

## RUDDY TURNSTONES, GREAT HORNED OWLS, AND EGG LOSS FROM COMMON TERN CLUTCHES

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ABSTRACT.—In two successive years, eggs of Common Terns (*Sterna hirundo*) disappeared or were found freshly perforated only from clutches initiated relatively early in the breeding season. Most of the losses were of single eggs from which an incubating adult was temporarily absent. Diurnal dreads of adult terns coincided with evidence of nocturnal predation by Great Horned Owls (*Bubo virginianus*). Ruddy Turnstones (*Arenaria interpres*) were observed breaking open and eating the contents of Common Tern eggs. We consider various explanations of the timing and pattern of egg loss. Circumstantial evidence supports the suggestion that nocturnal disturbance by owls at a time when Ruddy Turnstones are present at the colony may increase the risk of daytime predation by turnstones on tern eggs. Received 10 Apr. 1985, accepted 21 Oct. 1985.

The two principal nocturnal avian predators of Common Terns (*Sterna hirundo*) in North America are Black-crowned Night-Herons (*Nycticorax nycticorax*), which consume eggs and chicks (Collins 1970, Hunter and Morris 1976), and Great Horned Owls (*Bubo virginianus*), which prey upon chicks and adults (Nisbet 1975). Predation of tern eggs by Ring-billed Gulls (*Larus delawarensis*) occurs rarely (Courtney and Blokpoel 1980), whereas Herring Gulls (*L. argentatus*) have not been reported to consume tern eggs, although they sometimes prey heavily on chicks (Hatch 1970). Ruddy Turnstones (*Arenaria interpres*) eat eggs of several tern species (Crossin and Huber 1970, Loftin and Sutton 1979), including those of Common Terns (Parkes et al. 1971).

During four years of study at a colony of Common Terns in Lake Erie, the disappearance of eggs was responsible for from 18% (Morris et al. 1976) to 45% (Hunter 1976) of the total number of eggs that failed to hatch. Disappearance was most common during May, at the peak time of laying. As part of a larger study in 1982 and 1983, we obtained information on the timing and pattern of egg disappearance from Common Tern clutches, the eating of eggs by Ruddy Turnstones, and the association of these phenomena with probable predation by Great Horned Owls. We here report on these relationships.

### STUDY AREA AND METHODS

The tern colony was on an artificial breakwall, about one km off the north shore of Lake Erie near Port Colborne, Ontario (42°53'N, 79°16'W). Terns nested on a linear concrete

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shelf (approximately  $6 \times 270$  m) and traditionally have occupied the shelf area from west to east as the season progressed (Morris et al. 1976). One elevated observation blind was erected at the west end in front of an area (approximately  $6 \times 20$  m) that was covered by a layer of soil overgrown by mossy stonecrop (*Sedum acre*). A second blind was about 100 m to the east in front of an area (approximately  $6 \times 30$  m) containing gravel, logs, and plants that we had added to the existing concrete substrate (Richards and Morris 1984).

The study site was visited daily from 2 May to 16 July 1982 and from 1 May to 29 June 1983. We always approached each blind from the water and stepped onto the breakwall immediately behind it. Before entering the blinds, we marked new clutches with numbered wooden tongue depressors; eggs were marked soon after they were laid. Massed flights ("dreads") of all terns in the colony were frequent throughout May in both years (see below). Accordingly, to reduce the amount of time spent in the western study area during May, we obtained most information on the fate of eggs in clutches there by observation with binoculars from the blind. Vegetation growth was minimal early in the season, and the fate of eggs in many study clutches was readily followed by this procedure. Periodic nest checks were made to confirm the state of each clutch; we did not, however, take the extra time required to check hatching success of all clutches. Similar procedures were used to follow the fate of eggs in clutches initiated during late May, June, and July in the eastern study area. In addition, daily nest checks, made either after (morning) or before (evening) a blind watch, permitted a more detailed accounting of egg fate including hatching success.

In 1982, we made observations from both blinds each day during the 3 h following sunrise or the 3 h preceding sunset. In 1983, we were in both blinds for 8 h each day (4 h following sunrise and 4 h before sunset) until 14 May. Thereafter, daily observation periods of 3 or 4 h were made in each blind following sunrise or prior to sunset.

As one of several specific observations relating to a broader study of Common Tern behavior, we recorded the number of times that groups of terns simultaneously flew off their nests and the approximate percentage of all birds in the colony (total of 900–1000 pairs) that participated. We classified flights into two categories: those in which almost all birds departed virtually simultaneously ("dreads", Marples and Marples 1934), and those in which birds in only a small portion of the colony did so (hereafter called "up-flights"). Dreads were characterized by a sudden quietness in the colony followed by a departure of 90–100% of all terns in the colony. Up-flights were characterized by groups of terns in a small portion of the colony flying up and hovering a few meters above their clutches for brief periods of time before returning to incubate. Any obvious proximate stimulus associated with either type of flight was noted.

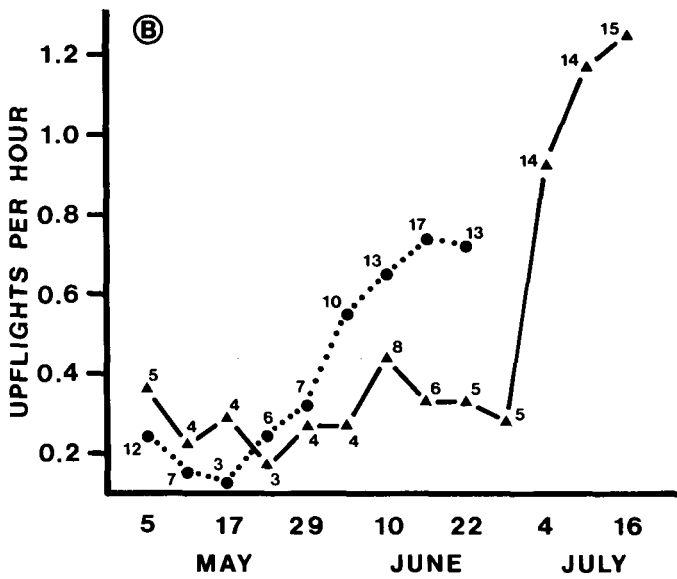
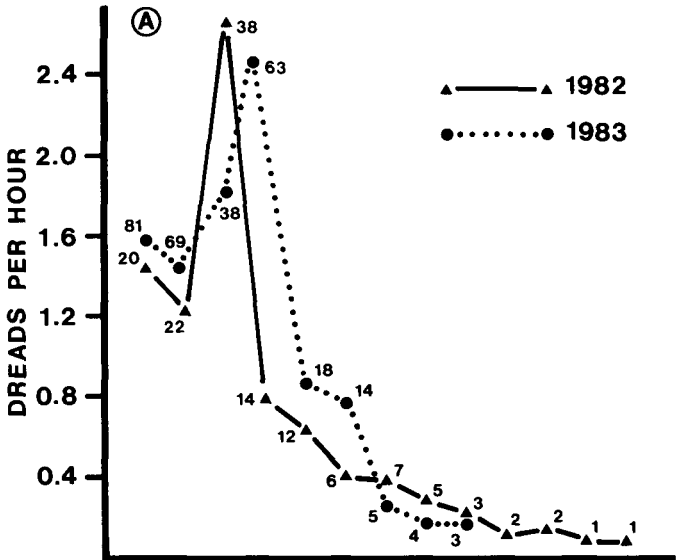
## RESULTS

*Diurnal tern flights.*—The patterns of dreads (major flights) and up-flights (minor flights) recorded in each year are shown in Fig. 1. In both years, the frequency of dreads gradually declined throughout the season with the exception of marked increases during mid-May (Fig. 1A). Most (>95%) dreads occurred without an obvious external stimulus; a few were preceded by a boat whistle or the approach of a fishing boat. During

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FIG. 1. Mean number of group flights per hour by Common Terns between 3 May and 16 July in each of two years. A. Major flights ("dreads") involved 90–100% of all terns in

<b>1982</b>	14	18	15	18	15	15	18	18	15	18	15	12	12	12
<b>1983</b>	51	48	21	26	21	18	20	23	18	-	-	-	-	-



the colony. B. Minor flights ("up-flights") were in response to a local disturbance (see text). The number of hours of observation during 6-day periods are shown across the top of the figure. Data points are connected by lines to aid the reader and do not imply interpolation.

TABLE 1  
THE NUMBER OF EGGS THAT DISAPPEARED (N = 27) OR WERE FOUND FRESHLY  
PERFORATED (N = 15) WITHIN THE STUDY AREAS

Year	Dates	No. clutches	Eggs present in scrape when loss occurred		
			1	2	3
1982	9-16 May	117 <sup>a</sup>	10	3 <sup>b</sup>	4 <sup>c</sup>
	29 May-14 June	96 <sup>a</sup>	12	3 <sup>d</sup>	6 <sup>e</sup>
	15 June-2 July	65	0	0	0
1983	6-10 May	34 <sup>f</sup>	4	0	0
	9-29 June	25	0	0	0

<sup>a</sup> Four- and five-egg clutches not included.

<sup>b</sup> One egg from three clutches.

<sup>c</sup> Two eggs from two clutches.

<sup>d</sup> One complete clutch; one egg from another clutch.

<sup>e</sup> Two complete clutches.

<sup>f</sup> About 100 other clutches present; fate of eggs not followed.

dreads, all adult terns were absent from the colony for from 3 to 10 min, with the longer durations characterized by a low sweep of all birds over the colony, followed by a high aerial flight several hundred m south over Lake Erie. Dreads occurred 16 times during the morning watch of 17 May 1982, about 3 times more often than the average during the previous 15 daily observation periods. Dreads were again frequent (10 times during the 3-h period) during the next regular watch on the evening of 18 May. On 17 May we found the head of a Common Tern and a partially eaten carcass adjacent to the western study area. On 18 May, we walked the length of the breakwall and found two additional heads of terns and another partially eaten carcass with the head missing.

Up-flights occurred at a low frequency during May of both years and increased sharply thereafter (Fig. 1B). An obvious external stimulus always preceded these flights. In most cases (>95%) during late June and July, the stimulus was a recently fledged Ring-billed Gull which, upon landing on the breakwall, was immediately harassed by the adult terns closest to it. In other cases, up-flights were stimulated in a portion of the colony by a Herring Gull flying down to capture a Common Tern chick.

*The pattern and timing of egg loss.*—Within our study areas, 42 eggs disappeared shortly after they were laid, or were found freshly perforated; 32 of these (76%) were lost within 1-3 days of laying, and all were in scrapes containing 1 or 2 eggs (Table 1). The remaining 10 eggs disappeared from completed 3-egg clutches within 2-5 days of clutch completion (2 cases of 2 eggs lost; 2 cases of complete clutch loss). Egg loss due to disappearance or perforation was restricted to clutches initiated during

TABLE 2  
THE FATE OF EGGS THAT FAILED TO HATCH FROM CLUTCHES IN THE EASTERN STUDY AREA<sup>a</sup>

Year	Dates	Eggs hatched (% of egg pool)	Fate of egg				
			Disap- peared/ perforated	Aban- doned	Incu- bated to 21 days (un- hatched)	Cracked	Un- known
1982	29 May–14 June	194 (78.9)	21/6	8 <sup>b</sup>	15	3	5
	15 June–2 July	143 (85.2)	0	9 <sup>c</sup>	12	1	3
1983	9–29 June	64 (88.8)	0	8 <sup>d</sup>	0	0	0

<sup>a</sup> Hatching success of clutches visible from the blind in the western study area: 9–16 May 1982, 39 clutches, 102 of 116 eggs hatched (87.9%); 6–10 May 1983, 34 clutches, 77 of 93 eggs hatched (82.8%).

<sup>b</sup> Two 1-egg clutches; three 2-egg clutches.

<sup>c</sup> All 1-egg clutches.

<sup>d</sup> Four 1-egg clutches; two 2-egg clutches.

the 2 intervals prior to 14 June 1982, and to those initiated in the period 6–10 May 1983 (Table 1). Furthermore, eggs lost from scrapes containing a single egg at the time of loss were disproportionately overrepresented in both years. Of all eggs present in study clutches at the time of loss, a slightly higher proportion of eggs disappeared or were perforated in 1982 (38 of 532, 7.1%) than in 1983 (4 of 93, 4.3%). We contrasted the number of clutches that lost eggs with those that did not lose eggs, according to the clutch size at the time of loss. In both years, 1-egg clutches experienced significantly greater loss than 2-egg or 3-egg clutches (1982,  $\chi^2 = 58.2$ ,  $df = 2$ ,  $P < 0.001$ ; 1983, Fisher's exact test,  $P = 0.0002$ ).

In addition to egg losses within our study areas, we recorded 83 freshly broken Common Tern eggs during a systematic search through the colony on the morning of 18 May 1982. Most of these eggs were broken open and the contents partially drained; the remainder were intact except for a small puncture hole on the top surface. Several dozen scrapes were noted in which no eggs were present, but dried yolk stain was visible in the nest cup or around the scrape.

The more-frequent nest checks in the eastern study area permitted us to determine other probable causes of egg failure there (Table 2). Twenty-seven eggs were incubated for at least 21 days and failed to hatch. Most (21 of 27, 77.9%) were third-laid eggs in 3-egg clutches; the remainder were eggs in 2-egg clutches ( $N = 3$ ) that failed to hatch. Abandoned eggs were observed in all time periods. Most ( $N = 15$ ) were in scrapes that contained only a single egg; the remainder ( $N = 10$ ) were in five 2-egg clutches.

*Ruddy Turnstone activity.*—Ruddy Turnstones were first seen at the

tern colony on 6 May 1982 and 9 May 1983; they were last seen on 12 June 1982 and 6 June 1983. These dates coincide with the usual timing of their northward migration each year in the eastern Lake Erie area (Buffalo Ornithological Society 1965). Flocks of 20–50 turnstones periodically congregated each day at loafing sites along the edge of the shelf, and on a rock pile near the water about 90 m to the west of the colony.

We recorded turnstones foraging individually or in small groups within our study areas on 14 occasions. Foraging behavior was characterized by rapid forward movement and periodic stops during which birds flipped over loose concrete chips and small rocks. Individuals restricted their activity to the edge of the colony and appeared hesitant to wander among incubating Common Terns. We observed turnstones cracking open tern eggs and eating the contents on six occasions. In five cases, the single egg in each of five scrapes was opened; in the remaining case, both eggs in a 2-egg clutch were opened. In each of these instances, an adult tern had been incubating the egg(s) within the few hours prior to loss to a turnstone. As the turnstone was undisturbed during the depredation event, we assume that the parents were not in the immediate vicinity of the nest during the attack (see below). The predator attacked the egg(s) with several sharp blows to the shell, opened a hole several cm in diameter, and consumed the contents, all within less than 60 sec. When uninterrupted, the turnstone ate all of the egg contents, leaving the empty shell(s). The shells were absent during our next visit to the colony, either on the day of loss or the day thereafter. Incubating tern parents adjacent to the egg-eating turnstone emitted a characteristic “churr” call at the intruder but did not chase it from the area. Foraging turnstones often oriented toward clutches that were unattended by either parent. In all but the six cases noted above, one or both parents were apparently present in the immediate area because an adult tern flew at the turnstone, which fled on foot. In all such cases, the attacking tern resumed incubation of the egg(s) after the turnstone left.

#### DISCUSSION

The pattern and timing of loss for eggs that disappeared or were found freshly perforated indicate that single eggs laid early in the season were particularly vulnerable. Eggs disappeared or were perforated only during that portion of the breeding season when Ruddy Turnstones were present. In previous years at this colony, egg disappearance from early clutches has been a common type of egg failure (Hunter 1976, Morris et al. 1976, Courtney 1977). Eggs in early clutches are often incubated infrequently by adult terns during the first few days after laying (Courtney 1979); such eggs would be particularly susceptible to damage by turnstones. Finally,

we observed Ruddy Turnstones breaking open and eating Common Tern eggs that were temporarily left unguarded by the incubating parents. Thus, actual and circumstantial evidence implicates Ruddy Turnstones as predators of Common Tern eggs.

When eggs disappear or are found perforated, the agents of loss or damage are often enigmatic, and coincident events, while circumstantially related, cannot necessarily be taken as correlated. The number of times that we saw turnstones cracking eggs and consuming the contents was very few, and no egg-eating was observed early in the season when dreads were frequent. Egg predation by Ruddy Turnstones did not appear to be a problem at this colony in previous years, and H. Blokpoel (pers. comm.) has only recently (1983, 1984) noted turnstones damaging Common Tern eggs at a colony near Toronto, Ontario. I. Nisbet (pers. comm.) does not consider turnstones a significant egg predator in Common Tern colonies on the east coast. Therefore, we examined other biological factors that might have produced the particular pattern and timing of egg loss observed in 1982 and 1983.

We considered three possible alternatives. First, although it occurs only rarely, Ring-billed Gulls take the eggs of Common Terns (Courtney and Blokpoel 1980). Second, at Common Tern colonies on the east coast, egg perforation and breakage were higher in years where Great Horned Owl predation was suspected; egg damage was attributed to the terns themselves although no actual observations were made of the behavior (Nisbet and Welton 1984). Third, Black-crowned Night-Herons take Common Tern eggs and chicks at night (Hunter and Morris 1976). Such predation can be especially severe when owls cause terns to depart the colony (Nisbet and Welton 1984).

In 1985, we observed a single Ring-billed Gull take a Common Tern egg on several different occasions. A bird that we assumed to be the same individual walked several m away from its own clutch near the extreme western end of the tern colony, removed a single egg from a tern nest, and consumed it whole. In three previous years of intensive observation from blinds at this colony, we never saw a Ring-billed Gull take a Common Tern egg, and we assume the 1985 observations were unique. Once terns begin nesting, they experience little interference of any kind from Ring-billed Gulls nesting nearby (Morris and Hunter 1976, Courtney and Blokpoel 1980). We do not exclude the possibility that adult terns themselves caused damage to their eggs during the many resettling events following dreads throughout May in both years. The disproportionate loss of eggs from mostly incomplete clutches, however, is not consistent with terns causing the damage. Finally, Black-crowned Night-Herons stimulate nocturnal desertion by adult terns independently of the presence of owls

(Hunter and Morris 1976). In predation events seen at the Port Colborne colony, recently hatched chicks and late pipping eggs (eaten whole) were particularly vulnerable, as the heron, oriented by sound to the prey. Such directed selection of prey items is not consistent with our current observation that single eggs laid early in the breeding season were particularly vulnerable, especially in the first few days after they were laid.

Ruddy Turnstone predation of tern eggs can be severe under certain circumstances. Wetmore (in Bent 1929:288) noted that eggs of both Sooty Terns (*Sterna fuscata*) and Gray-backed Terns (*S. lunata*) on the Laysan Islands were at greatest risk when incubating terns were disturbed by investigator activity. Furthermore, terns on these islands apparently had a limited chance of nesting success until most turnstones had left the island in northward migration (Crossin and Huber 1970). Thus, of possible explanations for the egg losses observed at Port Colborne in 1982 and 1983, we suggest that predation by Ruddy Turnstones best accounts for both the pattern and timing observed. Although less likely to have been the principal cause, predation by Black-crowned Night-Herons may have contributed to the egg losses.

Nisbet and Welton (1984) noted numerous indirect negative effects of Great Horned Owl predation on Common Tern eggs and chicks. In both years of our study, dreads occurred throughout May with sharp peaks during the middle of that month. Conversely, upflights were restricted to late in the season, were clearly related to an immediate proximate disturbance, and involved only a small portion of all adult terns in the colony. We suggest that an increase in tern "flightiness" during diurnal periods (noted as an increase in the frequency of dreads) may be another indirect consequence of owl predation. The severed heads and dismembered bodies of adult terns found during our single check of the total colony implicate Great Horned Owls as the predator. We did not search for dead adult terns on other days as the disturbance caused by such investigator activity could not be justified. Accordingly, we recognize that we do not have firm evidence that the frequency of diurnal dreads was correlated with owl predation on previous evenings. However, coincidence in the timing of nocturnal disturbance by owls, and the diurnal presence of Ruddy Turnstones may increase the susceptibility of tern eggs to these egg predators. Such events are not expected to coincide in all years at all tern colonies. When they do, we predict the loss of Common Tern eggs in the pattern noted.

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