

PREDATION OF HORSESHOE CRAB EGGS BY MIGRATORY SHOREBIRDS IN DELAWARE BAY, USA

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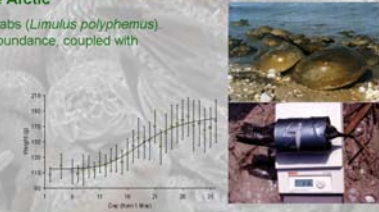


The problem – spring staging shorebirds may be failing to gain weight to breed successfully in the Arctic

100,000s of shorebirds stage in Delaware Bay on the east coast of the USA where their food is the eggs of horseshoe crabs (*Limulus polyphemus*). Crabs are harvested annually for the bait market which may threaten shorebird populations. Reported declines in crab abundance, coupled with declining numbers of Red Knot, have prompted intense research into shorebird status and demography.

Red Knot arrive from early May at about 110g, rapidly gaining weight to c.190g before leaving in late May (right). If birds do not refuel at a sufficient rate, they may fail to reach departure weight, potentially prompting breeding failure or mortality.

This study aims to understand the functional relationships between prey abundance, availability and intake rates as part of an individual-based model aimed ultimately at predicting the rate of body mass gain under different scenarios.



The approach – videoed foragers on trays with known initial and measured final egg densities

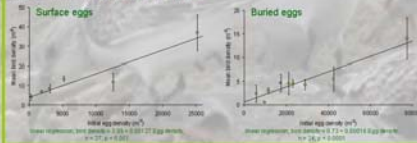
An experimental approach was used to determine critical egg densities and intake rate. Beach sand was processed to obtain clean egg-free sand and quantities of fresh eggs. Feeding trays containing sand with known initial densities of eggs were placed on beaches. Bird use was noted every 15s and the tray was videoed for 5 or 10 minutes (see filmstrip right). Trays were removed, and the number of eggs remaining determined. Videos were analysed by counting the number of pecks. Observations were restricted to the first 50s to minimise the effects of depletion. Two experiments were made:

- May 2002 – large shallow trays (44x65x2cm) and eggs were added on to the sand surface only. 5min observation period. Total eggs remaining determined.
- May 2003 – 5cm deep trays, sand and eggs were mixed to consider buried eggs. 10min observation. Total remaining egg abundance plus abundance in 1cm layers.



Aggregative response

High densities of birds fed on the experimental trays. The combined density of Dunlin, Knot and Semipalmated Sandpiper (plus Sanderling and Turnstone for buried eggs) throughout the observation period was positively related to the initial density of eggs, whether surface or buried.



Peck rate and functional responses

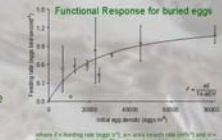
1 Surface eggs

Pecking rates were similar in each species, 1.7 s^{-1} in Semipalmated sandpiper, 2.0 s^{-1} in Dunlin and Knot, and were unrelated to initial egg density (right). It was not possible to directly measure whether each peck was successful. Instead, the probability of consuming an egg was calculated as follows: the total number of pecks made by each species in each experiment was estimated by multiplying the number of bird seconds each was present for by the species-specific mean pecking rate. The number of eggs per peck was then estimated in each experiment by dividing the total number of eggs consumed by the total number of pecks by all species.



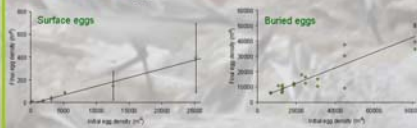
2 Buried eggs

The same procedure will be employed for video footage of experiments using buried eggs. In the meantime, a crude functional response (right) can be derived from observed depletion levels and bird presence on the tray. This is a cumulative functional response for all species. Whilst there was little interspecific difference in peck rate and handling time for surface eggs, such interspecific differences, mediated by bill length and foraging mode may explain the wide variation in intake rates.



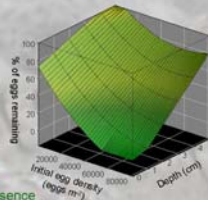
Depletion

80% of surface eggs were consumed throughout the observation period, irrespective of initial density. Depletion of buried eggs was more variable (3% - 80%). Although the same in % terms, more eggs were consumed in the higher egg density experiments for both surface and buried eggs.



Depletion and depth

In the buried egg experiments, percentage depletion was positively correlated with initial egg density. Depletion was greatest at the sand surface and declined with depth in the sand. However, there was also a significant densityxdepth interaction, whereby depletion occurred to a greater depth at higher initial egg densities. This may have been because the presence of Red Knot was positively correlated with initial egg density and their longer bills enable them to deplete deeper sand. Furthermore, Turnstones dig and defend pits over high density patches, possibly facilitating deeper depletion. Analysis of video footage will test this.



Conclusions and further work

- The Delaware Bay shorebird-crab system may be under threat.
- Bird weights suggest a problem due either to poor food supply and/or late arrival in staging areas.
- Understanding prey-predator interactions will identify where the problem lies.
- Experimental feeding trays were very successful with good aggregative responses of birds to egg density.
- Surface eggs were depleted to a constant % of initial density whereas buried eggs were more variable, possibly due to differing flock composition.
- Depletion of buried eggs differed with depth and initial density, and the rate of depletion with depth differed with initial density.
- For surface eggs, high pecking rates were maintained down to extremely low egg densities.
- Functional responses were similar across species, indicating that Red Knot, with its higher energetic demand, may be the first species whose net rate of mass gain may decline.
- Further work needs to assess levels of interference and spatial variation and correlates of egg abundance.
- Bay-wide surveys of spawning adult crabs and of egg densities are a priority.

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