Diet of Common Diving-petrels (*Pelecanoides urinatrix urinatrix*) in Southeastern Australia During Chick Rearing

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**Abstract.**—Unlike conspecifics in the subantarctic region, which typically begin breeding in mid-spring to summer, Common Diving-petrels *Pelecanoides urinatrix urinatrix* in southeastern Australia (towards the northern limit of the species’ distribution) commence breeding mid-winter. Knowledge of the foraging ecology of this species is crucial to understanding the factors that influence its timing of breeding in the region, yet there is currently little information available. Analysis of 43 stomachs of breeding adults, collected opportunistically after they were killed in a fire which burned through their colony, indicated that their diet was dominated by two taxa: a euphausid *Nytiphanes australis* which comprised 87% of the diet by number; and a hyperiid amphipod *Themisto australis* which constituted a further 12.5%. Mean lengths (±SE) of *N. australis* (*n* = 39) and *T. australis* (*n* = 41) were 12 mm (±0.3) and 5.2 mm (±0.2), respectively. The importance of *N. australis* in the diet of Common Diving-petrels is discussed in relation to their timing of breeding and the euphausid’s potential role in the Bass Strait pelagic ecosystem. Received 8 December 2007, accepted 2 May 2008.

**Key words.**—Common Diving-petrel, diet, *Nytiphanes australis*, *Pelecanoides urinatrix*.


Diving-petrels are the most distinct and morphologically similar group of seabirds within Procellariiformes (Warham 1990) and, unlike most other Procellariiformes, primarily dive for prey (Prince and Morgan 1987). The Common Diving-petrel *Pelecanoides urinatrix urinatrix* appears to locate food visually (Warham 1996) and typically captures prey by pursuit diving and pursuit plunging (Croxall and Prince 1980). In subantarctic regions, this species is known to feed upon copepods, euphausids (krill) and amphipods (Marchant and Higgins 1990).

Common Diving-petrels exhibit the widest distribution of the four diving-petrel species, with breeding colonies occurring mainly on numerous islands throughout the subantarctic region of the Southern Hemisphere (Fig. 1, Marchant and Higgins 1990; Warham 1990). It is the only diving-petrel species known to breed in south-eastern Australia, near the northern limit of its breeding distribution. Timing of breeding varies throughout the species’ range; breeding generally commences in mid-spring to early summer in the subantarctic, whereas in south-eastern Australia, breeding commences mid-winter (late July, Marchant and Higgins 1990). Knowledge of the diet of Common Diving-petrels is critical to understanding the ecology of the species in the northern part of its range and the factors which influence its timing of breeding. However, there is presently little information on the diet of Common Diving-petrels *P. u. urinatrix*.

![Figure 1. Major breeding sites of Common Diving-petrels *Pelecanoides urinatrix urinatrix* (represented by arrows, modified from Marchant and Higgins 1990) and the location of Seal Island where the samples analysed in this study were collected.](image)

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in south-eastern Australia. The sole dietary study involved beached individuals presumed to have starved and, accordingly, only plant debris and fragments of plastic, shells and rocks were found in digestive tracts (Norman and Brown 1987). The aim of this study was to investigate the diet of Common Diving-petrels during the chick-provisioning period in south-eastern Australia.

**STUDY AREA AND METHODS**

Stomach samples were obtained from 53 birds killed in a tussock-grass fire (initiated by lightning) on Seal Island, approximately twelve km east of Wilsons Promontory in Bass Strait, south-eastern Australia (Fig. 1), between 24 and 27 October 2005. These dates correspond with the chick-rearing period for Common Diving-petrels in the region (P. Dann, unpublished data). Carcasses were collected within several days of the fire and frozen (-90°C) within six h of collection until subsequent analyses.

In the laboratory, each carcass was thawed and dissected, and sex determined by internal examination of the gonads. Stomachs were removed and their contents preserved in 70% ethanol. Due to the high number of small prey remains, preserved stomach contents were spread evenly on a plastic tray for sub-sampling. The tray was pre-marked with a grid comprising nine cells and all prey items found within a randomly selected grid cell were removed for analysis (i.e., 1/9 subsample). Most prey items were poorly preserved. Euphausiids were identified with reference to the keys in Kirkwood (1982). The eyes of krill (divided by two), eye pairs of amphipods, and whole bodies of crab megalopa and copepods in each subsample were counted and the resulting values multiplied by nine in order to estimate the Frequency of Occurrence (hereafter FOO) and numerical abundance of each prey species. Inter-sexual differences in the diet were not investigated because a power analysis indicated that the sample sizes were too small.

Due to the poor state of preservation of most prey items, relatively few could be measured. The most intact individuals of prey species were selected for measurement. Total length of individuals of *Nyctiphanes australis* was measured from the anterior tip of the rostrum to the end of the uropods. *Themisto australis* individuals were measured from the anterior part of the rostrum to the base of the telson, copepods from the anterior part of the head to the end of the caudal ramus and crab megalopa from the anterior portion of the head to the posterior tip of the abdomen.

**RESULTS**

Of the 53 birds, 48 contained recognizable prey items. However, five of these were too severely digested to be analysed accurately and were, therefore, excluded from analyses. Thus, the final sample size was 43 (Table 1). Five prey taxa were identified in stomach samples: the euphausiid *Nyctiphanes australis*, the hyperiid amphipod *Themisto australis*, a calanoid copepod, a megalopa stage of an unidentifiable crab species, and the larvae of a mantis shrimp (Order Stomatopoda). Of these, *N. australis* was the dominant prey type, exhibiting a FOO of 100% and occurring at a substantially higher numerical abundance compared to other prey types (Table 1). It also represented the greatest proportion of all prey consumed numerically, contributing 87% to the diet (Table 1). Although *T. australis* was frequently ingested, displaying a FOO >58%, it occurred in low numbers, representing only 12.5% of the number of prey items consumed (Table 1). Crabs (megalopa), copepods and mantis shrimps were negligible components of the diet, contributing a combined numerical abundance of only 0.4% to the diet (Table 1).

The mean length of *N. australis* (*N* = 39) was 12.0 ± 0.3 mm (range 9.5-17.0 mm) suggesting that they were primarily adults (Young *et al.* 1993). *T. australis* (*N* = 41) ranged between 4.0 and 8.5 mm (mean 5.9 ± 0.2 mm) while crab megalopa (*N* = 5)

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<tr>
<td><em>N. australis</em></td>
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<td><em>T. australis</em></td>
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<td>Crab megalopa</td>
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<td>Unidentified crustacean remains</td>
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ranged between 2.7 and 8.0 mm (mean 5.2 ± 1.2 mm). Copepods (N = 23) were considerably smaller than other measured prey items, ranging from 2.3 to 4.8 mm (mean 2.9 ± 0.1 mm).

**DISCUSSION**

While the present study represents a snapshot of the diet only and does not account for temporal variations, it has demonstrated the importance of euphausiids in the diet of Common Diving-Petrels in south-eastern Australia during chick-rearing. The presence of euphausiids is consistent with the findings of studies on the conspecific *P. u. exsul* in subantarctic regions. However, in those regions, euphausiids were typically consumed in relatively small quantities. For example, studies at Heard Island, South Georgia (both south of the Antarctic Polar Front) and Îles Kerguelen (located in the Antarctic Polar Frontal Zone) reported a predominance of hyperiid amphipods and copepods (Reid et al. 1997; Whittington 1998; Bocher et al. 2000a, b). In contrast, Roby (1991) recorded mainly euphausiids in the diet of Common Diving-Petrels at South Georgia, with *Euphausia superba* constituting 78% by volume, while *E. valentini* and a *Thysanoessa* species represented approximately 66% of the number of prey at Îles Crozet (in the Antarctic Polar Frontal Zone). Hyperiid amphipods contributed an additional 29% (Ridoux 1994). Dietary differences between Common Diving-Petrels in the present study, which breed in a shallow continental shelf region north of the Subtropical Front, and conspecifics elsewhere in the range are likely to reflect differences in the local distribution and abundance of prey.

*N. australis* is largely restricted to shallow, coastal waters on the Australian and New Zealand continental shelves (Blackburn 1980). Since the distribution of prey directly influences foraging areas of seabirds (Hunt and Schneider 1987), results of the present study suggest that during chick-rearing, Common Diving-Petrels from Seal Island feed primarily in inshore regions of the continental shelf. This is consistent with previous observations of Common Diving-Petrels feeding in inshore waters elsewhere (Ryan and Nel 1999).

*N. australis* is the principal euphausiid in south-eastern Australian shelf waters (D. A. Ritz and R. J. Kirkwood, unpublished data) and, in northern central Bass Strait, has been shown to peak in abundance in November (Hobday 1992). It is a major component of coastal zooplankton biomass (Ritz and Hosie 1982) and forms an important element of coastal food webs for a broad range of avian and fish predators (O’Brien 1988). In particular, three other species of burrow-nesting seabirds which breed on Seal Island are also known to consume *N. australis*: Little Penguins *Eudyptula minor* (Cullen et al. 1992); Short-tailed Shearwaters *Puffinus tenuirostris* (Skira 1986); and Fairy Prions *Pachyptila turtur* (Imber 1981).

Common Diving-Petrel chicks in south-eastern Australia fledge between November and December (Marchant and Higgins 1990) whereas the other sympatric burrow-nesting species generally lay their eggs in mid to late spring, typically no earlier than October (see Marchant and Higgins 1990; Cullen et al. 1992). It is not known why Common Diving-Petrels in south-eastern Australia lay eggs in winter when throughout the southern part of the species’ range, breeding generally starts in mid-spring to summer (Marchant and Higgins 1990). However, as interspecific competition for prey may influence the timing of breeding among sympatric species (Lack 1968), the early onset of breeding in Common Diving-Petrels may reflect a strategy to minimize interspecific competition for food with sympatric seabirds during chick-rearing. Indeed, it has been suggested that this strategy applies at South Georgia where Common Diving-Petrels breed earlier than their congeners, South Georgian Diving-petrels *P. georgicus* (Croxall and Prince 1980). Common Diving-Petrels may also time their breeding to ensure that the chick fledging period coincides with peak prey availability, thereby maximizing post-fledging survival rates *sensu* Lack (1968). Alternatively, the timing of breeding may be determined by ambient tempera-
tures, with conspecifics in southern parts of the range unable to burrow and commence breeding until spring thawing of the ground. Breeding phenology may thus be a function of surface isotherm.

It has been proposed that *N. australis* may be suitable for harvest to supply feed for the growing mariculture industry in Australia (Virtue et al. 1995). The occurrence of *N. australis* in the diets of a range of other seabird species and marine mammals (O’Brien 1988), however, indicates that it plays an important role in the south-eastern Australian marine ecosystem. This is further supported by the results of the present study which suggest that, during chick-rearing, this euphausiid may form the main prey of Common Diving-petrels near the northern extent of their range. Detailed knowledge, therefore, of the spatial and temporal distribution and abundance of *N. australis*, and of its role in south-eastern Australian marine food webs, is needed for the development of appropriate management policies to ensure ecologically sustainable harvesting, should that occur. This is particularly important given the role of seabirds as indicators of marine ecosystem health and environmental change.

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**LITERATURE CITED**


