on 28 April 1988 and seven on Compass Cay, 29 April 1992 (RS), and 25–30 on Leaf Cay (east of Norman's Pond Cay), 17 May 1985 (AS).

Discussion.—The Blue-gray Gnatcatcher (*Polioptila caerulea*) is noteworthy by its apparent absence from the Exumas. It breeds commonly in the northern Bahamas and among the predominately scrub-covered southern islands, but is unknown from much of the central part of the archipelago. Additionally, Blue-gray Gnatcatchers that breed in continental North America have been recorded in the Bahamas and Antilles during August–May (Bond 1956), and Brudenell-Bruce (1975) reported the current status of *P. caerulea* on New Providence (just northwest of the Exumas) as "uncommon autumn passage migrant" only.

Additional fall and winter surveys are needed to assess the status of this and many other Exuma bird species more accurately. Doubtless many new nonbreeding visitors will be recorded, but we expect few if any additions to the list of 23 native, breeding land birds on these small, low-lying islands with little habitat diversity. Further explorations during summer may add some heron and egret species (of currently uncertain status) to the list of breeders and are certain to reveal many more seabird colonies, underscoring the importance of these islands as a breeding area for numerous seabird species.

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DONALD W. BUDEN, *Natural Sciences, Northern State Univ., Aberdeen, South Dakota 57401; and* ALEXANDER SPRUNT IV, *115 Indian Mound Trail, Tavernier, Florida 33070.* *Received 4 Jan. 1993, accepted 15 Feb. 1993.*

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Predation by Herring Gulls and Great Black-backed Gulls on Horseshoe Crabs.—Spring migration of shorebirds through Delaware Bay coincides with seasonal egg laying by horseshoe crabs (*Limulus polyphemus*) on intertidal beaches (Myers 1986). We here report on a previously undescribed aspect of the interaction between birds and horseshoe crabs, the predation by Herring Gulls (*Larus argentatus*) and Great Black-backed Gulls (*L. marinus*) on these large (ca 20–30 cm carapace width) arthropods. Adult horseshoe crabs live in sublittoral, mainly nearshore, coastal habitats for most of the year but migrate to estuaries every spring. In Delaware Bay, spawning occurs in the intertidal zone, on high tides throughout May and June (Shuster and Botton 1985). As much as 10% of the spawning population may be left stranded on the beach, principally due to wave action during spawning or disorientation during their return to the sea (Botton and Loveland 1987, 1989). Although

TABLE 1
LOCATIONS ON ADULT HORSESHOE CRABS ATTACKED BY HERRING GULLS AND GREAT BLACK-BACKED GULLS ON A 90-M STUDY BEACH IN DELAWARE BAY, SPRING 1989

	Location of attack					
	Book-gills		Chelicerae		Both	
Date	Male	Female	Male	Female	Male	Female
23 May	4	2	0	3	1	4
24 May	7	1	0	0	1	4
25 May	8	0	0	0	0	0
Total	19	3	0	3	2	8

predation on adult horseshoe crabs in subtidal waters is quite uncommon (Shuster 1982), Botton and Loveland (1989) found that about 40% of the dead stranded crabs on an intertidal beach in Delaware Bay were missing their book-gills, and they inferred that gulls were responsible for the damage. However, it was not clear whether the horseshoe crabs were alive or dead when they were eaten. We now report additional observations which demonstrate that Herring and Great Black-backed gulls attack live adult horseshoe crabs, and we discuss patterns of attack used by the gulls.

Methods.—From 23–25 May 1989, we conducted transect surveys to evaluate whether gulls ate live horseshoe crabs. The study site was a beach near the Rutgers Univ. Shellfish Laboratory in Cape May County, New Jersey. We began each day's survey by clearing all dead horseshoe crabs from a 90-m study area, which was sub-divided into six 15-m transects. We observed feeding of Herring and Great Black-backed gulls throughout the tidal cycle. On the next low tide, we inspected all moribund or recently dead crabs. Viewed from the ventral surface, a horseshoe crab has three main body regions. The widest region (prosoma) bears the walking legs, chelicerae, and mouth; the middle region (opisthosoma) bears respiratory structures called book-gills, and the body terminates with the sharply pointed telson. Crabs missing large pieces of book-gills and/or walking legs, or those having profuse bleeding on the ventral surface, were presumed to have been recently attacked by gulls.

To determine whether abnormalities of the crab's telson influenced the likelihood of predation by gulls, we recorded the probable cause of death of stranded horseshoe crabs collected during spring 1986. Abnormalities included missing, unusually short ("stubby"), and disarticulated telsons (Botton and Loveland 1989). Gull predation was inferred as the probable cause of death if a substantial portion of the book-gills had been torn out; dead horseshoe crabs with intact but brittle book-gills presumably died from desiccation. We tested the null hypothesis that the cause of death of the horseshoe crab was independent of telson condition, using a 2×2 contingency table, at $\alpha = 0.05$.

Results and discussion.—Over the three-day interval from 23–25 May 1989, 1.94 adult horseshoe crabs were killed per 15-m transect per day (Table 1). More males ($N = 21$) than females ($N = 14$) were killed, but males typically outnumber females in both the spawning population and among the fraction which becomes stranded on the beach (Botton and Loveland 1989). Herring and Great Black-backed gulls attack live overturned crabs in a consistent pattern (Table 1). The most common attack behavior (62.9% of observations) is to approach an overturned crab from either side, and use the bill to tear out the unprotected book-gills. A freshly stranded crab usually responds by flexing its opisthosoma upward, which compresses the book-gills, reducing the exposed surface area. When struck in the gill

TABLE 2

RELATIONSHIP OF INFERRED CAUSE OF DEATH (GULL PREDATION, DESICCATION) TO TELSON CONDITION (NORMAL, ABNORMAL), ON A 90-M STUDY BEACH IN DELAWARE BAY, NEW JERSEY, 1986

Cause of death and telson condition	Survey date						
	5/23	5/27	6/1	6/4	6/18	6/20	All dates
Desiccated, normal	15	13	92	59	115	60	354
Desiccated, abnormal	3	5	41	12	16	11	88
Gull predation, normal	50	11	7	25	27	25	145
Gull predation, abnormal	13	4	3	4	11	9	44
χ^2	0.14	0.01	0.00	0.15	6.14	1.80	0.91
P[a]	ns	ns	ns	ns	*	ns	ns

[a] Frequencies were tested using 2 × 2 contingency table; * = $P < 0.05$, ns = not significant.

region, a crab may also elevate and move its telson in an effort to resist the attack. The book-gills are composed of chitinous leaflets, and they are often discarded near the crab. Once having weakened the crab, the gulls proceed to remove the legs to expose the soft tissue in the prosoma, consisting largely of hepatopancreas ("liver") and in female crabs, eggs. A smaller number of live horseshoe crabs (8.6%) were killed by attacks to relatively soft tissue on the ventral surface of the crab's prosoma, located just anterior to the small, pincer-like chelicerae. Both the book-gill and chelicerae sites were attacked in 28.6% of the crabs.

We observed attacks on stranded, upside-down crabs on many beaches in Delaware Bay between 1986 and 1992 wherever *Limulus* and larger gulls were together. Feeding tactics of Great Black-backed and both juvenile and adult Herring gulls appeared to be similar. We have never seen a gull attempt to turn over a rightside-up stranded crab, nor have we witnessed gulls attempting to pierce the hard dorsal carapace.

Telson abnormalities predispose horseshoe crabs to beach stranding, because this structure is used as a lever in righting behavior (Botton and Loveland 1989). Although our behavioral observations suggested that stranded horseshoe crabs with normal telsons might offer more resistance to gull predation than crabs with stubby, missing, or disarticulated telsons, this was not the case (Table 2). The telson is probably an ineffective defense against gull predation because gulls are capable of rapid attacks to the ventral surface. In an overturned position, the crab's eyes are facing away from an attacking bird, and the movements of the telson are haphazard and ineffective.

Horseshoe crabs are capable of withstanding the desiccation stress associated with beach stranding for ca 18–24 h (Botton and Loveland 1989). Many crabs stranded on a receding tide are thus capable of surviving until the next high tide immerses them. Predation by gulls is an important source of mortality to horseshoe crabs during the hours of intertidal exposure. By projecting a mortality of 1.94 crabs per 15 m per day (Table 1), over a two month period (May–June), we estimated that ca 7760 crabs per km may be killed by the predatory activities of Herring and Great Black-backed gulls along the New Jersey shore of Delaware Bay.

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MARK L. BOTTON, *Division of Science and Mathematics, Fordham Univ., College at Lincoln Center, New York, New York 10023; and* ROBERT E. LOVELAND, *Dept. of Biological Sciences and Bureau of Biological Research, Rutgers-The State Univ., Nelson Biological Laboratories, Piscataway, New Jersey 08854.* *Received 2 Nov. 1992, accepted 5 Feb. 1993.*

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Ground nest predation and Ruffed Grouse densities in southwest Virginia.—Densities of Ruffed Grouse (*Bonasa umbellus*) are lower in the southern Appalachians than in northern portions of the species' range (Bump et al. 1947). Bergerud (1988) proposed that this resulted from greater southern nest predation. Furthermore, he contended that nest predation is density-dependent in that the proportion of nests destroyed by predators increases as density of nests increases. Because nest predation is believed to be greater southward and density-dependent, hens in the South should space their nests farther apart than hens in the North to achieve nesting success sufficient to maintain a stable population. To test this hypothesis, we measured predation rates on artificial ground nests in southwest Virginia and tested whether this predation was density-dependent.

Study areas and methods.—Three study sites within the ridge and valley province of the Appalachian hardwood subregion (Smith and Linnartz 1980) were selected in the Jefferson National Forest in Montgomery and Craig counties, Virginia. All sites were characterized by oak (*Quercus* spp.)-hickory (*Carya* spp.) forests, with pine (*Pinus* spp.), red maple (*Acer rubrum*), and yellow poplar (*Liriodendron tulipifera*) common in the overstory. Mountain laurel (*Kalmia latifolia*), vaccinium (*Vaccinium* spp.), flowering dogwood (*Cornus florida*), rhododendron (*Rhododendron* spp.), and saplings of overstory species were common in the understory. All three sites contained small (<5 ha) clear-cuts less than 25 years of age, with heavy regeneration of overstory species. Ruffed Grouse were observed and heard drumming on or near all three sites.

Two areas were delineated at each of the three study sites and were assigned high and low nest densities. High density areas were 500 × 500 m and low density areas were 500 × 2000 m. High and low density areas were separated by at least 1 km and were >100 m from any road open to vehicular use. Sites for nest placement were located using two random numbers, one was the number of meters along a transect that bisected the area (ranging from 1 to 500 for high density areas and 1 to 2000 for low density areas) and the other was