



Comparison of the Population Density of Oceanic Sea Skater of Halobates (Heteroptera: Gerridae) among Several Areas in the Tropical Pacific Ocean and the Tropical Indian Ocean 【Scientific note】

大洋性海龜在熱帶西太平洋與熱帶印度洋數個地區的族群密度調查【科學短訊】

Tetsuo Harada^{1*}, Takero Sekimoto¹, Koki Iyota¹, Takashi Shiraki¹, Shiho Takenaka¹, Mitsuru Nakajyo¹, Yuki Osumi¹, and Chihiro Katagiri²
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*通訊作者E-mail: haratets@kochi-u.ac.jp

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Abstract

The purpose of this study was to clarify the population density of oceanic Halobates in the western area of the tropical Pacific Ocean and the Indian Ocean around the equator (10°S-10°N). This study was carried out during 4 cruises (MR-06-05-Leg 3, KH-07-04-Leg 1, MR-08-02 and MR-09-04) by the Research Vessels Mirai and Hakuhomaru. Samplings were performed using Ocean Research Institute (ORI) nets and Neuston nets. Halobates micans showed to have a high population density of 10,000 individuals/km² or higher in the western area of the tropical Pacific Ocean at 0-10°N. In the relatively eastern region of this area which is less likely to be affected by freshwater flowing down from rivers of the tropical islands, the population density was around 5,000 individuals/km² and split between 147-156°E and 130-135°E. The distribution of H. sericeus has been reported to being limited to 13-45°N in the Pacific Ocean. However, a relatively moderate population density of between 2,010 to 7,100 individuals/km² was found in the four areas (including the area around the equator) of the western tropical Pacific Ocean. This species may have been transferred by several different currents including the Kuroshio Current, North Equatorial Current, Mindanao Current and the North Equatorial Counter Current throughout the large area of the western Pacific Ocean. In this study, the high population density of H. germanus was estimated to range between 13,000 and 60,000 individuals/km² throughout the longitudinal area of 130-156°E (0-10°N) of the western tropical Pacific Ocean. Halobates princeps (Halobates sp. 1) which has been reported as a shore species inhabiting widely Indonesia and might be a new oceanic specimen, was collected at 2°N, 130°E during the MR-06-05-Leg 3. The body length of males of H. sp. 1 (apical edge of the head to the penis like an arrow) is about 6 mm, and the reach of the mid-legs is 27 mm in a static posture on a flat surface. Individuals of H. sp. 2 were collected in the tropical Pacific Ocean during the three cruises, MR-06-05-Leg 3, MR-08-02, and MR-09-04. Halobates sp. 2 may be another new oceanic species in Halobates. Its size is similar to H. micans, while the body shape (morphometry) and color are very similar to H. sp. 1, which is much larger than that of H. sp. 2.

摘要

全球只有5種大洋性海龜 (Halobates) · 其中3種分布在西太平洋與印度洋。本研究的目地在了解牠們在熱帶太平洋西部與熱帶印度洋地區的族群密度。調查在「未來」和「白鳳丸」兩艘日本研究船於2006~2008年的四次巡航中進行 · 以海洋研究所與紐斯頓網兩種浮游生物網取樣。結果顯示在北半球的熱帶西太平洋地區 · H. micans與H. germanus密度遠高於H. sericeus。前二者在調查區域西端 (0~10°N, 130°E) 的密度皆高達57,000隻/km² · 但是在此以東地區密度驟減 · 並向東遞減 · 只有13,000~17,000隻/km²。此密度差異可能是由於西端靠近印尼與菲律賓 · 有來自溪流入海帶來的豐沛浮游動物或死魚等食物來源。在東經147°以東的調查區域 · H. germanus是優勢物種。H. micans在熱帶印度洋上的密度達42,000隻/km² · 約為H. germanus的17倍 · 而後者僅發現在赤道以北的採樣點。H. sericeus過去僅知分布在13~45°N的西太平洋 · 本研究則發現牠們也分布在熱帶地區 · 密度為2,010~7,100隻/km²。牠們可能是藉由此區域內數個洋流四處轉移或擴張領域。除了三種已知物種外 · 本研究另外發現兩個分布在熱帶西太平洋的大洋性的未定物種 · 但是數量只佔所有海龜的少數 · 牠們的確實身分須經更進一步的研究確認。

Key words: oceanic sea skaters, Halobates, population density, currents

關鍵詞: 大洋性海龜、Halobates、族群密度、洋流。

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Comparison of the Population Density of Oceanic Sea Skater of *Halobates* (Heteroptera: Gerridae) among Several Areas in the Tropical Pacific Ocean and the Tropical Indian Ocean

Tetsuo Harada^{1*}, Takero Sekimoto¹, Koki Iyota¹, Takashi Shiraki¹, Shiho Takenaka¹, Mitsuru Nakajyo¹, Yuki Osumi¹, and Chihiro Katagiri²

¹ Laboratory of Environmental Physiology, Faculty of Education, Kochi University, Kochi 780-8520, Japan

² Low Temperature Institute, Hokkaido University, Sapporo, Hokkaido Pref., Japan

ABSTRACT

The purpose of this study was to clarify the population density of oceanic *Halobates* in the western area of the tropical Pacific Ocean and the Indian Ocean around the equator (10°S-10°N). This study was carried out during 4 cruises (MR-06-05-Leg 3, KH-07-04-Leg 1, MR-08-02 and MR-09-04) by the Research Vessels Mirai and Hakuohmaru. Samplings were performed using Ocean Research Institute (ORI) nets and Neuston nets. *Halobates micans* showed to have a high population density of 10,000 individuals/km² or higher in the western area of the tropical Pacific Ocean at 0-10°N. In the relatively eastern region of this area which is less likely to be affected by freshwater flowing down from rivers of the tropical islands, the population density was around 5,000 individuals/km² and split between 147-156°E and 130-135°E. The distribution of *H. sericeus* has been reported to being limited to 13-45°N in the Pacific Ocean. However, a relatively moderate population density of between 2,010 to 7,100 individuals/km² was found in the four areas (including the area around the equator) of the western tropical Pacific Ocean. This species may have been transferred by several different currents including the Kuroshio Current, North Equatorial Current, Mindanao Current and the North Equatorial Counter Current throughout the large area of the western Pacific Ocean. In this study, the high population density of *H. germanus* was estimated to range between 13,000 and 60,000 individuals/km² throughout the longitudinal area of 130-156°E (0-10°N) of the western tropical Pacific Ocean. *Halobates princeps* (*Halobates* sp. 1) which has been reported as a shore species inhabiting widely Indonesia and might be a new oceanic specimen, was collected at 2°N, 130°E during the MR-06-05-Leg 3. The body length of males of *H.* sp. 1 (apical edge of the head to the penis like an arrow) is about 6 mm, and the reach of the mid-legs is 27 mm in a static posture on a flat surface. Individuals of *H.* sp. 2 were collected in the tropical Pacific Ocean during the

*Corresponding email: haratets@kochi-u.ac.jp

three cruises, MR-06-05-Leg 3, MR-08-02, and MR-09-04. *Halobates* sp. 2 may be another new oceanic species in *Halobates*. Its size is similar to *H. micans*, while the body shape (morphometry) and color are very similar to *H. sp. 1*, which is much larger than that of *H. sp. 2*.

Key words: oceanic sea skaters, *Halobates*, population density, currents

Introduction

A few thousand insect species belonging to more than 20 orders are considered to be marine (Cheng and Frank, 1993; Cheng, 2003). Most marine insects belong to the Coleoptera, Hemiptera, and Diptera orders and can be found in various marine habitats. However, the only insects that live in the open ocean are members of the genus *Halobates*, commonly known as sea skaters. They are part of the family Gerridae (Heteroptera), which also includes common pond skaters or water striders. In contrast to their fresh water relatives in Gerridae, the genus *Halobates* is almost exclusively marine. Adults are small, measuring only about 0.5 cm in body length, but they have rather long legs and may have a leg span of 1.5 cm or more, with the exception of the first finding of originally coastal species, *H. princeps*, in the open ocean currently being described (Harada *et al.*, unpublished results). This individual has a very long body length measuring 0.6 cm and a large mid-leg span of 2.7 cm and has only recently been collected in the tropical Pacific Ocean during the cruise, MR-06-05-Leg 3 by the Research Vessel MIRAI.

The only insects that inhabit the open sea are seven species of sea skaters: *H. micans*, *H. germanus*, *H. sericeus*, *H. splendens*, *H. sobrinus* (Cheng, 1985), *H. princeps* which has been reported as a coastal species, exclusively, so far (Andersen and Chen, 2004) the first finding in the open sea, and a new species, *H. sp. 2* currently being described (Harada

et al., unpublished results) from the 47 species included in the genus, *Halobates*. Three species, *H. sericeus*, *H. micans*, and *H. germanus* inhabit the tropical and temperate areas of the Pacific Ocean in the northern hemisphere, including The Kuroshio Current and the East China Sea (Andersen and Polhemus, 1976; Cheng, 1985; Harada, 2005). *Halobates sericeus*, *H. micans*, and *H. germanus* are reported from latitudes at 5-40°N, 0-35°N, and 0-37°N, respectively, in the Pacific Ocean (Miyamoto and Senta, 1960; Andersen and Polhemus, 1976; Ikawa *et al.*, 2002; Harada, 2005; Harada, unpublished results). Most of the remaining species of *Halobates* are coastal species and occur in near-shore areas of tropical seas associated with mangrove or other marine plants. Many are endemic to islands or island groups (Cheng, 1989).

The population density of oceanic sea skaters is as follows. The summarized data is presented in Table 1 in Andersen & Chen (2004). In the East Atlantic Ocean, *H. micans* has on average an estimated population density of 43,000 to 208,000 individuals/km² in the latitude from 10°N to 15°S (Chen and Schulz-Baldes, 1981). In the Caribbean Sea, the estimated density of *H. micans* is relatively high at an average of about 53,000 individuals/km² at 12°N and low at around 2,400 individuals/km² at 20-35°N (Andersen and Chen, 2004). The population density of *H. micans* in the northeastern Atlantic is 12,600 individuals/km² (Andersen and Chen, 2004) and in the Gulf of Mexico it is 39,000 individuals/km² at 27°N (Andersen

and Chen, 2004). In the eastern tropical Pacific Ocean, *H. micans* show a low population density of 2,000 individuals/km², even at the low latitude of 10-20°N. In the Indian Ocean (Banda Sea), *H. micans* show a low density as well, with 2,000 individuals/km² at 4°S while *H. germanus* has a high density of 15,300 to 71,700 individuals/km² at 4-5°S (Andersen and Chen, 2004). In the western Pacific Ocean, *H. micans* and *H. sericeus* have on average population densities of 3,000 and 7,000 individuals/km², respectively, at 13-20°N (Ikawa *et al.*, 2002). However, no such studies on population density have been carried out in the tropical western Pacific Ocean around the equator (10°N-10°S). In the southern region of the Indian Ocean, which is close to Australia (13-17°S, 114-121°E), the density of *H. micans* was calculated at between 13,000 to 25,000 individuals/km² in 1992-1993 (Ikawa *et al.*, 2007). However, to date little data has been reported on the tropical Indian Ocean in the northern hemisphere.

The purpose of this study was to clarify the population density of oceanic *Halobates* in the western tropical Pacific Ocean and Indian Ocean, for all areas around the equator (10°S-10°N).

Materials and Methods

During the four cruises, samplings were performed with a net during dark, between 1900 hrs and 0500 hrs (see Fig. 1). A net was towed for 15 min once at the starboard side of the Research Vessels Mirai and Hakuohmaru. The towing was replicated two to 8 times during one station with the ship at a speed of 2-2.5 knots.

Science cruise, MR-06-05-Leg 3 (Fig. 1: Region 1)

Samples were collected from 24 December, 2006 to 8 January, 2007 with an Ocean Research Institute (ORI) net (see Fig. 2). The net measured 6 m in

length with a diameter of 1.5 m. The ORI net was towed on the sea surface for 15 min. This was repeated 3 times, at a speed of 2.5 knot at 7 sampling stations ranging from 0°N to 8°N and 130°E or 138°E in the western Pacific Ocean on the starboard side of Research Vessel (R/V) MIRAI (8687 t), which is owned by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The surface area swept by the ORI nets is expressed as a value of the flowmeter x the diameter of the ORI net. During the towing, the duration of the flowmeter appearing above the water surface was measured and the reading of the flowmeter for that duration was then taken into account.

Science cruise, KH-07-04-Leg 1 (Fig. 1: Region 2)

Samples were collected from 24 to 30 December, 2007 using a Neuston net, 57 cm Dia., which was towed five or nine times (20 min duration each time) at each sampling station along the surface of the sea about 10-15 m from the starboard side of the Hakuohmaru (3,991 t), which is owned by JAMSTEC. The cruise was organized by the Ocean Research Institute, of the University of Tokyo. The towing was carried out at 2 knots mostly at night (daytime only at Station 1) at 13 sampling stations, which ranged from 8°N to 6°S and 76°E to 86°E in the Indian Ocean. The surface area swept by the nets is expressed as a value of the flowmeter x the front width of the nets. During the towing, the duration of the flowmeter appearing above the water surface was measured and the reading of the flowmeter for that duration was then taken into account.

Science cruise, MR-08-02 (Fig. 1: Regions 3, 4)

Samplings were performed from 1-27 June, 2008 using the above-mentioned ORI net which was towed for 15 min on the surface of the sea at 8 stations ranging

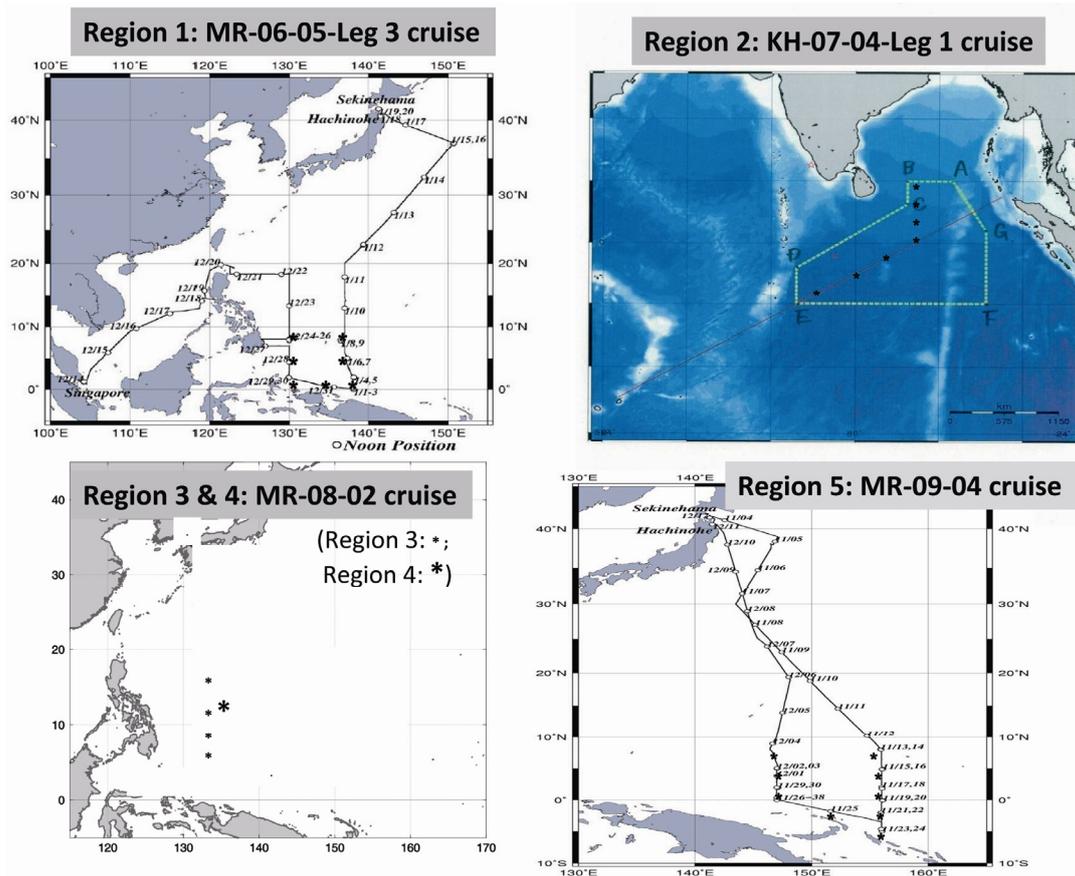


Fig. 1. The tracks of the science cruises of Regions 1-5. Region 1: 0-8°N, 130°N-138°E in the western tropical Pacific Ocean during cruise MR-06-05-Leg 3; Region 2: 8°N-6°35'S, 86°-76°36'E in the eastern tropical Indian Ocean during cruise KH-07-04-Leg 1; Region 3: 5°-17°30'N, 130°-134°E in the western tropical Pacific Ocean during cruise MR-08-02; Region 4: a fixed point of 12°N, 135°E in the western tropical Pacific Ocean during cruise MR-08-02; Region 5: MR-09-04: 0-10°N, 147°-156°30'E in the western and central tropical Pacific Ocean during cruise MR-09-04.

from 5°N to 17°N and from 130°E to 135°E in the western Pacific Ocean on the starboard side of the R/V Mirai. The towing was repeated three times at each station. At Station 8, the samplings were performed starting at 1900 hrs every day from 8-27 June, 2008 (Region 4).

Science cruise, MR-09-04 (Fig. 1: Region 5; Fig. 3)

Samplings were performed from 1-27 June, 2008 with a larger Neuston net (6 m

long and with a diameter of 1.3 m). The Neuston net was towed for 45 min (15 min each, repeated 3 times) on the sea surface at 8 stations ranging from 0°N to 10°N and 147°E or 156°E in the western Pacific Ocean on the starboard side of the R/V Mirai. The towing was performed for 15 min mostly at night (early in the morning at Station 6) at a speed of 2 knots. The surface area that was swept by the Neuston nets was evaluated and expressed as: [flow-meter value of the ORI net trial



Fig. 2. ORI net towed on the surface of the western Pacific Ocean on the starboard side of R/V MIRAI (Cruise No. MR-06-05-Leg 3) at night at a speed of 2.5 knots, using a net that was 6 m long and with a diameter of 1.5 m

at MR-06-05-Leg 3 x diameter of the ORI net x (130 cm of the width of the Neuston net/150 cm of the diameter of ORI net) x 2.0 knot/2.5 knot] based on the data obtained for similar samplings with an ORI net in MR-06-05-Leg 3, at which the ORI net was swept at the ship speed of 2.5 knots, whereas the Neuston net at MR-09-04 was done at that of 2.0 knots.

The area that was swept by the Neuston net during the 45 min towing was estimated at approx. 2905 m².

Results

Population density of *Halobates* in the western Pacific Ocean and Indian Ocean

Halobates micans have a high population

density of 10,000 individuals or more/km² in the tropical western Pacific Ocean at 0-10°N (Figs. 4, 5). In the eastern region of this area which is less likely to be affected by freshwater flowing down from rivers of the tropical islands, the population density of *H. micans* is around 5,000 individuals/km² split between 147-156°E and 130-135°E. *Halobates micans* occupies the tropical Indian Ocean with a high population density of more than 20,000 individuals/km², while *H. germanus* which inhabits only the tropical Northern hemisphere has a much lower population density at around 2,000 individuals/km² in the tropical Indian Ocean (Region 2, Fig. 5). A high population density of *H. germanus* at 15,000 individuals/km² was estimated for the eastern region of the tropical western Pacific Ocean (Fig. 5).

Many of the larvae of *H. princeps* [*H. sp. 1* in the open ocean, in accordance with the keys for all the described species of *Halobates* in the Appendix of Andersen & Chen (2004)] [reported as a shore-species widely distributed in Indonesia so far by Andersen and Chen (2004)] collected in Region 1 (at 2°N, 130°E during MR-06-05-Leg 3) in this study might be a new 6th oceanic species in the oceanic *Halobates* (Harada *et al.*, 2011). The body length of these males (apical edge of the head to the penis like an arrow) is about 6 mm, and the reach of the mid-legs is 27 mm in a flat static posture on a surface. Individuals of another smaller species, *Halobates sp. 2* were collected in Regions 1, 3, 5 during the three cruises, MR-06-05-Leg 3, MR-08-02, and MR-09-04.

Discussion

The distribution of *H. sericeus* has been reported to be limited to 13-45°N in the Pacific Ocean (Andersen and Chen, 2004). However, a moderate population density of 2,010-7,100 individuals/km² was estimated for the four areas (including the area around the equator) in the western



Fig. 3. Neuston net towed on the surface of the western Pacific Ocean on the starboard side of R/V MIRAI (Cruise No. MR-09-04) at night at a speed of 2 knots, using a net that was 6 m long and with a diameter of 1.3 m.

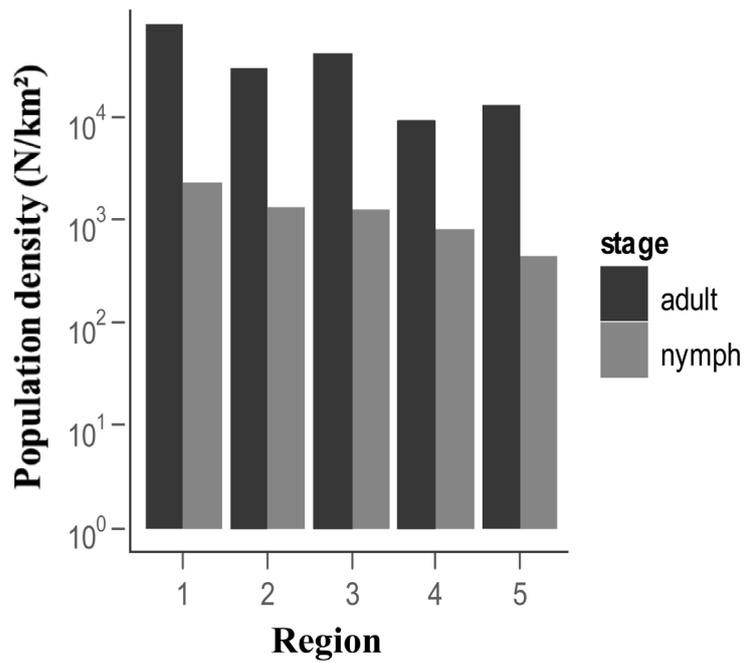


Fig. 4. Comparison of the estimated total population density of adults and larvae of the ocean sea skaters, *Halobates* at 5 regions in the tropical Pacific and Indian Oceans. The area swept by the net was 0.0293303 km² in Region 1, 0.044292 km² in Region 2, 0.0293303 km² in Region 3, 0.0838009 km² in Region 4 and 0.0335203 km² in Region 5.

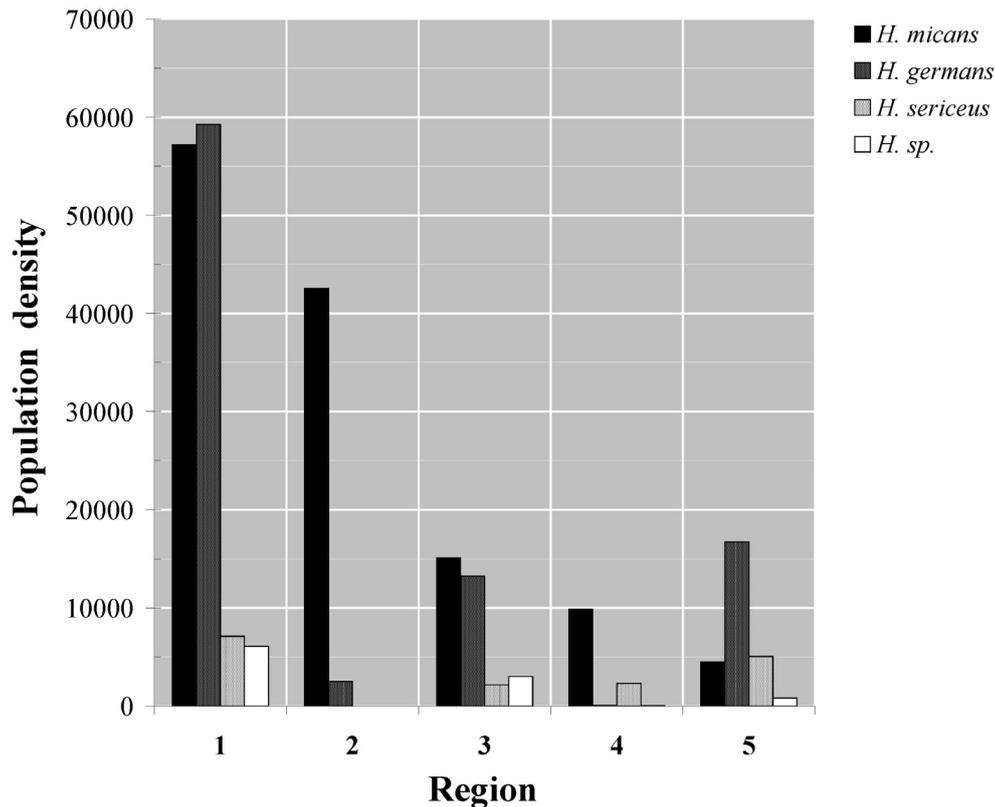


Fig. 5. Comparison of the estimated population density of each species of ocean sea skaters at 5 regions in the tropical Pacific and Indian Oceans. For the explanation of the Regions, see the legend for the Fig. 1. Region 1: *Halobates* sp. 1 [*H. princeps* which has been reported as exclusively shore-species in the East Asia by Andersen & Chen (2004)] and *H. sp.* 2 (proposed *H. moomario*) combined; Regions 3, 4, 5: *Halobates* sp. 2 exclusively.

tropical Pacific Ocean. This species may have been actively transferred by several currents, including the Kuroshio Current, North Equator Current, Mindanao Current and the North Equator Counter Current, throughout a wide area of the western Pacific Ocean.

No studies have been performed at all so far on the population density of *H. germanus* in the low latitude area of 0-10°N in the tropical Pacific Ocean (Andersen and Chen, 2004). The present study estimated a high population density of 13,000 to 60,000 individuals/km² of this species throughout the large longitudinal

area of 130-156°E (0-10°N) of the western tropical Pacific Ocean. At the western point of 130°E, we measured a high population density of around 50,000 individuals/km² for both *H. germanus* and *H. micans*. This high density may be due to the supply of fresh water from the rivers on the Indonesian and Philippine Islands, resulting in a rich food supply zooplankton (Chen, 1985) and dead fish for the oceanic *Halobates*. In the eastern region of 147-156°E, 0-10°N, *H. germanus* may be the dominant species among the oceanic sea skaters.

Only the three species *H. micans*, *H.*

germanus and *H. sericeus* have been reported in the western Pacific Ocean (Chen, 1985). *H. princeps* (*H.* sp. 1) which has been found in the open ocean for the first time in this study, is larger than the largest species, *H. micans*, of the three known oceanic species to inhabit the Pacific Ocean. Moreover, *H.* sp. 2 (the proposed species name, *H. moomario*) may be another new oceanic species in *Halobates*. Its size is similar to that of *H. micans*, while the body shape (morphometry) and color are very similar to *H. princeps* (*H.* sp. 1), which is much larger than the *H.* sp. 2.

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大洋性海龜在熱帶西太平洋與熱帶印度洋數個地區的族群密度調查

Tetsuo Harada^{1*}, Takero Sekimoto¹, Koki Iyota¹, Takashi Shiraki¹, Shiho Takenaka¹, Mitsuru Nakajyo¹, Yuki Osumi¹, and Chihiro Katagiri²

¹ Laboratory of Environmental Physiology, Faculty of Education, Kochi University, Kochi 780-8520, Japan

² Low Temperature Institute, Hokkaido University, Sapporo, Hokkaido Pref., Japan

摘要

全球只有 5 種大洋性海龜 (*Halobates*)，其中 3 種分布在西太平洋與印度洋。本研究的目地在了解牠們在熱帶太平洋西部與熱帶印度洋地區的族群密度。調查在「未來」和「白鳳丸」兩艘日本研究船於 2006~2008 年的四次巡航中進行，以海洋研究所與紐斯頓網兩種浮游生物網取樣。結果顯示在北半球的熱帶西太平洋地區，*H. micans* 與 *H. germanus* 密度遠高於 *H. sericeus*。前二者在調查區域西端 (0~10°N, 130°E) 的密度皆高達 57,000 隻/km²，但是在此以東地區密度驟減，並向東遞減，只有 13,000~17,000 隻/km²。此密度差異可能是由於西端靠近印尼與菲律賓，有來自溪流入海帶來的豐沛浮游動物或死魚等食物來源。在東經 147° 以東的調查區域，*H. germanus* 是優勢物種。*H. micans* 在熱帶印度洋上的密度達 42,000 隻/km²，約為 *H. germanus* 的 17 倍，而後者僅發現在赤道以北的採樣點。*H. sericeus* 過去僅知分布在 13~45°N 的西太平洋，本研究則發現牠們也分布在熱帶地區，密度為 2,010~7,100 隻/km²。牠們可能是藉由此區域內數個洋流四處轉移或擴張領域。除了三種已知物種外，本研究另外發現兩個分布在熱帶西太平洋的大洋性的未定物種，但是數量只佔所有海龜的少數，牠們的確實身分須經更進一步的研究確認。

關鍵詞：大洋性海龜、*Halobates*、族群密度、洋流。