

DAYTIME FEEDING BY LEACH'S STORM-PETREL ON A MIDWATER
FISH IN THE EASTERN TROPICAL PACIFIC¹

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Information on the diet of Leach's Storm-Petrel (*Oceanodroma leucorhoa*) has been obtained almost exclusively from breeding colonies where crustaceans (mainly euphausiids, but with amphipods and copepods locally important) and fish (mainly myctophids) make up the bulk of the diet (Linton 1978, Watanuki 1985, Vermeer and Devito 1988). Almost nothing is known about this species' foraging habits in the tropical



FIGURE 1. Section of strip chart showing continuous sea surface temperature (T) and salinity (S) during the day of our observation; during the time between the two arrows the ship was stopped for storm-petrel collection.

open ocean where it is commonly found during the nonbreeding season (Crossin 1974, Pitman 1986). The only reference that we know of is Ainley's (1984) comment that Leach's Storm-Petrel "feeds rather heavily" on marine insects (*Halobates* spp.) while in the tropics.

While conducting marine bird and mammal survey transects in the eastern tropical Pacific (ETP), we stopped our research vessel at approximately 13:00 LMT on 19 November 1988 at 3°44'S, 114°08'W to investigate an inordinately large concentration of storm-petrels. We had observed only small to moderate numbers of Leach's and Galapagos (*O. tethys*) storm-petrels earlier in the day (0.59/km² and 0.34/km², respectively), but in the area of concentration we saw hundreds of storm-petrels at any one time in groups of 50 to over 200. Most of the birds were sitting on the water, apparently satiated (see below), but others were in scattered flocks hovering over the water and feeding. Leach's Storm-Petrel was the predominant species though a few Galapagos Storm-Petrels were also present. One Pomarine Jaeger (*Stercorarius pomarinus*) and one White-winged Petrel (*Pterodroma leucoptera*) were the only other bird species present.

We collected six Leach's Storm-Petrels, including five from sitting groups and one bird that was actively feeding. The feeding bird was carrying a fish in its beak that was also collected. We took the specimens back to the ship and immediately examined the stomach contents.

Every bird had been feeding exclusively on a gonostomatid fish, *Vinciguerria lucetia*; stomachs were crammed with recently ingested fish as well as fish mush and otoliths. The mean weight of the six birds that we collected, to the nearest 0.5 g, less the weight of the stomach contents, was 42.0 g (range = 38.0–45.0 g); all had a light to moderate amount of subcu-

taneous fat. The mean weight of the stomach contents, to the nearest 0.5 g, was 8.5 g (range = 7.0–10.0 g).

Stomach contents averaged 20.4% of the body mass with a range of 15.6–24.4%. (This last mean is biased downward because one of the birds regurgitated and lost part of its stomach contents when it was collected. Also, we did not include as stomach contents the fish that was carried in the beak of the feeding bird we collected.) The range that we recorded is in close agreement with Croxall et al. (1988) who found that meal sizes for adult Wilson's Storm-Petrels (*Oceanites oceanicus*) breeding at South Georgia Island ranged from 15–25% of adult body mass. The birds that we collected appeared to have recently fed to satiation, suggesting that 25% was probably an accurate upper limit to the food-carrying capacity of Leach's Storm-Petrel (at least for a diet of fish).

In addition to the above, on 1 August 1989, at 22°43'N, 114°20'W, two separate Leach's Storm-Petrels flew onboard the authors' drifting research vessel, 45 and 90 min after dark. One regurgitated four and the other five *Vinciguerria*. The prey were half-digested and therefore were probably taken around dusk. We released the storm-petrels unharmed.

These were the first recorded instances of Leach's Storm-Petrel feeding on *Vinciguerria*. Harrison et al. (1983) found unidentified *Vinciguerria* and *V. nimbaria* to be a small but not insignificant part of the diets of nine of the 18 breeding seabirds that they studied in Hawaii; Mörz Bruyns and Voous (1965) reported that a Sooty Tern (*Sterna fuscata*) flew aboard their ship at night in the ETP and regurgitated approximately six fairly fresh *Vinciguerria* cf. *lucetia*. We also found small numbers of *Vinciguerria* in the stomachs of Black Storm-Petrels (*Oceanodroma melania*), White-winged Petrels (*Pterodroma leucoptera*), and Juan Fer-

andez Petrels (*Pterodroma externa*) that were collected in the ETP during the daytime.

The storm-petrels that we collected had been taking adult *V. lucetia* that had fed recently, possibly at the surface. The abdominal area of all of the more intact fish was noticeably distended. We examined the stomach contents of a freshly caught fish dropped from the beak of the feeding storm-petrel that we collected. This fish was an adult (51 mm, standard length; Ahlstrom and Counts 1958) and was similar in size to most of the other fish that were found in the stomach samples. Its stomach was packed with freshly ingested copepods, but also contained a few euphausiid parts, an amphipod, and two fish larvae (G. Moser, pers. comm.). Diet studies on *Vinciguerria* elsewhere have found copepods to be their main prey (Shevchenko 1986, Clarke 1974).

Despite the fact that *V. lucetia* may be the most abundant and widespread fish in the ETP (Ahlstrom 1969), any daytime surface occurrence of this species is probably an unusual phenomenon. It belongs to a genus of midwater fishes known to undertake diurnal vertical migrations, and postlarval forms are rarely encountered at the surface, even at night (Clarke 1974). For example, dolphinfish, (*Coryphaena hippurus*), a large, diurnal, surface predator, occurs throughout the ETP but rarely takes *Vinciguerria* (Pitman, unpubl. notes); deeper-foraging tunas, on the other hand, prey heavily on *Vinciguerria* in the ETP (Alverson 1963; Pitman, pers. observ.).

We feel, however, that the storm-petrels that we collected were taking *Vinciguerria* which were feeding at the surface (rather than being driven there by predators from below), and we offer two lines of evidence to support this. First, most seabird flocks in the pelagic waters of the ETP form in association with tuna/dolphin aggregations because these predators often drive prey to the surface (Au and Pitman 1986). In those situations, both prey and predatory fish are regularly seen breaking the surface during their interactions and that is where foraging birds focus their attention. In the storm-petrel aggregation that is reported on here, we saw no signs of predatory fish or prey in areas where subgroups of storm-petrels were feeding. Additionally, storm-petrels do not normally join mixed-species flocks that are associated with schools of large, predatory fishes (Au and Pitman 1986).

Secondly, oceanographic data collected at the time of our observation indicated that an anomalous physical event was correlated with the observed feeding aggregation. Figure 1 shows a continuous strip chart recording of sea surface temperature and salinity for the day in question. Although the temperature remained fairly constant throughout the day, the salinity dropped precipitously (nearly 1 ppt) at approximately 13:00, when the storm-petrel concentration was noted. In the immediate area of the bird aggregation, evidence of convergent current flow at the surface was apparent to the naked eye: a thin, jagged streak of foam at least 1 km long separated flat calm water from darker, heavily rippled water. Brown (1988) discussed the importance of similar oceanographic anomalies for Leach's Storm-Petrels foraging off eastern Canada.

It appears that a local, physical oceanographic process may have served to concentrate an abundance of prey (apparently mainly copepods in this case) which

attracted *Vinciguerria* to the surface. Similarly, Brown et al. (1979) reported on the daytime surface swarming in the Bay of Fundy of *Meganyctiphanes norvegica*, a vertically migrating euphausiid normally found at the surface only at night. The authors suggested that the swarms may have actively swam to the surface to prey upon copepods caught in turbulent upwelling.

Although daytime surface occurrences of diel vertical migrators like *Vinciguerria* are most likely quite rare, they can, as shown above, provide at least occasional food sources for surface feeders. Myctophids, which are also preyed upon by Leach's Storm-Petrel, are another group of vertically migrating midwater fishes normally found at the surface only at night; they have also been found on rare occasions to swarm at the surface during the daytime (Alverson 1961).

Feeding on daytime surface swarms is one of several possible ways that seabirds can feed on midwater organisms. We occasionally dipnetted Portuguese man-of-war (*Physalia*) at night that had fish caught in their tentacles, including *Vinciguerria* and myctophids. Birds that we collected in the tropics occasionally had *Physalia* tentacles draping from their beaks and it is possible that instead of eating *Physalia* they were actually stealing *Physalia* prey. We also occasionally observed Leach's Storm-Petrels feeding on dead fish and squid floating on the surface. Scavenged specimens ranged in size from over 1 m, from which birds had to tear off pieces, to smaller organisms that were swallowed whole.

These observations all indicate that care must be taken in interpreting foraging habits of seabirds based on the presumed behaviors of their prey species. For example, Linton (1978) and Vermeer and Devito (1988) studied the diets of Leach's Storm-Petrels in eastern Canada and British Columbia, respectively. Among the identified prey in both studies was a high proportion of midwater species that were vertical migrators, generally known to occur at the sea surface only at night, and from this the authors concluded that the storm-petrels had been feeding at night. Our observations suggest that some "nocturnal" prey species of Leach's Storm-Petrels also occur at least occasionally at the surface during the daytime.

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