

FIRST REPORT ON TWO OSTRACOD GENERA *Loxoconcha* Sars, 1866 (Loxoconchidae) AND *Xestoleberis* Sars, 1866 (Xestoleberididae) ALONG THE COAST OF VIETNAM

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ABSTRACT

One survey was done with SCUBA diving in Ha Long Bay and Cat Ba Island, Northern Vietnam (December 2013) and another one at Nha Trang Bay Marine Protected Area, Nha Trang city, Central Vietnam and Phu Quoc Marine Protected Area, Kien Giang Province, Southern Vietnam (November 2014). Sixteen species of the genus *Loxoconcha* and fourteen species of the genus *Xestoleberis* were found and identified. Eight species of the genus *Loxoconcha* were identified in group A, three species in group B, two in group C and three unidentified. Meanwhile, twelve species of the genus *Xestoleberis* were classified in group A and two in group B according to phylogenetic groups. From geographical distribution of the pore groups of the species in two genera *Loxoconcha* and *Xestoleberis* showed that the fauna of these genera in Vietnam is close to those of southern part of Japanese Island Arc, i.e., from Amami Island to the Philippines and Australia rather than Japanese Island Arc faunas.

Keywords: Ostracods, bioinventory, Cat Ba Island, Ha Long Bay, Nha Trang Bay, Phu Quoc MPA.

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INTRODUCTION

Loxoconcha Sars, 1866 (Loxoconchidae) and *Xestoleberis* Sars, 1866 (Xestoleberididae) are the most diverse ostracod genera. A total of 575 *Loxoconcha* species and 344 *Xestoleberis* species have been recorded around the world (Brandão et al., 2015). The members of these two genera are distributed in low to middle latitude areas in marine and brackish waters (Kempf 1986a, 1986b). Many have been described from Southeast and East Asia (Brady, 1880; Kajiyama, 1913; Ishizaki, 1968, 1971; Schornikov, 1974; Okubo, 1979, 1980, 1985; Sato & Kamiya, 2007; Tanaka et al., 2009; Le & Tsukagoshi, 2014; Le et al., 2016).

For the genus *Loxoconcha*, basing on the distributional pattern of pore systems below the eye tubercle, the *Loxoconcha* species were divided into the two groups (A and B) by Ishii et al. (2005) so far, and later, Le & Tsukagoshi (2014) showed the third group C (Fig. 1). For the genus *Xestoleberis*, morphologically, three types of carapace pores were found and identified in this genus, i.e., lip-type (Fig. 2a, 2b), sieve-type (Fig. 2c)

and simple-type (Fig. 2d) (Hanai & Ikeya, 1991; Sato & Kamiya, 2007). Based on the combination of the morphological types of pore systems on carapace, species of *Xestoleberis* were divided into three groups (Sato & Kamiya, 2007). The Group A of *Xestoleberis* has both sieve-type and lip-type pores. The Group B has only sieve-type pore. The Group C has simple-type and sieve-type pores (Fig. 2). These groupings are consistent with their estimated phylogeny and reflects phylogeny of each genus (Ishii et al., 2005; Sato & Kamiya, 2007).

Few newly ostracod species described from Vietnam's fauna. The study by Tanaka et al. (2009) on *L. ocellata*, *L. vietnamensis* and *Caudites huyeni* from the northeastern coast of Vietnam was the first one. The second work by Tanaka et al. (2016) on the ostracod species from Vietnam was concerning *Paracobanocythere vietnamensis* collected in southwest area of Vietnam. Le & Tsukagoshi (2018) described three new species of the genera *Loxoconcha* and *Xestoleberis* from central and southern Vietnam, and this was the third work on Vietnamese ostracods.

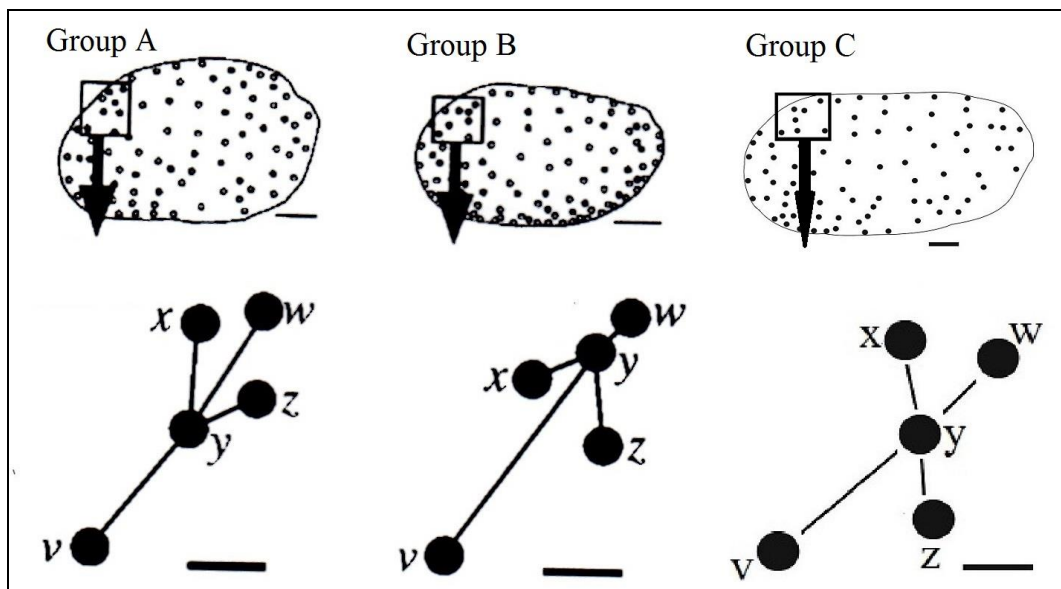


Figure 1. Illustration about the difference of pore systems below the eye tubercle of three groups of *Loxoconcha*. Groups A and B were defined by Ishii et al., 2005; Group C by Le & Tsukagoshi, 2014. Scale bars = 200 μm

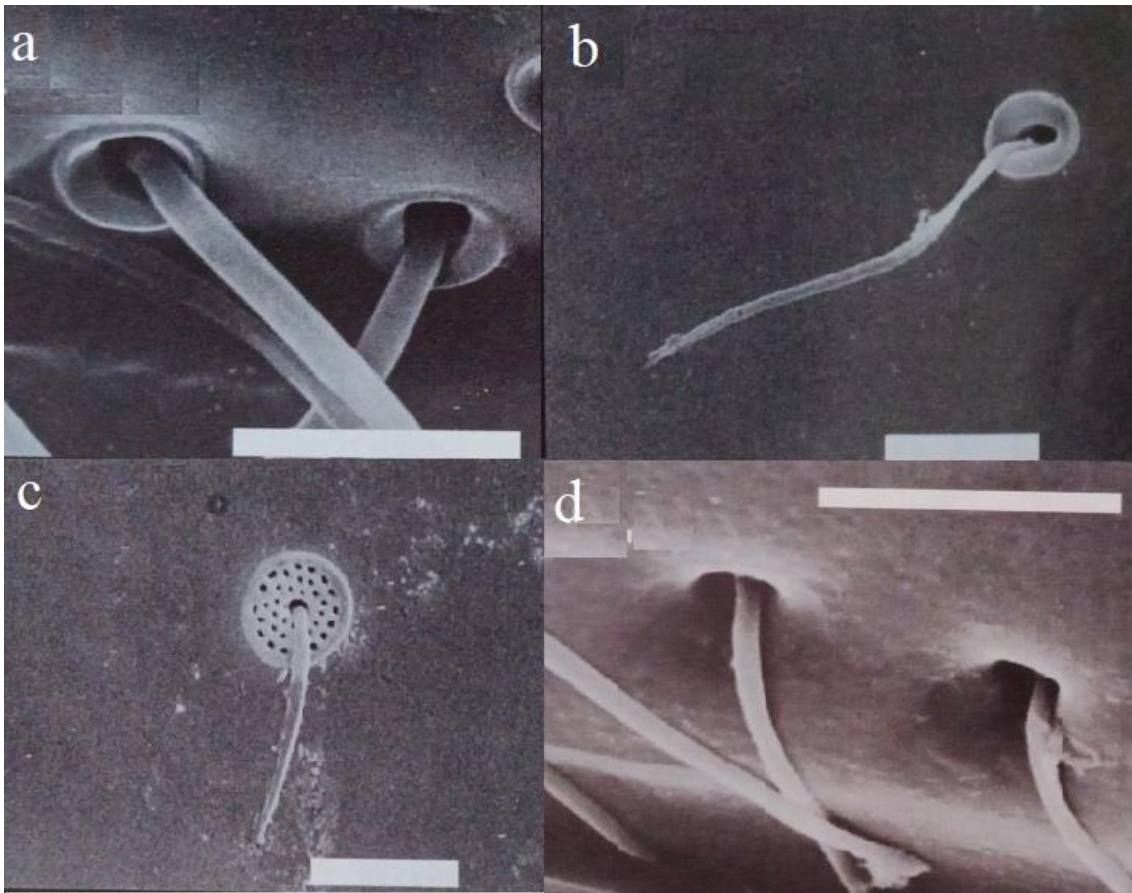


Figure 2. SEM images of three types of pore of *Xestoleberis* (Sato & Kamiya, 2007): a, b- Lip-type of *X. ryukyuensis*; c-Sieve-type of *X. ryukyuensis*; d-Simple-type of *X. sagamiensis*. Scale bars = 5 μ m

This study will not only contribute to the understanding of the ostracod fauna of Vietnam, but allow a comparison of the ostracod faunas between Vietnam and adjacent seas according to soft anatomy as well. In addition, a new angle to meiofauna in the discussion of marine biodiversity hotspot (see Roberts et al. 2002), likely harboring abundant undescribed species was also provided.

MATERIALS AND METHODS

Sampling was conducted during low tide with SCUBA diving where the diver used a self-contained underwater breathing apparatus (SCUBA) in the four areas, i.e., Phu Quoc Marine Protected Area, Phu Quoc Island, Kien Giang Province Southwest

Vietnam; Nha Trang Marine Protected Area, Nha Trang city, Central Vietnam; World Heritage Area, Ha Long Bay, and Cat Ba Island, Northern Vietnam (Fig. 3). Of two surveys conducted in 2013 and 2014, the first was at the coast of Ha Long Bay and Cat Ba Island in December 2013 and the second was at Nha Trang Bay Marine Protected Area and Phu Quoc Marine Protected Area in November 2014.

In the research sites (Fig. 3), where the water depth was estimated about 4–6 m, sea weed and sea algae living in coral reefs were collected and put into a plastic bottle using a scoop. Then, all of the collected specimens were fixed in 5–10% formaldehyde that had

been neutralised with hexamethylenetetramine, before being washed through 16-mesh (# 1 mm) and 250-mesh (# 0.063 mm) sieves. Part of the washed material was fixed with 70–80% alcohol for later observations of the appendages, and the remaining material was dried.

sizes, the type of pore, and number of pore. Data on carapace sizes are included in the description section of this paper.

All the specimens were deposited in the collections of the Shizuoka University Museum (Japan) and are identified by numbers with the prefix SUM-CO.

RESULTS AND DISCUSSION

Species composition

Sixteen species of the genus *Loxoconcha* and fourteen species of the genus *Xestoleberis* were identified and found at the Ha Long Bay, Quang Ninh Province; Nha Trang Bay, Khanh Hoa Province and Phu Quoc island, Kien Giang Province of Vietnam (Fig. 4, table 1). Because of lacking of living specimens, a considerable number of specimens were not identified to species yet, i.e. unidentified species are indicated using sp. (table 1). Only four species of the genus *Loxoconcha* and two species of the genus *Xestoleberis* were named. According to living habitat, species of *Loxoconcha* and *Xestoleberis* belong to two types, phytal and bottom species. All species of the two genera lived in the normal marine water, especially *Loxoconcha ocellata* can live in marine and brackish water.

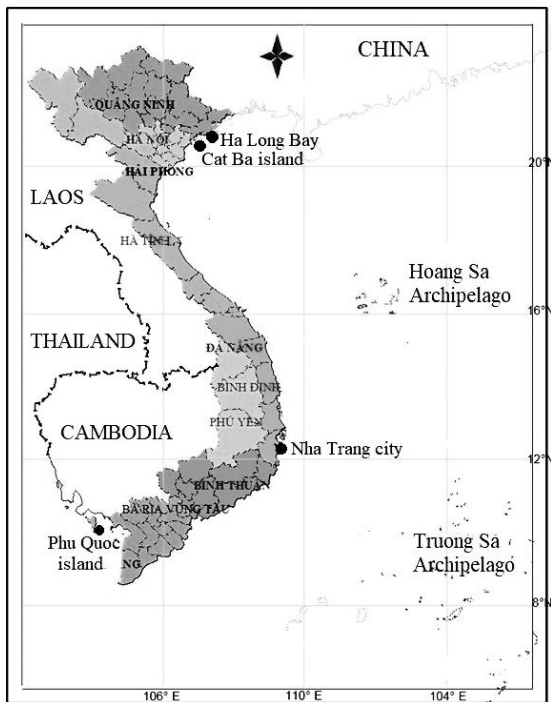


Figure 3. Map of Vietnam showing four surveyed areas with solid circles, Phu Quoc Island, Nha Trang Bay, Ha Long Bay and Cat Ba Island

All the specimens were dissected under a stereoscopic microscope in the laboratory. Appendages and carapaces were observed and sketched using a differential interference contrast microscope with a camera lucida (BX-50, OLYMPUS). Dried valves and individuals were coated with gold using a quick auto-coater (JFC-1500, Ion Sputtering Device) and were then observed with a scanning electron microscope (SEM) (JSM-5600LV, JEOL). SEM photos were used to measure carapace

In comparison with the other adjacent areas, the total number of species of these two genera in Vietnam is fewer than that of other areas, e.g., Okinawa Islands, Philippines, Australia, Japanese Island Arc (table 2). The reasons for explaining this matter are due to limitations of number of specimens and investigated locations.

According to the phylogenetic groups, eight species of the genus *Loxoconcha* were identified in group A, three species in group B, two in group C and three unidentified. Meanwhile, for the case of the genus *Xestoleberis*, twelve species of this genus were classified in group A and two in group B (Figs. 5, 6, table 1).

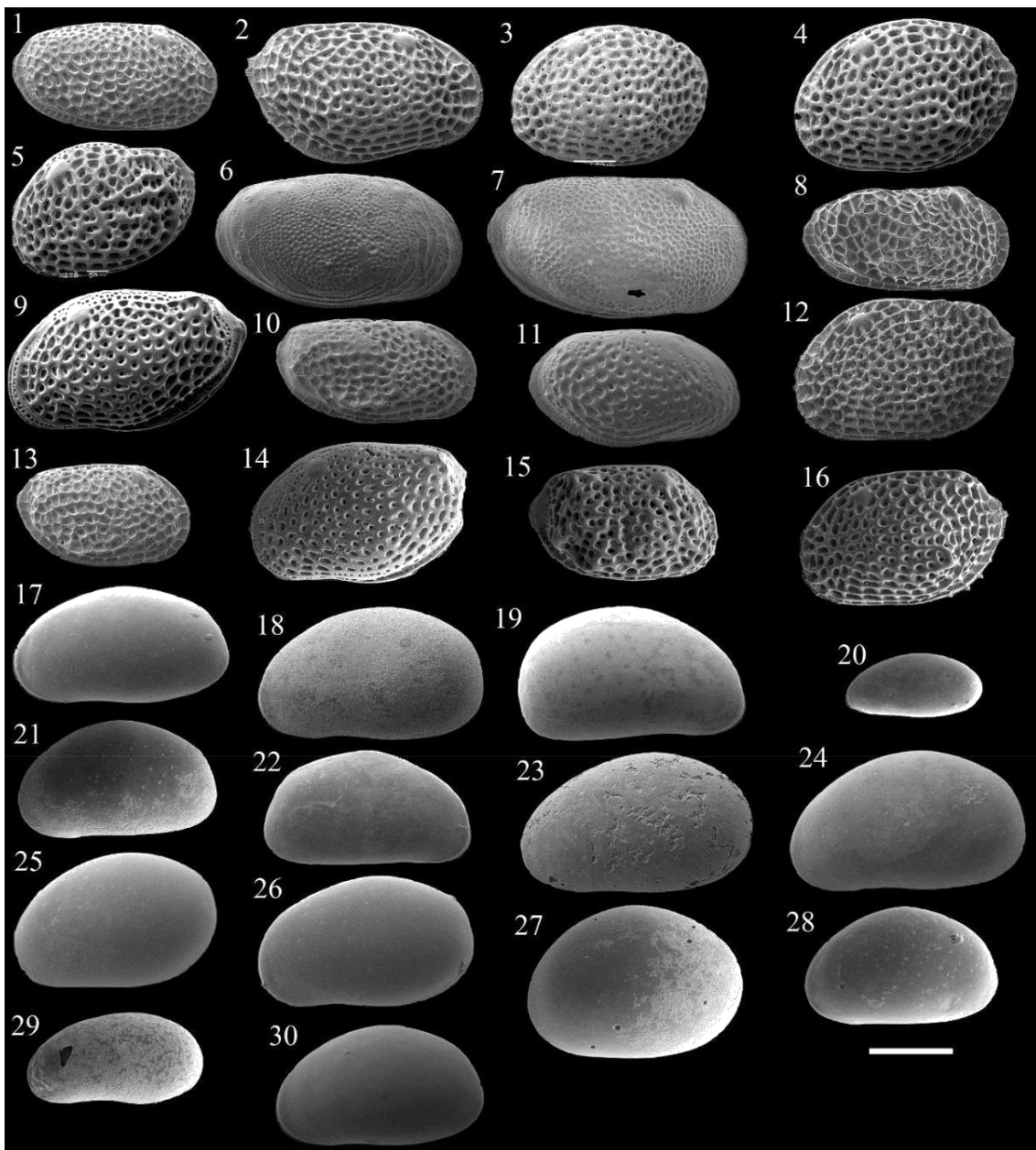


Figure 4. External view of examined ostracod carapaces from Vietnam: 1, *Loxoconcha* sp. 11 (male, RV); 2, *L.* sp. 18 (male, RV); 3, *L.* sp. 19 (LV); 4, *L.* sp. 20 (LV); 5, *L.* sp. 21 (LV); 6, *L.* sp. 22 (male, RV); 7, *L. ocellata* (male, RV; after Tanaka et al., 2009); 8, *L. vietnamensis* (male, RV); 9, *L. damensis* Le & Tsukagoshi, 2018 (male, RV); 10, *L.* sp. 23 (RV); 11, *L.* sp. 24 (LV); 12, *L.* sp. 25 (LV); 13, *L.* sp. 26 (female, RV); 14, *L. lilljeborgii?* (LV); 15, *L.* sp. 28 (RV); 16, *L.* sp. 29 (LV); 17, *Xestoleberis* sp. 7 (male, LV); 18, *X.* sp. 9 (LV); 19, *X.* sp. 10 (RV); 20, *X.* sp. 11 (LV); 21, *X.* sp. 12 (LV); 22, *X. vietnamensis* Le & Tsukagoshi, 2018 (male, RV); 23, *X.* sp. 13 (LV); 24, *X.* sp. 14 (LV); 25, *X.* sp. 15 (LV); 26, *X.* sp. 16 (LV); 27, *X.* sp. 17 (LV); 28, *X. munensis* Le & Tsukagoshi, 2018 (LV); 29, *X.* sp. 19 (LV); 30, *X.* sp. 20 (male, LV). Scale = 200 μ m. Abbreviations: LV, left valve; RV, right valve

Table 1. List of examined species in this study and their sampling location, habitat, habitat salinity and the phyletic group to which they belong

Species name	Sampling location	Habitat	Salinity	Group
<i>Loxoconcha</i> sp. 11	Soi Sim island, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	Bottom	n	C
<i>L.</i> sp. 18	Ba Trai Dao island, Cat Ba Island, Hai Phong city, northern Vietnam	Phytal	n	A
<i>L.</i> sp. 19	Ba Trai Dao island, Cat Ba Island, Hai Phong city, northern Vietnam	-	-	A
<i>L.</i> sp. 20	Sung Sot cave, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	-	-	A
<i>L.</i> sp. 21	Sung Sot cave, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	-	-	A
<i>L.</i> sp. 22	Ba Trai Dao island, Cat Ba Island, Hai Phong city, northern Vietnam	Bottom	-	B
<i>L. ocellata</i>	Thien Cung cave, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	Bottom	b-n	B
<i>L. vietnamensis</i>	Van Don island, Quang Ninh Pro., northern Vietnam	Bottom	n	C
<i>L. damensis</i> Le & Tsukagoshi, 2018	Dam Ngoai island, Phu Quoc MPA, Phu Quoc Island, Kien Giang Pro., southern Vietnam	Phytal	n	A
<i>L.</i> sp. 23	Bai Thom beach, Phu Quoc Island, Kien Giang Pro., southern Vietnam	-	n	-
<i>L.</i> sp. 24	Saraku resort, Nha Trang city, central Vietnam	-	n	-
<i>L.</i> sp. 25	Saraku resort, Nha Trang city, central Vietnam	-	n	A
<i>L.</i> sp. 26	Saraku resort, Nha Trang city, central Vietnam	Bottom	n	B
<i>L. lilljeborgii</i>	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	Phytal	n	A
<i>L.</i> sp. 28	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	-	n	-
<i>L.</i> sp. 29	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	Phytal	n	A
<i>X.</i> sp. 7	Sung Sot cave, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	Bottom	n	A
<i>X.</i> sp. 9	Ba Trai Dao island, Cat Ba Island, Hai Phong city, northern Vietnam	-	n	A
<i>X.</i> sp. 10	Vung Tau, Long Chau island, Cat Ba island, Hai Phong city, northern Vietnam	-	n	A
<i>X.</i> sp. 11	Soi Sim island, Ha Long Bay, Ha Long city, Quang Ninh Pro., northern Vietnam	-	n	A
<i>X.</i> sp. 12	Ba Trai Dao island, Cat Ba Island, Hai Phong city, northern Vietnam	-	n	A
<i>X. vietnamensis</i> Le & Tsukagoshi, 2018	Dam Ngoai island, Phu Quoc MPA, Phu Quoc Island, Kien Giang Pro., southern Vietnam	Bottom	n	A
<i>X.</i> sp. 13	Bai Thom beach, Phu Quoc Island, Kien Giang Province, southern Vietnam	-	n	A

X. sp. 14	Dam Trong island, Phu Quoc MPA, Phu Quoc Island, Kien Giang Pro., southern Vietnam	-	n	A
X. sp. 15	Dam Trong island, Phu Quoc MPA, Phu Quoc Island, Kien Giang Pro., southern Vietnam	-	n	B
X. sp. 16	Saraku resort, Nha Trang city, central Vietnam	-	n	A
X. sp. 17	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	-	n	B
X. <i>munensis</i> Le & Tsukagoshi, 2018	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	-	n	A
X. sp. 19	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	-	n	A
X. sp. 20	Hon Mun island, Nha Trang Bay MPA, Nha Trang city, central Vietnam	-	n	A

Geographical distribution of species groups of the genera *Loxoconcha* and *Xestoleberis*

Basing the distributional pattern of pore systems below the eye tubercle, the, Ishii et al. (2005) divided *Loxoconcha* species from Japan into the two groups (A and B), further, Le & Tsukagoshi (2014) showed the third group C. The groups of the genus *Loxoconcha* living around the Okinawa Islands include the groups A, B and C, meanwhile those around Japanese Island Arc fauna are the groups A and B. For the case of the genus *Xestoleberis*, the species of the older taxonomic groups (Groups A and B) are abundantly found in the Okinawa Islands, whereas most of species around Japanese Island Arc belong to the

derived taxonomic Group C and few species classify into the Group A. Along the coast of Vietnam, the species of the genus *Loxoconcha* belong to the Groups A, B and C; the species of genus *Xestoleberis* to the Groups A and B; of the Philippines, the genus *Loxoconcha* (Groups A and C), the genus *Xestoleberis* (Groups A and B); of Australia, the genus *Loxoconcha* (Groups A and C), the genus *Xestoleberis* (Groups A and B) (Figs. 5, 6 and table 2). Overall, geographical distribution of the pore groups of the species of two genera *Loxoconcha* and *Xestoleberis* in Vietnam is close to southern faunas of Japanese Island Arc, i.e., from Amami Island to the Philippines and Australia rather than Japanese Island Arc faunas.

Table 2. Geographical distribution of species of the genera *Loxoconcha* and *Xestoleberis*

Genus	Pore group	Geologic age	Japanese Island Arc	Amami Island	Okinawa Islands	Vietnam	Philippines	Australia
<i>Loxoconcha</i>	A	Old	x	x	x	x	x	x
	B	Median	x	x	x	x	?	?
	C	Young	-	x	x	x	x	x
	Number of species		26	18	22	20	22	33
<i>Xestoleberis</i>	A	Old	x (*)	x (**)	x (**)	x (**)	x (**)	x (**)
	B	Old	-	x	x	x	x	x
	C	Young	x	-	-	-	-	-
	Number of species		13	ND	13	14	16	37

Notes: (x) Present; (-) No present; (*) Rare; (**) Common; (ND) No data.

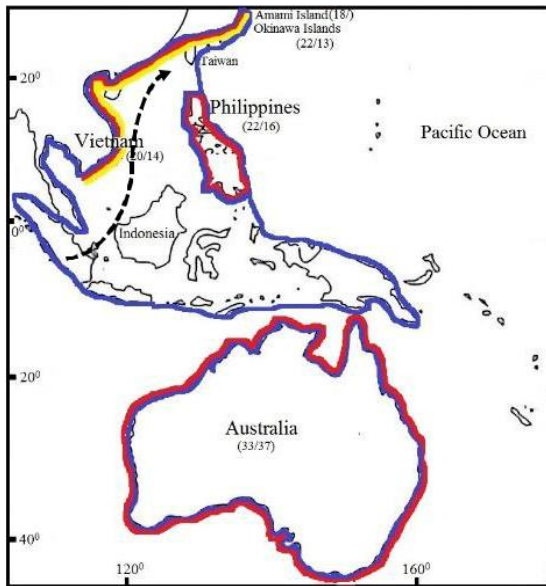


Figure 5. Geographical distribution of three groups and suggested migratory route of the genus *Loxoconcha*. Group A: blue colour; Group B: yellow colour; Group C: red colour; Migratory route: black dot arrows. Bracketed figures indicate the number of species of *Loxoconcha* (numerator) and of *Xestoleberis* (denominator)

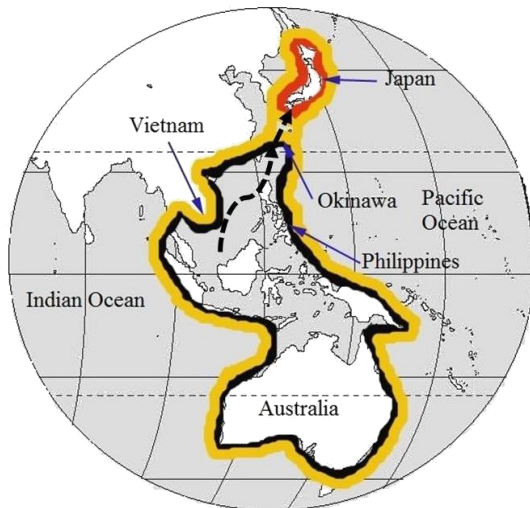


Figure 6. Geographical distribution of three groups and suggested migratory route of the genus *Xestoleberis*. Group A, yellow colour; Group B, red colour; Group C, black colour; migratory route, black dot arrows

CONCLUSIONS

Although there is very little research on ostracoda in along the coast of Vietnam, the results from this study show that ostracoda's biodiversity in Vietnam's waters is diverse with sixteen species of the genus *Loxoconcha* and fourteen species of the genus *Xestoleberis* identified.

According to the phylogenetic groups, eight species of the genus *Loxoconcha* were identified in group A, three species in group B, two in group C and three unidentified. For the case of the genus *Xestoleberis*, twelve species of this genus were classified in group A and two in group B. Species groupings are consistent with their estimated phylogeny and reflects phylogeny of each genus.

Geographical distribution of the pore groups of the species in two genera *Loxoconcha* and *Xestoleberis* in Vietnam is close to southern faunas of Japanese Island Arc, i.e., from Amami Islands to the Philippines and Australia rather than Japanese Island Arc faunas.

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