

response to playback (0 of 8 trials) than did robins with one or more neighbors (5 of 7 trials) (Fisher's exact test,  $P = 0.014$ ). Because of the geometry of the habitat, riparian birds could be surrounded by neighbors, and encounters between males should be more frequent. Males in shelterbelts, however, rarely can have more than two neighbors. The lower singing rates and response to playback indicate that robins breeding in shelterbelts exhibit reduced territorial defense, probably due to the small number of neighboring males.

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**Early experience and vegetation preferences in Common Tern chicks.**—The importance of physiognomic features in habitat selection has been studied in both the field and laboratory (Klopfer 1963, Gluck 1984). Noseworthy and Lien (1976) studied the ontogeny of nesting habitat preference in neonatal Herring Gull (*Larus argentatus*) chicks in nature. Herring Gull chicks preferred the nest site during the first week; thereafter this preference waned but never disappeared. However, Noseworthy and Lien's (1976) tests were conducted in the field where colony sounds and the presence of parents could affect the outcome. Although field studies are very useful in developing habitat recognition paradigms, laboratory studies under controlled conditions are necessary to isolate the effect of particular factors. Wiens

(1970, 1972) examined the role of experience on anuran habitat selection, and he reported that tadpoles raised over featureless or striped substrates showed no preference while those raised on a background of squares preferred their natal substrate. Similarly, Eurasian Linnetts (*Acanthis cannabina*) raised with natural foliage preferred the species that they were reared on, while those reared with plastic perches showed no preferences (Gluck 1984). In the laboratory, gull chicks *Larus* also showed a preference for natal conditions (Evans 1970). These experiments consistently show preferences for the habitat which young organisms experience, a situation known as habitat imprinting. However, animals were not given a choice of natural habitat features that might be equally attractive. In nature, animals are not only exposed to substrate and vegetation variations in their environment, but many young vertebrates are also exposed to siblings. Siblings may serve as clues to appropriate habitats or locations.

Habitat selection in adult birds could reflect the operation of innate mechanisms, or of learned mechanisms (imprinting), or of both (Lack and Venables 1933, Miller 1942). Early studies focused on behavioral aspects of habitat selection (Klopfer 1965) and the role of habitat selection on reproductive success (Southwood 1977). Recently, there have been numerous studies of habitat selection by nesting birds (see papers in Cody 1985), but there remain few experimental studies of the effect of early experience on either habitat preferences or the shelter sites used to avoid predators or heat stress.

In this paper we examine the role of early experience with vegetation on the behavior of Common Terns (*Sterna hirundo*). Previous studies have not exposed animals under controlled conditions to different, but naturally occurring habitats, to test for the effects of experience on recognition of specific habitat features.

Common Terns nest in a variety of habitats, including *Spartina* salt marshes and vegetated sandy beaches (Austin 1929, Burger and Lesser 1978). On beaches, the terns nest on the ground, often placing their nests close to beach grass (*Ammophila breviligulata*), seaside goldenrod (*Solidago sempervirens*), or other vegetation or debris. Vegetation provides shade from sun, shelter from heavy rains or wind, and protection from predators. Common Tern chicks are semi-precocial at hatching and within hours walk about near the nest. After hatching, siblings usually remain together and stay in or near the nest for two or three days. They begin to move about the territory thereafter but remain close to the nest unless disturbed. By a week to 10 days, chicks typically wander about the territory, are often left alone by parents, and frequently hide under vegetation to avoid thermal stress, heavy rains, or predators. We predicted that young chicks would quickly learn familiar landmarks in their territories. We designed a series of experiments to test this prediction.

*Methods.*—One chick was collected on the day of hatching from each of 24 nests on 30 June 1984 and from each of 28 nests on 14 July 1986 from Barnegat Bay, New Jersey, and brought into the laboratory. The chicks were weighed, color banded for individual identification, and placed in the rearing cages in groups of four chicks (functional sibgroups). Thus the siblings we speak of shared the same rearing cage from day 1, but did not share parentage. Chicks that share the same parents might have inherited genetic preferences for vegetation (or configuration of vegetation). Chicks were maintained at a room temperature of 29–31°C for the first week of life, and were fed four or five times a day with live or frozen fish (*Menidia*, *Ammodytes*, *Fundulus*).

In 1984, sibgroups were randomly divided into two treatments: one had beach grass (*Ammophila*) in the cages (three cages with four chicks each), and the other had goldenrod (*Solidago*) in the cages (three cages with four chicks each). Each cage (30 × 50 cm) had a 5-cm deep layer of sand covering the floor, and vegetation was placed at only one end forming a shelter 15 cm wide and 36 cm high. Plants were selected to be of equal height and width to provide equivalent physiognomic cues. For each species, stems were tied

TABLE 1  
DISTANCE<sup>a</sup> OF CHICKS FROM END WITH VEGETATION

Day	Goldenrod	Grass	No vegetation	Both species of vegetation <sup>b</sup>
1	9 ± 1.2	11 ± 2.1	22 ± 10.1	10 ± 1.0
2	10 ± 1.5	10 ± 2.3	21 ± 9.3	7 ± 1.2
3	18 ± 1.0	9 ± 3.3	27 ± 12.1	8 ± 1.8
4	15 ± 3.1	2 ± 0.5	21 ± 13.1	7 ± 1.0
5	19 ± 2.5	13 ± 4.3	21 ± 10.3	8 ± 1.2
6	1 ± 0.5	7 ± 3.1	23 ± 12.1	6 ± 0.1
7	2 ± 0.5	16 ± 2.0	18 ± 9.3	4 ± 0.1
8	2 ± 0.5	15 ± 3.1	23 ± 13.7	3 ± 0.8

<sup>a</sup> Mean ± SE in cm.

<sup>b</sup> Goldenrod at one end, grass at the other. Measurements are from the end chicks were closest to.

together at the base to insure similar appearance. In 1986 the sibgroups were randomly divided into two treatments: one had no vegetation (three cages with four chicks each), and the other had beach grass at one end and goldenrod at the other end (four cages with four chicks each), otherwise cage size and substrate were similar. The long axis of the cage was divided into equal sections from 0 at one end (under vegetation in three tests) to 6 at the opposite end to facilitate recording the location of chicks.

Beginning on the first day of captivity, for eight days we recorded the location of each chick at 0600, 1000, 1400, and 1800 (except on day 8) using a spot scan. On day 8 and 9 chicks were tested for vegetation preferences since this is the time when they begin to move around in nature.

On day 8 each chick was placed in the center of a test chamber (100 cm long × 25 cm wide × 40 cm high) with an *Ammophila* plant at one end and a *Solidago* at the other end. Chicks were allowed 2 min to move towards one or the other end before we recorded their position. Later in the day chicks were again placed in the test chamber and were startled by the sudden approach, from above, of an unfamiliar person dressed in a bright red shirt. We then recorded the chicks' location at 15, 30, 45, and 60 sec. On day 9 we repeated the experiment, reversing the location of the vegetation types.

We calculated Goodness of Fit tests with Yates corrections, yielding  $\chi^2$  to determine differences (Sokal and Rohlf 1981), using a hand-held calculator.

*Results.*—Common Tern chicks raised with vegetation normally remained near the vegetation in their rearing cages, seldom moving more than 20 cm from it (Table 1). Initially chicks remained about 18–20 cm from the base of the vegetation. In all experiments each chick's location was noted four times a day for eight days (except for the 1800 census on day 8, N = 31). For all cages with vegetation each chick was within 25 cm of the vegetation on at least 29 of the censuses, indicating a clear preference for the vegetation. No such distribution was obvious for chicks in cages without vegetation. During the eight days, chicks in cages with only goldenrod eventually moved directly under the vegetation whereas chicks in cages with only grass remained near, but not under it and showed no clear daily change in location. Thus when undisturbed in their natal cages, tern chicks with only one plant remained near it, and those near goldenrod moved under it when they were older. Chicks raised with two plants initially stood near the middle and later moved to one or the other plants. Chicks raised in cages without plants moved about the cage. Some did not remain

TABLE 2  
RESPONSE (CELL COUNTS) OF COMMON TERN CHICKS WHEN DISTURBED AND UNDISTURBED<sup>a</sup>

Response	Natal habitat			
	Goldenrod	Grass	No vegetation	Both species vegetation
Undisturbed				
Goldenrod	58 (7)	42 (5)	2 (3)	44 (7)
Grass	42 (5)	58 (7)	25 (3)	31 (5)
None	(0)	(0)	50 (6)	25 (4)
Disturbed				
Goldenrod	92 (11)	8 (1)	19 (2)	19 (3)
Grass	8 (1)	92 (11)	19 (2)	62 (10)
None	(0)	(0)	62 (8)	19 (3)

<sup>a</sup> Chicks were tested only once when undisturbed and once when disturbed.

consistently in any one spot (variable mean and large standard error, Table 1); others consistently leaned against one side of the box.

When placed in a test chamber, chicks from all four treatments showed no significant preference for vegetation species when not frightened (Table 2,  $\chi^2$  test with Yates correction  $< 4.40$ ,  $df = 1$  not significant, Sokal and Rohlf 1981). Chicks often walked to one vegetation type, and then walked to the other, looking around. They usually stood next to vegetation after 1 min, but they did not hide under it. Some chicks raised with both or neither plant did not move close to vegetation during the test. When tested in a relaxed situation chicks raised with one plant species were consistent in their responses from the first to the second test, whereas those raised with both or neither plant species were not ( $\chi^2$  with Yates correction = 8.1,  $df = 1$ ,  $P < 0.01$ ).

When exposed to a startling stimulus, there was a difference among groups in the proportion of birds responding ( $\chi^2$  with Yates correction = 15.4,  $df = 3$ ,  $P < 0.001$ ), and in their response ( $\chi^2$  with Yates correction = 21.9,  $df = 1$ ,  $P < 0.001$ ). All birds raised with only one plant species responded, but only 67% of the chicks raised with neither or both plant species in their cages responded. Chicks raised with only one plant species showed a significant preference for their natal vegetation ( $\chi^2 = 8.24$ ,  $df = 1$ ,  $P < 0.001$ , Table 2). Most chicks immediately ran, without hesitation, to their natal vegetation and scurried under it, often disappearing from view. After 20 or 30 seconds chicks sometimes walked to the edge of the vegetation and peered about. When exposed to a startling stimulus 81% of chicks raised in cages with both plants also ran to vegetation but showed no significant preference for grass or goldenrod, and no tendency to move toward the vegetation they had preferred in the cage.

*Discussion.*—In mammals and birds heredity as well as experience appears to play a role in habitat preference (Wecker 1963) and presumably in selection of shelter sites. Partridge (1974) showed that naive tits (*Parus ater*, *P. caeruleus*) raised in cages devoid of vegetation preferred the type of tree in which they were most often found in the wild. However, chicks were not given a choice of trees found in the wild. In our study tern chicks, normally exposed to different species of plants in nature, were given a choice of the common natural species.

In this study Common Tern chicks from 1–8 days of age preferred to remain near vegetation. Chicks raised in cages with goldenrod moved under it while those raised in grass did

not, and chicks raised with a choice of both plants preferred goldenrod when they were in their cages. Chicks raised with no vegetation moved around the whole cage. The difference in vegetation preference may be due to the structure of the vegetation. In nature both vegetation types provide cover and protection, and we duplicated this in the laboratory. However, goldenrod provides more room under the leaves, and because the leaves are broader the chicks could peer out between them. *Ammophila* grass has many more stems, and sometimes does not provide an open place under it for all siblings to hide.

When startled, chicks raised with either plant species alone immediately ran to their natal vegetation, and moved easily under the leaves, whereas those raised with both plants ran to vegetation but showed no clear preference. Chicks raised with both or neither plants showed no preference for either plant species when tested in a relaxed atmosphere or when startled. This indicated that the plants we used for our tests were equally attractive. We concluded that the preferences shown by chicks raised with only one species, but tested with both, were the result of their early experience.

In nature, chicks could be warned of danger by calls of parents, or by the behavior of other chicks, or by the dangerous stimulus itself. In any case it would be adaptive for young chicks to hide quickly under cover. Moving to familiar vegetation has several advantages: (1) quick and rapid choice with a minimum of delay, (2) assurance that there is room to hide, and (3) increased likelihood that only siblings will be under that particular bush. If other non-sibling chicks are present, particularly larger ones, the escaping chick may be forced out into the open sand and danger. Our study, in contrast to others, showed a temporal increase in preference for the natal vegetation (for chicks raised with goldenrod), and a preference for their natal vegetation when offered a choice between two plants found in nature. Since chicks raised with only one plant ran to it when startled, but chicks raised with both plants or no plants showed no clear preference for plant species when startled, we conclude that experience rather than innate preferences obtain. These results thus extend previous studies in documenting the role of experience in temporary habitat choices.

Taken together, the results of these experiments indicate that chicks prefer to remain near cover, and select a familiar vegetation type when startled. Strong vegetation affinity developed early, enabling chicks to find quickly familiar cover when startled or threatened by predators or conspecifics, increasing their overall survival. These preferences and abilities develop in the first week of life.

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**Brood adoption and apparent infanticide in a north-temperate House Wren population.**— In many bird species, a mate who dies or deserts during a breeding attempt may be replaced by another bird before the breeding attempt terminates. Replacement can also occur after physical eviction of one member of a pair by an unpaired floating bird (i.e., Freed 1986, Arcese 1989). “Replacement mates” may respond to eggs or young of the previous mate by killing them (infanticide), providing them with some form of parental care (brood adoption), or ignoring them (indifference). Rohwer (1986) reviewed the distribution of these behaviors among replacement mates in 26 species of birds. Additional cases of infanticide (among non-cooperatively breeding species) have now been reported in the Little Egret (*Egretta garzetta*), Palestine Sunbird (*Nectarinia osea*), Tristram’s Grackle (*Onychognathus tristramii*), and the Barn Swallow (*Hirundo rustica*) (Fujioka 1986, Goldstein et al. 1986, Hofshi et al. 1987, Møller 1988). Brood adoption has been reported in the Black-capped Chickadee (*Parus atricapillus*), and Black-billed Magpie (*Pica pica*) (Howitz 1986, Buitron 1988). Bowman and Bird (1987) found indifference to broods among replacement mates in American Kestrels (*Falco sparverius*). In tropical House Wrens (*Troglodytes aedon inquietus*) and Tree Swallows (*Tachycineta bicolor*), replacement mates may either kill young or show indifference to broods (Freed 1986, Robertson and Stutchbury 1988). We report here on a case of brood adoption and a case of apparent infanticide by replacement males in a north-temperate