The Condor 101:635–644

SHOREBIRD DIET DURING SPRING MIGRATION STOPOVER ON DELAWARE BAY[1]

NELLIE TSIPOURA AND JOANNA BURGER
Rutgers University, Division of Life Sciences, Nelson Biological Labs, 604 Allison Rd., Piscataway, NJ 08854, e-mail: tsipoura@rci.rutgers.edu

Abstract. During spring migration, thousands of shorebirds gather in Delaware Bay at the same time as horseshoe crabs (*Limulus polyphemus*) are spawning. During their stopover, the birds store enough fuel in the form of fat and muscle protein to complete their migration to the Canadian breeding grounds. We documented the changes in body mass of shorebirds migrating through Delaware Bay and determined how much of the shorebird diet during this period consisted of horseshoe crab eggs. Migrating shorebirds were captured, morphometric measurements taken, and gut samples collected by stomach flushing. Red Knots (*Calidris canutus*), Ruddy Turnstones (*Arenaria interpres*), Sanderlings (*C. alba*), and Semipalmated Sandpipers (*C. pusilla*) increased their body mass up to 70–80% while staging on Delaware Bay. Horseshoe crab egg membranes constituted the bulk of the gut contents for all species at all collection sites. Polychaete and oligochaete worms were found in substantial concentrations in gut samples collected from shorebirds in certain beaches. Sand and unidentified decomposed material were found in varying amounts in gut samples of all species and locations. Apparent declines in spawning horseshoe crab populations may adversely affect migratory shorebirds.

Key words: *body mass, Delaware Bay, diet, gut sampling, horseshoe crabs, migration, shorebirds.*

INTRODUCTION

During May, thousands of shorebirds gather in Delaware Bay along the coasts of New Jersey and Delaware, coinciding with the spawning of the horseshoe crab (*Limulus polyphemus*). As many as 270,000 shorebirds have been recorded in a single count (Clark et al. 1993), the largest concentration of northbound shorebirds on the east coast of the United States. During their stopover at Delaware Bay, shorebirds need to store enough fuel in the form of fat and muscle protein to complete the 4,000 mile journey to the Canadian Arctic. Shorebird populations have been declining (Howe et al. 1989, Clark et al. 1993), and in the past decade much international attention has focused on the dependence of shorebirds upon critical stop-over areas during their migration (Morrison 1984, Senner and Howe 1984, Myers et al. 1987). Delaware Bay became the first hemispheric site in the Western Hemisphere Shorebird Reserve Network, an international network of wetlands established to protect sites important for shorebird populations and assist in managing these areas.

While staging on Delaware Bay beaches, the shorebirds forage intensively in areas with high concentrations of horseshoe crab eggs (Botton et al. 1994). Reductions in spawning horseshoe crab populations have caused up to 70% decreases in the availability of horseshoe crab eggs on some Delaware Bay beaches since the mid 1980s (Loveland and Botton, pers. comm.). These changes in horseshoe crab populations may threaten the delicate interaction between the migratory shorebirds and their prey, particularly if horseshoe crab eggs are a significant part of the diet for many different species of shorebirds. For successful management, it is important to understand how the shorebirds use the horseshoe crab eggs during this critical stage in their migration and what other prey items are found in the shorebird diet.

Assimilation efficiency of captive Sanderlings, *Calidris alba,* feeding on horseshoe crab eggs has been found to be relatively low, about 38% (Castro et al. 1989). It may be the sheer abundance of the eggs that makes them a desirable food source, and decreases in the number of horseshoe crab eggs may be detrimental to foraging shorebirds (Castro and Myers 1990). However, Sanderlings in Castro et al.'s (1989) laboratory study did not gain weight while foraging on the eggs, as opposed to shorebirds in the wild that normally double their weight during their stopover in the Delaware Bay area.

[1] Received 16 June 1998. Accepted 19 March 1999.

Horseshoe crab eggs may be important to the migrating birds in combination with other ingested items. In that case, selection for certain prey items to complement the horseshoe crab eggs will result in a diet which is not directly proportional to the availability of all prey items, but in which certain items will be over-represented. On the other hand, assimilation efficiency of horseshoe crab eggs may be higher in shorebirds in the wild than in the laboratory.

Prior to this study, the contribution of the horseshoe crab eggs to the shorebird diet and the increases in shorebird body mass in preparation for migration to the breeding grounds had not been quantified. In this paper we demonstrate that the shorebird diet during stopover in Delaware Bay consists mainly of horseshoe crab eggs. We also investigate differences in diet between species at different habitats and between the two years of the study. Finally, we present information on changes in body mass of shorebirds migrating through Delaware Bay. These data are a subset of an ongoing morphometric study of the migrants.

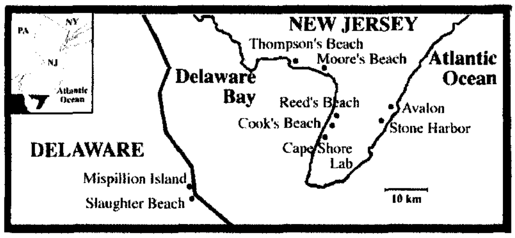

FIGURE 1. Map of capture locations of shorebirds during spring migration in Delaware Bay.

METHODS

FIELD COLLECTION

Under appropriate state and federal permits, we captured shorebirds on the Delaware Bay shore and on Atlantic Ocean beaches of Cape May, New Jersey, with mistnets during spring migration (May and early June) from 1990 to 1997. Capture took place at night for Sanderlings and Semipalmated Plovers (*Charadrius semipalmatus*), or during the day for Semipalmated Sandpipers (*Calidris pusilla*), and Least Sandpipers (*C. minutilla*). We used a net-launching gun and cannon nets to capture Sanderlings, Dunlin (*C. alpina*), Red Knots (*C. canutus*), and Ruddy Turnstones (*Arenaria interpres*) during the day.

Capture sites include five Delaware Bay beaches (Reed's Beach, Cape Shore Lab [North Beach], and Cook's Beach in Cape May County, New Jersey; Slaughter Beach and Mispillion Island, Delaware); a creek entrance to Delaware Bay (Moore's Beach, Cumberland County, New Jersey); a tidal flooded mudflat (Thompson's Beach, Cumberland County, New Jersey); and the Atlantic Ocean beaches of Avalon and Stone Harbor Townships, Cape May County, New Jersey (Fig. 1).

Gut sample collection took place during May 1996 and 1997. We collected gut samples from 2 Least Sandpipers, 17 Semipalmated Sandpipers, and 20 Sanderling in 1996; and from 2 Dunlin, 21 Red Knots, 9 Ruddy Turnstones, 17 Sanderling, 2 Semipalmated Plovers, 10 Least Sandpipers, and 13 Semipalmated Sandpipers in 1997. Within 15 min after capture, we collected gut contents from each bird by inserting a 3 mm diameter Tygon tube through the mouth and into the stomach of the bird and flushing with approximately 30 cc of distilled water, while holding the bird's bill over a jar. This methodology is a modification of the collection methods described by Dhalgren (1982), Wilson (1984), and Martin and Hockey (1993) and made it possible to collect gut samples without sacrificing the birds. Mortality was low, about 3%, which is similar to average mist-netting mortality.

We took body measurements, including bill length (exposed culmen in mm), flattened wing length (mm), and body mass (g) on all the birds for which we collected gut samples, and on birds collected in 1993, 1994, and 1995 for another study. We banded birds with U.S. Fish and Wildlife Service metal bands and color band combinations before releasing them. Additional body mass measurements were provided by the Endangered and Non-game Species Program of the New Jersey Department of Environmental Protection for the years 1990 and 1991.

The study of shorebird food habits can be problematic because the rapid digestion of prey in these birds (Pienkowski 1984) can result in underestimating the intake of soft bodied prey. Fecal analysis reveals prey identity from undigested material, and although it can be very useful in some cases (Dekinga and Piersma 1993), it completely ignores soft-bodied, completely digestible prey. Many of the prey items in our study such as polychaetes (Annelida) and ribbon worms (Nemertea) are soft bodied and could go undetected in a fecal study. Despite disadvantages of the stomach-flushing technique, it seemed the best possible approach for this study. We caught birds that were actively foraging and immediately flushed the digestive tract before prey was digested. Our samples represent prey items that were consumed shortly before capture, and thus our data give no indication of what prey items were consumed earlier, except for the highly indigestible horseshoe crab egg membranes.

LABORATORY ANALYSIS

We placed the gut contents from each bird in separate labeled jars and preserved them in 10% alcohol or buffered formalin. We numbered each sample and, to avoid investigator bias, we proceeded with identification by number rather than collection site or species. We viewed gut samples on a 1 cc volumetric slide, using an inverted microscope at 4 × 10 magnification. Using this methodology, we could not determine the overall volume of the gut contents for each bird, and made no corrections for stomach size. Instead, we quantified prey as percent coverage of each field as seen under the microscope, thus incorporating prey volume into this percentage measurement. Under the magnification used, we could scan the whole sample in about 30 scope fields. We identified individual items to the lowest possible taxon. We estimated percentage coverage of the larger items making up the bulk of the gut contents for 11 scope fields, constituting about 36% of total sample, and then extrapolated for the full sample. We also recorded the number of individuals of smaller items in the gut sample for 11 scope fields. We then scanned the complete sample for unusual items by viewing it under a dissecting scope with an overhead light source to identify items unrecognizable under the inverted microscope.

We averaged the percentage field coverage of the most abundant items in the gut contents for the 11 fields recorded for each sample. We totaled the number of individuals of smaller ingested items for each sample.

STATISTICAL ANALYSIS

We analyzed body measurements using multiple regression and analysis of variance (ANOVA; Hatcher and Stepanski 1994). Body mass by date for each species was regressed on year to determine whether there was a significant difference in the slopes between years. ANOVA (unbalanced design) was performed by species for all body measurements, with date of capture as the between group factor. Multiple regression analyses were performed to determine which variables best explained differences in body mass.

We calculated average percent coverage of the microscope slide by the more common items found in the gut samples by species, capture location, and habitat. Comparisons by species, location, and habitat were performed using nonparametric statistics (Mann-Whitney *U*-test). For non-food items, patterns of presence/absence were determined, and *G*-tests were performed to test for significant differences in occurrence by habitat. Because the species and collection sites differed between the two years of the study, diet data from each year were analyzed separately. Finally, for Sanderlings and Semipalmated Sandpipers, for which some samples were obtained from the same sites in both years, comparisons between years were performed using Mann-Whitney *U*-tests. We considered a $P < 0.05$ statistically significant.

RESULTS

CHANGES IN BODY MASS

We found no significant differences between years in the increases of body mass during the migration stopover for any of the species studied ($F_{4,16} = 0.2$, $P > 0.66$; Fig. 2). Analysis of variance of mass revealed a significant effect of date for all species studied: for Semipalmated Sandpipers, $F_{12,412} = 10.5$, $P < 0.001$, $r^2 = 0.23$; Sanderling, $F_{19,301} = 17.3$, $P < 0.001$, $r^2 = 0.52$; Ruddy Turnstones, $F_{9,56} = 20.4$, $P < 0.001$, $r^2 = 0.76$; Red Knot $F_{10,159} = 20.1$, $P < 0.001$, $r^2 = 0.56$; Least Sandpiper, $F_{11,55} = 6.7$, $P < 0.001$, $r^2 = 0.57$. There was no effect of date for wing or bill size for any of the species, indicating that the body mass change is not the result of increased overall body size.

Standardized regression coefficients and uniqueness indices were reviewed to assess the relative importance of date, wing length, and bill length in predicting body mass (Table 1). Date accounted for 64% of the variation in mass for Ruddy Turnstones, 46% in Sanderling, 42% in Red Knots, 34% in Least Sandpipers, and 12% in Semipalmated Sandpipers. The contribution of wing and bill length, although in some cases

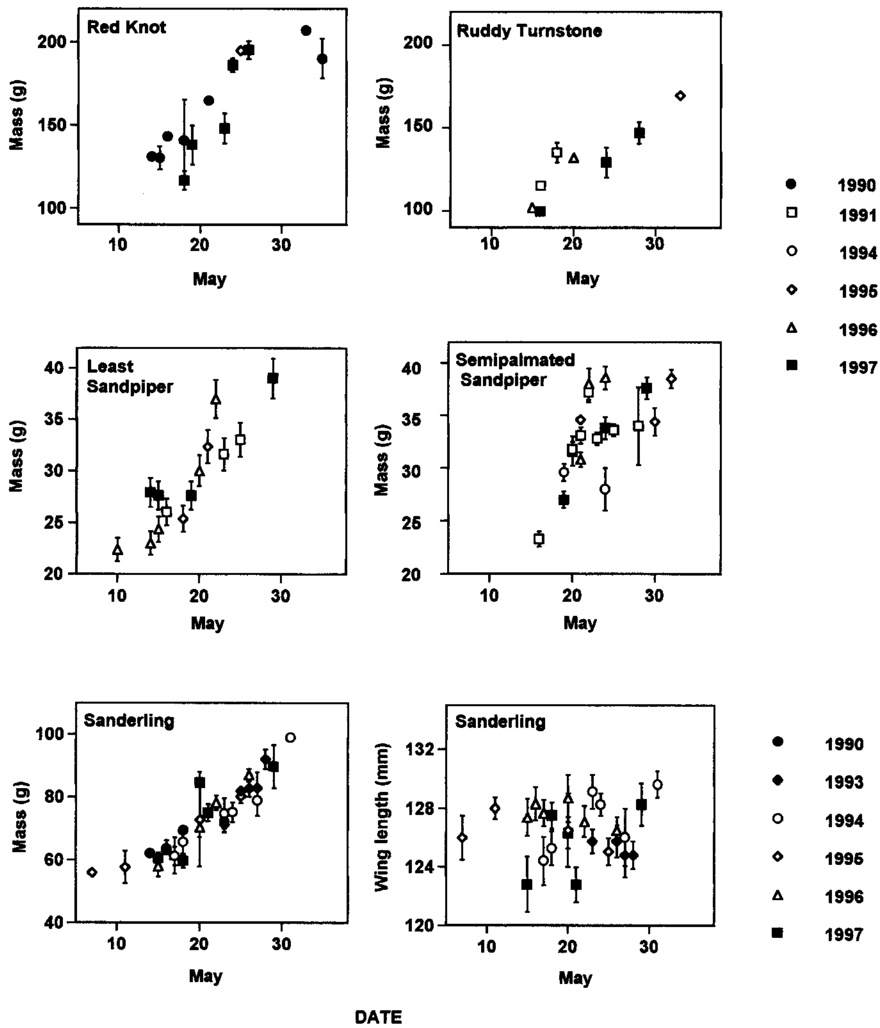

FIGURE 2. Body mass changes of five shorebird species, and Sanderling wing length by date during spring migration through Delaware Bay. Sample sizes by species and year: for Ruddy Turnstones in 1990 n = 23, 1991 n = 4, 1996 n = 8, 1997 n = 22; for Red Knots in 1990 n = 108, 1995 n = 14, 1997 n = 47; for Least Sandpipers in 1991 n = 11, 1995 n = 11, 1996 n = 25, 1997 n = 21; Semipalmated Sandpipers in 1991 n = 229, 1994 n = 15, 1995 n = 20, 1996 n = 37, 1997 n = 48; for Sanderlings in 1990 n = 109, 1993 n = 36, 1994 n = 46, 1995 n = 20, 1996 n = 49, 1997 n = 48.

a significant determinant of mass, contributed less overall to the variation in mass (Table 1). Differences of the predictive value of date in predicting mass in the five species are probably the result of different sampling periods as well as different rates of weight gain.

Average mass increase, estimated using the mean measured mass from early Delaware Bay arrivals and from birds just prior to departure, was 49% in Red Knots, 59% in Sanderlings and Ruddy Turnstones, 44% in Least Sandpipers, and 78% in Semipalmated Sandpipers. This drastic increase in mass was achieved over a two to three week period of average daily body mass gains of 34% for all species.

GUT CONTENTS

We found intact horseshoe crab eggs in gut samples of Sanderlings, Ruddy Turnstones, and Red Knots, collected while the birds were actively foraging along Delaware Bay beaches on both the New Jersey and Delaware side. Horseshoe

TABLE 1. Standardized regression coefficients obtained in multiple regression analysis predicting body mass of shorebirds.

	R^2	Standardized regression coefficients	n
Red Knot			170
Date	0.42	0.65**	
Wing	0.03	−0.01	
Bill	0.00	−0.04	
Ruddy Turnstone			66
Date	0.65	0.78**	
Wing	0.06	0.42*	
Bill	0.02	0.51*	
Sanderling			321
Date	0.46	0.65**	
Wing	0.11	0.12*	
Bill	0.02	0.13*	
Semipalmated Sandpiper			428
Date	0.12	0.34**	
Wing	0.02	0.14**	
Bill	0.00	−0.02	
Least Sandpiper			67
Date	0.34	0.37*	
Wing	0.33	0.11	
Bill	0.24	0.39*	

* $P < 0.05$, ** $P < 0.001$.

crab egg membranes constituted the bulk of identifiable prey items in the gut for all species and all collection sites, except for samples collected along the Atlantic Ocean (Figs. 3, 4). Polychaete worms of the families Capitellidae and Spionidae, in a state of decomposition not allowing for further identification, made up the most significant portion of the Sanderling and Semipalmated Plover samples from Stone Harbor (Figs. 3, 4). We found both polychaete and oligochaete worms in substantial concentrations in gut samples from Least Sandpipers and Semipalmated Sandpipers collected at Thompson's Beach (Fig. 4). The presence of unidentifiable polychaete worm setae in several samples indicates further ingestion of worms. We also found sand and unidentified decomposed material (detritus) in varying amounts in gut samples from all species and locations.

In 1996 there were no statistically significant differences between species or between locations in the amounts of egg membranes and decomposed material found in gut samples. Spionid and capitellid polychaete worms constituted more of the Sanderling diet in ocean than in bay habitats, and more of the overall diet of Sanderlings than Semipalmated Sandpipers. None of these differences, however, were significant, probably because of the high variability in worm intake between individuals. In samples collected from birds on the Bay, sand was present in sig-

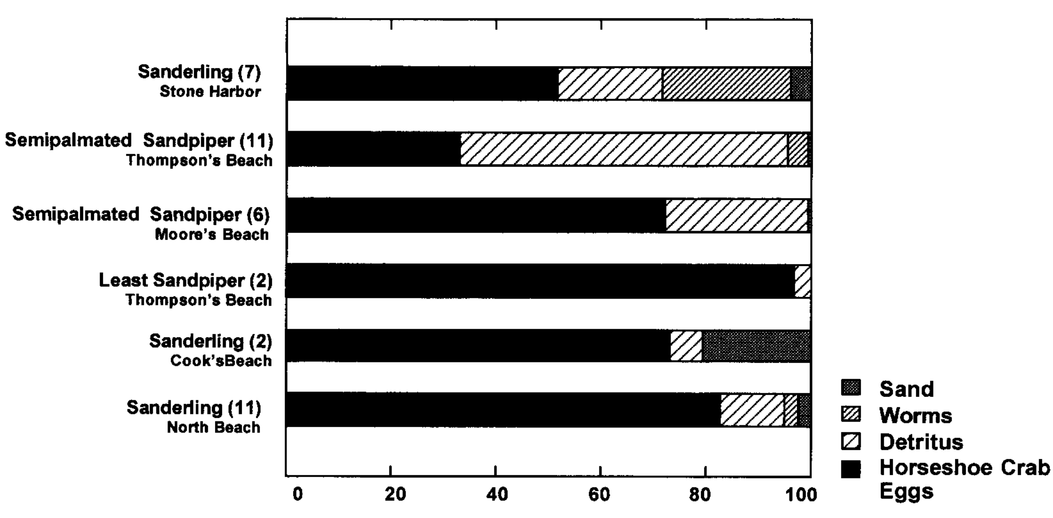

FIGURE 3. Cumulative percentage of the most common food items found in the digestive tract of shorebirds migrating through Delaware Bay during northbound migration, May 1996. Sample sizes in parentheses.

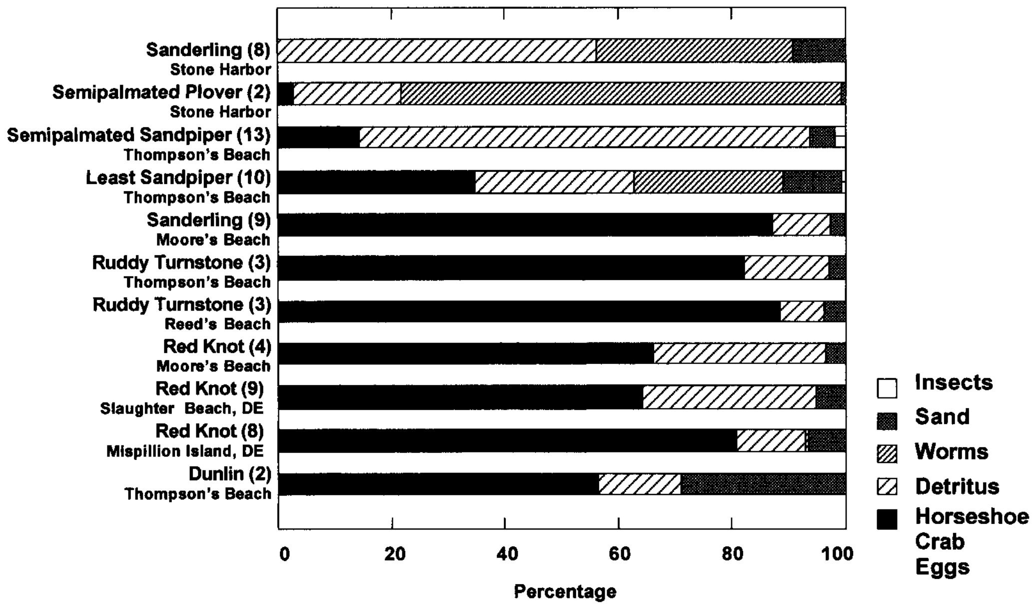

FIGURE 4. Cumulative percentage of the most common food items found in the digestive tract of shorebirds migrating through Delaware Bay during northbound migration, May 1997. Sample sizes in parentheses.

nificantly higher amounts in Sanderlings than in Semipalmated Sandpipers ($U = 106$, $n_1 = 12$, $n_2 = 11$, $P < 0.01$). In 1997 there were no differences between Sanderling, Red Knots, and Ruddy Turnstones, or between Least and Semipalmated Sandpipers in gut concentrations of the most common food items. When comparing the two groupings (the two smaller sandpipers vs. sanderlings, knots, and turnstones), we found significantly lower concentrations of horseshoe crab egg membranes ($t_{69} = 2.12$, $P < 0.05$) and sand in the two sandpipers ($t_{69} = 2.11$, $P < 0.05$). We found significantly more egg membranes in guts of Sanderlings from Delaware Bay beaches than from the Atlantic Ocean beaches ($t_{35} = 3.09$, $P < 0.01$).

In 1997, the only year when we sampled birds on both sides of Delaware Bay, the average number of intact eggs in guts of birds in Delaware was much greater (almost double) than the number of those from Bay beaches in New Jersey. There were also higher average percentages of horseshoe crab egg membranes in gut samples collected on the Delaware side, except for the samples collected from Ruddy Turnstones at Thompson's Beach. However, these differences in gut concentrations of horseshoe crab eggs from the two states were not statistically significant because of the high variation between samples.

Food items making up less than 5% of the gut samples included dipteran insect parts, found in the digestive tract of Least and Semipalmated Sandpipers and Ruddy Turnstones at Thompson's Beach and in Sanderlings at Cook's Beach, Moore's Beach, and Stone Harbor. Nemerteans *Lineus* sp. (ribbon worms) were found in Sanderlings at North Beach, and in a Red Knot at Mispillion Island. Small nematodes were found in almost all samples. Other incidentals were occasional unidentified crustacean parts and an eye lens from an unidentifiable small fish which was found in a Sanderling sample at Stone Harbor.

Non-food items, occurring incidentally and making up less than 1% of the total contents, included diatoms, feathers, oak leaf scales, and pollen. Oak leaf scales and pollen occurred in gut samples from marsh habitats significantly more often than in beach habitats ($\chi^2_2 = 16.7$, $P < 0.01$), as would be expected for plant material originating in a terrestrial habitat.

COMPARISONS BETWEEN YEARS

There were higher concentrations of horseshoe crab egg membranes in all gut samples collected in 1996 compared to those collected in 1997.

These differences between years were statistically significant for gut samples from Semipalmated Sandpipers at Thompson's Beach (U = 139, n_1 = 11, n_2 = 13, $P < 0.01$) as well as for pooled samples from Sanderlings captured along Delaware Bay beaches (U = 73, n_1 = 12, n_2 = 9, $P < 0.05$). Sanderlings collected along the Atlantic Ocean beaches in 1997 also had lower egg membrane concentrations than in 1996 (U = 42, n_1 = 8, n_2 = 7, $P < 0.01$).

DISCUSSION

Delaware Bay is a staging area for a large number of shorebirds that stop briefly to replenish their energy reserves during their long-distance migration between temperate and tropical nonbreeding areas and arctic breeding grounds (Senner and Howe 1984, Myers et al. 1987). This type of long distance migration with few stops along the way may not be as common as once believed. For example, at inland stopovers, shorebirds seem to migrate through more gradually, move shorter distances, and depend on continuously changing ephemeral resources (Skagen and Knopf 1993, 1994, Robinson and Warnock 1997). Along the coast of western North America, Western Sandpipers use a short-flight migratory strategy and depend on a series of intertidal wetlands during their northbound journey (Iverson et al. 1996). Thus, Delaware Bay may be an area of unique biological importance, because it serves as an intermediate step between two long-distance legs of a migratory journey for several shorebird species.

This research was prompted by apparent declines in spawning horseshoe crab populations and by the policy issue of managing increased use of horseshoe crabs by the conch and eel bait fisheries. Castro and Myers (1993) estimated consumption of horseshoe crab eggs based on assimilation efficiency estimates and assumptions on energetic parameters of fattening and flight ranges, but there are no published data from Delaware Bay on either shorebird body mass changes or field consumption rates of horseshoe crab eggs. To manage the resource, it is crucial to document both the shorebird mass gain in this staging area and the biological interaction between the shorebirds and the horseshoe crab eggs.

We found that shorebirds migrating through Delaware Bay significantly increase their body mass during a short period of time in preparation for migration, and this significant increase is not the result of overall changes in body size. Based on unpublished resightings of banded birds and on radiotracking information that reveal shorebirds spend an average of two weeks at Delaware Bay (K. Clark and S. Meyer, pers. comm.), we are confident that the body mass changes are the result of gains while staging at Delaware Bay and are not due to the arrival of heavier birds later in the season. The birds increase their mass by up to 70–80% in a three week period, and the timing of these body changes does not differ significantly from year to year. The consistency between years is probably the result of a constrictive breeding schedule requiring the birds to arrive at the breeding grounds in subarctic and arctic Canada in late May or early June to initiate nesting, coupled with the timing of the horseshoe crab spawn, which peaks in late May and June (Botton and Loveland 1989).

We further determined the diet that enables the birds to undergo this rapid mass change during their stopover. Horseshoe crab eggs made up a significant portion of the diet of all six species collected along Delaware Bay for both years of the study (Figs. 3, 4). The eggs were represented mostly by membranes, a fact which suggests that breakdown of the eggs in the gizzard takes place efficiently and rapidly. By observing foraging sanderlings and then capturing and flushing their stomach, we estimated that within 20–30 min no intact eggs could be found in the gut sample. This indicates that under natural conditions assimilation efficiency of the horseshoe crab eggs is higher than originally suggested by Castro et al. (1989). The presence of sand in gut samples from all species, in some cases in high concentrations, most likely indicates that sand plays an important role in breaking and grinding down the horseshoe crab egg membranes so that the eggs can be more easily digested.

Egg membrane concentrations in gut samples from locations on the New Jersey side of the Delaware Bay, significantly lower in 1997 than in 1996, correlate with the lower concentrations of eggs in the surface layer of beach sediment obtained by R. Loveland and M. Botton (pers. comm.). Surface eggs are the ones available to most species of shorebirds, because the deeper layers of eggs at 15–20 cm are not reachable by birds with a short bill. There were more horseshoe crabs on the Delaware side of the Bay in 1997, and much higher concentrations of shorebirds on those beaches. Gut samples from Red Knots in Delaware beaches contained more horseshoe crab eggs than those from New Jersey beaches, indicating that the birds were more successful finding eggs in Delaware. Unfortunately, there are no data on shorebird diets for the Delaware sites for 1996 to compare with 1997 samples, and no data on horseshoe crab egg concentrations from Delaware locations. However, the fact that the differences between egg membrane concentrations of gut samples in the two states were not statistically significant suggests that horseshoe crab eggs are important to the birds on both sides of the Bay. Very likely, the mass movements of Red Knots, Sanderlings, and Ruddy Turnstones that took place during mid- to late-May 1997 and resulted in much higher numbers of shorebirds along the Delaware side than along the New Jersey side of the Bay, and in much lower numbers on New Jersey beaches in 1997 than in 1996 (Clark 1996, 1997), occurred because of the low availability of horseshoe crab eggs in New Jersey.

One possible exception to the interaction between horseshoe crab egg availability and bird distribution is the Ruddy Turnstone. Large numbers of turnstones used Thompson's Beach, and the gut samples collected at this site had high concentrations of egg membranes. It is possible that the decline in abundance of horseshoe crab eggs, which occurred mainly for eggs available on the surface (R. Loveland, pers. comm.), may not have been a deterrent to the foraging success of this species as long as there were still sufficient numbers of eggs available in lower strata. Ruddy Turnstones use their bill to dig into the sand (or gravel) and can make holes that are several inches deep, thereby reaching the eggs that are buried deeper in the sand. This feeding technique may be the reason why, based on aerial flight surveys, Ruddy Turnstone populations still appear to be fairly stable in this stopover area despite the dwindling food supplies (Clark 1996, 1997). However, the population could be compromised with further declines of the horseshoe crabs.

The occurrence of horseshoe crab egg membranes in the digestive tract of Sanderlings captured foraging along the ocean beaches (Figs. 3, 4), where there is no horseshoe crab spawning, is most likely the result of earlier foraging bouts along Delaware Bay. There were no horseshoe crab egg membranes in the gut samples from two Semipalmated Plovers collected at Stone Harbor. The presence of these membranes in the digestive tract of shorebirds foraging on ocean beaches supports the idea that egg membranes are highly indigestible. It also indicates that the same individual Sanderlings forage both along the bay and along the ocean. In 1996 we recaptured one and resighted several birds along the Atlantic Ocean beaches which had originally been banded on the Delaware Bay side, confirming that individual birds travel between bay and ocean in their search for profitable food sources. In 1997 there were very few horseshoe crab egg membranes in Sanderling gut samples from Stone Harbor compared to 1996 samples. This is in agreement with the overall lower percentage of egg membranes in 1997.

Polychaete worms and ribbon worms were important prey items in Sanderlings from the ocean beaches and in Semipalmated and Least Sandpipers from Delaware Bay marshes. Gut samples from Semipalmated and Least Sandpipers collected in 1997 had higher abundance of polychaete and oligochaete worms than in 1996, and birds were observed feeding extensively on worms in the marshes. Eggs may still be the preferred prey of these two shorebird species, but the birds may switch to a marsh invertebrate diet when egg abundance is low.

Unfortunately, we have no information on invertebrate prey abundance and availability during these two years. The presence of insect body parts and crustacean appendages shows that these types of prey were taken and digested. Our study may underestimate the presence of smaller and more easily digestible prey items, but we are confident that our study accurately represents the most abundant items in the shorebird diet. The large concentrations of horseshoe crab eggs in gut samples and the presence of intact worms, which are soft bodied and therefore rapidly digested, indicate that indeed these are the two major components of the diet of shorebirds on Delaware Bay.

In conclusion, this study confirms the importance of horseshoe crab eggs in the diet of migrating shorebirds. Because horseshoe crab eggs seem to make up the bulk of ingested prey, it is important for shorebird management to closely monitor the horseshoe crabs to determine whether there have been declines in their population. Eggs are not taken to the exclusion of other items, like worms and arthropods. Marsh habitats are important for shorebirds, and can be managed for shorebird use (Weber and Haig 1996). In Delaware Bay, at least Semipalmated Sandpipers use the marshes extensively (Burger et al. 1996), and that can be seen in our study by the occasional presence in gut samples of oak leaf scales and pollen which characterize terrestrial habitats. Even though further research is needed to ascertain the contribution of food items from different habitats, the results of this study indicate that Delaware Bay marshes should be managed as shorebird foraging habitats.

ACKNOWLEDGMENTS

We thank Larry Niles and Kathy Clark of the Non-game and Endangered Species Program, New Jersey Division of Fish, Game, and Wildlife for their help during various stages of field work and manuscript preparation, and Bob Loveland for his helpful recommendations and assistance in identifying invertebrate prey, and contributions throughout this project. Elizabeth Baumgartner, Susan Elbin, Sam Wainright, and two anonymous reviewers provided useful comments on the manuscript. We thank the many volunteers and field assistants during the field work, including Paulo Antas, Barbara Ballantine, Jose Bronfman, Andrew Debrul, Ole Folmer, Chris Jennelle, Jay Kelly, Andy Papadatos, Juan Carlos Riveros, Albert Spry, Eric and Lydia Stiles, Mike Tyrrell, Kelly Volansky, and Michelle Walsh. We especially thank the 1997 International Shorebird Team, organized by Allan Baker, for their collaboration and field companionship. Housing and logistical support were provided by the Wetlands Institute and by the Rutgers Haskin Shellfish Research Laboratory, Cape Shore Facility. This research was supported by the Leathem-Steinetz Memorial Fund, the Hellenic University Club of New York, The Wetlands Institute, and contracts with the Non-game and Endangered Species Program, NJ Division of Fish, Game, and Wildlife.

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