

into the nest, all of which were subsequently tossed out by the female.

Northern White-winged Crossbills (*Loxia l. leucoptera*) construct deep, saucer-shaped nests from locally available lichens, coniferous twigs, bark, moss, lichens (including *Usnea*), hair, and mammal fur, either low to the ground or high in pine trees, up to 23 m (Bent, U.S. Natl. Mus. Bull. 237:527, 1968). The Hispaniolan nest appeared to differ little, if at all, from descriptions of the size and shape of nests of the North American race.

Aside from Bond's speculations, the only previous information available on the breeding season of *Loxia leucoptera megaplaga* was descriptions of specimens collected by R. H. Beck and J. Bond. All 11 adults collected by Beck from 23 February to 19 March 1917 that we have examined (AMNH, BM) had labels indicating that the specimens had large or swelling gonads (six males, five females). Bond (pers. comm.) collected two adult males and one adult female in Haiti on 7 and 8 June 1930, and all had minute gonads. Of 15 immatures collected by Beck from 23 February to 19 March 1917, one had a tail only partly grown, and was presumably only a few days out of the nest (5 March); one female had a bill only half the adult size (10 March); and

11 had primaries shorter than adult length (Wetmore and Swales 1931). On the basis of these skins, it is reasonable to conclude that many birds do breed in mid-winter, with young fledging in late February or early March. However, the adults collected in February and March all showed enlarged gonads, suggesting that breeding continues into early spring, which is confirmed by the present observations. The incubation and fledging period in *L. leucoptera* is unknown (Bent 1968; Newton, Finches, p. 81, Collins, London, 1972), but if it is 29–41 days, as it is in *L. curvirostra* and *L. pytyopsittacus* (Newton 1972, p. 76–80), then the breeding season may extend from at least January to May, with Bond's three specimens in June suggesting that breeding later in the year is less likely.

We thank Dean Amadon (American Museum of Natural History) and David Snow (British Museum) for letting us use skins at their museums, Rev. Donald Dod for his great help in getting us to the remote Baoruco Range, James Bond for providing information on crossbills he collected in Haiti, and the late David Lack and the staff at the Edward Grey Institute, Oxford, for providing facilities during the preparation of this note.

Accepted for publication 7 February 1974.

ROSE-THROATED BECARD IN JEFF DAVIS COUNTY, TEXAS

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On 11 June 1973 about 15 miles S of Ft. Davis, in Jeff Davis County, Texas, my attention was attracted to an unusual bird call. Upon investigation, a male Rose-throated Becard (*Platypsaris aglaiae*) was found in a Grave's Oak (*Quercus gravesii*). An attempt at collecting this bird failed.

This record is the first from West Texas. The A.O.U. check-list of North American Birds (Fifth ed., 1957) does not list the Rose-throated Becard as occurring in this area. The only documented records of this bird are from southern Arizona and the lower Rio Grande valley of Texas. Wauer (Birds of the Big Bend National Park and vicinity, Univ. Texas Press, 1973:207) mentioned a possible sighting of three males and two females in a flock at the

Santa Elena Canyon picnic site on 24 September 1965 by Richard B. Starr.

On 18 July 1973 in the same area as above, I collected a male Rose-throated Becard. The skull was completely ossified and the remiges showed much wear. Measurements of the specimen (DMNH #6231) were: length 172mm, wing 92.5, tail 67.2, exposed culmen 15.0, width at nostrils 8.5, tarsus 21.2. The weight was 33 g with very little fat. The testes measured 9.5×4.5 . I believe that this was the same bird that I had located in June. Both sightings of the becards were in Grave's Oaks (about 35 ft tall), along a precipitous igneous canyon at an altitude of 5400 ft.

The stomach of the bird contained one large caterpillar and several small caterpillars, one aquatic beetle larva, grasshopper parts, beetle parts, one spider, and one nematode.

Whether this occurrence represents an instance of wandering or possibly an extension of breeding range must be determined by future study.

Accepted for publication 7 February 1974.

SELECTIVE EFFECTS OF PREDATION IN A TERN COLONY

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Predation is one of the selective pressures which can act to maintain synchronization of nesting in colonial birds (Lack 1968). In circumstances where the food requirements of a predator remain more or less constant, the predator will take a larger fraction of the available prey when few individuals are present (i.e., at the beginning and end of the season) and a smaller fraction in the middle of the season when the larger numbers of individuals are nesting. This has

been demonstrated, for example, by Ashmole (1963) for predation by feral cats (*Felis domestica*) on adult and young Sooty Terns (*Sterna fuscata*), by Patterson (1965) for predation by Carrion Crows (*Corvus corone*) on eggs and chicks of Black-headed Gulls (*Larus ridibundus*), and by Parsons (1971) for cannibalism by Herring Gulls (*Larus argentatus*) on chicks from their own colony. On the other hand, it might be expected that a predator which specializes on chicks would inflict the most damage at the beginning of the season, when the earliest-hatched chicks are small so that correspondingly more are needed to satisfy its appetite. This paper demonstrates this effect—higher predation rates early in the season—for predation on chicks in a colony of Common Terns (*Sterna hirundo*).

STUDY AREA AND METHODS

The colony studied was on a line of low sand dunes at Gray's Beach, Yarmouth, Massachusetts ($41^{\circ}43' N$, $70^{\circ}15' W$), separated from the mainland of Cape Cod by about 900 m of salt marshes which are flooded at spring tides. In 1973 slightly more than 2000 pairs of Common Terns and 300–400 pairs of Roseate Terns (*Sterna dougallii*) nested there. A study-plot of 190 m² was selected at the time of egg-laying in May and enclosed during June with a low wire fence to isolate chicks hatched inside the plot for study (Nisbet and Drury 1972). Three nests fenced individually in other parts of the colony are also included in the study. The study-plot was on the edge of an open sandy area, with scattered clumps of beach grass (*Aimophila arenaria*) and beach pea (*Lathyrus japonicus*). Some Common Tern territories were on bare sand, most had a little cover, and a few were in dense grass. About half the terns in the colony nested in similar areas; the other half, including nearly all the Roseate Terns, nested in denser cover and were probably less exposed to predation.

The study-plot was visited on 17, 21, 26, 27, 28, and 31 May and on 22 days in June. Nests were marked with numbered stakes and eggs were marked with a waterproof marker when first seen. The date of laying of each egg could be determined within ± 1 –2 days, either by direct observation, by inference from the laying of other eggs in the clutch, and/or by the flotation method of Hays and LeCroy (1971). After 17 June, when the first egg hatched, the colony was visited every day until 31 July with the exception of three rainy days (27 June, 15 and 21 July). Chicks were banded at hatching and weighed daily until they died, disappeared, or fledged. On most daily checks, a few chicks (typically 3 or 4) were missed; where necessary to compile averages their weights have been estimated from those on the two adjacent days, assuming a normal growth pattern.

Chicks found dead and intact are assumed to have died from natural causes. Those found dismembered, or missing without trace, are assumed to have been taken by predators. It is possible that one or two of the latter may have died in dense cover, or have escaped from the plot and died outside, but none was found despite repeated searches.

In several cases, eggs that were pipped on one day and presumed to be on the point of hatching were missing without trace the next day. It is assumed in such cases that the chicks had hatched before evening, that the eggshells were carried away by the parents in the usual way, and that the chicks were taken by predators during the night. For statistical purposes, these pipped eggs (and no others) have been added to the tally of chicks for the days on which they were last seen.

PREDATION AND NIGHT DESERTION

Predation was first noted in the colony in late May, and by 31 May nine adult terns had been found dead (none in the study-plot). Similar predation by Great Horned Owls (*Bubo virginianus*) had been recorded in this colony in previous years (Nisbet 1972) but had not prevented successful reproduction. By 20 June 1973, however, all the chicks hatched in the first four days had disappeared, and hatching at other nests was overdue. On nocturnal visits later in the month, J. Loughlin and I found that the adult terns were deserting the colony at about 21:00 each evening and not returning until morning.

One consequence of this "night desertion" (Mar-

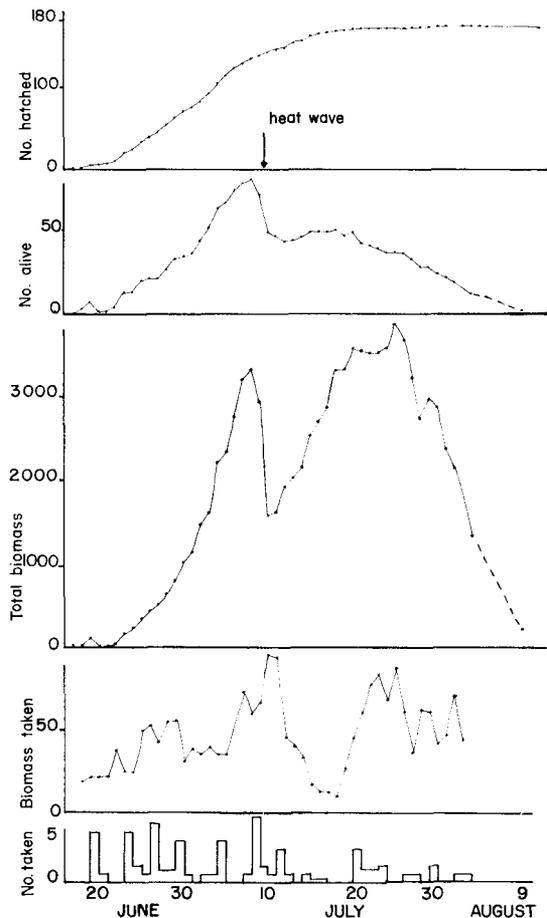


FIGURE 1. Development and predation of Common Tern chick population. Top line: cumulative number of chicks hatched in study-plot. Second line: number of chicks found alive. Third line: total biomass of live chicks. Lowest line: biomass taken by predators (5-day running average). Histogram: number of chicks taken between daily checks.

shall 1942) was a delay in hatching. Incubation periods estimated for 164 individual eggs varied from 24 to 32 days, with a mean of 27.8, about 6 days longer than the means for the species that I have recorded in other Massachusetts colonies. Because hatching was similarly delayed in all clutches, except perhaps the two earliest, I infer that the night desertion had started soon after the first layings on 21–23 May. One of its consequences was to relieve predation on adults, for only a few were found dead after 31 May. However, unattended chicks were giving distress calls all over the colony, effectively advertising their locations to nocturnal predators. One or more chicks disappeared from the fenced plots on 27 of the 44 nights between 17 June and 31 July.

Night desertion was presumably a response to nocturnal predation. Although I failed to trap or even to see the predators, I believe that one or more Great Horned Owls were primarily responsible. Both adult terns and chicks were found with their heads severed in the manner characteristic of this species (Austin 1948). Fresh owl feathers were found every few days in various parts of the colony, including the study-plot. A large owl pellet containing two tern

TABLE 1. Fate of Common Tern chicks hatched in different periods of the season.

Hatching period	Died in heat wave 8-9 July	Died on other dates	Taken by predators	Fledged	Total
17-24 June	9 (27%)	1 (3%)	23 (70%)	0	33
25-28 June	10 (36%)	4 (14%)	13 (46%)	1 (4%)	28
29 June-2 July	1 (3%)	3 (10%)	10 (34%)	15 (52%)	29
3-5 July	2 (6%)	9 (29%)	13 (42%)	7 (23%)	31
6-11 July	4 (17%)	9 (37%)	6 (25%)	5 (21%)	24
12-28 July	0	15 (56%)	9 (33%)	3 (11%)	27

skulls was picked up on 28 July. No footprints were found at nests where chicks were missing, even those surrounded by smooth sand. Among other potential nocturnal predators, Black-crowned Night Herons (*Nycticorax nycticorax*) were fairly numerous in the salt marshes and their footprints were found up to the edge of the colony, but not in the study-plot. Footprints of a raccoon (*Procyon lotor*) were found once near the tide-line, but not in the study-plot. No diurnal predators were seen in the colony except during 27-29 July, when a Marsh Hawk (*Circus cyaneus*) was seen taking tern chicks on each day: it may have taken one or two chicks from the study-plot, but was not seen hunting at that end of the colony. Herring Gulls, although numerous in the area, were not seen to enter the colony. For the above reasons, I assume that most of the predation in the study-plot was carried out by one or more Great Horned Owls.

NUMERICAL RESULTS

Between 21 May and 29 July, 107 clutches were initiated in the study-plot. The last eight clutches (all those started after 1 July) were deserted in late July or early August before they were due to hatch. Nine other nests were deserted soon after laying, probably before the clutches were complete; in some cases desertion appeared to follow breakage of the first egg. A further 13 clutches were incubated for substantial periods, but failed to hatch altogether. The remaining 77 clutches in which one or more eggs hatched are the subject of this paper.

Of 194 eggs laid in these clutches, 172 hatched. This degree of hatching success is substantially lower than that recorded in other Massachusetts colonies (Nisbet and Drury 1972), but is surprisingly high in view of the night desertion. The progress of hatching between 17 June and 28 July is shown in the top line of figure 1.

The next two lines on figure 1 show the number of chicks alive on each day, and their total biomass. The histogram shows the number of chicks found missing (presumed taken by predators) on the succeeding daily check. The lowest line shows the biomass of the missing chicks (expressed as a 5-day running average because of the irregular incidence of predation).

Three general features of the predation are noteworthy. (1) Subject to daily fluctuations, the average daily biomass taken by the predators remained roughly constant throughout the season at 40-60 g day⁻¹, despite a hundredfold increase in the biomass of prey available. The apparent increase late in the season—to an average of 59 g day⁻¹ in the last quarter of the season, versus 33 g day⁻¹ in the first quarter—may reflect the fact that the predators did not eat all the large chicks taken then, but left some remains in the study-plot. (2) The mean

weight of prey taken increased four- to fivefold during the season, so that the average number of chicks taken from the study-plot decreased from about three per day at the start to less than one per day at the end. (3) On every day except two (2 and 10 July) the mean weight of the chicks taken was less than the mean weight of the chicks in the plot. Hence, although the impact of predation was only moderate in terms of biomass (averaging 2-3% per day over the 44-day period), it was more serious in terms of the numbers of individuals (averaging 4-5% per day).

The selective effects of the predation may be seen by dividing the chick season into five periods.

1. *17-22 June.* Hatching progressed slowly and for the first five days average daily recruitment was less than the average demand of the predators. Nine of the first 10 chicks that hatched and 7 of the next 12 were taken.

2. *22 June-7 July.* As the hatching rate increased, the proportion of chicks taken fell from 50% to below 10% per day. Through 29 June the predators took primarily newly hatched chicks: those that survived the first few days were able to grow rapidly. By 7 July, a few days after the peak of hatching, the population had run ahead of the predators and the daily increase of biomass was several times larger than the predators' demands.

3. *8-11 July.* On 8-9 July an exceptional heat wave occurred, culminating on the clear, windless afternoon of 9 July with reported air temperatures over 38°C in coincidence with a low tide. Twenty-six chicks died, including all but two of those more than 10 days old; most of the others lost weight. The total biomass in the plot fell by more than half, the average age fell from 8.2 to 6.7 days, and the average weight from 41.6 g to 33.2 g. The predation rate increased correspondingly again for a few days, peaking at 9% on 11 July.

4. *12-25 July.* The surviving chicks grew rapidly and the rate of predation fell again to average less than 3% per day between 18 and 25 July. The predators continued to take chicks smaller than average and three of the last five chicks to be hatched were taken. However, none of the preceding seven chicks were taken.

5. *26 July onwards.* The first chick fledged on 25 July, and thereafter it was impossible to determine whether missing chicks had fledged or had been taken. Three chicks were found dismembered between 26 and 31 July and a fourth either was taken or fledged exceptionally early. Two final checks on 2 and 8 August revealed dismembered remains of two more chicks (one of which was known to have fledged before 31 July), and one more chick had disappeared before it was due to fledge. Thus the rate of predation was probably similar after 26 July to that before.

Table 1 summarizes the fates of the chicks hatched

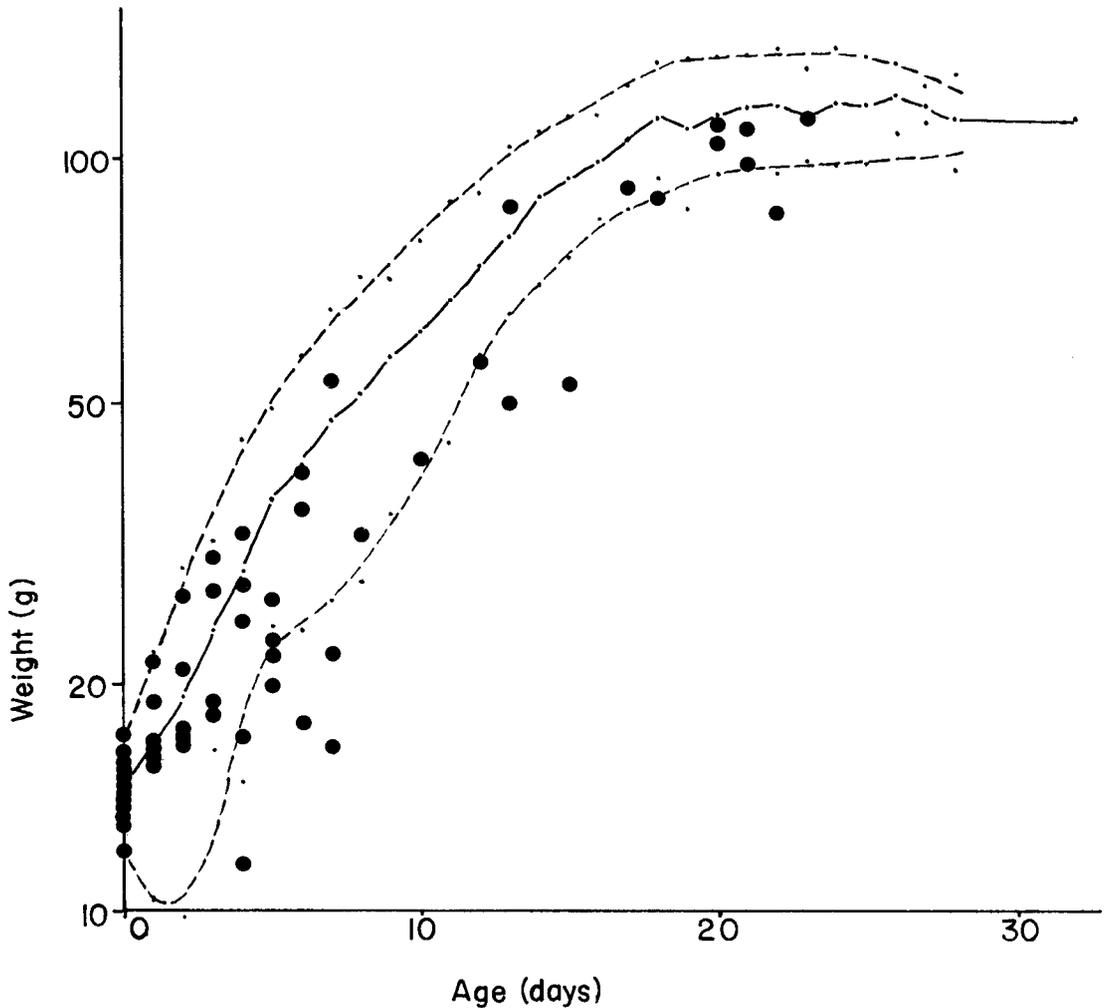


FIGURE 2. Weights of chicks taken by predators compared with weights of surviving chicks (logarithmic scale). Solid line: mean weights of 31 chicks that survived to fledging, as a function of age. Dotted lines: ± 2 standard deviations (smoothed curves). Filled circles: weights of 74 chicks taken by predators when last encountered.

in six different periods. The predation rate was highest for chicks hatched in the first two periods, especially in the first. Deaths from natural causes were most important in the second period (mostly from heat stress) and in the last two (mostly from starvation and/or neglect). Most of the chicks that

fledged had hatched in the third and fourth periods, at the peak of the season.

Figure 2 plots the weights of the 74 chicks taken by predators as a function of their age when last recorded and compares them with the mean weights of the 31 chicks that survived to fledging. During

TABLE 2. Fate of Common Tern chicks according to their position in the clutch and brood.

Order of laying	Order of hatching	Died	Taken by predators	Fledged	Total
First	First	22 (31%)	34 (47%)	16 (22%)	72
Second	First ^a	4	0	1	
	Second	22	27	10	
	Total	26 (41%)	27 (42%)	11 (17%)	64
Third	Second ^a	5	3	1	
	Third	13	10	3	
	Total	18 (51%)	13 (37%)	4 (12%)	35
Fourth	Fourth	1 (100%)	0	0	1

^a Chicks advanced in the hatching order in cases where the first or second egg did not hatch.

TABLE 3. Fate of Common Tern chicks according to the vegetative cover in their parents' territories.

Cover	Died in heat wave 8-9 July	Died on other dates	Taken by predators	Fledged	Total
None	5 (11%)	9 (20%)	19 (42%)	12 (17%)	45
Sparse	4 (7%)	17 (31%)	25 (46%)	8 (15%)	54
Moderate	12 (21%)	10 (18%)	27 (48%)	7 (13%)	56
Dense	5 (29%)	5 (29%)	3 (18%)	4 (24%)	17

the first three days of life, there was no significant difference between the weights of the missing and the surviving chicks. From four days of age onward, however, 26 of the 29 chicks taken by predators were lighter than the mean weight of the surviving chicks at the corresponding ages; 16 of them were so much lighter that their survival to fledging would have been doubtful even without predation. Thus the predators rather consistently took chicks that were already in poor condition—perhaps because these chicks were easier to catch or concealed themselves less efficiently. However, there was no tendency for the predators to select the younger chicks within a brood (table 2). Indeed, predation of the older chicks allowed an unusually large fraction of the third chicks to survive to fledging (table 2; cf. Nisbet 1973b, Langham 1972).

Each nest was classified into one of four categories according to a subjective assessment of the amount of vegetative cover available to the chicks in its vicinity. Table 3 shows that there was no marked tendency for predation to fall more heavily on chicks from the more exposed nests. Significantly more chicks died in the heat wave from nests with moderate or heavy cover than from exposed nests; this is probably due to the fact that laying and hatching took place earlier in the nests with more cover. It is possible that the intense predation on these early hatched broods offset any protection that they might have received from the denser cover available to them.

Approximately 31 chicks were fledged from the study-plot (about 0.3 per pair based on the number of clutches started, or 0.4 per pair based on the number that hatched at least one egg). To judge from the favorable rates of growth after 10 July, even in broods of two or three chicks, it is likely that at least half of the 22 chicks taken after the heat wave, and several of those taken earlier, would otherwise have fledged. Thus the effect of the predation was to cut the expected rate of production of young by at least one-third. This calculation does not reflect the intense predation on the early hatched chicks because many of them would have died in any case in the heat wave. But for the heat wave, the effects of predation would have been even more serious.

DISCUSSION

It is unlikely that predation in the study-plot was facilitated by my fencing the chicks into an area with relatively little cover. Most of the chicks were taken at ages of less than nine days (fig. 2) when they normally stay within their parents' territories. Checks of other open areas in the colony suggested that the average reproductive success there was no higher than in the study-plot. However, chicks raised in areas of denser cover appeared to have survived the heat wave better than those in the study-plot: several hundred chicks fledged from these areas in the third and fourth weeks of July. If the predation rate in the study-plot can be extrapolated to all the open

areas in the colony, the predators would have taken roughly 500 g of tern chicks per day. If it was similar in the areas with denser cover, they would have taken roughly 1 kg per day. Even the lower figure would satisfy the requirements of two or three Great Horned Owls (Craighead and Craighead 1956); it seems possible that an entire family of owls was involved.

Breeding activities of Common Terns at Gray's Beach in 1973 were unusually prolonged. The laying period, extending from 21 May to 26 July, was unusually long and had two peaks, around 30 May and 8 June. The incubation period was then six days longer than usual, associated with the night desertion. Finally, the first half of the nesting was wiped out by predation and the heat wave, so that most of the chicks that fledged were relatively late. The interval of 65 days between the laying of the first egg and the fledging of the first chick is some 20 days longer than usual for the species. Thus the predators had an unusually prolonged opportunity to exploit this colony.

In studies in other colonies, I have found that Common Terns which breed early consistently perform better than those breeding later. Those laying after mid-June tend to lay small clutches and to raise few young, while those laying in July often desert their eggs before hatching. The case described in this paper is the first evidence that I have found for selection against the very early birds that usually raise most young. This selection was exerted in 1973 not only by the predators but also by the heat wave (table 1). However, heat waves of this extreme type are more likely to occur in late July than in early July, and hence to exert selection against late-nesting birds. Even in 1973, many of the chicks that died in the heat wave would have fledged by 9 July, or would have been more fully feathered, but for the six-day delay in hatching. Since this delay was probably caused by the presence of the predators, it might be said that predation was indirectly responsible for the effects of the heat wave falling on the first rather than the second third of the chicks.

The former strongholds of Common Terns in Massachusetts were on offshore islands (Nisbet 1973a) where they were relatively secure both from extreme heat and from mainland predators such as Great Horned Owls. It seems likely that predation and heat waves are among the factors involved in the low breeding success of the terns in the inshore colonies to which they are now confined (Nisbet 1973a). Predation by Great Horned Owls was intermittently important at the large inshore colony at Tern Island, Chatham, in the 1920s and 1930s (Floyd 1925, Austin 1948) and was apparently responsible for its abandonment in 1973 (unpubl. data from this study).

Selective predation of the kind described in this paper is likely to take place whenever the demands of a predator are relatively constant in relation to the rise and fall in abundance of its seasonal prey.

(It will be less marked, or absent altogether, if the predator's demands also rise and fall—e.g., if the breeding season of the predator is synchronized with that of its prey.) The selective effect will fall most heavily on the early recruits to the prey population, in circumstances where individual prey grow throughout the season, so that the rate of addition of biomass at the beginning of the season is less than the rate of loss of biomass at the end. The same phenomena might be expected to occur, for example, in predation on larval insects, in which first instar recruits are much smaller than the final instar larvae which leave the population on pupation. Likewise, herbivores might be expected to exert the greatest grazing pressure on the plants that start to grow earliest in the season. The experience of gardeners whose earliest lettuce is eaten by rabbits provides a familiar illustration of the principle.

SUMMARY

Nocturnal predators, probably Great Horned Owls, took some adults and many chicks from a large colony of Common Terns in Massachusetts. The adult terns deserted the colony at night, starting early in the laying period. In consequence, incubation periods were unusually long (28 instead of 22 days), about 12% of the eggs failed to hatch, and others were deserted.

The biomass of prey taken each day was roughly constant throughout the season, despite a hundred-fold increase in biomass available. Predators consistently took smaller chicks than the average in the study-plot, and chicks that were already in poor condition. However, they did not consistently take the second and third chicks within each brood, nor chicks from the more exposed nests.

Predation was most intense on the earliest-hatched chicks because of their small numbers and small size. The rate of predation fell from 100% for the chicks hatched in the first four days of the season to 2–3% per day at the end of the season.

Selective predation on early and late breeding individuals is likely to occur whenever the demands of a predator are relatively constant in relation to the seasonal rise and fall in abundance of prey. Predation will fall much more heavily on early than late individuals if individuals grow progressively during the season, so that the biomass of a new recruit to

the population is less than that of an individual leaving the population.

I thank F. S. and M. C. Sterrett, M. Y. Stoeckle, T. L. Israel, M. E. Golberg, and J. Loughlin for assistance in the field. This study was supported by a grant from the Frederick W. Beinecke Fund. This is Contribution No. 113 from the Scientific Staff, Massachusetts Audubon Society.

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Accepted for publication 4 April 1974.

HUNTING BY THE WHITE-TAILED KITE (*ELANUS LEUCURUS*)

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Forty years ago the White-tailed Kite (*Elanus leucurus*) was near extinction in California (Pickwell 1930, 1932), yet today its numbers and range have increased (Morgan 1948, Kimsey 1955, Bolander and Arnold 1965, Eisenmann 1971, G. W. Salt pers.

comm.). These increases probably are due not only to the kites' tolerance of habitat disruption by expanding agriculture (a tolerance apparently uncommon among raptors), but also to the increased abundance of prey species that thrive under agricultural conditions (Krebs 1966). The present study examines the predatory behavior of kites with regard to seasonal variation in hunting habitat, hunting success and strike efficiency, and also the difference between sexes in hunting activities during nesting.

In winter, kites are solitary, diurnal hunters but return to communal roosts each night. Although pairing begins in January, the communal roost is used until nest construction begins in mid-February. Both sexes construct the nest, and both continue to hunt. However, once incubation begins, and until the young approach fledging, the male provides food for both the female and the young.

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