

Predation of Fishes on Open-ocean Species of Sea-skaters (*Halobates* spp.)

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Abstract *Halobates* specimens were found in the stomachs of six fish species, representing five families, collected by purse-seining flotsam in the tropical West Pacific. The insects occurred in the diets of 52 out of 85 trevally, *Caranx sexfasciatus*, but in only one of 130 individuals of seven other carangid species. The rudderfish, *Kyphosus cinerascens*, was also a significant predator of *Halobates*. *Halobates* eaten by trevally comprised almost exclusively *H. micans* and *H. germanus*, which agrees with the known distribution ranges of both species. A single male and female of *H. sericeus* were recorded from different trevally, caught at ca. lat. 4°N. These are the first records of *H. sericeus* from waters within lat. 10° of the Equator. Fishes, like sea birds, may be significant predators of open-ocean *Halobates* species.

Halobates spp. (Gerridae, Hemiptera) are small-bodied, wingless marine insects. The body length (BL, distance between tips of head and last abdominal segment) rarely exceeds 5 mm, even in the biggest open-ocean species, *H. micans*, whereas the distance between the tips of the middle legs may reach 30 mm when extended. All species spend a strictly two-dimensional life on the sea surface, although of the 44 known species only 5 are truly open-ocean forms (Cheng, 1989a, b). Of these, 3 have been reported from the West Pacific; *H. micans*, *H. germanus* and *H. sericeus* (Herring, 1961; Cheng, 1973, 1989b).

Little is known of the biology of open-ocean *Halobates* spp., other than geographical distribution, because of the limited opportunities for and difficulties in making observation on such insects at sea.

Sea birds have been reported as major predators of *H. micans* and *H. sericeus*. The latter have been found in the diets of five sea bird species from Christmas Island (Pacific Ocean) and the north-western Hawaiian Islands (Ashmole and Ashmole, 1967; Cheng, 1973; Cheng and Harrison, 1983).

Predation by fishes is little known, even for coastal *Halobates* spp. Cheng (1974) anecdotally recorded *Halobates* remains from a young Pacific anchovy (*Engraulis mordax*?) (locality unknown) and a clupeid, *Sardinella siim* (sic) (= *Amblygaster sirm*?), from Jakarta Bay. *H. robustus* in the Galapagos Islands were observed, being preyed upon by a clu-

peid, *Sardinops sagax*, and a small, unidentified mugilid (Foster and Treherne, 1980; Treherne and Foster, 1982).

Predation of open-ocean *Halobates* species by fish has been reported only by Mori (1967), who found from 1-19 *Halobates* in the stomachs of 4 young slender-tuna, *Allothunnus fallai*, which were themselves removed from the stomachs of fishes caught on tuna longlines in the South Pacific Ocean (28°30'S, 116°15'W).

During ecological studies of fishes associated with flotsam in the tropical West Pacific, some species were found to have fed on oceanic *Halobates* species. These findings are reported.

Materials and Methods

Fishes associated with flotsam were collected with a small purse seine (35 m headline length, 7.5 m deep, 1 cm mesh-width) in the tropical West Pacific Ocean within lat. 2 and 8°N and long. 140 and 151°E, in July, September and November each year from 1988 to 1990 inclusive (Fig.1). Of a total of 3,946 fish specimens (23 species representing 13 families) collected, 635 were dissected for examination of stomach contents (Table 1).

Halobates spp. attracted by night to a fish lamp were collected by scoop net, for use as reference specimens during the identification of *Halobates*

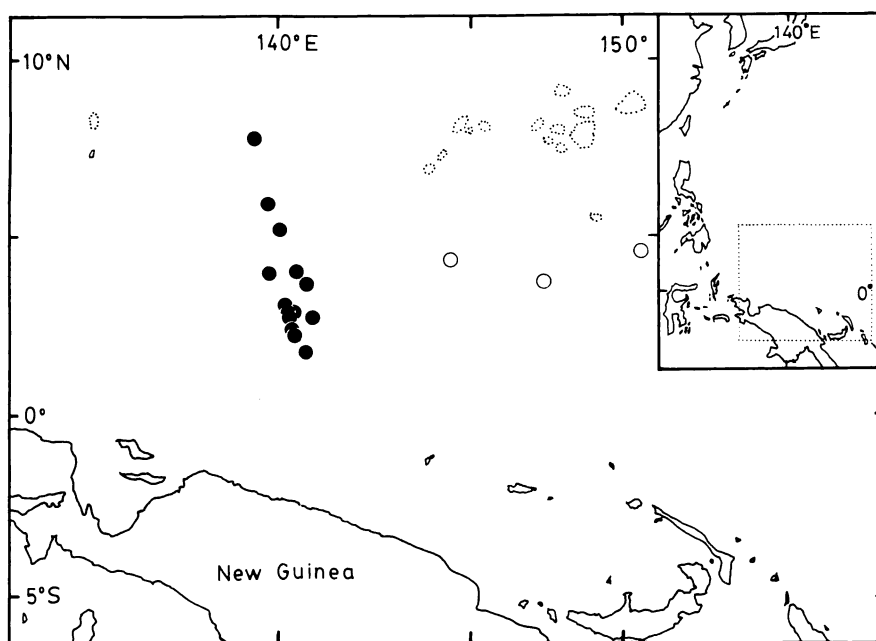


Fig. 1. Collection points of fishes accompanying flotsam: Some *Halobates* found in fish stomachs (●); no *Halobates* found (○).

found in the fish stomachs.

Identification of *Halobates* spp. was based on Miyamoto (1961), Herring (1961) and Cheng (1981).

Results

Six fish species, representing 5 families, were found to have taken *Halobates*, the highest occurrences being in trevally, *Caranx sexfasciatus*, and rudderfish, *Kyphosus cinerascens* (Table 1).

Together with copepods, *Halobates* was an essential dietary component of the trevally. Although most of the latter contained fewer than 10 insects, one specimen had taken 38. In the other fishes, *Halobates* seemed to be a less important food item, small crustaceans such as gastropods, amphipods and arrowworms occurring at much higher frequencies (Table 2).

Of the 23 fish species recorded in total (Table 1) 11, including the 6 above, were found to have eaten other fishes (Table 3). In most cases, juvenile anchovy (smaller than 30 mm standard length), *Stolephorus buccaneeri*, was consumed at the highest frequency.

Halobates was found only in one of 130 stomachs of seven other carangid spp. examined (Table 1). Similarly, although *Halobates* had been eaten by *Kyphosus cinerascens*, none were recorded from *K. lembus*. Some other differences between the kyphosids were the taking of more anchovies and Brachyura by *K. cinerascens* and more Siphonophora by *K. lembus* (Tables 2, 3).

The size of *Halobates* eaten by the trevally ranged from 1 to 5.5 mm BL (Table 4), i.e., the size from a first instar (Cheng, 1974) to a fully grown adult. There was no significant relationship between the size of the fish and the mean body length of *Halobates* consumed ($r=0.083$, d.f.=24).

About 66% of *Halobates* found in the trevally were *H. micans*, almost all of the rest being *H. germanus* (Table 5). The adult sizes tended to be a little larger in *H. micans*, which concurred with the known size difference between two species (Herring, 1961; Miyamoto, 1961).

Two individuals of *H. sericeus* were found to have been eaten by trevally (Table 5); a male by a fish caught at 4°01.0'N, 139°42.1'E and a female by a fish caught at 4°03.3'N and 140°29.6'E.

Discussion

Fishes feeding on *Halobates* varied both systematically and morphologically. On the other hand, the incidence of *Halobates* in the diets of closely-related species (Carangidae and Kyphosidae) showed no similarity. Although an explanation of the latter is difficult, the following points should be made.

All of the fishes were collected within 7.5 m of the surface. Their diets consisted either of coexisting planktonic animals and small fishes or of epifauna

living on flotsam. The six species from which *Halobates* were recorded also took juvenile anchovies. However, the feeding intensities on the latter bore no relation to those on *Halobates* (Tables 1-3).

Because *Halobates* can skate at a speed of 50-100 cm/s (Cheng, 1974), potential predators might be expected to require agility and good sight. *Caranx sexfasciatus*, a popular target of lure fishing, seems to be qualified. However, it is difficult to explain why the rainbow runner, *Elagatis bipinnulata*, which is also caught by lure fishing, seldom feeds on *Halo-*

Table 1. List of fishes collected around flotsam in the tropical West Pacific and examined for *Halobates* in their diets

Fish species	FL (mm)	No. indiv. examined	Fish containing <i>Halobates</i>	
			No.	%
Carcharhinidae				
<i>Carcharhinus falciformis</i>	750-898*	3	0	0
Antennariidae				
<i>Histrio histrio</i>	11- 13*	4	0	0
Carangidae				
<i>Elagatis bipinnulata</i>	92-244	65	1	1.5
<i>Seriola rivoliana</i>	194-289	21	0	0
<i>Decapterus macarellus</i>	106-189	25	0	0
<i>Selar crumenophthalmus</i>	95-185	15	0	0
<i>Uraspis helvola</i>	184	1	0	0
<i>Caranx sexfasciatus</i>	64-192	85	52	61.2
<i>Carangoides orthogrammus</i>	153, 197	2	0	0
<i>Carangoides ferdau</i>	157	1	0	0
Lobotidae				
<i>Lobotes surinamensis</i>	174-410*	18	0	0
Kyphosidae				
<i>Kyphosus lembus</i>	79-177	47	0	0
<i>Kyphosus cinerascens</i>	106-198	54	9	16.7
Lutjanidae				
<i>Lutjanus gibbus</i>	85	1	0	0
Teraponidae				
<i>Terapon theraps</i>	68-135	57	3	5.3
Ephippidae				
<i>Platax</i> sp.	78-196	6	0	0
Pomacentridae				
<i>Abudefduf vaigiensis</i>	33-108	68	4	5.9
Scaridae				
<i>Leptoscarus vaigiensis</i>	53-172*	4	0	0
Nomeidae				
<i>Psenes cyanophrys</i>	52-163	56	0	0
Blenniidae				
<i>Petroscirtes</i> sp.	43- 53	5	0	0
Balistidae				
<i>Canthidermis maculatus</i>	118-316	66	2	3.0
Monacanthidae				
<i>Aluterus monoceros</i>	163-385*	26	0	0
<i>Aluterus scriptus</i>	174-237*	5	0	0

* Total length is given instead of fork length (FL).

bates. Furthermore, it is doubtful that the rudderfish (*Kyphosus cinerascens*), damsel-fish (*Abudefduf vaigiensis*) and triggerfish (*Canthidermis maculatus*), all of which consumed *Halobates*, can be considered agile.

Since *Halobates* species are epineustons, fishes need to break the water surface, at least for a moment, to feed on them. The presence or absence of such feeding behavior must have resulted in food

segregation among coexisting, closely related species.

Two different ways of capturing *Halobates* have been observed (Treherne and Foster, 1982). Individual clupeids, of schools swimming at depths of 25–50 cm, hunted *Halobates* by rising swiftly to the surface, pecking at an insect, and then rapidly rejoining the school. A mugilid species hunted in groups of up to 50 individuals, which broke the water surface whilst feeding. The method of predation employed

Table 2. Percentage frequency of occurrence of food organisms in the stomachs of six fish species which had taken *Halobates*, and the rudderfish *Kyphosus lembus* (included for comparison with *K. cinerascens*). The number of individuals examined are shown in parentheses

Food organisms	Fish species						
	<i>Elagatis bipinnulata</i> (65)	<i>Caranx sexfasciatus</i> (85)	<i>Kyphosus cinerascens</i> (54)	<i>Kyphosus lembus</i> (47)	<i>Terapon theraps</i> (57)	<i>Abudefduf vaigiensis</i> (68)	<i>Canthidermis maculatus</i> (66)
<i>Halobates</i>	1.5	61.2	16.7	0.0	5.3	5.9	3.0
Seaweeds	0	0	0	0	0	20.6	0
Siphonophora	6.2	2.4	37.0	85.1	38.6	10.3	27.3
Gastropoda	64.6	7.1	77.8	87.2	77.2	8.8	83.3
Copepoda	90.8	80.0	81.5	100	98.2	98.5	33.3
Thoracia	0	0	1.9	0	40.4	26.5	4.5
Amphipoda	64.6	16.5	68.5	83.0	56.1	26.5	84.8
Euphausiacea	43.1	9.4	38.9	53.2	19.3	8.8	6.1
Macrura	30.8	9.4	29.6	44.7	7.0	7.4	21.2
Brachyura	29.2	4.7	14.8	4.3	22.8	1.5	22.7
Stomatopoda	24.6	1.2	5.6	12.8	0	0	34.8
Polychaeta	21.5	0	66.7	68.1	56.1	32.4	3.0
Sagittidae	56.9	23.5	75.9	83.0	10.5	8.8	0.0
Thaliacea	40.0	1.2	16.7	31.9	40.4	7.4	3.0
Fish eggs	10.8	1.2	25.9	40.4	26.3	10.3	18.2
Fish	38.5	29.4	29.6	34.0	21.1	23.5	28.8

Table 3. List of fishes containing fish material in their stomach contents. Figure indicates average number of prey items per individual

Predatory fishes	Fish species in diets					
	<i>Stolephorus buccaneeri</i>	<i>Caranx sexfasciatus</i>	Other carangids	<i>Coryphaena equiselis</i>	<i>Abudefduf vaigiensis</i>	Other spp. (12)
<i>Carcharhinus falciformis</i>	18.7	0.3	0.7	0	0	0.3
<i>Elagatis bipinnulata</i>	26.7	0	*	0	0	*
<i>Seriola rivoliana</i>	0.6	0.1	0.1	*	0	0.6
<i>Decapterus macarellus</i>	8.9	0	0	0	0	0
<i>Caranx sexfasciatus</i>	9.0	0.1	*	*	0	0
<i>Lobotes surinamensis</i>	0	0.3	*	0	0.2	0.2
<i>Kyphosus cinerascens</i>	15.5	0	0	0	0	*
<i>Kyphosus lembus</i>	4.8	0	0	*	0	*
<i>Terapon theraps</i>	0.1	0	0	0	0	9
<i>Abudefduf vaigiensis</i>	0.3	0	0	0	0	0
<i>Canthidermis maculatus</i>	7.9	0	0	*	0	*

* < 0.05.

by the species reported here is unknown.

Fishes may be more serious predators on *Halobates* than sea birds, because their approach from underneath would give much less warning to *Halobates* than airborne predators (Foster and Treherne, 1980; Treherne and Foster, 1981).

The finding that *Halobates* contained in the diet of the trevally were almost exclusively either *H. micans* or *H. germanus* is compatible with the known distribution of these insects (Cheng, 1973, 1989b). Although *H. micans* had been taken in greater numbers, this does not necessarily reflect differences in population density of the two species in the study area. *H. micans* is possibly more vulnerable than *H. germanus* to predation by fishes, since it always glides on the water surface, whereas the latter often moves by jumping (Y. Shojima, pers. comm.).

Two individuals of *H. sericeus* had been eaten by the trevally caught at about 4°N, far from the known distribution range of the species in the West Pacific (Herring, 1961; Cheng, 1973, 1989a). A similar instance of extended geographical distribution of *H. micans* was reported by Cheng and Harrison (1983), who considered the specimen to have been a stray.

The unidentified *Halobates* in the diets of slender-

tuna from the eastern South Pacific (Mori, 1967) must have been *H. sericeus*, because no other *Halobates* species is known in that area (Cheng and Schulenberger, 1980; Cheng, 1989a). This suggests that in its main distribution range *H. sericeus* must also be frequently consumed by fishes.

The three open-ocean *Halobates* species mentioned above are commonly found off the west coast of Kyushu (Miyamoto and Senta, 1960). No *Halobates*, however, was found in the diets of 85 *C. sexfasciatus* specimens caught around bamboo rafts set off the Goto Islands (S. Hitomi, pers. comm.). Low population densities of the insects might explain this.

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Table 4. Body length frequency distribution of *Halobates* found in *Caranx sexfasciatus* of different size groups. Number of fish examined given in parentheses

<i>Halobates</i> (mm BL)	<i>Caranx sexfasciatus</i> (mm FL)						
	61-80 (3)	81-100 (2)	101-120 (8)	121-140 (6)	141-160 (8)	161-180 (4)	181-200 (1)
1.0-1.5	2	2	1	3	1		
1.6-2.0		1	7	3	9		
2.1-2.5		2	1	6	6		
2.6-3.0		1	4	5	5	1	
3.1-3.5	3	1	2	8	6	3	
3.6-4.0	1		4	4		1	
4.1-4.5	2	1	14	2	4	1	
4.6-5.0		1	11	4	5	1	1
5.1-5.5			1	2			

Table 5. Monthly species composition of *Halobates* found in *Caranx sexfasciatus*

Month	<i>H. micans</i>			<i>H. germanus</i>			<i>H. sericeus</i>		Unidentified	
	♂	♀	Nymph	♂	♀	Nymph	♂	♀	Adult	Nymph
July	28	24	30	7	15	13	1	0	24	10
September	6	14	27	7	8	15	0	1	9	15
November	3	3	5	2	2	0	0	0	2	1
Total (%)*	140 (66.4)			69 (32.7)			2 (0.9)		61	

* Exclusive of unidentified specimens.

Central Salt and Marine Chemical Research Institute, India, who helped us with English.

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魚類による遠洋性ウミアメンボの捕食

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西太平洋熱帯域(北緯2-8°, 東経140-151°)の漂流物に随伴する魚類の胃内容物を調べたところ、5つの科に属する6種がウミアメンボを食していた。特にギンガメアジでは61%と高い捕食率であったのに対し、他の7種のアジ科魚類130個体では1個体のツムブリを除いてウミアメンボを食していたものはなかった。捕食されていたウミアメンボのうち、66.4%がツヤウミアメンボ、32.7%がセンチウミアメンボであった。それぞれ1個体の雌雄のコガタウミアメンボが、従来本種は分布していないと考えられていた北緯4°付近で採集したギンガメアジ(別個体)に食されていた。魚類は海鳥とともに、遠洋性ウミアメンボの無視できない捕食者であると考えられた。

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