TIMING OF FORAGING BY THE WANDERING ALBATROSS
DIOMEDEA EXULANS

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Abstract: Deployment of devices which record timing and magnitude of food ingestion in two wandering albatrosses *Diomedea exulans* at sub-Antarctic Marion Island shows that feeding occurred both at night and during the day, but with most ingestion events (70%) occurring during daylight hours. Seventy-six per cent of the estimated mass of food was ingested during the day. Earlier workers concluded that foraging occurred mostly during the night. We suggest that nocturnal foraging represents mostly capture of live prey close to the water surface. Daytime foraging is suggested to be mainly for moribund prey that has floated to the surface. Duration of foraging trips and timing of arrival back at the nest are similar to those reported elsewhere. The arrival of females soon after dawn is considered to be a consequence of a reluctance to land on the island at night. Differences in the temporal pattern of male and female arrivals may reflect sex-specific foraging patterns.

1. Introduction

Albatrosses have been regarded as primarily nocturnal predators of squid and fish, obtaining prey nearly exclusively by surface seizing (*e.g.*, Ashmole, 1971; Harper *et al.*, 1985; Harper, 1987; Brooke and Prince, 1991). An emphasis on nocturnal foraging in the literature may have come about because of the paucity of actual observations of albatrosses capturing prey during daylight hours (*e.g.*, Prince, 1980; Griffiths, 1982; Brooke and Prince, 1991). However, observations made from a vessel at sea of three species of southern albatrosses foraging on "natural food" indicated that foraging is about equally divided between daylight and night hours (calculated from Harper, 1987). These observations may have been biased by the presence of the vessel itself, which was well lit at night.

Data from activity recorders attached to albatrosses indicate birds spend more time on the sea surface at night than during the day (Prince and Francis, 1984; Prince and Morgan, 1987). This was considered to reflect a higher incidence of night-time foraging. However, birds may be resting on the sea surface for some of the night and not feeding, so the question of whether most prey is captured at night or during the day by albatrosses remains unresolved.

Most albatross prey (squid, fish and crustaceans, Prince and Morgan, 1987) are poikilothermic. We examined the timing of foraging and mass of ingested food of wandering albatrosses *Diomedea exulans* using a device that records changes in stom-

ach temperature that occur in response to ingestion of cold food (WILSON et al., 1992).

Wandering albatrosses are dimorphic in size, males being appreciably larger than females (CROXALL and RICKETTS, 1983). Differences in foraging behaviour may therefore exist. We observed the timing and duration of foraging trips undertaken by breeding wandering albatrosses of both sexes to examine whether any sex-specific differences exist.

2. Methods

Nine occupied nests of the wandering albatross were kept under observation at 5–15-min intervals from before sunrise to last light (a period of approximately 11.5 h) on a daily basis from 13 April to 1 May 1991 at sub-Antarctic Marion Island (46° 54'S, 37° 45'E). Observations were made from three vantage points in the Meteorological Station using binoculars and a telescope. Arrivals and departures of adults attending nests were recorded to the nearest 15 min or to the nearest minute if actually observed. Breeding adults were banded for individual recognition and their sex determined from plumage characteristics and relative size. Nests contained downy chicks, approximately 25–55 days old, who were either brooded, guarded or left unattended for varying periods by their parents. During the periods 1–21 May 1982 and 13–25 May 1983, respectively 10 and 9 nests were observed and arrivals of adults recorded. Chicks were older (42–72 days) than were the chicks observed in 1991, and were no longer being brooded.

Three temperature-sensitive electronic sensor/data-loggers known as EATLs (Einkanalige Automatische Temperatur Logger) described by WILSON et al. (1992), were set to record and store temperatures every 32 s for a maximum of 12 days over the range 20°C to 45°C at a precision of 0.1°C. Temperatures below and above this range were recorded as 20°C and 45°C, respectively. Recorded data were accessed by computer for later analysis. EATLs record the time of ingestion of poikilothermic prey and also allow an estimate of the mass ingested (WILSON et al., 1992).

In 1991, following changeovers at the nest, six brooding or guarding birds were caught a few minutes after the arrival from sea of their partners and induced to swallow EATLs by holding the mandibles slightly open with a gloved hand while massaging the inserted EATL down the throat. To facilitate swallowing, EATLs were first moistened. For subsequent identification some birds were then dyed on the head and back-of-neck feathers with a solution of picric acid in water before release at the nest site. The nest was then kept under continual observation until the bird with the EATL had flown out to sea. Time of departure was recorded to the nearest minute, as was the times the EATL was switched on and swallowed by the bird. To avoid excessive disruption of food delivery rates to chicks only one member of a breeding pair was subjected to the experimental procedure and only once.

When birds containing EATLs returned to their nests after a foraging trip they were captured and induced to regurgitate their stomach contents of food and EATL by multiple stomach-flushing (WILSON, 1984; RYAN and JACKSON, 1986; GALES, 1987) either at the nest site or in the nearby laboratory. Approximately 5–7 l of lukewarm water was used at each flushing until only clear water emerged. Experimental birds were

released at their nest sites.   The data on recovered EATLs were then read into the computer, and the EATLs reset for redeployment.

Food from stomach regurgitations was drained, weighed and stored for analysis (COOPER et al., 1992).

3. Results

Mean foraging trip length of wandering albatrosses attending chicks aged 25 to 55 days was 55.9 ± 38.7 h (n = 43).   Trip lengths were highly variable (range 1.75–165.8 h).   Consequently, we failed to detect significant differences between males and females or between birds carrying EATLs and those without (t-tests, Ps>0.05).

The arrival times of male wandering albatrosses were distributed throughout the day (Fig. 1).   This pattern contrasted with that for females where peak arrival times were soon after dawn and approaching midday (Fig. 2).   No males arrived in the 0600–0700 period, in contrast to nearly 20% of the females.

EATLs were successfully recovered from one male and one female after return from their foraging trips.   On three occasions, EATLs were not recovered after stomach flushing birds up to three times and are presumed to have been regurgitated at sea. One bird regurgitated an EATL beside its nest before departing for sea.

A total of 99.4 h at-sea stomach temperatures was logged and 20 primary ingestion events (sensu WILSON et al., 1992) with a mean estimated ingested mass of 204 ± 278 g (range 9–866 g) were identified (Fig. 3, Table 1).   Fourteen ingestion events (70%) occurred during the day, most during the early morning.   Six ingestion events were recorded at night (light levels <5 lux).   However, the male bird fed only during the day (Fig. 3, Table 1).   Neither bird fed on the last night before returning to the nest.   In the female, the first ingestion event occurred 8 min after leaving the nest, followed by another 51 min later.   In the male, the first ingestion event occurred within 5 min of
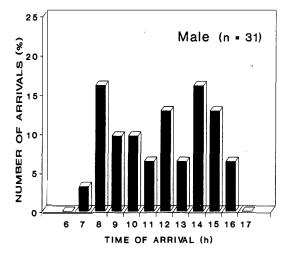

Fig. 1.   Timing of arrivals of male wandering albatrosses Diomedea exulans at the nest site to feed chicks after foraging at sea.
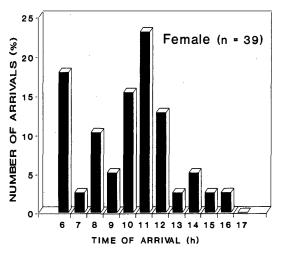
Fig. 2.   Timing of arrivals of female wandering albatrosses Diomedea exulans at the nest site to feed chicks after foraging at sea.
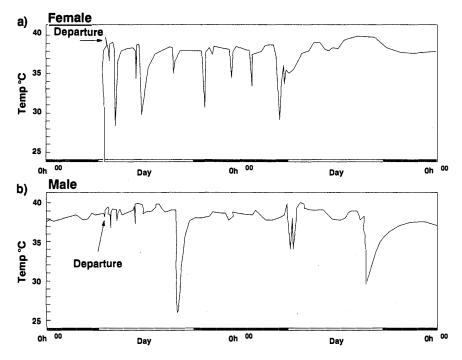
Fig. 3.   *Output from EATLs recovered from one female (a) and one male (b) wandering albatross Diomedea exulans after foraging at sea. The device indicates stomach temperature in relation to time. Departure for sea is arrowed. Spikes indicate ingestion events. Integral of recovery curve for each event allows calculation of the mass of ingested material (WILSON et al., 1992). No feeding events were recorded on the last night before recapture at the nest and data are not plotted for this period.*

Table 1.   *The time (local) of ingestion and the estimated mass of food recorded by EATLs in a female and male foraging wandering albatross Diomedea exulans.*

Time of ingestion		Estimated mass (g)	Time of ingestion		Estimated mass(g)
	Female			Male	
0732	Day	34	0755	Day	13
0815	Day	378	0846	Day	9
1051	Day	49	1055	Day	12
1130	Day	862	1225	Day	25
1534	Day	143	1611	Day	615
1913	Night	206	0544	Day	65
2015	Night	16	0612	Day	25
2231	Night	66	1415	Day	9
0058	Night	78	1504	Day	866
0407	Night	397			
0455	Night	212			
Mean		222 ± 250	Mean		182 ± 323
			Overall		204 ± 278

leaving the nest, followed by a second event 43 min later (Table 1). The mean interval between ingestion events was 2.9 ± 3.2 h. The average mass of food ingested on each

occasion during the night (222 ± 323 g) was greater than that recorded during the day (163 ± 140 g) (Table 1). Overall, 76.1% of the estimated total mass (4080 g) of food was ingested during daylight hours, 23.9% at night.

The stomach contents of the female albatross weighed 747 g and contained the mantle of an onychoteuthid squid as well as digested material that could not be identified. The male bird contained remains of a Cusk Eel *Spectrunculus grandis* and digested material totalling 416 g.

4. Discussion

There was no evidence that EATLs and handling associated with deployment of EATLs affected foraging trip duration (see also WILSON *et al.*, 1992). However, sample sizes are small; and given that such effects have been demonstrated for several seabird species (*e.g.*, WANLESS *et al.*, 1988, 1989; WILSON and WILSON, 1989) we must caution against dismissing any potential effects, especially since three birds were presumed to have regurgitated EATLs at sea, suggesting that their normal behaviour may have been altered. However, the two birds that returned with EATLs had normal stomach contents (COOPER *et al.*, 1992).

The foraging trip durations of wandering albatrosses recorded at Marion Island are similar to those recorded elsewhere for adults attending small chicks. Brood shifts of wandering albatrosses at Bird Island, South Georgia were 2.6 days (62.4 h) (TICKELL, 1968). Although we did not maintain watches throughout the night, we are confident that arrivals and departures of adults were restricted to daylight hours. We recorded no change-overs of brooding and guarding adults between the last observation at night and the first observation the next morning. Based on data from regular weighings of chicks, TICKELL (1968) came to a similar conclusion.

The less time spent flying by albatrosses at night compared to the day, initially determined from deployment of activity meters (PRINCE and FRANCIS, 1984) has been considered to reflect nocturnal foraging at the sea surface (PRINCE and MORGAN, 1987; BROOKE and PRINCE, 1991). More daylight flying has been subsequently confirmed for foraging wandering albatrosses by satellite tracking (JOUVENTIN and WEIMERSKIRCH, 1990; PRINCE *et al.*, 1992; WEIMERSKIRCH *et al.*, 1992). However, it is clear from the deployment of EATLs that wandering albatrosses are able to feed at any time of the day and night and do so. Long periods on the surface of the water at night may reflect an unwillingness to navigate over long distances in complete darkness (JOUVENTIN and WEIMERSKIRCH, 1990).

Wandering albatrosses apparently capture live prey as well as scavenging moribund material (CLARKE *et al.*, 1981; IMBER and BERRUTI, 1981; WEIMERSKIRCH *et al.*, 1986; HARPER, 1987; RODHOUSE *et al.*, 1987; CROXALL *et al.*, 1988). Some prey items (especially squid) of albatrosses recovered as parts of whole organisms are presumed to be large to have been captured while alive. The fact that some, but not all, caphalopods float after death, and that these "floater" species are found more abundantly in the diets of albatrosses than are "sinker' species (LIPINSKI and JACKSON, 1989; COOPER *et al.*, 1992; COOPER and KLAGES, 1993; M. R. LIPINSKI, *in litt.*) adds credence to the idea that much albatross prey is scavenged.

We suggest that capture of live prey should occur more often at night than during the day, because this coincides with the period that squid and fish are presumed to migrate to surface waters (IMBER, 1973; IMBER and RUSS, 1975; IMBER and BERRUTI, 1981). However, their should be little advantage (and probably a disadvantage) to scavenging at night and much prey should be captured during the day when visibility is superior and dead and moribund prey at the sea surface are presumably more easily detected.

It is the anomaly between 24-hour feeding and movements at sea and the exclusively diurnal nest arrivals that may account for the temporal pattern of arrival times in wandering albatrosses. The predominantly morning arrival times noted here have also been recorded at Bird Island, South Georgia (TICKELL, 1968). We presume that the reluctance of birds to land at their nest sites at night leads to a build up of returning adults offshore from the breeding island. These birds complete the final part of their trip the following morning.

The tendency for females to arrive back at the nest site earlier than do males suggests sex-specific differences in foraging patterns. That TICKELL (1968) has noted that the total length of brooding shifts and the length of individual shifts of wandering albatrosses are significantly longer for males than for females provides additional support for this suggestion. Such differences could arise from spatially distinct foraging areas for male and female birds (*e.g.*, PRINCE *et al.*, 1992).

The immediate prospect of combining stomach temperature loggers, to measure timing and mass of ingestion, with satellite tracking to provide data on spatial distribution, promises major advances in our understanding of the foraging behaviour of pelagic seabirds.

Acknowledgments

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