

## Diet of Nestling Black-crowned Night-herons in a Mixed Species Colony: Implications for Tern Conservation

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**ABSTRACT.**—Boluses were collected from Black-crowned Night-heron (*Nycticorax nycticorax*) nestlings in 1992 to examine the impact of night-heron predation on a restored tern colony. Boluses ( $n = 101$ ) were collected from 18 nests. Fish remains occurred in 89% of nests, sand shrimp (*Crangon septemspinosa*) in 50%, birds in 28%, and amphibians in 16% of nests sampled; mammalian, eel, squid, and marine invertebrate remains were also noted. Regurgitated bird remains were found in five nests and included four species, Common Terns (*Sterna hirundo*), Common Eiders (*Somateria mollissima*), Gulls (*Larus* sp.), and the legs of an unknown wading bird. Nestling night-herons from three nests were fed tern chicks, but 92% of tern chicks known to have been eaten were fed to nestling Black-crowned Night-herons in one nest. No tern chicks fledged in 1992 and night-herons were observed in the tern colony on multiple occasions. This study suggests that individual night-herons will specialize on waterbird prey. The subsequent removal of a specialist night-heron predator resulted in improved tern productivity. Received 16 February 2007. Accepted 16 October 2007.

Black-crowned Night-herons (*Nycticorax nycticorax*) are a generalist predator with a varied diet, which includes fish, mollusks, crustaceans, mammals, amphibians, reptiles, invertebrates, vegetation, and bird eggs and chicks (Marshall 1942, Palmer 1962, Collins 1970, Wolford and Boag 1971, Szlivka 1985, Yen 1991, Davis 1993). They are reported to feed by sight (Watmough 1978) and sound (Hunter and Morris 1976), and will take advantage of temporary abundances of food (Davis 1993). Food preference is reported to

vary between colonies and years (Collins 1970). Night-heron predation in colonial waterbird colonies has been widely noted (Beckett 1964, Collins 1970, Hunter and Morris 1976, Nisbet and Welton 1984) and negative impacts have been documented on nesting colonial seabirds (Hunter and Morris 1976, Shealer and Kress 1991).

Stratton Island is a diverse waterbird colony in Maine that provides habitat for both a restored nesting colony of terns (Arctic [*Sterna paradisaea*], Common [*S. hirundo*], Least [*S. antillarum*], and Roseate [*S. dougallii*]) (Kress [1983] provides a discussion of tern restoration techniques) and nesting wading birds including Black-crowned Night-herons. Nocturnal losses of tern eggs and chicks were first observed in 1989, 3 years after tern restoration was initiated. Tern reproductive success was poor in 1989 (0.07 chicks/pair; Shealer 1989) and 1991 (0.0 chicks/pair; Hedges and Whitaker 1991), and good in 1990 (1.5 chicks/pair; Skinner 1990) when productivity monitoring only occurred in an area where startle lights were used to deter night-heron predation. Overall, recruitment to the tern colony slowed during this period and birds were abandoning the colony at night and between seasons. Observations of terns mobbing adult and juvenile night-herons in or adjacent to the tern colony were recorded from 1989 to 1992, but night-herons were only observed taking tern chicks and eggs in 1992 (Benz and D'Angelo 1992).

The objectives of our study were to: (1) quantify Black-crowned Night-heron nestling diet, (2) identify the number of night-heron pairs that were feeding terns to their young, and (3) examine the impact of night-heron predation on a tern colony.

### METHODS

**Study Area.**—The study was conducted in 1992 on Stratton Island (43° 31' N, 70° 19'

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TABLE 1. Black-crowned Night-heron nestling diet, Stratton Island, Maine, 1992. Frequency equals the number of nests containing the designated prey type and not the total number of individuals recovered for each prey type.

Prey item	Nests ( <i>n</i> = 18) Frequency of nests (%)
Bird	5 (27.7)
<i>Sterna</i> sp.	3 (16.7)
<i>Larus</i> sp.	3 (16.7)
<i>Somateria mollissima</i>	3 (16.7)
Unk - ardeid	2 (11.1)
Unk - bird	1 (5.6)
Fish	16 (88.9)
Unknown fish	16 (88.9)
<i>Alosa pseudoharanguis</i>	1 (5.6)
<i>Catostomus</i> sp.	1 (5.6)
<i>Fundulus majalis</i>	1 (5.6)
Unk - Catfish	1 (5.6)
Sand Shrimp ( <i>Crangon septemspinosa</i> )	9 (50.0)
Amphibian	3 (16.7)
<i>Rana clamitans</i>	2 (11.1)
<i>Rana</i> sp.	1 (5.6)
Eel	1 (5.6)
Mammal	1 (5.6)
<i>Tamias striatus</i>	1 (5.6)
Invertebrate	2 (11.1)
Squid	1 (5.6)

W), 3 km east of Prout's Neck, York County, Maine. The National Audubon Society's Sea-bird Restoration Program monitors and manages this mixed species, 12.2-ha inshore island. Stratton Island has been Maine's most diverse waterbird colony with 21 nesting species; in 1992, the wading bird colony included ~250 pairs of Snowy Egret (*Egretta thula*), Little Blue Heron (*E. caerulea*), Tri-colored Heron (*E. tricolor*), Cattle Egret (*Bubulcus ibis*), Glossy Ibis (*Plegadis falcinellus*), and Black-crowned Night-heron.

**Bolus Collection and Processing.**—Night-heron nests were flagged during the annual wading bird census for subsequent visits. We collected spontaneous regurgitations from captured nestlings and obtained additional boluses by gently massaging the neck of captured nestlings. Samples were labeled, placed in plastic bags and preserved in a 70% ethanol solution for future processing. Samples were not collected from every nest on each visit to reduce disturbance.

The colony contained 53 night-heron pairs

and 18 of the nests were included in the study. Nest inclusion was dependent on hatching fate, chick survival, and our ability to sample nestlings (nests at the top or on outer branches of a nesting tree could not be sampled). Nests were visited 5–14 times between 11 June and 7 August while tern chicks were present on the island. One to 33 samples were collected from each nest (mode = 4 samples/nest).

Samples were identified in January 1993 to the most precise taxa possible by initially sorting bolus contents by size and taxa. The contents were screened by passing water over the boluses and through a hardware cloth sieve. Voucher specimens were preserved in glass jars with 70% ethanol. All bird remains and fish scales (mounted on slides) were washed (feathers were dried) before examination under a stereo dissecting scope. Unidentified fish samples were submitted to the Maine Department of Marine Resources for identification.

**Tern Monitoring.**—An annual nest census was conducted by walking through the tern colony and marking all nests following the procedures of Kress and Hall (2004). The count was timed to coincide with the maximum number of nests prior to hatch. Two hundred and twenty-one pairs of Common Terns, seven pairs of Roseate Terns, and five pairs of Arctic Terns nested in 1992. Productivity (fledglings produced/pair) was measured from a sample of nests (*n* = 25) in five enclosures, which were enclosed to permit recapture of chicks. Enclosures measured 7.62 × 3.66 m and were constructed from chicken wire wrapped with landscape fabric. Enclosure locations were random and constructed in tern nesting habitat prior to clutch initiation. All chicks were banded within 1 day of hatching with a USGS band and followed through fledging.

## RESULTS

One hundred and one boluses were collected from Black-crowned Night-heron nestlings; 58% contained bird remains, 33% fish, and 16% sand shrimp. However, sixty-two boluses were collected from just three nests. Additional prey items (small proportions) included eel, squid, amphibians, mammals, and insects. Fish were found at 89% of the sampled nests, sand shrimp at 50%, and bird remains at 28% (*n* = 5). Fifty percent (39 total sam-

ples) of the bird remains were tern chicks (most were *S. hirundo*), 24% (19 total samples) were Common Eider ducklings, and 22% (18 total samples) were gull chicks (either *L. argentatus* or *L. marinus*). Most bird remains (97%) were found at three nests and 92% of the tern chick remains were in one nest including 21 of 22 recovered tern bands from a total available sample of 66 banded Common Tern chicks. Remains of gull chicks and eider ducklings were found in three nests, although 70% of gull chicks were found at one nest (different than the nest with tern chicks) and 53% of eider ducklings were found in another nest.

No tern chicks fledged from enclosures in 1992. Sixty-five eggs were laid in 25 enclosure nests, 26 disappeared (6 were pipping), 12 were abandoned, 2 were depredated, and 25 hatched. All hatched chicks disappeared before they reached 8 days of age; 18 disappeared by the age of 3 days. We assumed all chicks that disappeared were predated as no remains were found within or outside enclosures and night-herons were observed feeding in the colony.

#### DISCUSSION

Black crowned Night-heron nestlings on Stratton Island were fed a diverse diet consisting of marine, tidal/estuary, freshwater, and upland-derived vertebrate and invertebrate prey. Fish (4+ species), shrimp, and birds (4+ species) were the dominant prey by frequency in boluses and at nests. Unlike other studies (Szlivka 1985, Yen 1991), amphibians occurred in less than 5% of boluses, suggesting that night-herons nesting on Stratton Island forage primarily in marine or estuarine habitats, rather than freshwater habitat. Most food habit studies or summaries of Black-crowned Night-heron diets have reported that fish were the principal food (Collins 1970, Hoffman 1978, Szlivka 1985, Yen 1991, Davis 1993, Riehl 2006) but, in this study, while fish occurred in 89% of nests, shrimp and bird remains occurred in greater numbers and frequency in boluses. Bird remains have been reported in many other food studies of night-herons (Collins 1970, Wolford and Boag 1971, Hunter and Morris 1976, Yen 1991). The presence of wading bird remains in night-heron boluses is also consistent with other

studies (Beckett 1964, Wolford and Boag 1971, Riehl 2006).

Although bird remains were prevalent, nestlings at only five of 18 nests were provisioned with birds and, of these, 97% of bird remains were at three nests. Parents at only one of these three nests provisioned their young exclusively with birds and this pair concentrated on gulls, but also delivered eider ducklings and tern chicks. Tern chicks were observed at all three nests with bird remains, but 92% of tern remains (36 of 39 total tern remains) were concentrated at one nest. However, 49% of the diet at this nest was comprised of sand shrimp (and 1 green frog [*Rana* sp.]); 51% were bird remains (11% gulls, 13% eiders, 76% terns) suggesting that each adult in this pair had specific food or foraging habitat preferences. Thus, night-heron predation in this tern colony appeared to be a specialized feeding behavior with just one adult consistently using this food resource.

Despite the low frequency of this specialized feeding behavior by night-herons, the consequences for nesting terns on Stratton Island were pronounced. No tern chicks fledged from study nests in 1992. Direct predation (inferred from predated eggs, missing young chicks, and from direct observation of predation with night vision binoculars) by night-herons was the principal cause of mortality in 1992. Several other studies have noted significant impacts of night-heron predation on tern reproductive success (Collins 1970, Hunter and Morris 1976, Nisbet and Welton 1984, Shealer and Kress 1991).

A single adult Black-crowned Night-heron was shot on 5 July 1994 while feeding on tern chicks. No additional predation by night-herons was noted in the tern colony in 1994. Night-heron predation was not observed again on Stratton Island until 2002. In response to the removal of one night-heron, tern productivity increased to 1.9 chicks/nesting pair in 1994. The average tern productivity during years of night-heron predation (1989–1993, 2002) was 0.42 chicks/pair and, with no observed night-heron predation, it was 1.6 chicks/pair from 1994 to 2001. This suggests that night-heron predation was a major factor in affecting tern nesting success on Stratton Island.

Night-heron predation can have significant

impacts on nesting waterbirds and the exploitation of tern chicks is likely a specialized feeding behavior. The subsequent removal of an individual night-heron and corresponding positive breeding response by terns suggests that removal of specialist night-heron predators can reduce impacts to nesting terns.

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#### LITERATURE CITED

- BECKETT, T. A. 1964. Black-crowned Night-heron feeding behavior. *Chat* 29:93–94.
- BENZ, S. AND P. D'ANGELO. 1992. Stratton and Bluff islands, The National Audubon Society's Phineas W. Sprague Memorial Sanctuary, Saco Bay, Maine. 1992 Season Report. National Audubon Society Seabird Restoration Program, Ithaca, New York, USA.
- COLLINS, C. T. 1970. The Black-crowned Night-heron as a predator of tern chicks. *Auk* 87:584–586.
- DAVIS, W. E. 1993. Black-crowned Night-heron. *The birds of North America*. Number 74.
- HEDGES, S. AND H. WHITAKER. 1991. Stratton and Bluff islands, The National Audubon Society's Phineas W. Sprague Memorial Sanctuary, Saco Bay, Maine. 1991 Season Report. National Audubon Society Seabird Restoration Program, Ithaca, New York, USA.
- HOFFMAN, R. D. 1978. The diets of herons and egrets in southwestern Lake Erie. Pages 365–369 in *Wading birds* (A. Sprunt IV, J. C. Ogden, and S. Winkler, Editors). Research Report Number 7. National Audubon Society, New York, USA.
- HUNTER, R. A. AND R. MORRIS. 1976. Nocturnal predation by a Black-crowned Night-heron at a Common Tern colony. *Auk* 93:629–633.
- KRESS, S. W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. *Colonial Waterbirds* 6:185–196.
- KRESS, S. W. AND C. S. HALL. 2004. Tern management handbook: coastal northeastern United States and Atlantic Canada. USDI, Fish and Wildlife Service, Hadley, Massachusetts, USA.
- MARSHALL, N. 1942. Night desertion by nesting Common Terns. *Wilson Bulletin* 54:25–31.
- NISBET, I. C. T. AND M. J. WELTON. 1984. Seasonal variations in breeding success of Common Terns: consequences of predation. *Condor* 86:53–60.
- PALMER, R. S. 1962. Handbook of North American birds. Volume 1. Loons through flamingos. Yale University Press, New Haven, Connecticut, USA.
- RIEHL, C. 2006. Widespread cannibalism by fledglings in a nesting colony of Black-crowned Night-herons. *Wilson Journal of Ornithology* 118:101–104.
- SHEALER, D. A. 1989. Stratton and Bluff islands, The National Audubon Society's Phineas W. Sprague Memorial Sanctuary, Saco Bay, Maine. 1989 Season Report. National Audubon Society Seabird Restoration Program, Ithaca, New York, USA.
- SHEALER, D. A. AND S. W. KRESS. 1991. Nocturnal abandonment response to Black-crowned Night-heron disturbance in a Common Tern colony. *Colonial Waterbirds* 14:51–56.
- SKINNER, J. M. 1990. Stratton and Bluff islands, The National Audubon Society's Phineas W. Sprague Memorial Sanctuary, Saco Bay, Maine. 1990 Season Report. National Audubon Society Seabird Restoration Program, Ithaca, New York, USA.
- SZLIVKA, L. 1985. Data on the food of the Purple (*Ardea purpurea*), Night (*Nycticorax nycticorax*) and Squacco (*Ardeola ralloides*) herons on Lake Luda. *Larus* 36–37:175–182.
- WATMOUGH, B. R. 1978. Observations on nocturnal feeding by night-herons (*Nycticorax nycticorax*). *Ibis* 120:356–358.
- WOLFORD, J. W. AND D. A. BOAG. 1971. Food habits of Black-crowned Night-herons in southern Alberta. *Auk* 88:435–437.
- YEN, CHUNG-WEI. 1991. Food of nestling egrets and night herons in the western lowlands of central Taiwan. *Journal of the Taiwan Museum*. 44:309–320.