



**World-first discovery**  
**A variety of shorebirds are fueled by biofilm**  
**Assisting conservation of declining shorebird populations and**  
**intertidal flat ecosystems**

**1. POINT**

An international collaborative research team from Japan, Canada and the United Kingdom, led by Dr. Tomohiro Kuwae, Group Head of the Port and Airport Research Institute, Japan, report that many shorebird species are feeding on biofilm\*<sup>1</sup> on intertidal flats. The research article was published in the world's topmost scientific journal in the field of ecology "*Ecology Letters*" (Blackwell Publishing Ltd/CNRS) on February 6, 2012 (online). The study can assist in recovering worldwide declines in shorebird biodiversity as well as conservation of the integrity of intertidal mudflat ecosystems.

**2. CONTACT**

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\*<sup>1</sup> Biofilm: a thin layer comprised of microbes (diatoms and bacteria), their extracellular mucus substances ("snot"), and detritus. Biofilm develops naturally on the surface of intertidal mudflats.

### **3. RESEARCH HIGHLIGHTS**

To date, macroinvertebrates such as worms, clams, crustaceans and insects have been considered the principal prey of shorebirds. However, such prey cannot account for their complete diet. In turn, invertebrates and some highly specialized fish have long been considered as the sole consumers of biofilm.

An international collaborative research team from Japan, Canada and the United Kingdom, led by Dr. Tomohiro Kuwae, discovered that many shorebird species consume surficial intertidal biofilm, a hitherto unsuspected food, and are the first in the world to demonstrate that biofilm feeding is indeed widespread. They estimate that the contribution of biofilm to total diet is up to ca. 70%. Also, they revealed that the determinants of shorebird reliance of biofilm include shorebird body size, foraging rate, and phylogeny as well as biofilm density.

The team conducted field observations on shorebird foraging behavior on Japanese and Canadian tidal flats, analyzed chemical components of the bird droppings and prey items. Using lines of evidence from these data, they found that small sandpipers, such as Dunlin (a very common species worldwide) and Western Sandpiper (very common in North America) feed on biofilm as a major part of their diet. This means that “a critical missing link” between birds and biofilm in intertidal flat ecosystems has now been identified.

The team also found that biofilm-feeding birds have “spines” on the tip of their tongues, which are used to scrape biofilm up from surficial sediments, and that the spines are more developed in smaller birds. From morphological characteristics and energy budget calculations, the team infers that the diets of smaller birds are more dependent on biofilm.

They argue that small-bodied birds have difficulty utilizing larger and harder prey due to the constraints of digestive organ size. Also, small-bodied birds cannot obtain prey in deep sediments due to their shorter bills. Thus, the team infers that small-bodied birds evolved their tongue morphology and foraging behavior to exploit smaller and softer foods, such as biofilm, in the context of competition among birds.

### **4. GENERAL IMPLICATIONS**

Food web theory predicts that the biofilm-shorebird link stabilizes the food web structures and supports a persistent coexistence of basal species (biofilm), consumers (invertebrates), and predators (birds). Thus, declines in shorebird populations raise an alarm for far-reaching effects on the stability of whole ecosystems.

Worldwide declines in shorebird populations (decreasing approximately 50% in recent 20

years) underscore the need to better understand their biology. The present study can assist in recovering shorebird biodiversity as well aid conservation of the integrity of intertidal flat ecosystems as a whole.

## **5. PUBLICATION INFORMATION**

### **5.1 Journal**

Ecology Letters (Blackwell Publishing Ltd/CNRS); Impact Factor (2010) = 15.253

### **5.2 Title**

Variable and Complex Food Web Structures Revealed by Exploring Missing Trophic Links between Birds and Biofilm

### **5.3 Authors**

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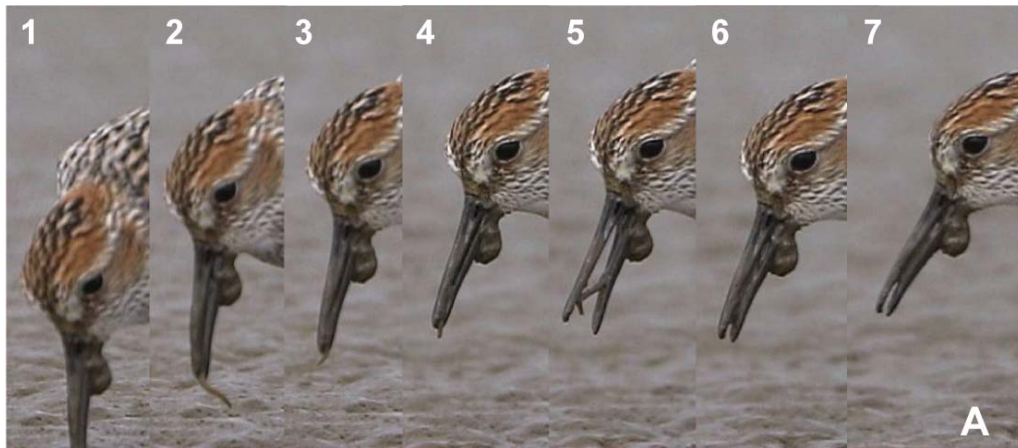
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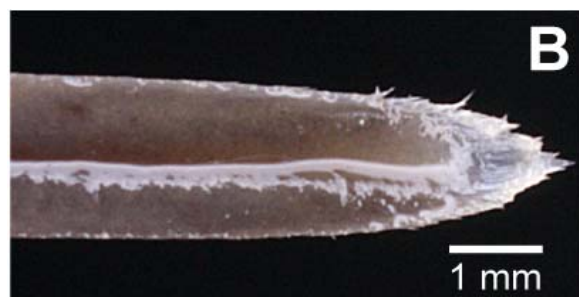
<sup>9</sup> Pacific Wildlife Research Centre, Environment Canada



Photo of biofilm (green colored)

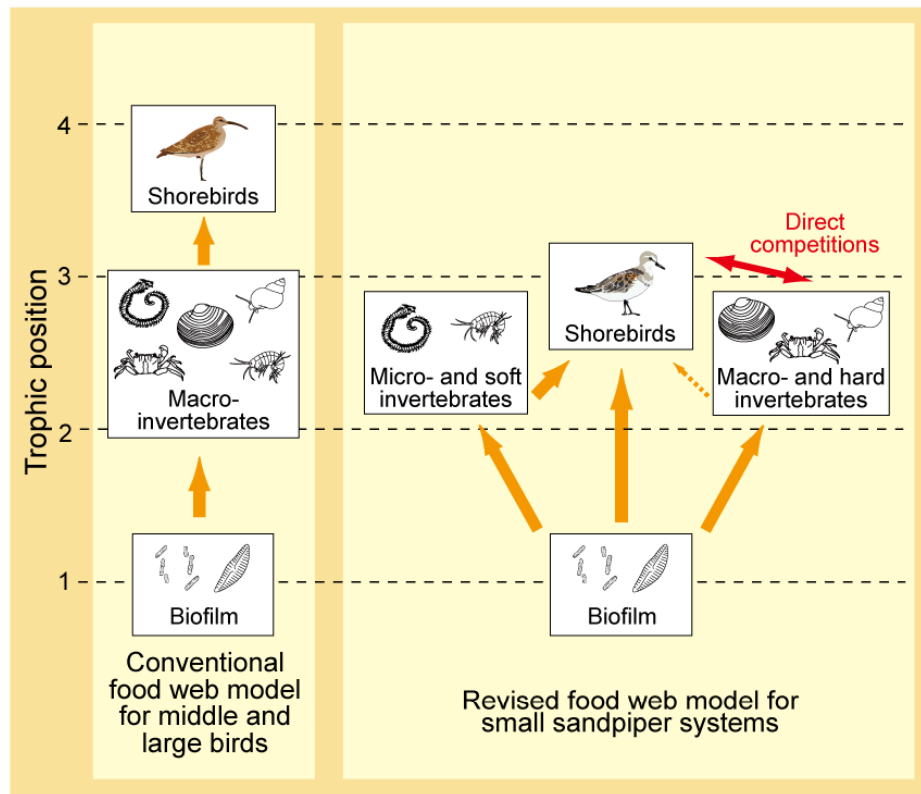


Biofilm foraging behavior of a Western Sandpiper

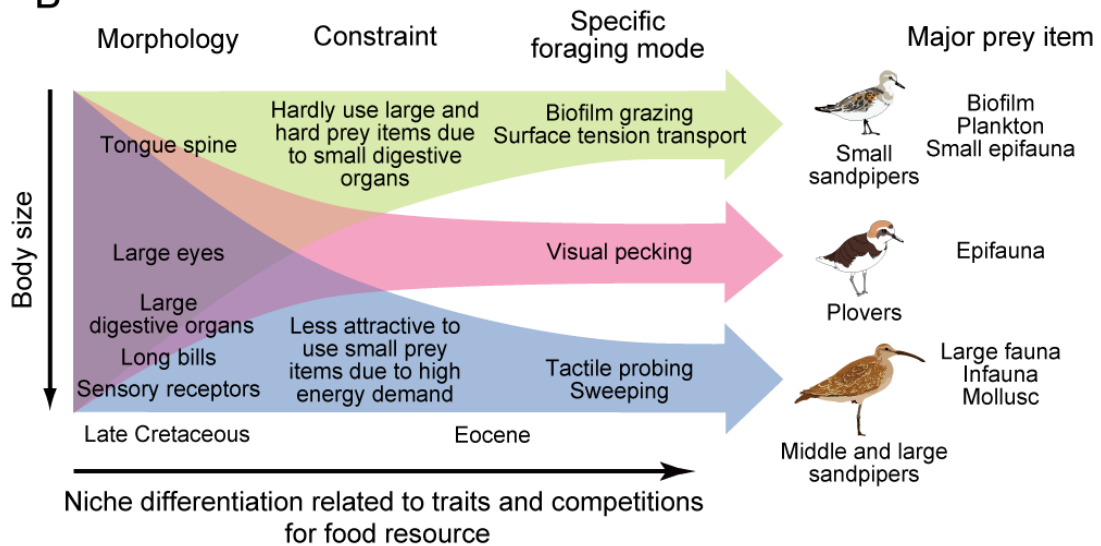


Tongue spine of a Sharp-tailed Sandpiper

A



B



(A) The study revised (lowering) the trophic position of shorebirds and provided a new perspective showing greater food web complexity. This includes, in the presence of the biofilm-shorebird trophic link, the major three components of intertidal flat ecosystems, i.e., biofilm, invertebrates and shorebirds, form an intraguild predation (IGP) module (a type of omnivory). Also, small sandpipers compete with other biofilm grazers, such as mud snails.

High densities of these snails on intertidal flats indicate strong biofilm grazing pressure and direct competition, with a consequential negative effect on the sandpipers. Further, small sandpipers hardly provide top-down control of the snails due to their limited digestion trait.

(B) The discovery of biofilm as a major food source for small sandpiper species generates a contradiction to the functional morphology adaptation hypothesis to date, because the narrow tubular bills of sandpipers are considered adapted to exploit infaunal prey. Instead, the authors propose a new conceptual model of body-size based diversification as a result of adaptive radiation for feeding in shorebirds. Evolutionary and phylogenetic indications are that sandpipers differentiated from the same ancestor and evolved to access larger prey in deeper sediments, while plovers specialized on surface prey. The authors argue that sandpipers are further differentiated because small-bodied birds were thwarted by larger, harder prey, due to the constraints of digestive organ size, and switched to smaller, softer foods, such as biofilm.