNH nesting at these wetlands has fluctuated widely over the last two decades. However, this population remained relatively stable at between 300 and 400 pairs during 1997–2003 (Marcisz et al. 2005).

Interest in the rehabilitation of these wetlands as part of the Calumet Open Space Reserve created the need for a better understanding of the ecology of this urban BCNH colony, in order to aid conservation planning and guide management activities. Accordingly, we examined the nesting ecology of BCNH at Lake Calumet's IRM during the 2002 and 2003 seasons.

METHODS

2002

The activities of BCNH were observed for two-to-four-hour periods on eight occasions during April 5 to May 10 to document the timing of breeding activities. Nest building, pairing, breeding, and nesting behaviors were recorded. Nest monitoring was initiated at IRM on May 15, when 30 nests were marked by placing plastic flagging on *Phragmites* stems adjacent to each nest. The number of eggs and chicks was recorded for active nests. Additional nests were added May 20 (n= 9), May 26 (n= 6), May 30 (n= 2), and June 4 (n= 1). Nests were checked every four to seven days depending on weather and staff availability. The number and disposition of eggs (cracking, pipping, hatched, fell out, depredated, missing) and nestlings (present, missing, depredated) were recorded during each visit; eggs were numbered with a nontoxic marker. Twelve nests located in cottonwood trees at a colony located 13 km to the east at ISPAT Inland Steel (IIS), East Chicago, IN, were monitored for comparison; each monitored nest was numbered on a hand-drawn map of the site and observed from an elevated vantage point.

We conducted post-breeding surveys at IRM every two weeks during June–August 2002 to monitor the relative abundance of juvenile BCNH from about the time the first young became flighted through dispersal. These surveys consisted of walking an established transect adjacent to and the length of the colony at a slow pace, counting and aging the herons as the observer passed by them. To avoid double-counting, herons that took flight at the observer's approach and landed within an unsurveyed portion of the colony were not counted at that time.

2003

The activities of BCNH were observed for 1- to 2.5-hour periods on 11 occasions during April 9 to May 13. Nest building, pairing, breeding, and nesting behaviors were recorded. Nest monitoring at IRM was initiated on May 16; a total of 55 nests were marked (n= 20 on 5/16, 23 on 5/21, and 12 on 5/29). A total of 17 nests located at IIS were also monitored. Nest monitoring at IRM and IIS, respectively, was concluded July 10 and 23. Dates of first known arrival of BCNH at Lake Calumet Wetlands (LCW) are based on periodic checks each spring of known previous nesting locations. Post-breeding surveys were initiated June 12 and concluded on August 21.

RESULTS

Nesting Habitat at Lake Calumet Wetlands 1984–2003

Throughout much of the early part of the 20th century, the Lake Calumet BCNH colony was located along the Calumet River just north of the confluence with the Grand Calumet River (Landing 1986). The construction of the Thomas J. O'Brien Lock and Dam resulted in the BCNH relocating to stand of eastern cottonwood (*Populus deltoides*) trees at Lake Calumet's Big Marsh (Fig. 1) during the early 1970s. The BCNH nested in the *Phragmites* at Big Marsh from 1984 through 1998; however, prolonged high-water levels in 1999 killed the *Phragmites* used for nesting structure. Although the emergent vegetation has recovered, as of 2003 the BCNH had not returned to nest at Big Marsh.

The cottonwoods at IRM were second in importance as a nesting site for this colony over the past 19 years (Table 1). The herons nested in the cottonwoods along the Calumet River at the southern portion of IRM during 1987–89; their abandonment of that rookery coincided with nesting by Red-tailed Hawks (*Buteo jamaicensis*) at that location in 1990. The BCNH began nesting at the cottonwood grove at IRM near 122nd St. in 1991, but have not nested at that site since 1996 after a pair of Red-tailed Hawks nested there. A lack of tree regeneration coupled with the death/poor condition of larger trees due to beaver (*Castor canadensis*) damage or high-water levels have been suggested as the causes for the failure of BCNH to return to nest in the cottonwoods. The *Phragmites* at the northern portion of IRM and at Heron Pond have become important nesting sites in recent years (Fig. 1).

During 2002 and 2003 the portion of IRM occupied by the nesting BCNH was characterized as a hemi-marsh condition, i.e., irregular-shaped and -sized stands of *Phragmites* interspersed with open water. The *Phragmites* cover ranged from narrow "fingers" and

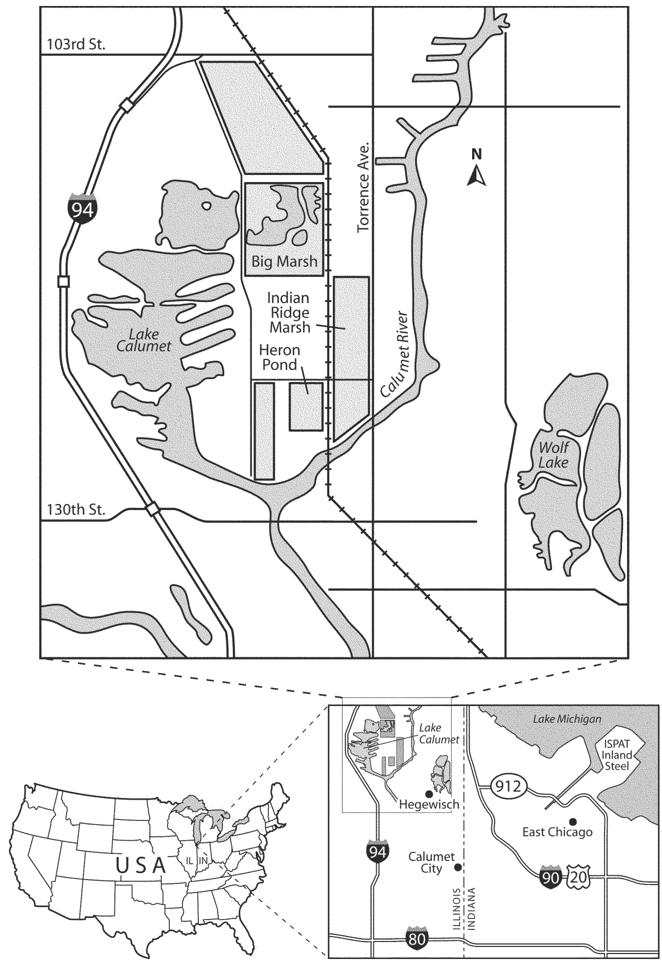

Figure. 1. Map of southeastern Chicago, Illinois, and northwestern Indiana, showing locations used by nesting Black-crowned Night-Herons.

Table 1. Known Black-crowned Night-Heron nesting locations at Lake Calumet Wetlands, 1984–2003.

Location Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Indian Ridge Marsh (IRM) *Phragmites*										X	X					X	X		X	X
IRM S. cottonwoods				X	X	X														
IRM N. cottonwoods								X	X	X	X	X								
Big Marsh *Phragmites*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
Heron Pond *Phragmites*												X	X					X	X	

smaller isolated patches or clumps to larger blocks of cover. Thus, the area where the breeding colony was located was heterogenous with regard to available cover.

The BCNH colony was comprised of three "sub-colonies," each isolated from each other by an expanse of open water (Fig. 2). The northern subcolony held a greater proportion of the nests than either the eastern or southern subcolonies. Isolation of nesting areas from the shoreline by deeper water and thick emergent cover may have reduced the incidence of mammalian predation and vandalism/disturbance. Least isolated from shoreline by distance or deep, open water, nests in the eastern subcolony did experience greater predation loss in 2002 than in the monitored portion of northern subcolony.

The BCNH constructed nests of the previous year's *Phragmites* stems (occasionally lined with purple loosestrife (*Lythrum salicaria*) or unidentified woody stems) placed within a clump of standing stems. Nest distribution was generally clumped. There were concentrations of nests in close proximity (some less than a meter apart), generally in areas of sparser cover (i.e., near edges of cover or where *Phragmites* stems were less dense). Occasional nests were located in single clumps of reeds or scattered in denser cover.

Arrival and Courtship

The earliest date that BCNH have been observed at LCW during the period 1993 to 2003 was on March 10, 1994 (Table 2). During 1993, 1994, 1995, 2000, 2001, and 2003 no herons were observed on earlier (i.e., prior to date first observed) visits; no previous visits were recorded for 1996, 1997, 1998, and 2002. No BCNH were observed on March 29, 1992 or March 23, 1999, thus the herons apparently began arriving after those dates. Although we cannot be sure of the exact date of arrival based on these data, they do indicate that BCNH typically began arriving in substantial numbers during the latter half of March.

BCNH may continue to arrive at LCW well after others have begun nest building and pairing. In 2002 the number of BCNH at IRM greatly increased between April 26 and May 12. Also, no BCNH were observed at nearby Heron Pond (HP) until April 6 of that year. Similarly, BCNH were present at IRM as early as March 10 in 1994, but were not observed at nearby Big Marsh (BM) as late as May 1, though were known to be successfully nesting there later in the season.

In 2002 BCNH were first observed at LCW on March 17, and were initially seen (n=4) carrying sticks on April 6. Early in the breeding cycle this behavior signifies beginning of nest building by males just prior to courtship and accepting a female at the nest (Meyerriecks 1960, Palmer 1962). Later, after pair formation, the male will present twigs to females prior to copulation and this behavior persists until after the eggs are laid. Gross (1923) reported that the first eggs were laid an average of seven days after start of nest construction; based on this information the first eggs would have appeared at LCW around April 13.

The first pairs were observed at nests at IRM on April 16; the number of pairs seen from an unobstructed vantage point increased from 2 on April 16, to 10 April 23, and 22 on May 2. Circling flights (synchronization of sexual behavior in early pair formation, Meyerriecks 1960) were observed on April 16; precopulatory displays (including billing, feather nibbling, twig presentation, erection of feathers, and neck stretch), and copulation were recorded as early as April 18 and April 19. According to Allen and Mangels (1940) the first eggs are laid an average of 3.3 days after copulation or 4–5 days after pair formation. Based on this information the first eggs would have appeared on April 20 or 21.

In 2003 BCNH were first observed carrying sticks on April 9, thus the first eggs would have appeared at LCW around April 16; in fact, pairs were first observed at nests on April 16. Precopulatory displays (including billing, feather nibbling, twig presentation, erection of feathers, and neck stretch) were recorded as early as April 18, thus the first eggs would be expected to have appeared on April 21. Based on our sample of nests, the first clutches were initiated on April 16, with half the nests initiated by May 8, and the last on May 23.

Nesting Phenology

The phenology of BCNH clutch initiation, egg hatching, and juvenile fledging/dispersal at IRM was reconstructed based on direct observation (i.e., nest monitoring) and the following assumptions:

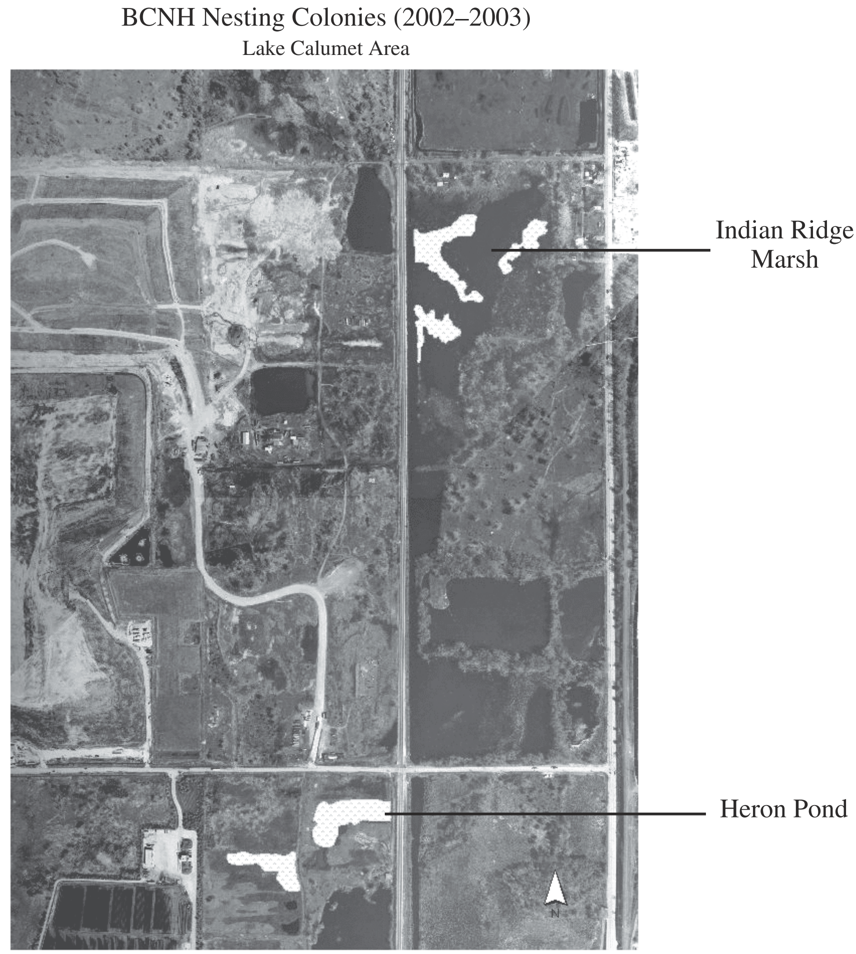

Figure. 2. Location of Black-crowned Night-Heron colony in *Phragmites* cover at Indian Ridge Marsh during 2002 and 2003 and Heron Pond in 2002.

Table 2. Number at first sighting by week of occurrence of Black-crowned Night Herons at Lake Calumet Wetlands, 1993–2003.

Year / Week	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
March 1–7											
March 8–14		1									
March 15–21							No Data			16	
March 22–28			14		40	3		2			18
March 29– April 4	25			17					75		

1) approximately two days to lay each egg (Gross 1923, Palmer 1962, Tremblay and Ellison 1980);
2) an average incubation period of 24 (23.5) days for A-eggs (i.e., first egg laid; Custer et al. 1992);
3) hatching one day after pipping, two days after cracking (Custer and Peterson 1991);
4) B-egg hatches about one day after A-, and C- hatches two days after B- (Custer et al. 1992); we assumed D-egg hatched one day after the C-egg;
5) flight is attained at about six weeks (42 days) of age (Palmer 1962, Wolford and Boag 1971);
6) on average, young of the year disperse at 58 days of age (Erwin et al. 1996).

In 2002 we initially marked 30 nests on May 15 and added new nests as encountered in that portion of the colony (n= 9 on May 20, n= 6 on May 26, n= 2 on May 30, and n= 1 on June 4). Based on our monitored sample of nests, we estimated that clutches were initiated as early as April 20, with half being initiated by mid-May, and the last on June 7 (Fig. 3). The last clutches initiated were in recycled nests; excluding second and third clutches (i.e., recycled nests) the latest a clutch was initiated, based on our marked sample, was May 23.

The estimate of April 20 for the initiation of laying coincides with estimates of clutch initiation based on our observations of pre-copulatory displays and copulation and information provided in Allen and Mangels (1940).

The first eggs would have hatched by mid-May, with A-eggs from half of the monitored nests hatching by the second week in June; A-eggs from the last nests initiated would have hatched on July 1 (Fig. 3). Thus, eggs would have been present at IRM over a period of about two and one-half months (April 20 to July 4–5).

Based on a flightless period of six weeks (Palmer 1962), the first and last young, respectively, attained flight on June 25 and August 10 (Fig. 3). Erwin et al. (1996) reported that age of dispersal in BCNH averaged 55 and 60 days in the two years of their study. Thus, based on an average dispersal age of 58 days, dispersal of juvenile IRM BCNH began about mid-July and continued through late August, with most having reached dispersal age by the middle of August. This coincides well with the results of our post-breeding surveys, which revealed a precipitous decline in juveniles observed at IRM between August 10 and 24 (see Fledging and Dispersal below).

In 2003 the first eggs would have hatched by mid-May; A-eggs from half of the monitored nests would have hatched by early June; A-eggs from the last nests initiated would have hatched on June 16 (Fig. 4). Thus, eggs would have been present at IRM over a period of about two

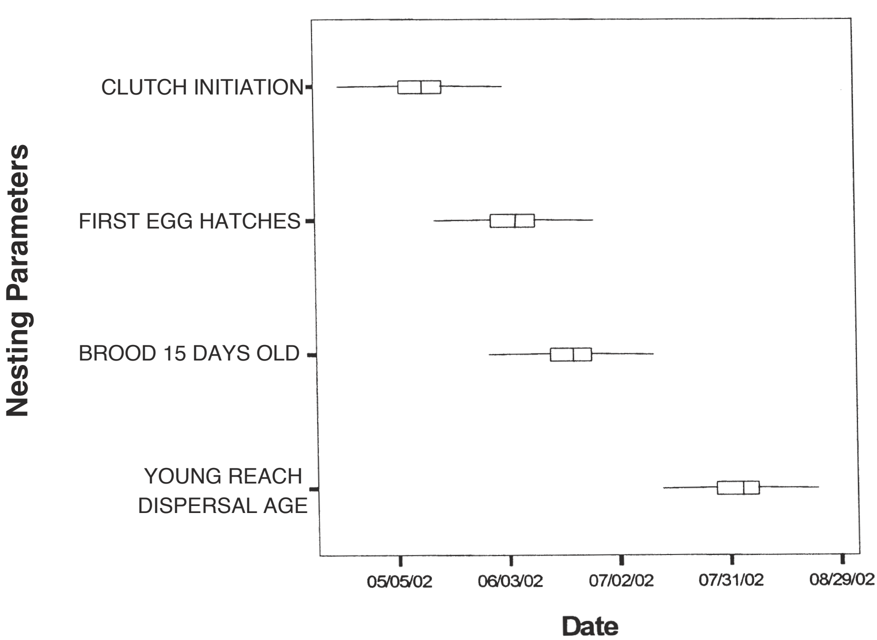

Figure 3. Nesting phenology of Lake Calumet Black-crowned Night-Herons, 2002.

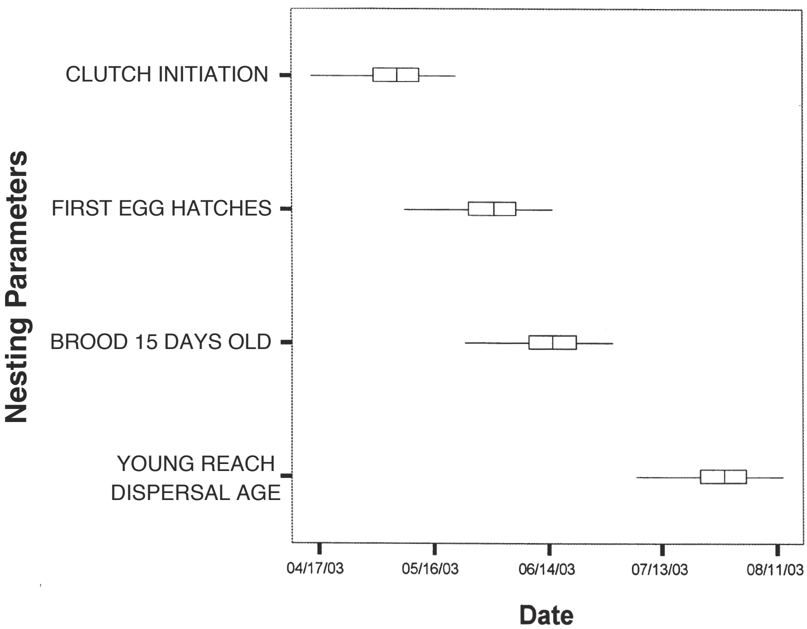

Figure 4. Nesting phenology of Lake Calumet Black-crowned Night-Herons, 2003.

months. The first young attained flight on July 5, and dispersal of juvenile BCNH from IRM began the first week in July and continued through mid-August, with most having reached dispersal age by the end of July. This coincides well with the results of our post-breeding surveys which revealed that most juveniles had left by mid-August of that year (see Fledging and Dispersal below).

Clutch Size

Mean clutch size (all clutches) of BCNH nesting at IRM in 2002 was similar to that of clutches in tree nests at nearby ISPAT Inland Steel (IIS) (Table 3). Mean clutch sizes (all clutches) at IRM in 2002 and 2003 were very similar; clutch size declined considerably at IIS in 2003.

A total of six monitored nests at IRM was recycled (one nest with second and third clutches) in 2002. Mean clutch size for initial clutches was slightly higher than for all clutches (Table 3). We did not document any recycled nests at IRM in 2003.

When sorted by median date of initiation (5/13, see Nesting Phenology above), i.e., early nests < median date, late nests > median date, the average clutch size in 2002 was 0.48 eggs larger in nests initiated on or prior to the median date. Thus, early clutches were nearly 16% larger than late clutches; however, we did not detect this difference statistically (t_{28}= 1.8, P= 0.08).

At least four nests at IRM in 2002 had additional eggs laid in them after the original clutches were complete (based on the time interval between last egg of the clutch laid and presence of new eggs). In two cases one additional egg was laid after clutches of three were complete; in the other two nests, one or more of the original eggs were found in the water and new eggs added to the nest. In one of these, a known total of five eggs were laid. In the other, the nest was recycled following the disappearance of the original clutch of three eggs. At least six eggs were subsequently found in the nest, with all eventually disappearing; four eggs (some from both clutches) were found in the water below this nest. We did not identify any such "dump nests" at IRM in 2003.

Nest, Egg, and Nesting Fate

The most common cause of failed clutches at IRM in 2002 was through poorly constructed nests, which allowed eggs to roll out into the water (Table 4). Predation was the next most common cause of nest failure; the complete disappearance of two clutches/broods may also have represented predation events. Including these, 7 of 51 (13.7%; includes second clutches) monitored clutches/broods were lost to predation at IRM. This amounted to the loss of 13 eggs and 7 chicks; coupled with 2 eggs with bill marks found in completed clutches, a minimum of 22 eggs or nestlings were lost to nest predators. It was difficult to determine the cause of death of most nestlings due to condition of carcasses upon discovery. BCNH

Table 3. Clutch size for Black-crowned Night-Herons nesting at Indian Ridge Marsh (IRM) and Inland Steel, 2002 and 2003, and as reported in previous studies.

Location/Status	n	Mean	S.E.	Min-Max	Mode	Comments	Citation
IRM 2002 — all clutches 2002	40	3.40	0.11	2-5	3	includes second clutches; nearly bimodal (3- and 4-egg clutches)	this study
IRM 2002 — first clutches only	36	3.42	0.12	2-5	3/4	excluding second clutches; bimodal	this study
IRM 2002 — first clutches ≤ May 13	18	3.56	0.17	2–5	4	initiated prior to or on median date; nearly bimodal (3- and 4-egg clutches)	this study
IRM 2003 — all clutches		3.36					this study
IRM 2002- first clutches > May 13	17	3.08	0.19	2–4	3	initiated after median date	this study
ISPAT Inland Steel, IN 2002 — first clutches	13	3.38	0.21	3–5	3	tree nests; exposure to environmental contaminants likely	this study
ISPAT Inland Steel, IN 2003		3.06				tree nests; exposure to environmental contaminants likely	this study
Maryland	69	3.46	NA	2–5	4	nearly bimodal (3- & 4-egg clutches); shrub/tree nests; no apparent impact environmental contaminants	Rattner et al. 2001
Oregon and Washington — all clutches	260	3.45[1,2]	0.08–0.11	2–5	NA	means 3.10 to 3.92; shrub/tree nests; no apparent impact environmental contaminants	Blus et al. 1997
Oregon and Washington — first clutches	208	3.47[1,2]	0.08–0.12	2–5	NA	means 3.09 to 3.93; shrub/tree nests; no apparent impact environmental contaminants	Blus et al. 1997
Idaho	281	3.6[1,2]	0.08–0.13	1–6	3/4[2]	means 3.4 to 3.7; shrub/trees; DDE impacts on reproduction	Findholt and Trost 1985
NV, OR, WA — ≤ 8 ppm DDE	133	3.75[1,2,3]	0.15[1]	NA	NA	means 3.67 to 3.80; shrub/tree nests; no apparent impacts environmental contamination	Henny et al. 1984
NV, OR, WA — > 8 ppm DDE	50	3.17[1,2,3]	0.19[1]	NA	NA	means 3.00 to 3.41; shrub/tree nests; DDE impacts on reproduction	Henny et al. 1984
Massachusetts and Rhode Island	346	3.79[1,2,3]	NA	2–5	4	means 3.66 to 3.96; possible DDE impacts on reproduction	Custer et al. 1983
North Carolina	121	3.32[1,2,3]	NA	2–5	3	means 3.08 to 3.50; no apparent impacts environmental contaminants	Custer et al. 1983
Quebec	98	4.1[1,2,3]	0.1	1–6	NA	means 3.9 to 4.2; shrub/tree nests; no apparent impacts environmental contaminants	Tremblay and Ellison 1980
Alberta — first clutches	116	3.60[1,2,3]	NA	1–6	3/4[2,3]	means 3.2 and 4.0; emergent vegetation nests	Wolford and Boag 1971
CA — pre-1947	35	3.86	NA	NA	NA	unknown status	(see Henny et al. 1984)
NV, OR, WA — pre-1947	41	3.80[1,2,3]	NA	2–5	NA	unknown status	Henny et al. 1984
Utah — pre-1947	41	4.1	0.13	2–6	4	unknown status	Findholt and Trost 1985

[1] Grand mean; [2] Multiple colonies; [3] Multiple years

Table 4. Fate of Black-crowned Night-Heron Clutches/Broods at Indian Ridge Marsh, Cook County, Illinois, 2002.

Fate of Clutch	Number of Clutches	Percent of Clutches
Successful[1]	34	66.7
Eggs Rolled Out, Poorly Constructed Nest	7	13.7
Depredated[2]	5	9.8
Abandoned[3]	3	5.9
Eggs/Nestlings Gone, No Signs	2	3.9

[1] at least one nestling survived to 15 days post hatch
[2] one clutch assumed abandoned after one egg depredated
[3] one damaged egg abandoned

Notes-

a) another 4 broods known to completely fail after 15 days
b) determined minimum 6 predation events (clutch/brood or single eggs/chicks)
c) 11 chicks dead in nest= 3 depredated (same nest), 8 unknown fate

eggs hatch asynchronously and later-hatching nestlings may be disadvantaged, with competition by older siblings leading to starvation, drowning, or trampling of younger nestlings. This was undoubtedly the cause of the disappearance of many nestlings. We frequently visited nests with two or three thriving siblings, and the smaller, less thrifty individual was often missing at our next visit.

Several eggs had apparently been depredated by Ring-billed Gulls (RBG), judging by bill marks, although in at least one case the gulls may have scavenged a previously abandoned clutch. Large numbers of RBG frequented the area and were often seen fishing in open-water portions of IRM. We did not observe Gulls at BCNH nests, although we did note a BCNH briefly chase a RBG that was flying low over the colony. We did find and examined three siblings < 5 days old that had been killed by single pecks to the back of their skull.

Most nests successfully fledged at least one young on 2003 (Table 5); there were no known or suspected losses of entire clutches or broods to predation. Although no eggs were observed in water, all eggs missing from two flat-topped nests were assumed to have rolled out into the water. One nest was presumed abandoned as the marked eggs were present well after they should have hatched. At least 25 eggs were missing or otherwise failed to hatch. Twenty-three nestlings did not survive to fledging (i.e., 15 days post-hatch); of these, 21 were missing, 1 was found dead in nest (cause unknown), another had fallen out of the nest and was found with its neck caught between *Phragmites* stems.

Fledging and Dispersal

The number of juveniles observed in 2002 increased dramatically between mid-July and mid-August. The first appearance of juveniles between June 29 and July 13 coincides rather well with our first observation of flighted juveniles on July 3 while performing nest checks, and estimated dates that older chicks attained flight. The number of juveniles observed peaked on August 10, before declining precipitously between August 10 and 24 (Fig. 5). This reduction in juveniles is consistent with our expectation, based on nesting phenology (see above), that 97% of juveniles would have reached dispersal age (~58 days post-hatch) by August 24. In 2003 the number of juveniles observed peaked earlier than in 2002; in 2003 most young were gone from IRM by mid-August (Fig. 5).

Productivity

While comparisons of productivity between studies are useful, the ratio of breeders to non-breeders, food availability, local weather patterns, climate/growing season (latitude), predation, and a variety of density-dependent factors can influence productivity. Most powerful are comparisons with contemporary local/regional populations. The only sizable colony in the south Chicago area available to us for comparison during 2002 and 2003 was at IIS, located on the Lake Michigan shoreline only 15 km from the Lake Calumet colony (Fig. 1). This colony is located at the same latitude as LCW; the IIS BCNH nested in cottonwood trees during this study.

Daily nest survival rate was similar between the colonies we examined (Table 6). In 2002 clutches at IRM and IIS had a lower likelihood of surviving the incubation period, when compared to 2003 when the survival rate of nests to hatch was relatively high at both locations.

Daily survival rate of nests during the nestling period was similar between the IRM and IIS colonies (Table 6). Survival of broods to 15 days of age was lower at IIS than at IRM; brood survival at IRM was similar between years.

In 2002, nest success (a function of survival rate to hatching and survival rate to fledging) at IRM was greater than at IIS, which was poor (Table 6). Nest success at both IRM and IIS improved between 2002 and 2003, although remained poor at the latter.

Egg success, the probability of an egg hatching, was low at IIS during 2002, though improved between 2002 and 2003 at this site and at IRM. Nestling survival was low at IIS in 2002; survival of young to 15 days improved at both IRM and IIS between years (Table 6).

The mean number of young surviving/nest was very low at IIS, whereas “recruitment” was relatively high at IRM by comparison (Table 6). Recruitment increased at both IRM and IIS between 2002 and 2003.

Table 5. Fate of Black-crowned Night-Heron Clutches/Broods at Indian Ridge Marsh, Cook County, Illinois, 2003.

Fate of Clutch	Number of Clutches	Percent of Clutches
Successful[1]	52	94.5
Eggs Rolled Out, Poorly Constructed Nest	2	3.6
Depredated	0	0
Abandoned	1	1.8
Eggs/Nestlings Gone, No Signs	0	0

[1] at least one nestling survived to 15 days post-hatch
[2] no confirmed or suspected predation of marked nests
Notes-
a) 23 chicks failed to survive 15 days= 21 missing, 2 chicks dead in nest (1 accidental death, 1 unknown cause of mortality)

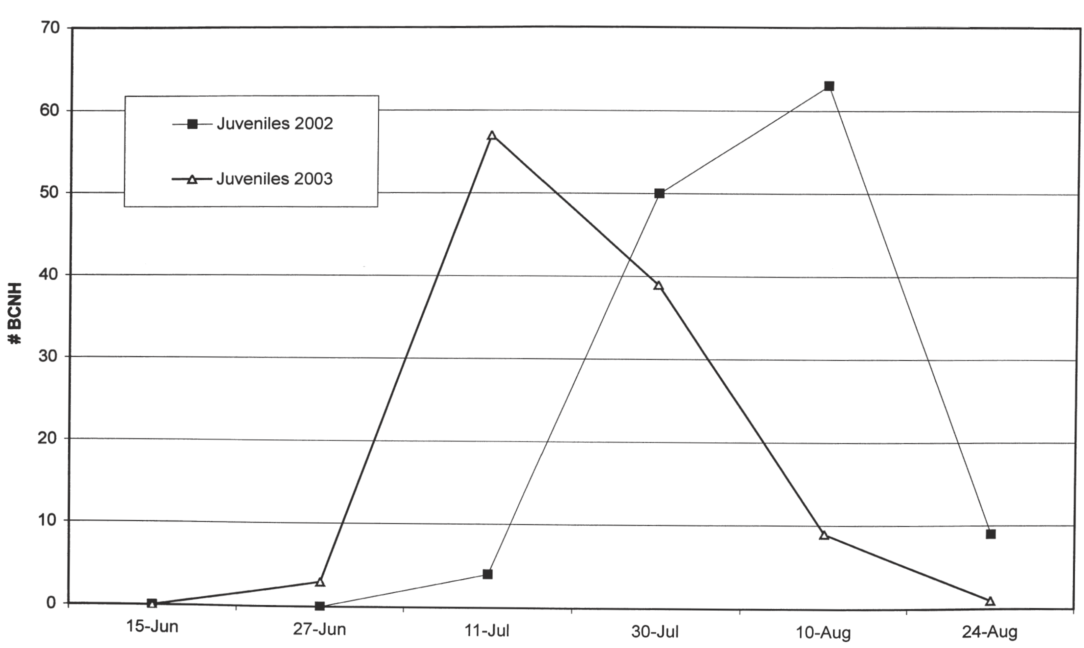

Figure 5. Numbers of juvenile Black-crowned Night-Herons observed at Indian Ridge Marsh colony during 2002 and 2003 post-breeding surveys.

Table 6. Reproductive parameters in a Black-crowned Night-Heron colony located in the Calumet region of Illinois and northwestern Indiana, 2002 and 2003.

Location / Nesting Parameters	Indian Ridge Marsh—This Study 2002	Inland Steel —This Study 2002	Indian Ridge Marsh—This Study 2003	Inland Steel —This Study 2003	Maryland —Rattner et al. 2001	Pacific Northwest —Blus et al. 1997	San Francisco Bay —Hothem et al. 1995	East Coast —Custer et al. 1983
Egg Laying and Incubation (n)	46	15	55	17	69		485	531
Daily Survival Rate	0.9895	0.9855	0.9985	0.9931	0.9936	0.9240–0.9934[4]		
Survival Rate to Hatch	0.7762[1]	0.7043[1]	0.9635	0.8474	0.8517[2]		0.475–0.701	0.547–0.902[2]
Nestling Period (n)	37	13	52	15	59		395	(<531?)
Daily Survival Rate	0.9922	0.9864	0.9899	0.9809	0.9911	0.9782–1.000[5]		
Survival Rate to Fledging	0.8892[3]	0.6245[3]	0.8593	0.7485	0.8745[3]		0.691–0.896	0.758–1.000[3]
Nest Success	0.6920	0.4398	0.8280	0.6343	0.7448			0.530–0.867
Probability of Egg Hatching	0.8860	0.6852	0.9195	0.8333	0.8933			0.852–0.917
Probability Young Survived 15 days	0.8365	0.5143	0.8688	0.7714	0.8917			0.771–1.000
Egg Success	0.5115	0.1550	0.6614	0.4078	0.5932			0.385–0.716
Mean Clutch Size	3.40	3.38	3.36	3.12	3.46			3.08–3.96
Mean Number of Young Surviving 15 Days	1.74/nest	0.52/nest	2.22/nest	1.27/nest	2.05/nest	0.41–1.83/nest	1.45–2.04/nest	1.19–2.65

[1]= 24 day laying and incubation period; [2]= 25 day laying and incubation period; [3]= 15 days post-hatch; [4]= 27 day laying and incubation period; [5]= 14 days post hatch

DISCUSSION

BCNH utilize a wide range of arboreal habitats for nesting including upland orchards (Gross 1923), bottomland forests (Bjorklund and Holm 1997), coastal islands (Parsons 1995) , and trees in towns and cities (Farwell 1919, Cunningham 1945). Breeding colonies are also frequently located in emergent vegetation such as *Phragmites* or cattails (*Typha*), with nests located just inches above the water (Nelson 1876–1877, Rockwell 1910, Greenwood 1981). During the 20 years from 1984 to 2003 the Lake Calumet BCNH changed nesting locations as habitat conditions dictated, i.e., when nesting cover was impacted by fire, flooding, or succession (or lack thereof). The colony has maintained a high degree of fidelity to this area in spite of these changes. This supports Graber et al.'s (1978) assertion that the quality of the surrounding foraging habitat is a more important criterion for nesting than the particular habitat in which the nests are actually placed.

There appeared to be a clear preference for relatively open nest sites (i.e., of lower *Phragmites* stem density). A more open nest would seem to result in greater nest predation risk. However, 1) nests tended to be clumped in these more open areas and there may be higher survival of individual nests within groups, and 2) there may be greater inclusive fitness in that parents may be better able to avoid predators at some risk of clutch/brood predation.

Clutch size may be affected by a variety of factors linked to female condition and/or environmental quality (Winkler and Allen 1996). Mean clutch size in our study in 2002 was similar to that of recently-studied colonies in Maryland and the Pacific Northwest. The average clutch size at IRM was at the upper end of the range of average clutch sizes observed in colonies that were thought to be impacted by DDE, and below the range of clutch sizes observed for "clean" colonies in the Unites States and Canada. Interestingly, mean clutch size for first and second clutches in our study differed by the same amount as those in colonies in Oregon and Washington. The reason for the decline in clutch size between 2002 and 2003 at IIS was unknown.

Early clutches (< median date) were larger, as compared with those completed later (> median date). Custer et al. (1983) noted that BCNH clutches initiated later in the season had a larger proportion of smaller clutches (i.e., < four eggs) than earlier clutches. It is unclear as to whether such seasonal declines in clutch size are related directly to female condition or an adaptive response to declining resources as nesting season progresses (Winkler and Allen 1996).

Our estimate of April 20 to June 10 for the egg-laying period at IRM in 2002 is similar to April 24 to June 18 reported by Graber et al. (1978) for northern Illinois colonies. However, our estimate of April 20 to May 26 for the egg-laying period in 2003 is somewhat shorter than reported by Graber et al. (1978). In 2002, eggs would have been present at IRM over a period of two and one-half months; this is a longer egg period than in 2003 by about two weeks. This is consistent with the number of juveniles present during our post-breeding surveys; most young were gone from IRM by mid-August of that year, or about two weeks earlier than in 2002. We did not encounter recycled nests in 2003, thus there may have been fewer renesting attempts in that year.

Daily survival rate of nests at IRM and IIS during the nestling period were similar to those examined by others. Survival of broods to 15 days of age was lower in tree-nesting BCNH at IIS than the *Phragmites*-nesting colony at IRM or reported in previous studies. Parsons (1995) reported that nestling survival was lower in Cattle Egrets nesting in shrubs as compared to those nesting in *Phragmites* in the same colony (Parsons 1995). We sometimes noted eggs and carcasses of young on the ground below nesting trees at IIS. This colony was directly exposed to winds off of Lake Michigan, and we assume that some of this loss may have been due to high winds and other mishaps causing nestlings to fall out of trees. Brood survival at IRM was similar between years, and was relatively high in comparison with past studies.

Although some eggs and young where lost to predation, we were not able to determine the cause of all losses. It is plausible that RBG were responsible for the disappearance of some of the eggs and smaller nestlings that weren't accounted for. However, predation by this species did not seem to be an important factor at IRM, particularly in light of the large numbers of RBG frequenting this wetland. In contrast, RBG were responsible for the poor productivity of some BCNH colonies in Alberta (Wolford and Boag 1971). Predation by Common Ravens (*Corvus corax*) essentially eliminated production in one colony in the western United States (Henny et al. 1984), and egg depredation by American Crows (*Corvus brachyrhynchos*) affected nest success in some colonies in the Pacific Northwest (Blus et al. 1997). Although gulls, crows, and other avian predators were present, predation did not have a demonstrable impact on productivity of the LCW BCNH colony.

Henny (1972) determined that 2.0–2.1 young produced/breeding pair is needed to maintain BCNH populations, and Wolford and Boag (1971) calculated that a colony producing 1.1 fledged young/pair would disappear in 20 years. Thus, the estimated fledging rates (actually survival to 15 days) at IRM in 2002 in this study may not have been high enough to maintain a stable population. However, recruitment in 2003 was among the highest reported in other studies. It is not unusual for productivity of BCNH colonies to vary between years. For example, Greenwood (1981) reported annual production of 0.23, 0.57, and 2.20 fledglings/pair for a colony occupying a marsh in North Dakota; strong storms with hail and high winds were responsible for large losses of nests and young in two of those years. However, in the absence of such catastrophic events (including heavy losses to predation) productivity of BCNH does not vary this dramatically between years (e.g., see Custer et al. 1983).

Exposure to environmental contaminants has been associated with impaired reproduction (Custer et al. 1983, McEwen et al. 1984, Henny et al. 1984, Findholt and Trost 1985, Hoffman et al. 1993, Hothem et al. 1995) and teratogenic effects (Hoffman et al. 1993, Hothem et al. 1995) in BCNH. At the time of this writing we are examining selected environmental contaminants and biomarkers of exposure in pipping embryos collected from this colony in 2002; the results of this work are not addressed here. However, we did not observe any gross deformities in pipping embryos or nestlings and, as noted above, reproductive parameters for BCNH nesting at IRM were within normal limits for this species. Thus, it would appear that environmental contaminants are not having observable impacts on the productivity of this population.

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