Halobates (Heteroptera: Gerridae) from Micronesia with Notes on a Laboratory Population of *H. mariannarum*

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Abstract—Seven species of sea-skaters, marine insects of the genus *Halobates*, are reported from Micronesia. Nymphs of nearshore species (*H. mariannarum, H. flaviventris, H. nereis, H. princeps*) are generally found in sheltered waters among mangrove roots and branches, whereas adults are usually found in more open water. Specimens of open-ocean species (*H. micans, H. sericeus, H. germanus*) may be found washed to shore after storms. Under laboratory conditions, each nymphal stadium of *H. mariannarum* lasts 12–14 days.

Introduction

The following Micronesian islands were visited and sea-skaters (*Halobates* spp.) were often found in various coastal locations: Marshall Islands (Enewetak Atoll, Kwajalein Atoll), Mariana Islands (Guam), and Caroline Islands (Palau, Truk, Ponape). For each island or islet, the localities visited and the species collected are presented, together with notes on their habitats, biology, and behavior.

There are 42 described species of *Halobates*. Five are pelagic, and have been found in the open ocean hundreds of miles from land; the others are confined to nearshore habitats and are often endemic to islands or island groups (Cheng, 1973a, 1974). There are very few records in the literature on the *Halobates* of Micronesia. The following species were reported by Herring (1961):

- *H. mariannarum* Esaki—described from Rota (Marianas); also known from Guam, Yap, Ponape, Kosrae and Arno Atoll.
- *H. flaviventris* Eschscholtz—reported from Palau; widely distributed along the tropical Indian Ocean shores.
- *H. nereis* Herring—described from Koror, Palau; also known from New Guinea.
- *H. princeps* White—one male collected from Palau; also known from New Guinea, Celebes, Indonesia and Malaya.

I collected *H. mariannarum* from Guam, Yap, Truk and Ponape, and *H. flaviventris* and *H. nereis* from Palau. *H. princeps* was not found at any of the sites visited. Specimens of the open-ocean species, *H. micans, H. sericeus* and *H. germanus*, may be washed to shore after storms, but the only published record I could find of such occurrences is that of Bryan and Swezey (1926), who reported *H. sericeus* on a sand

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beach at Johnston Island. *H. micans* was collected from Enewetak, Palau and Truk; *H. germanus* was collected from Palau, but *H. sericeus* was not found.

Methods

Sea-skaters are fast, agile animals. Specimens of open-ocean species can normally be collected in a net towed at about 4 knots at the sea surface. Plastic vegetable strainers (22–25 cm diam.) were ideal for collecting nearshore species. Unless otherwise mentioned, all the specimens reported in this study were collected this way, generally at low tide, by wading in lagoons, or bays with fringing mangroves (*Rhizophora*), that could be approached by land. In general, nymphs of the nearshore species of *Halobates* were found in sheltered waters among the mangrove roots and branches, whereas adults were found further away from the mangroves in more open water. Since sea-skaters not only move fast but can also jump to heights of 10–12 cm, they were placed in plastic buckets as soon as they were scooped from the water. They can also climb up the sides of buckets (especially those with rough surfaces), so buckets 30 cm high with little or no water in the bottom were used for collecting. Although these insects have water-repellent surfaces, they tend to become waterlogged and then drown when tossed in water. In a closed vessel lined with moistened paper towels, they can be kept alive and apparently healthy for one or two days even

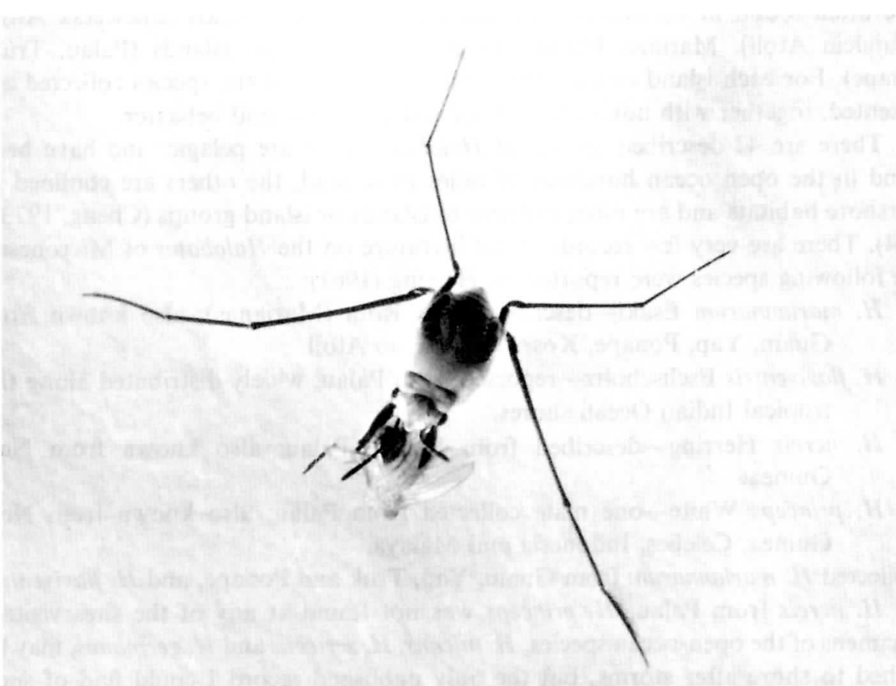

Fig. 1. *Halobates* adult female feeding on *Drosophila* (flightless), top view.

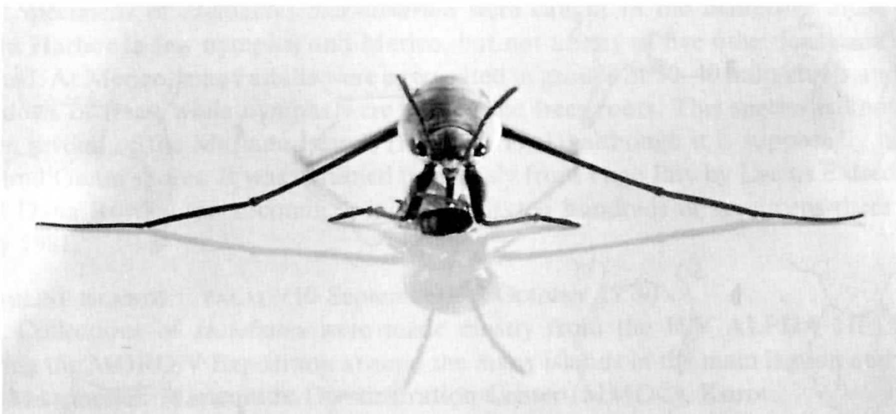

Fig. 2. As above, front view, showing rostrum adpressed to prey.

in the absence of water.

Specimens were maintained in clean glass or plastic containers with only a little sea water in the bottom. Many plastics used in buckets and other kinds of containers contain various amounts of plasticizers such as phthalates which are toxic to insects; they must be avoided if specimens are to be kept alive. Polystyrene containers, though breakable, seem to be safe for keeping sea-skaters, whereas many brands of polyethylene or polypropylene buckets, though less fragile, may release toxins which kill insects such as *Halobates* in a few minutes. Generally, hard plastics contain fewer plasticizers than do soft plastics and are therefore more suitable as containers for living sea-skaters.

Halobates feed readily on *Drosophila* (wild-type adults killed by freezing, or living vestigial-winged flies; Figs. 1 and 2); adult sea-skaters have been kept alive for more than 2 months on this diet alone. Other freshly killed small insects are also acceptable. Specimens captured for taxonomic studies are best kept in 70% alcohol; 5–10% formalin is also a good preservative. For determination of Cd content, samples collected in the field were oven-dried and later examined by flameless atomic-absorption spectroscopy (Schultz-Baldes and Cheng, 1980).

Specific determination of *Halobates* can be made fairly easily by examining the male genitalia (Fig. 3), or by using the keys of Herring (1961) or Cheng (1975; pelagic species only).

Results

MARSHALL ISLANDS: ENEWETAK ATOLL (2–23 September 1975)

There are no mangrove swamps on this atoll. Several surveys were made around the shores of Ikuren, Japtan, Medren and Enewetak. On the main islet of Enewetak, night-lighting was tried at both the Cargo pier at the southwestern end and the Marine pier at the northern end of the islet. A few 10-minute neuston tows were made in the lagoon. A total of 33 individuals were caught, 5 in the neuston tows and the rest by

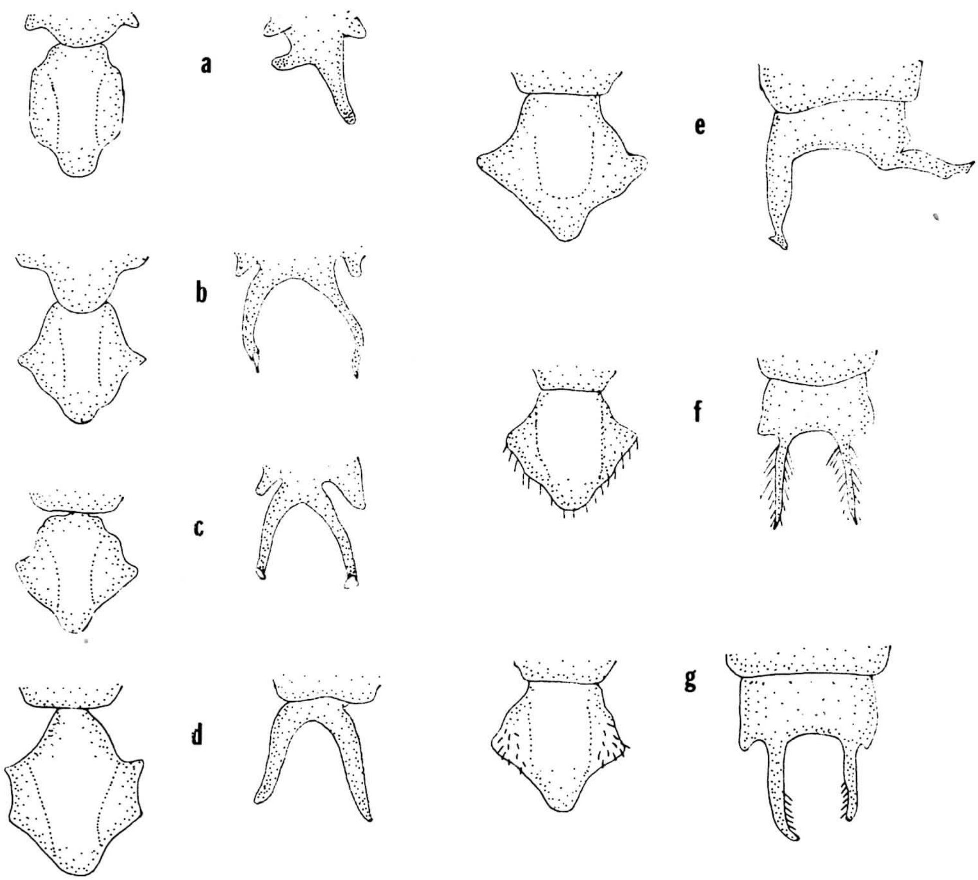

Fig. 3. Male genitalia of *Halobates* (a–d: nearshore spp.; e–g: open-ocean spp.) showing shape of 9th tergum (dorsal view) and styliform processes: a) *H. mariannarum,* b) *H. flaviventris,* c) *H. nereis,* d) *H. princeps,* e) *H. micans,* f) *H. sericeus,* g) *H. germanus* (after Herring, 1961 and Cheng, 1975).

night-lighting.

All the specimens collected were identified as *Halobates micans*, a cosmopolitan open-ocean species which rarely occurs near shore; it was not surprising that so few were caught in the lagoon. *Halobates* had never before been reported from Enewetak Atoll, although a few specimens of *H. micans* were dip-netted by Dr. Michael Pilson (University of Rhode Island) at night from a boat anchored off Japtan.

MARSHALL ISLANDS: KWAJALEIN ATOLL (23–24 September 1975)

Night lighting was tried at the yacht harbor and the main harbor; the shore near the airport was searched by day, but *Halobates* was not found. There is still no record of *Halobates* from Kwajalein Atoll, although *H. micans* may occur offshore.

MARIANA ISLANDS: GUAM (4–6 October 1978)

Specimens of *Halobates mariannarum* were caught in the mangrove areas of Apra Harbor (a few nymphs) and Merizo, but not at any of five other locations we visited. At Merizo, many adults were aggregated in groups of 30–40 individuals under shadows of trees, while nymphs were among the trees roots. This species is known from several of the Mariana Islands (Herring, 1961), although it is supposedly rare around Guam shores. It was collected previously from Pago Bay by Lucius Eldredge and Dana Rowley (pers. comm.), and we collected hundreds of specimens there in July 1981.

CAROLINE ISLANDS: PALAU (10 September—2 October 1979)

Collections of *Halobates* were made mostly from the R/V ALPHA HELIX during the MORO V Expedition around the many islands in the main lagoon and at the Micronesian Mariculture Demonstration Center (MMDC), Koror.

Halobates nereis, the larger of the two nearshore species collected, was less abundant in the more offshore regions and probably breeds in nearshore mangrove areas. Only adults and a few later-instar nymphs were collected by night light. However, numerous younger nymphs were found near several islands, where they sometimes occurred in dense aggregates (100–200/m^2).

Halobates flaviventris was extremely abundant at two anchorages: about 1.5 km offshore north of Malakal Harbor, and near Eil Malk. At the first site, they aggregated under the light at the ship's stern where the water appeared to be boiling with these insects; several thousands were collected within an hour or so. At the second site they were found during the daytime at the outer margin of the fringing reef where the coral grew close to the sea surface and then sloped down steeply to a depth of about 200 m. Dense patches of *Halobates* occurred at the edge of the blue water all along the reef margin, but no individuals were found on the shallow water over the reef, and only a few were observed on the blue water offshore. The reasons for aggregations at the reef margin are not known, though it is suggested that current patterns there bring up zooplankton which may become trapped at the surface and serve as prey for the sea-skaters. Almost 1,000 specimens, adults and nymphs of all stages, were collected in this area. Such reef-edge aggregates have not been reported from anywhere else in Palau or on other tropical reefs. *Halobates robustus* aggregations maintaining floating stations in relation to the shore have been reported at the Galápagos Islands (Birch et al., 1979), and it is likely that similar behavioral patterns could maintain *H. flaviventris* populations at the reef margins in Palau.

In addition to these nearshore species, we collected a few specimens of each of two oceanic species: *Halobates germanus* (at light just off the sea wall at MMDC) and *H. micans* (at light from an anchorage in the Western Passage). Both of these species are widely distributed in this area of the Pacific (Cheng, 1973a) and are likely to occur in appreciable numbers offshore. Our specimens were probably driven inshore by the strong onshore winds that prevailed during our visit.

CAROLINE ISLANDS: YAP (3–4 October 1979)

Several sites were visited in the extensive mangrove areas around the main island. No *Halobates* were found in areas with only a few mangrove plants sparsely scattered along the shore, but a few specimens of *H. mariannarum* were collected where groups of trees provided some shelter from onshore wave action.

CAROLINE ISLANDS: TRUK (7–12 October 1979)

Many adults and nymphs of *H. mariannarum* were collected at 3 of the sites visited on Moen. In addition, after a stormy night on the sandy beach by the hotel, large numbers of *Halobates mariannarum* and several *H. micans* were found mixed in with cast seagrasses at the wash-line; they probably had been washed up after onshore storms. Their density was estimated to be 5–10 per meter of wrack; many adults and some older nymphs (mostly 5th instar) were collected. The following day, hundreds of *H. mariannarum* were found congregated in the next bay to the northeast, the insects swarming in dense patches (200–300/m^2) on water above white sandy bottoms. Such dense patches have not been seen anywhere else or at any other times on the island.

CAROLINE ISLANDS: PONAPE (13–16 October 1979)

Ponape is almost completely surrounded by mangroves. We collected specimens from 3 sites. All the specimens from Ponape were identified as *Halobates mariannarum*, a species also found on Truk, Yap, and Guam. As on the other islands, adults and older nymphs were found beyond the immediate shadows of the trees, while younger nymphs were found among the trees. Aggregates of 50 to 100 adults were not uncommon.

CADMIUM CONTENT OF MICRONESIAN *Halobates* SAMPLES

Since exceptionally high concentrations (100–200 ppm dry wt) of the toxic metal Cd were found in samples of *Halobates* collected on the open ocean (Cheng et al., 1976), and relatively low concentrations (<7 ppm dry wt) were found in nearshore *Halobates* species (Cheng et al., 1979), several of the Micronesian *Halobates* were analysed for this element. Our results indicated that specimens of 3 *Halobates* species from the coastal areas of Palau, Guam and Truk contained less than 5 ppm dry wt of Cd: *H. nereis* from Palau—2.1 ppm; *H. flaviventris* from Palau—4.9 ppm; *H. mariannarum* from Guam—3.4 ppm and *H. mariannarum* from Truk—1.5 ppm.

MORPHOMETRICS OF *H. mariannarum* NYMPHS

It is still not known whether *Halobates mariannarum* has any definite breeding season. The samples collected in the field included adults and nymphs of all five stages (I–V) in the following proportions: 1—4.9%; II—17.7%; III—23.5%; IV—23.0%; V—4.9% and adults—26.0%.

The separate nymphal stages of *Halobates mariannarum*, like those of other *Halobates* species, are difficult to distinguish. Although the insects increase in body length and width as they progress from one nymphal stage to the next, these two gross characters are rather variable and thus not suitable for distinguishing the various instars. Therefore, the limb joints were analyzed morphometrically by

Table 1. Range (in mm) of length and width of body, middle femur and tibia, and hind femur and tibia of nymphal stages (I–V) and adults of *Halobates mariannarum*.

Stage		Body Length	Body Width	Mid Femur	Mid Tibia	Hind Femur	Hind Tibia
I		0.6–0.9	0.4–0.6	1.0–1.2	0.9–1.0	0.9–1.1	0.4–0.5
II		1.0–1.8	0.7–1.0	1.5–1.6	1.1–1.3	1.3–1.4	0.6–0.7
III		1.6–2.5	0.9–1.2	2.0–2.2	1.6–1.7	1.7–1.9	0.8–1.1
IV		2.4–2.9	1.2–1.5	2.8–3.1	2.2–2.5	2.2–2.5	1.0–1.2
V	♂	2.7–3.2	1.4–1.5	3.7–4.2	2.8–2.9	2.7–3.1	1.4–1.6
V	♀	2.6–3.0	1.4–1.6	3.6–3.9	2.7–3.0	2.7–3.2	1.5–1.6
Adult	♂	4.0–4.2	1.6–1.9	4.4–4.8	3.2–3.6	3.3–4.0	1.7–2.0
Adult	♀	3.3–4.2	1.6–1.9	4.3–5.0	3.2–3.5	3.3–4.0	1.8–2.1

methods similar to those described by Cheng and Maxfield (1980). Briefly, the lengths of appendage segments of nymphs were measured for at least 10 individuals of each stage. (By comparing the measurements, the specimens can easily be arranged into nymphal groups.) As for the two other *Halobates* species studied by Cheng and Maxfield (1980), there was no overlap in the lengths of the middle femurs of the various nymphal stages, so this character alone is sufficient to distinguish among the nymphs of the various developmental stages (Table 1).

OBSERVATIONS ON *H. mariannarum*

Some 100 nymphs of stages 2–5, collected among mangroves near the airport at Ponape, were flown back to California in plastic jars with moistened paper towels on the bottom. Fifty-seven survived the 40-hour journey without food and despite fluctuating temperatures (18–30°C). On arrival at the laboratory at La Jolla, the surviving insects were transferred to seawater in plastic jars and kept at room temperature (20–23°C). Individuals that appeared water-logged were removed, briefly dried with paper towels, and refloated on the water surface. Some recovered and skated normally; others did not and died after a day or two, probably having sustained damage to their water-repellent surfaces. Small isopods and collembolans were offered on the first day, but no *Halobates* was observed to feed on any of these. Laboratory-reared *Drosophila* (of a flightless mutant strain) were then supplied; the skaters commenced to feed as soon as the fruit flies were dropped into the container. They were fed *Drosophila* once a day. Observations were made every 2–3 hours during the first 7 days and daily thereafter.

Three *Halobates* adults and 54 individuals of third to fifth nymphal stages survived the trip. Eighteen individuals (5 III, 8 IV, 4 V, and 1 adult female) died during the next 48 hours. Some specimens moulted within 24 hours after arrival and 3 died during moulting (exuviae remained attached to the bodies). A total of 27 moults were recorded, including 8 of the third, 17 of the fourth, and 2 of the fifth instar. One fifth-instar female died during moult, and the other died 48 hours after the moult.

Moulting occurred only during the morning hours (0530–1100 h); usually before 0800 h. No moulting individuals were found in the daytime between 1300–0500 h. Newly moulted insects were very pale yellow with brown markings; tanning of the cuticle occurred shortly after the moult. Within one hour they had turned greyish and then dull brown; normal coloration (brown with dark brown markings) was achieved in three hours. They were ready to feed within 1–2 hours after the moult.

Almost every day, one or more specimens died, although the water surface was kept clean and all the insects appeared to feed. Dying individuals became sluggish in their movements and seemed somewhat waterlogged. (Active, normal insects place only the tarsal segments of their legs in contact with the water surface; waterlogged insects have tarsus and tibia, and sometimes even the femur, on the water surface.) Such individuals generally died within 24 h. Dead individuals were noted at various times of day or night. Although no insects moulted after the 18th day, mortality continued; the last individual died 29 days after capture.

It is possible that some of the insects could have moulted twice in the month (at 20–23°C), so each nymphal stadium may have lasted 12–14 days. This period is similar to those reported for *Halobates hawaiiensis* (Herring, 1961) and *Metrocoris tenuicornis* (Cheng, 1966).

Although living *Halobates mariannarum* could be transported from the field to a laboratory in California and maintained as a declining population there for one month, none of the nymphs was reared through to the adult stage. One of the factors controlling viability is probably water temperature. In their natural habitat, *H. mariannarum* occur on water at 28–30°C, whereas in the laboratory at La Jolla the water temperature was only 20–23°C. It is not known if they require any special item of diet besides that available from *Drosophila*. Cheng (1966) reared freshwater gerrids through several generations on this diet alone. A recent study at the Galápagos Islands has shown that *Halobates* feed mainly on terrestrial insects trapped at the sea surface (Foster and Treherne, 1980).

Discussion

As the only insect known to have conquered the oceanic habitat, *Halobates* exhibits special adaptations not found in other aquatic or terrestrial insects. They prey on zooplankton trapped at the sea surface (Cheng, 1974), lay eggs on floating material so that they are independent of land for their reproduction (Cheng, 1972), have an efficient water-repellent cuticle which prevents them from drowning when accidentally submerged (Cheng, 1973c), possess well-developed eyes which presumably help them to avoid capture by predators or nets (Cheng, 1973b; Cheng and Enright, 1973), store triglycerides which may enable them to withstand periods of starvation (Lee and Cheng, 1974), and deposit a strongly UV-absorbent material in the cuticle which helps to protect them from possible UV damage (Cheng et al., 1978). There are doubtless many other adaptive features of these interesting marine insects yet to be discovered.

Although the sea-skaters are relatively unknown to scientists working in Micronesia, they are apparently well-known to the local people who call them *Ya-ku-chil* in Palauan, *Li-sa-fi-chi-fich* (meaning fast-moving) in Mortlokese, *Fa-ka-ran* in Yapese, or *Ka-tul We-i-sa* (sea-surface cats) in the outer Yap Islands, and *Ni-fi-chi-fich* in Trukese. *Halobates* are reportedly used in native folk medicine; when taken with coconut juice they reputedly enable one to run faster, while when given to sick persons they may help to exorcise evil spirits. It is suspected that there are no scientific bases to these claims.

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