J. Mar. Biol. Ass. U.K. (2000), **80**, 953–954
Printed in the United Kingdom

Feeding habits and prey selection by the skate *Dipturus chilensis* (Elasmobranchii: Rajidae) from the south-western Atlantic

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The diet of *Dipturus chilensis* was composed mainly of the nototheniid fish *Patagonotothen ramsayi*, squid *Illex argentinus*, hake *Merluccius hubbsi*, serolid isopods, and crustaceans. Our results suggest that *D. chilensis* feeds selectively on some teleosts and rejects eel-like fishes. Total length of consumed *P. ramsayi* was significantly correlated with the skate's mouth width.

The skate *Dipturus chilensis* (Guichenot, 1848) ranges from Uruguay to central Chile, around southern South America. The diet of *D. chilensis* from a south-western Atlantic scallop bed is described, and compared with the availability of prey in its habitat to assess possible prey selection habits.

Sampling was carried out on a commercial trawler targeting Patagonian scallop, *Zygochlamys patagonica*, between 41°36′ and 42°04′S, and between 58°00′ and 58°22′W off Argentina, during April and May 1998. Depth range was 89.8–124 m. Trawls were performed with two nets fishing simultaneously, one for each side of the vessel. Each net had a mesh size of 70 mm and a height of 1.3 m. The footropes of the nets were 17 m long and had chains. Tow speed was 4 knots. Total length (TL, to the nearest cm) and mouth width (to the nearest 0.1 mm) were measured for all skate caught. The stomachs were removed, frozen, and subsequently analysed in the laboratory. Prey was identified to the lowest taxonomic level possible, with number, weight (to the nearest 0.01 g) and volume (measured by water displacement) being recorded.

The gravimetric index of relative importance (IRI_g) was calculated as:

$$IRI_g = \%F \times (\%N + \%W) \quad (1)$$

where %F is the per cent frequency of occurrence (i.e. the number of stomachs in which a given prey was found as percentage of the number of stomachs with food); %N is the number of a given prey as percentage of the total number of prey; and %W is the number of a given prey as percentage of the total weight of prey. Volumetric IRI (IRI_v) was calculated as was IRI_g but replacing %W with percentage volume.

Prey-specific abundance (P_i) was calculated as the number of prey *i* divided by the total number of prey in the stomachs which contained the prey *i* (Amundsen et al., 1996). We plotted P_i against %F to know the feeding strategy of the predator (Amundsen et al., 1996). Size-frequency distributions of *Patagonotothen ramsayi* from the catch and from the stomachs of skates were estimated, and compared by using the Kolmogorov–Smirnov test. The Spearman Rank correlation coefficient was calculated between skate mouth width and *P. ramsayi* TL.

One hundred and sixteen specimens were examined (from 57 trawls) of *Dipturus chilensis* ranging from 45 to 95 cm TL. Of these, 96 contained food. *Patagonotothen ramsayi* was the most abundant teleost (95% of the total catch), while *Merluccius hubbsi*, *Bassanago albescens* and *Genypterus blacodes* comprise the remaining 5%.

The principal prey was *P. ramsayi* (IRI_g 6570.1; IRI_v 6586.6), followed by unidentified teleosts (IRI_g 2654.6; IRI_v 2636.6) and the squid *Illex argentinus* (IRI_g 138.3; IRI_v 139.4). Other prey included hake, *M. hubbsi* (IRI_g and IRI_v 10.6), crustaceans (IRI_g and IRI_v 6.4), unidentified remains (IRI_g 3.3; IRI_v 3.2) and serolid isopods (IRI_g and IRI_v 3.2). Several remains of *I. argentinus* and *M. hubbsi* discarded from commercial fishing vessels were observed. This was inferred from the cutting marks made during processing of the fish. The P_i–%F plot shows that *P. ramsayi* was the main prey, followed by unidentified teleost remains, *I. argentinus* was a secondary prey and few skates consumed crustaceans or hake (Figure 1).

Size-frequency distributions of *P. ramsayi* from the catch and from the stomachs of *D. chilensis* were significantly different (Kolmogorov–Smirnov test, $d_{max}=21.12$, $N=45$, $k=34$, $P<0.001$). No *P. ramsayi* larger than 25 cm TL were observed in skate stomachs and *P. ramsayi* between 14 and 22 cm TL were highly consumed (Figure 2). The scallop net may however affect the observed size-distribution of both predators and prey.

The correlation between predator's mouth width and TL of consumed *P. ramsayi* was significantly different from 0 ($r=0.48$, $N=45$, $P<0.001$).

Our results show that *D. chilensis* predates primarily on teleosts. The scallop fishery from which we have taken our data takes a large amount of invertebrate bycatch (up to 70% of the total catch, Bremec et al., 1998). Invertebrates were under-represented in the diet of *D. chilensis*, as inferred from invertebrate abundances on south-western Atlantic scallop beds presented by Bremec et al. (1998). Thus, we concluded that fishes are the preferred prey of these skates. The piscivorous nature of the diet was confirmed by the method of Amundsen et al. (1996). The smallest individuals we sampled were 45 cm TL, and our data will be biased to the piscivorous individuals. As the gear employed caught high numbers of juveniles 10–20 cm TL of other skates (e.g. *Amblyraja doellojuradoi*, *Bathyraja brachyurops* and *Rhinoraja macloviana*), the absence of *D. chilensis* <45 cm TL may be due to a size-based spatial segregation, rather than to sampling bias.

Of seven species of *Bathyraja* studied in the north-west Pacific, only *Bathyraja parmifera* consumed predominantly fishes (Orlov, 1998). The diet of at least 11 species of skates from European

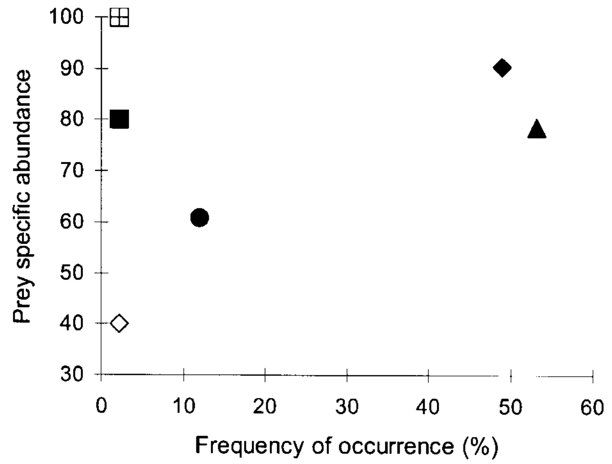

Figure 1. Prey-specific abundance (P_i) plotted against frequency of occurrence (%F) of prey items of the skate *Dipturus chilensis* from the south-western Atlantic. ▲, *Patagonotothen ramsayi*; ◆, unidentified teleosts; ●, *Illex argentinus*; ■, crustaceans; +, *Merluccius hubbsi*; ◇, serolid isopods; □, unidentified remains.

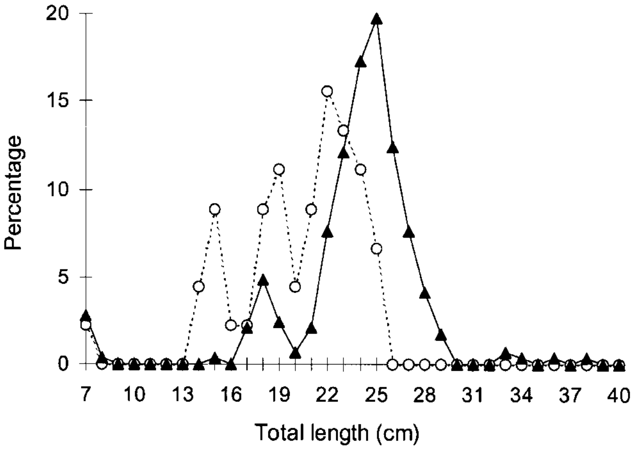

Figure 2. Size-frequency distributions of the nototheniid teleost *Patagonotothen ramsayi* from the catch (▲) and from the stomachs of the skate *Dipturus chilensis* (○) from the south-western Atlantic.

waters has been studied (e.g. Ajayi, 1982; Berestovskiy, 1989; Ellis et al., 1996; Gordon & Duncan, 1989; Jardas, 1972; Quiniou & Rabarison-Andriamirado, 1979). Of these, only four feed predominantly on fishes, at least during the adult stage: *Raja brachyura* (Ellis et al., 1996; Quiniou & Rabarison-Andriamirado, 1979), *Raja microocellata* (Ajayi, 1982), *Dipturus nidarosiensis* (Gordon & Duncan, 1989) and *Leucoraja naevus* (Ellis et al., 1996). Ebert et al. (1991) described the diet of 14 skate species from south-west South Africa and Namibia, and only *Dipturus pullopunctatus* and *Rostroraja alba*, predated significantly on fish. It is interesting that all species of the genus *Dipturus* whose diet has been analysed (i.e. *D. nidarosiensis*, *D. pullopunctatus* and *D. chilensis*) have been found to be mainly ichthyophagous. It is common that larger skate species (like *Dipturus* spp.) eat proportionately more fishes than smaller skates.

In this study, most individuals of *D. chilensis* preyed on *P. ramsayi*, the most abundant fish in the study area as inferred from the vessel catch. In contrast, *B. albescens* and *G. blacodes* were under-represented in the diet of *D. chilensis*. This may be the result of the body shape of these potential prey species. *Dipturus chilensis*, like most skates, is gape-limited and eats whole prey. Both *G. blacodes* and *B. albescens* have an eel-like body, and may evade skate predation because of inefficient prey capture and handling. The feeding behaviour of *D. chilensis* would likely differ between feeding on *P. ramsayi* and eel-like fishes. Given a small mouth in relation to its orobranchial cavity, *D. chilensis* (like most skates) is presumably well suited for suction feeding. This specialization may explain the under-representation of eel-like fishes in the diet of *D. chilensis*.

Robichaud et al. (1991) found no correlation between the size of *Amblyraja radiata* and their crab prey. In contrast, larger individuals of *D. chilensis* feed on larger individuals of *P. ramsayi* (up to a size of 25 cm TL) and small individuals of *P. ramsayi* were absent from the diet of large skates. We suggest that the upper size limit of prey consumed by *D. chilensis* is imposed by morphological constraints, which can have profound effects on ecological aspects such as feeding.

We thank the crew of the F/V 'Erin Bruce' for help provided on board. We also thank Gabriela Palomo, Roberto Menni and two anonymous referees for comments that highly improved the manuscript. L.O.L. and J.L.V. were supported by scholarships from CONICET (Argentina) and Fulbright Commission, respectively.

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Submitted 20 October 1999. Accepted 5 May 2000.