



A new ostracod species of the genus *Xestoleberis* from Nansen Island, Wilhelmina Bay, Southern Ocean, Antarctica

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Abstract

Comparing to the ostracod studies on the other islands in the world, studies on the ostracod fauna of the islands in Antarctica are scarce. During the sixth Turkish Antarctica Expedition (TAE 6) to the islands (Dismal, Horseshoe, Nansen, Livingstone) in Western Antarctica, sediment and water samples were collected from 32 different water bodies (lakes, ponds, creeks, springs, littoral zones of sea). Among several new reports of different taxonomic groups which are under investigation, a new marine ostracod species (*Xestoleberis nansenensis* n. sp.) was encountered from Nansen Island. This is the first report of an ostracod from this island below 60° S in Antarctica. The new species has several different features both in the carapace and soft body parts. Absence of ostracods from other islands sampled may be related to several a/biotic factors, such as water chemistry (e.g., relatively low calcium levels), extreme aquatic conditions (e.g., low-temperature values), improper habitat conditions (e.g., too little or absence of sediment in the water bodies), and isolation of the island(s) from the mainland. Although our new species is a marine form, comparative literature review indicated that there is no non-marine living ostracod species reported from the islands visited during the expedition. Possible reasons are discussed.

Keywords Antarctica · Nansen Island · Water chemistry · Distribution · Ecology

Introduction

Previous studies on marine ostracods [Kornicker 1970, 1975; Hartmann 1986, 1992; Whatley et al. 1998 (and references in there)]; Dingle 2000, 2003; Brandão and Dingle 2014; Brandão et al. 2019; De Broyer et al. 2021; Salvi et al. 2022) and on other taxonomic groups (e.g., Pugh et al. 2002; Hodgson et al. 2013; Melis and Salvi 2020) showed relatively high and unique (e.g., mostly endemic, rare) species diversity in Antarctica, the fifth largest continents of the world. Accordingly, there are between 571 and 515 marine ostracods (Brandão and Dingle 2014; Brandão et al. 2019) reported from the continent. Also, there are about 223 species of the genus *Xestoleberis* distributed worldwide (Brandão et al. 2023). In contrast to the marine ostracods, knowledge on the non-marine ostracods within 60° S is not well known from the area. Although studies (e.g., Pugh et al. 2002; Dartnall 2017) listed nine non-marine taxa, none of

them seems to be found from the islands visited during the present study within 60° S. The aims of this study are to (1) describe a new ostracod species from Nansen Island, (2) provide information about physicochemical properties of water samples and discuss possible reasons of the species absence, and (3) inquire into the previous reports on non-marine ostracods from the continent Antarctica south of 60° S latitude.

Materials and methods

During the sixth Turkish Antarctica Expedition (TAE 6) to Western Antarctica including four islands, about 200-mg materials for the ostracods were collected in the plastic bottles and fixed with 70% ethanol in situ. Also, 100 mL of sediment and water samples were separately collected from 32 different water bodies (lakes, ponds, creeks, springs, marine, etc.) for the chemical analyses (Fig. 1). Plankton hand net (mesh size 150 µm) was used to collect samples from littoral zones and shallow water bodies, while core samplings were done from the middle of the lakes along with drilling core sampler. Samples were brought to the laboratory in the

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Fig. 1 Four islands (1-Dismal, 2-Horseshoe, 3-Nansen, 4-Livingstone) visited during the TAE 6 expedition



cooler where ostracod samples were kept in 70% of ethanol after filtering them under tap water through three standardized sieves with mesh size of 1:0.25:0.125 mm. Olympus BX-51 model stereo microscope was used to separate ostracods from the sediment. Fine needles were used to dissect specimens within lactophenol solution on slides. Specimens dissected were covered by a cover slip. Line drawings of the soft body parts were sketched with a camera lucida. All samples and slides are numbered and deposited in the Limnology Laboratory of the Biology Department. During the field studies, YSI multiprobe was used to measure the values of water variables (e.g., temperature, pH, salinity, electrical conductivity, redox potential, and dissolved oxygen), while water chemistry (i.e., major anions and cations) analyses were done at the Water Chemistry Laboratory, Hacettepe University (Türkiye). Standard Methods for the Examination of Water and Wastewater, Methods (APHA 1989) along with

using DIONEX LC25, ICS-1000 Ion Chromatography system was run for the chemical analyses. Geographic information (e.g., ambient temperature, humidity and atmospheric pressure, latitude, longitude, elevation) was gathered with Kernel Anemometer before sampling at each site. Scanning Electron Microscope (SEM) photographs were taken at the Hacettepe University, Türkiye.

Results

Taxonomy

Description:

Superfamily Cytheroidea Baird, 1850
Family Xestoleberididae Sars, 1928

Genus *Xestoleberis* Sars, 1866*Genus: Xestoleberis* Sars, 1866

The genus *Xestoleberis* is characterized as follows: Valves with crescent shaped scar so-called “Xestoleberis-eye spot” (Athersuch et al. 1989). Carapace surface is smooth and its shape strongly inflated from ovate, reniform to trigonal. Antennula (A1) has six segments, while Antenna (A2) has two segmented exopodite spinneret seta and three endopodite segments terminating into two stout claws. Males bear a pair of brush-shaped organs located between the first and second pair of thoracic legs. The thoracic appendages are known as walking legs.

Xestoleberis nansenensis n. sp.

Holotype: Adult female collected (February 28, 2022) from station 29, the type locality (64° 33.036' S, 62° 05.142' W; a water body (small puddle) about 50 m away from the sea on the coastal zone of the Nansen Island, Antarctica) mounted on a slide and covered with a cover slide (No: Ant-OK-01), valves were used in SEM photographing and kept (No: Ant-OK-02) in the laboratory.

Paratypes: 1 female collected from the type locality is kept in the micropaleontological slide.

Etymology: The new species is named by adding the suffix *-ensis* to the type locality (Nansen Island). Gender feminine.

Description: Carapace whitish in color. In lateral view, carapace subovate; dorsal margin rounded, ventral margin slightly concave, posterior margin rounded, and anterior margin pointed (Fig. 2A–D). Left valve (LV) overlapping right valve (RV). Hinge merodont. Four long adductor muscle scars (Fig. 2E, H–G) vertically located closer to ventral margin, one oval dorsal (antennal) scar with a thin tubercle-like structure inside located upper right (anterodorsally) of the adductor scars (Fig. 2H).

The area of “Xestoleberis spot” is not well seen externally but in internal view, it is inconspicuous, small in shape, and located anterodorsally above the adductor muscle scars (Fig. 2A). Carapace surface with thin, partially completed longitudinal striations and normal pore openings with short seta (Fig. 2E, I). Carapace moderate in size ($L=0.50$ mm; $H=0.27$ mm; $n=2$). Internal view, both margins with two lists on the calcified region.

Antennula (A1) (Fig. 3A): Five segmented; first segment with a medium-size short smooth seta. Second segment long about size of last three segments and with a short anterior seta. Third segment short about half of previous segment with a short medial seta and antero-ventral seta. Penultimate segment long about 2/3 of second

segment with three setae; a long smooth seta extending about half of terminal segment, two antero-ventral setae unequally long, a short seta about size of terminal segment, long seta extends tips of terminal setae. Terminal segment ending with three almost equal size smooth short setae about size of the segment.

Antenna (A2) (Fig. 3B): Five segmented. First segment subrectangular and long about size of next two segments. Second segment with a long stout two-joined exopod reaching tips of terminal claws, two unequally long ventro-apical setae present, short seta almost half of the third segment, and long seta reaching half of penultimate segment. Third segment subdivided, subrectangular narrowing to distal margin with one short anterior seta. Penultimate segment thin with one stout small claw-like ventral seta and one anterior seta. Terminal segment very small, ending with one well-developed claw.

Mandibula (Md) (Fig. 3C): Coxa without teeth (diagnostic character). Exopod with two almost equally long and smooth setae reaching about size of first endopodial segment. Endopod with three segments. First segment with one long antero-ventral seta, extending tips of terminal setae. Second segment very short with two anterior setae. Terminal segment with one long medial seta slightly plumose and four smooth terminal setae medium in size.

Maxillula (Mxl) (Fig. 3G): Vibratory plate with 12 hirsute setae (not shown). Exopod with two plumose long setae. Endopodite with 3 endites (masticatory lobes) and with two-segmented palp. First palp segment without seta and second palp segment very short with two unequally long setae and one claw-like smooth seta. Endites ending with 5, 4, and 4 short setae, respectively. First endite with one smooth antero-distal seta; second endite with two almost equally long distal setae (not shown in Fig. 3G).

First thoracic leg (T1) (Fig. 3D): Four segmented with a well-developed terminal claw. First segment without seta. Second segment with one smooth anterior apical seta about length of third segment. Third segment with very small postero-distal seta. Fourth segment smooth without seta.

Second thoracic leg (T2) (Fig. 3E): Three segmented with a well-developed terminal claw. First and third segments without seta. Second segment with one anteromedial smooth seta.

Third thoracic leg (T3) (Fig. 3F): Four segmented with a well-developed terminal claw. First, third, and fourth segments without seta. Second segment with one medial size antero-apical seta. Fourth segment anteriorly with bump-like structure.

Uropod (Fig. 3H): With two medium-size setae.

Genital organ rounded. Males not observed.

Color: Translucent to whitish.

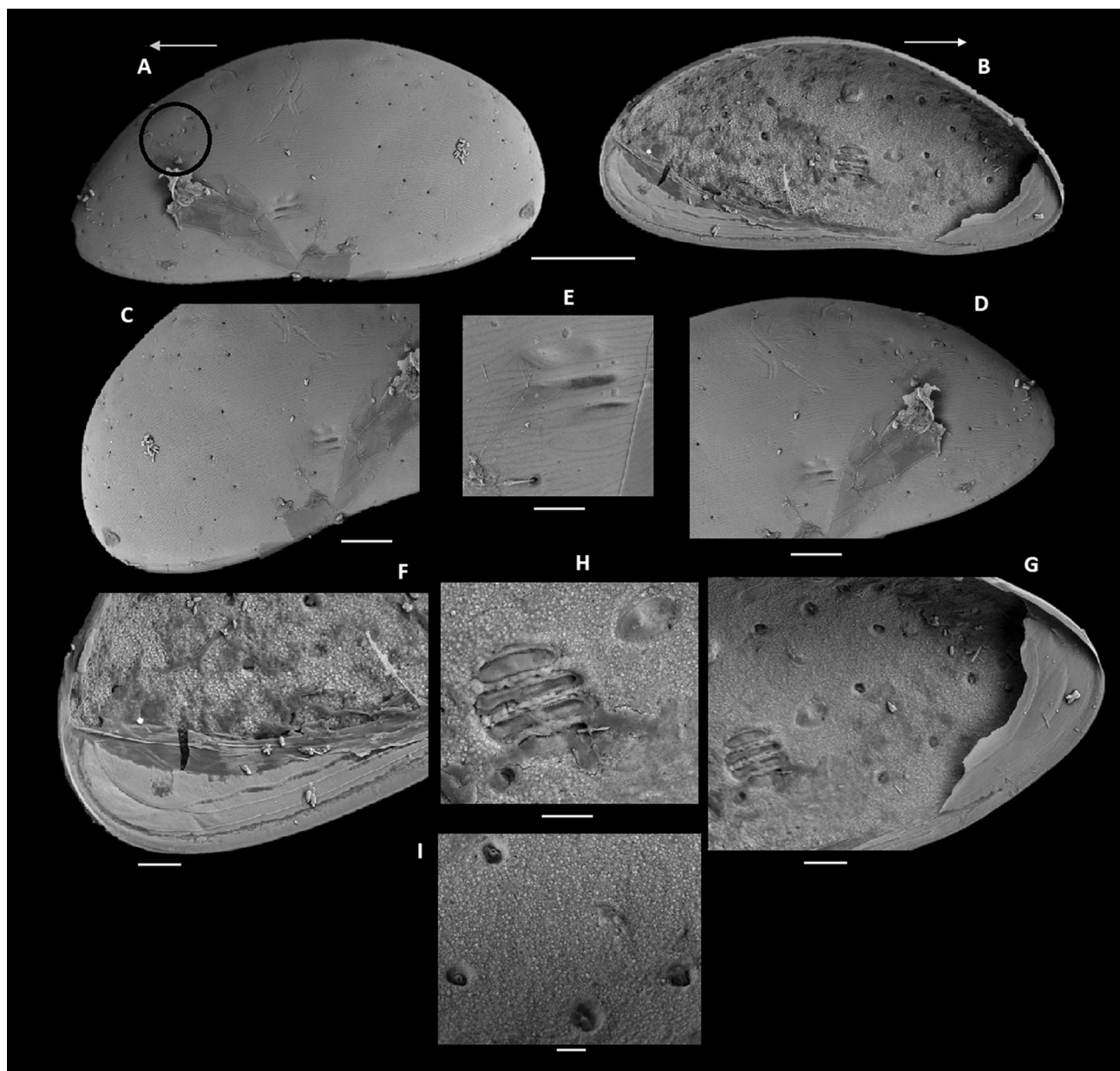


Fig. 2 *Xestoleberis nansenensis* n. sp. (Holotype). Female. **A** LV with pore openings external view, **B** LV internal view (attention to the postero-dorsal margin slightly bending down), **C** LV close external view of posterior end, **D** LV close external view of anterior end, **E** Adductor muscle scars external view, **F** LV close internal view of posterior margin, **G** LV close internal view of anterior margin, **H**

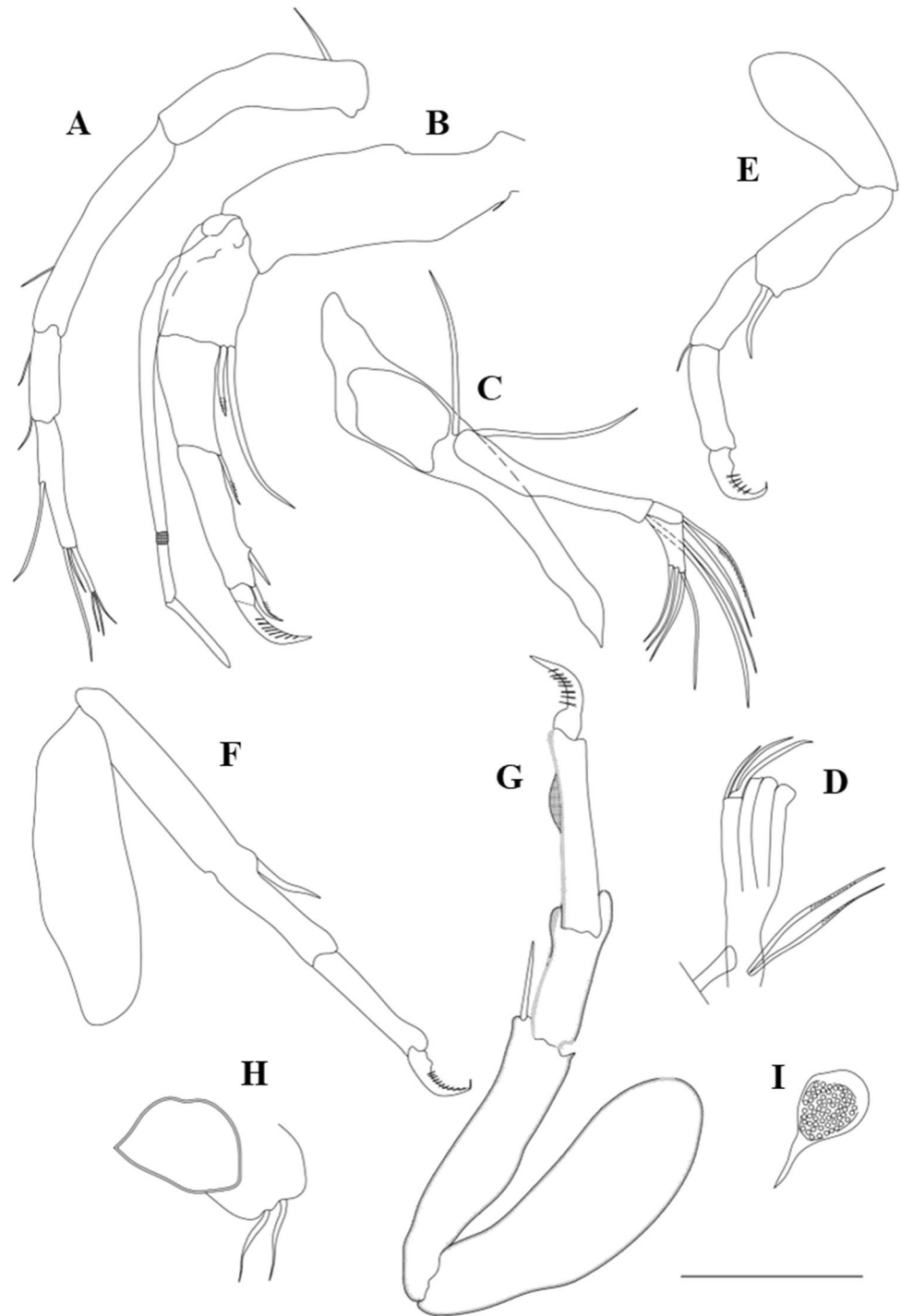
Adductor muscle scars internal view, and **I** Close internal view of pore openings. Circled area covers *Xestoleberis* spot. Note to views of **C–E** which are reversed from **A** to show details on the carapace. Note to oblique views of **F** and **G**. Scale: **A, B** 100 μ m; **C, D** 35 μ m; **E** 10 μ m; **F, G** 30 μ m; **H** 20 μ m; and **I** 10 μ m

Water chemistry

Tables 1 and 2 display measurements of physicochemical water properties. Among them, water temperature and electrical conductivity (referring to salinity) appear to be most effective on species occurrence. Accordingly, water characteristics of the type locality of the new species

(Tables 1 and 2) can be characterized as cold, saline, highly alkaline, and well oxygenated. Among the variables, chloride and sodium were the dominant elements (Fig. 4), while magnesium level was higher than calcium. Except bromide ion, levels of some ions measured (e.g., NO_2^- , NO_3^- , PO_4^- , NH_4^+ , F^- , and Li^-) were below the standard values and not significant.

Fig. 3 *Xestoleberis nansenensis* n. sp. Holotype female. **A** A1, **B** A2, **C** Md, **D** Mx1, **E** T1, **F** T2, **G** T3, and **H** uropod with genital organ, **I** eye. Scale bar: 5 μ m



Discussion

Distinguishing features of *X. nansenensis* n. sp.

Figures 2 and 3 obtain possibility of comparing several dis/similarities of the new species from its congenics. Some of those distinguishing features are discussed below.

- (1) Carapace shape, ornamentation, muscle scars, and *Xestoleberis* spot:

Xestoleberis nansenensis n. sp. carapace shape is very much identical to *X. setouchiensis* of Okubo (1979); however, the new species differs based on the following features: (i) anteriorly *X. setouchiensis* is more pointed than *X. nansenensis* n. sp., (ii) ventral margin in the new species

Table 1 Measurements of the variables from the sampling sites from four islands in Antarctica

St.No	St. Name	St. Type	pH	DO	%DO	EC	Tw	Ta	Atmp	ORP	Hum	Wind	W.Ch	Alt	Sal	TDS
1	Dismal Island 1	Small puddle	7.11	19.02	148.6	310.3	4.7	4.2	747.8	31.5	69.3	13.2	0.7	34	0.25	330.2
2	Dismal Island 2	Small puddle	7.07	15.8	124.3	164.3	4.3	4.0	748	29.7	69.3	13	0.7	33	0.13	176.15
3	Dismal Island 3	Small puddle	7.04	15.22	108.3	137.3	1.7	3.8	749.3	36.6	70.7	3.2	4	28	0.12	161.2
4	Dismal Island 4	Sea water	7.04	18.21	146.5	21,193	0	6.7	750.8	86.3	56.2	3.3	4.1	0	20.95	26,780
5	Dismal Island 5	Shallow ditch	7.03	13.48	111.2	322.9	7	2.8	748.9	16.8	77.5	6.2	NA	2	0.25	328.6
6	Horseshoe Island 1	Sea water	6.77	16.82	125.7	8117	1	6.1	731.9	23.1	58.5	11.9	3.3	0	8.05	10,582
7	Horseshoe Island 2	Stream	6.86	18.29	128.5	94.5	0.5	8.3	729.9	-22.6	59.1	7.6	8.1	50	0.08	115.05
8	Horseshoe Island 3	Stream, poll	7.03	16.63	124	96.5	3.2	6.7	725.4	-11.6	58.4	12.4	4.7	70	0.08	107.25
9	Horseshoe Island 4	Col 1 lake	7.07	16.2	116.7	85.8	1.5	2.8	725.4	1.5	69.8	12.3	-0.4	114.5	0.07	100.75
10	Horseshoe Island 5	Sea water	6.65	14.07	128.9	34,127	1	1.2	732.5	67.9	86.5	11	NA	61	40.87	41,001
11	Horseshoe Island 6	Lake water	7.3	15.09	109.3	157.6	2	-0.1	725.9	15.5	89.7	13.2	-2.8	103	0.13	182
12	Horseshoe Island 7	Lake water	7.3	15.59	110.2	99.2	1.1	-0.3	727.2	27.4	89.2	15.6	-2.7	86	0.09	118.3
13	Horseshoe Island 8	Stream	7.32	16.84	115.2	84.3	0.1	0.8	727.2	36.3	75.1	11.2	-1.6	86	0.08	104.65
14	Horseshoe Island 9	Col 1 lake	7.01	13.85	107.3	270.6	5.3	8.7	727.3	-76	37.4	5.4	6.4	114.5	0.21	279.5
15	Horseshoe Island 10	Sea water	7.58	14.61	133.8	34,627	0.6	1.7	729.3	73.1	51.2	6.1	-1.8	0	41.97	42,289
16	Horseshoe Island 11	Puddle	7.64	16.42	116.1	268.3	1.1	3.7	723.7	58.6	31.3	23.3	1.6	62	0.22	305.6
17	Horseshoe Island 12	Puddle	7.6	17.63	120.7	97.2	0.1	4.6	727.8	47.6	38.3	13.2	5	24	0.09	120.9
18	Horseshoe Island 13	Pond	7.52	17.75	123	94.8	0.1	4.6	728	63.5	38.3	13.2	5	26	0.08	117
19	Horseshoe Island 14	Col lake 2	7.45	17.76	121	40.5	0	4.1	727.6	-29.4	45.2	0	2.1	95	0.04	50.7
20	Horseshoe Island 15	Helocene spring	9.93	16.23	123.7	92.7	3.9	6.1	734.7	-15.4	39.8	2.8	6.1	7.8	0.07	100.75
21	Horseshoe Island 16	Skua Lake	9.4	16.33	115.3	82.7	-0.1	3.4	726	10.3	83.6	3.1	2.3	10	0.07	103.35
22	Horseshoe Island 17	Sea water	9.4	14.24	124.5	26,896	1.1	3.1	727.9	86.9	87.2	1.1	0.5	6.7	31.02	32,149
23	Horseshoe Island 18	Skua Lake	9.21	19.47	137.3	110.3	1.1	3.1	727.2	20.6	82.4	1	NA	10	0.1	131.95
24	Horseshoe Island 19	Small puddle	9.27	16.68	116.1	194.1	0.5	2.5	722.6	6.2	82.5	3.1	3.4	66	0.17	237.9
25	Horseshoe Island 20	Sea water	9.2	13.46	128.6	37,078	0.9	2.1	728.9	77.6	93.2	0.5	NA	5.6	44.57	44,636
26	Horseshoe Island 21	Zano Lake	8.79	16.24	112.4	150.4	-0.1	1.8	729	-28.2	78.2	4.3	NA	NA	0.14	192.4
27	Horseshoe Island 22	Sea water	9.18	16.14	127.8	18,869	-0.3	1.5	742.4	NA	NA	13	NA	60	22	23,602
28	Nansen Island	Sea water	8.89	14.92	128.1	25,661	0.7	1.9	740.4	3.6	75.3	2.1	0.5	2	29.82	31,089
29	Nansen Island*	Sea water	10.37	14.28	122.3	26,194	0.3	2.4	740.1	-16.4	76.3	25.5	3.9	2	30.9	32,188
30	Nansen Island	Sea water	10.94	13.62	118.5	27,029	0.8	2.3	740	-19.9	76.4	30.3	0.4	2	31.55	32,721
31	Livingstone Island	Toolorina Buza Lake	9	16.28	120.2	116.2	3.7	2.5	NA	NA	76.5	3.4	2.4	24	0.08	113.1
32	Livingstone Island	Pond	10.38	16.89	118.5	23.7	0.9	3	752.5	NA	64.7	0.5	5.8	18	0.02	28.6

St.No station number; St. Name station name; St. Type habitat type, DO dissolved oxygen (mg/L), %DO percent oxygen, EC electrical conductivity (µS/cm), Tw water temperature (°C), Ta air temperature in situ (°C), Atmp atmospheric pressure (mmHg), ORP redox potential (mV), Hum humidity (%), Wind wind speed (m/h), W.Ch wind chill point (°C), Alt altitude (m), Sal salinity (psu), TDS total dissolved solids (mg/L), NA not available

*Type locality

Table 2 Coordinates, sampling date, and chemical values of the 32 water samples

St.No	Coordinates	Date	Na	K	Ca	Mg	HCO ₃	Cl	SO ₄	NO ₂	NO ₃	PO ₄	NH ₄	F	Br	Li
1	68° 05.369' S, 68° 50.692' W	10.02.2022	27.67	1.8	6.24	3.24	24.16	39.12	7.3	1.01	1.71	5.35	2.43	0.03	0.09	≤0.01
2	68° 05.369' S, 68° 50.692' W	10.02.2022	21.96	1.35	20.35	2.56	66.5	31.59	5.9	0.03	5.12	3	3.41	0.14	0.11	≤0.01
3	68° 05.435' S, 68° 50.662' W	10.02.2022	22.47	1.13	5.88	3.06	24.16	37.15	4.83	0.6	0.33	0.29	≤0.01	0.01	0.09	≤0.01
4	68° 05.392' S, 68° 50.715' W	10.02.2022	8146.41	260.02	564.74	1157.87	163.07	15,313.5	1678.7	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	38.5	≤0.01
5	68° 05.388' S, 68° 50.679' W	10.02.2022	26.2	2.7	18.46	3.7	54.48	37.69	5.95	3.9	0.05	1.96	≤0.01	0.04	0.1	≤0.01
6	67° 49.403' S, 67° 12.388' W	12.02.2022	3642.85	129	382.77	650.86	72.48	6961.34	793.48	≤0.01	≤0.01	≤0.01	≤0.01	1.48	20.2	≤0.01
7	67° 49.455' S, 67° 12.734' W	12.02.2022	28.51	0.89	3.68	3.25	24.16	44.11	5.66	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.09	≤0.01
8	67° 49.598' S, 67° 13.158' W	12.02.2022	17.25	0.6	11.61	2.15	36.24	25.8	4.11	≤0.01	0.01	≤0.01	≤0.01	0.12	0.07	≤0.01
9	67° 49.720' S, 67° 13.593' W	12.02.2022	14.35	0.5	11.91	1.78	42.28	20.63	2.89	≤0.01	≤0.01	≤0.01	≤0.01	0.04	0.03	≤0.01
10	67° 49.794' S, 67° 13.330' W	12.02.2022	11,499	342.53	908.58	1552.45	150.99	20,363.97	2258	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	58.3	≤0.01
11	67° 49.305' S, 67° 13.305' W	13.02.2022	21.34	0.76	17.31	2.81	60.52	30.96	5.68	≤0.01	0.04	≤0.01	≤0.01	0.08	0.07	≤0.01
12	67° 49.491' S, 67° 13.214' W	13.02.2022	61.99	1.87	14.58	7.96	24.16	97.99	14.55	≤0.01	0.07	≤0.01	≤0.01	0.05	0.24	≤0.01
13	67° 49.441' S, 67° 13.14' W	13.02.2022	16.5	0.55	12.49	1.91	42.28	22.91	4.28	≤0.01	≤0.01	≤0.01	≤0.01	0.03	0.05	≤0.01
14	67° 48.837' S, 67° 22.592' W	14.02.2022	15.02	0.62	13.09	2.2	42.28	22.96	3.08	≤0.01	0.06	≤0.01	≤0.01	0.04	0.05	≤0.01
15	67° 49.428' S, 67° 14.158' W	15.02.2022	11,068.4	348.51	927.35	1702.5	150.99	20,242.38	2178.3	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	48.8	≤0.01
16	67° 49.554' S, 67° 13.582' W	15.02.2022	22.72	0.65	4.13	2.99	18.12	36.88	5.72	≤0.01	≤0.01	≤0.01	≤0.01	0.01	0.07	≤0.01
17	67° 49.493' S, 67° 13.387' W	15.02.2022	42.92	1.74	11.86	4.93	48.44	63.8	10.1	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.16	≤0.01
18	67° 49.493' S, 67° 13.387' W	15.02.2022	127.22	4.32	27.48	14.64	84.74	202.01	25.16	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.53	≤0.01
19	67° 49.602' S, 67° 13.644' W	16.02.2022	8.84	0.36	12.85	0.98	36.24	12.33	3.78	≤0.01	0.03	≤0.01	≤0.01	0.02	0.02	≤0.01
20	67° 49.932' S, 67° 14.266' W	16.02.2022	12	0.41	17.87	1.8	60.4	19.07	1.88	≤0.01	≤0.01	≤0.01	≤0.01	0.05	0.03	≤0.01
21	67° 48.783' S, 67° 18.156' W	21.02.2022	25.81	0.97	26.83	2.93	84.55	37.01	6.87	≤0.01	≤0.01	≤0.01	≤0.01	0.05	0.1	≤0.01
22	67° 48.315' S, 67° 17.433' W	21.02.2022	8083.47	236.29	478.97	1056.48	120.79	14,371.73	1563.9	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	35.3	≤0.01
23	67° 48.315' S, 67° 18.027' W	21.02.2022	185.61	6.08	52.07	24.79	114.87	331.89	45.44	≤0.01	≤0.01	≤0.01	4.5	0.17	0.76	≤0.01
24	67° 48.582' S, 67° 19.025' W	21.02.2022	20.68	0.89	4.21	2.18	30.26	25.06	3.76	≤0.01	0.5	0.05	≤0.01	0.02	0.06	≤0.01
25	67° 49.198' S, 67° 19.320' W	21.02.2022	10,362.6	332.12	736.84	1592.34	163.07	18,782.06	2079.8	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	50.2	≤0.01
26	67° 81.939' S, 67° 26.484' W	22.02.2022	12.31	0.51	20.04	1.5	60.4	18.31	2.95	≤0.01	0.06	≤0.01	≤0.01	0.02	0.04	≤0.01
27	67° 51.651' S, 67° 17.532' W	23.02.2022	8672.42	284.36	879.14	1408.49	169.11	16,144.54	1835.7	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	41.5	≤0.01
28	64° 33.047' S, 62° 05.212' W	28.02.2022	10,662.4	329.62	726.57	1642.09	150.99	19,053.2	2121.8	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	47.4	≤0.01
29*	64° 33.036' S, 62° 05.142' W	28.02.2022	8388.48	291.71	790.24	1432.48	181.19	15,821.63	1693.4	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	29.3	≤0.01
30	64° 33.035' S, 62° 05.182' W	28.02.2022	9790.01	316.41	702.54	1502.34	169.11	17,688.07	1965	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01
31	62° 38.780' S, 60° 22.241' W	02.03.2022	13.71	0.64	6.98	2.59	30.32	20.86	2.88	≤0.01	0.02	≤0.01	0.22	0.03	0.05	≤0.01
32	62° 38.485' S, 60° 21.894' W	02.03.2022	4.53	0.17	2.98	1.1	18.18	5.13	0.88	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.01	≤0.01

Na⁺, sodium; K⁺, potassium; Ca⁺, calcium; Mg⁺, magnesium; HCO₃⁻, bicarbonate; Cl⁻, chloride; SO₄⁻, sulfate; NO₂⁻, nitrite; NO₃⁻, nitrate; PO₄³⁻, phosphate; NH₄⁺, ammonium; F⁻, fluoride; Br⁻, bromide; Li⁺, lithium. All values are in mg/L

*Type locality

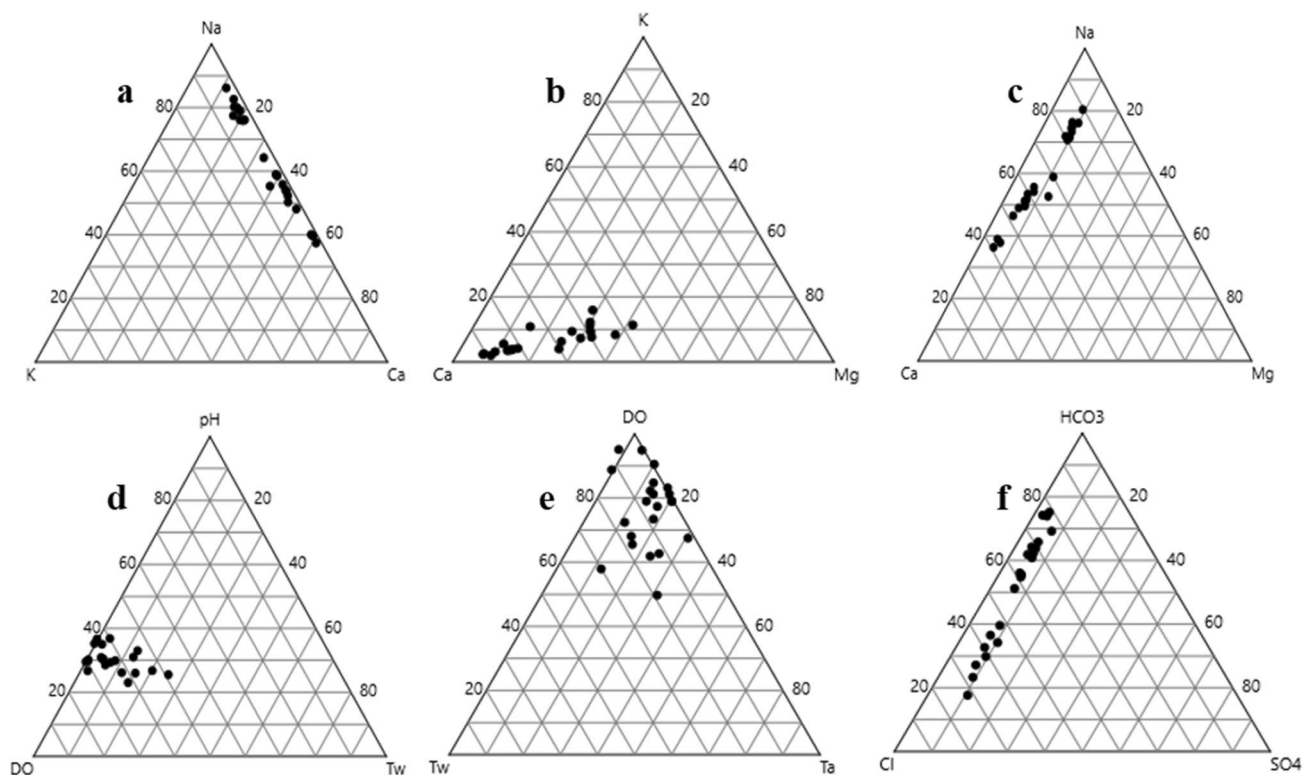


Fig. 4 Ternary plots (a–f) of 22 freshwater sites sampled during the expedition show percent values of the relationships among physicochemical variables. Abbreviations are given in Table 1 and 2

is concave but it is convex in *X. setouchiensis*, and (iii) *X. setouchiensis* has both sieve-type and lip-type pores (Group A of Sato and Kamiya 2007), but a few lip-type pores and normal pores are dominant in the new species. Additional differences are also found in the soft body parts discussed below. At first glance, the members of the genus *Xestoleberis* can be separated from others by having a relatively smooth carapace and subovate shape (Luz and Coimbra 2015; Le and Tsukagoshi 2018). In contrast, carapace surface of *X. nansenensis* n. sp. bears fine longitudinal striations which are completed or incomplete along the valves in appearance and easy to observe in SEM photographs (Fig. 2A, E). This feature is comparatively different than most (if not all) other species of the genus with smooth surface but some species (e.g., cf. *X. granulosa* in Brady 1880; *X. kerguelenensis*, *X. capensis* in Müller 1908) are also known with ornamentations, such as fine to large pores and/or pits (e.g., see *X. davidiana* in Chapman 1915 and *X. gracilariiai* in Chand and Kamiya 2016).

Besides smooth surface, pore type(s) on the carapace is also used for taxonomic descriptions; for instance, species of the genus generally consists of two (or three) types of pore opening: a normal type (or simple pore), lip type and a sieve type of pores (Puri 1974; Hanai and Ikeya 1991; Sato and Kamiya 2007; Luz and Coimbra 2015). In some cases,

multiple pore types are observed; for example, Sato and Kamiya (2007) grouped their 13 species into three groups as Group A (sieve and lip types), Group B (sieve type), and Group C (sieve and simple types). *Xestoleberis nansenensis* n. sp. has different combination of pore types as is the case in Chand and Kamiya (2016). Its carapace consists mostly of lip type scattered over the carapace and a few normal pore types mostly located closer to the ventral edge and a few through the anterior and posterior edges. In total, there can be about 53 (46 lip, 7 simple type) pores on each valve. Moreover, some species did only have one pore type. Sato and Kamiya (2007) pinpointed that females do have more pore numbers than males, but this is not applicable for our new species due to lack of males. Although numbers of pores are not commonly used during species description, this may be an important tool for future studies (Sato and Kamiya 2007).

In terms of muscle scars, at first glance, the new species resembles members of the genus by means of having four adductor muscle scars. The main difference is that these scars are longitudinally placed and relatively longer than scars reported in other species. However, comparing to other species (e.g., cf. *X. munensis* in Le and Tsukagoshi 2018, *X. amazonica* in Luz and Coimbra 2015) with a common type of U-shaped upper (frontal) muscle scar located vertically,

this scar in the new species is almost oval in shape with a small spine-like part developed inside.

Among the differences, “Xestoleberis spot” is also used to separate the genus from other related genera Keyser (1988 p. 184) provided detailed information about the formation of this spot, indicating that the spot is probably formed due to “...an irregularity in the inner calcified layer of the shell. Apart from that it is just a place where two muscle scars are present.” Accordingly, one possible reason of the flexibility of the shape of the spot is considered as “...the different degree of filling of the reservoir of the spinning gland alters the direction of the pulling force of the muscles” (Keyser, opt. cit.). Based on this explanation, one may consider reasons for different occurrences of the shape of the spot. For example, in some species (*X. brasilinsularis*), the spot is very small and/or almost not visible (Luz and Coimbra 2014). In some other species, for example, see *X. vietnamensis*, it is divided into two pieces (Le and Tsukagoshi 2018). Therefore, this view may explain finding a small inconspicuous shape of the spot in the new species. Nevertheless, this character should be carefully used to identify the species from others.

In size comparison, *X. nansenensis* n. sp. most resembles two species (*X. machadoae* and *X. brasilinsularis*) in Luz and Coimbra (2014). However, the new species is relatively larger (length = 0.50 mm) than these two when the lengths of the type species, *X. brasilinsularis* and *X. machadoae*, are 0.42 and 0.34 mm, respectively. On the other hand, it should be underlined that the range among the species vary; therefore, such information should be used carefully.

(1) Chaetotaxy and soft body parts:

Xestoleberis nansenensis n. sp. covers several unique and diagnostic characteristics in the soft body parts as discussed:

- (i) First antenna (A1) has five segments. Similar to *X. petrosa* (Chand and Kamiya 2016) and few more species listed in Sato and Kamiya (2007), the first segment is comparatively longer than that in the other species. Okubo (1980) stated *X. setouchiensis* has five segments (podomeres), but line drawings show six segments. Thus, this needs to be confirmed with further studies. Also, it should be noted that numbers of segments are not possible to compare with many of the other species because of lack of line drawings of many *Xestoleberis* species but see exception in Hartmann (1984). This is mostly due to the reports based on fossil and/or only carapace descriptions (see Kaesler and Waters 1972). However, a few resembling species with soft body parts can be compared to the new species. For example, Le and Tsukagoshi (2018) reported two species (*X.*

vietnamensis and *X. munensis*) with six podomeres that the length ratios of these species ranged from 25:24:7:13:1:6 to 25:24:8:8:13:6, respectively. There is a gradual decrease from proximal to distal segment. This ratio in *X. nansenensis* n. sp. differs from others as 3.5:4.0:1.6:2.2:1.0. Similarly, Sato and Kamiya (2007) described 7 of 13 species with five segments from the coast of Japan. They indicated that numbers of segments on A1 can be used during taxonomic description. If this is true, the genus *Xestoleberis* may be separated into several subgenera or genera. Further studies may focus on this issue. Besides segmentation, other differences are seen in the location and numbers of setae. For example, unlike one short seta on the first segment of *X. nansenensis* n. sp., such seta is absent in several species (e.g., see *X. vietnamensis*, *X. munensis*, *X. planuenter*, *X. kurosio*, *X. sagamiensis*, *X. notoensis*, *X. ryukyuensis*, *X. sesokoensis*, *X. magnoculus*) (Sato and Kamiya 2007), while a small setal group was observed in several other species (e.g., cf. *X. penna* and other six species in Chand and Kamiya 2016). Comparing the locations of the setae, there are only a few setae located on the anterior edges of the new species compared to others; however, most of the setae on A1 are indeed seen on the anterior ends of the segments. Also, terminal segment ends with three smooth, short, and almost equal sized setae, while these setae are unequally long in those species (e.g., *X. vietnamensis*, *X. munensis*) compared here. It should be noted that the middle one of the terminal setae on A1 of the new species is most probably aesthetasc “Ya” but is very much seen like a seta.

- (ii) Second antenna (A2) has differences clearly seen in chaetotaxy compared to the other species discussed here. First, the third segment is subdivided. In some ostracod species, for example, in the males of candonid [e.g., *Neglecandona neglecta* (Sars 1887)] species, A2 includes five segments (Meisch 2000). For example, the terminal segment of the new species ends with a well-developed hook-like claw but there are two claws in almost all the species (e.g., *X. vietnamensis*, *X. munensis*, *X. gracilariiai*, *X. marcula*, and see species listed in Sato and Kamiya 2007, Chand and Kamiya 2016). Another difference is seen in the exopod which includes a three-segmented spinneret seta located antero-distally. This seta is usually without division (e.g., see *X. concava*, *X. gracilariiai* in Chand and Kamiya 2016) or two segmented (e.g., *X. marcula*, *X. setouchiensis*).
- (iii) Mandibula (Md) has a very interesting, unique, and different characteristics. Unlike other ostracod species (see e.g., Okubo 1979, 1980; Sato and Kamiya

2007; Hirosaki 2013; Chand and Kamiya 2016), the teeth on the coxa are either reduced or absent. This is considered a diagnostic characteristic of the species; however, without further speculation, there can be two possible reasons for this unusually interesting feature; (1) this may be an anomaly in this individual. To support this view, there should be more individuals checked out for this character, but none are available at the moment, and (2) the part of the coxa might have been broken and lost during the dissection. This approach is unlikely since both mandibulae (Fig. 3C) are clearly seen in the slide. Future studies are needed to compare the character, and again, more individuals should be analyzed to clarify the issue. Additionally, there are only three segments (or so-called podomere) in the new species. In comparison, there are generally four segments in most of the ostracod species, but exceptions occur (cf. *X. ryukyuensis* in Sato and Kamiya 2007). Also, numbers of setae on exopod of the first segment (2 setae) is similar to *X. ikeyai* reported from Japan (Sato and Kamiya 2007) and six other species (*X. becca*, *X. concava*, *X. gracilariiai*, *X. marcula*, *X. natuvuensis*, *X. penna*) reported from Fiji Archipelago by Chand and Kamiya (2016). Differences in the setal group in the endopodial segments and length of the segments are clearly seen among the species. For example, unlike the smooth and almost equally long setae in the new species, there is one long and one short hirsute seta found in *X. ikeyai* and two hirsute setae in other species. First segment is not divided and is longer than the next two segments. Claws are not well developed (or not claw like) on the third (terminal) segment. Readers are suggested to compare mandibula with all other known species of the genus (e.g., see Chand and Kamiya 2016).

- (iv) Reporting 12 hirsute setae on the vibratory plate of the maxillula is another different character even though number varies among the species from 13 to 17 smooth and/or plumose or hirsute setae (Sato and Kamiya 2007; Chand and Kamiya 2016). For example, *X. setouchiensis* has 15 feather-like setae and first palp with four antero-distal setae (Okubo 1980) but two small setae occur in the first palp in the new species (Fig. 3).
- (v) Thoracic legs: They are all similar in shape ending with a claw. Thoracic legs (T1–T3) have four segments. Basal setae are not observed in the new species even though many species of the genus bear at least one or more basal setae. There may be one exception in *X. ikeyai* where the first thoracic leg seems to have three segments (see Fig. 12E in Sato and Kamiya 2007). However, these authors stated

four segments (podomeres) in the text. This information needs to be confirmed.

- (vi) Uropod is reduced in all the species of the genus *Xestoleberis*. This is also the case in the new species where there are two smooth setae in the uropod. Comparison of the numbers of setae among the species, variations can be seen from one to three smooth or hirsute or both types of setae. There are at least three species (*X. petrosa*, *X. gracilariiai*, *X. becca*) (see Chand and Kamiya 2016) known with one short seta, while four (*X. penna*, *X. concava*, *X. marcula*, *X. natuvuensis*) and nine species (*X. sagamiensis*, *X. notoensis*, *X. ryukyuensis*, *X. sesokoensis*, *X. kuroshio*, *X. magnoculus*, *X. ikeyai*, *X. vietnamensis*, *X. munensis*) are described with two and three setae, respectively. Numbers of setae and shape of the uropod are commonly used in taxonomic descriptions of many ostracods, but this is not common in the genus *Xestoleberis*. However, this may be used to make groups of the species and can be more commonly used during the taxonomic description of the live species.

Female genital organ is rounded in the new species similar to the other species while male organs (e.g., hemipenis) cannot be discussed in here due to lack of males.

Importance of reporting a new species

Brady (1907) using samples from the National Antarctic Expedition of Great Britain was the first to report nine ostracods from Winter Quarters and environs in Antarctica (see details in Brady 1907). Among them, *X. reniformis* was the only species of the genus described as a new species from Antarctica. Later, studies on the ostracods from the continent have been increased although the frequency seems to be relatively low. Following Brady's reports, Müller (1908) (five species of the genus collected from the Indian Ocean sector of the Antarctic shelf) and Chapman (1916, 1919) (five species from McMurdo Sound and Recent muds of the Ross Sea) announced several other species, including members of *Xestoleberis*. Benson (1964) introducing an undescribed *Xestoleberis* sp. provided a list of early studies on ostracods reported from Antarctica. As it was underlined, these species are mostly marine benthonic and/or planktonic ostracods (and few were sub/fossils) collected from open sea and/or nearby the mainland. Similarly, Majewski and Olempska (2005) listed 29 marine podocopid ostracods around Admiralty Bay on King George Island, in which *X. cf. rigusa* was reported. The authors concluded that there was no clear relationship between ostracods and environmental variables used in their study (see discussion below). Most recently, Nazik et al. (2022) described six species belonging to six

genera from two (Hovgaard and Horseshoe islands) of seven sites with 12 samplings collected around the islands, including King George, Horseshoe, Calmette, Videla, Hovgaard, Nansen, and Deception islands. The authors did not report the species of the genus *Xestoleberis* in their study. Also, ostracods were not reported from Nansen Island by the authors. In contrast, *Xestoleberis nansenensis* n. sp. is the first ostracod report from a water body (a puddle with about 100 cm² of surface area and 30 cm of depth ca. 50 m away from the sea) on the Nansen Island even though there are some species already reported from the areas nearby (e.g., see Nazik et al. 2022). As stated above during the present study, ostracods were solely collected from this island and other 31 water samples did not cover a sign of ostracods. Absence of ostracods from other samples can be correlated with (i) improper aquatic conditions and water chemistry (i.e., low water temperature, levels of calcium or magnesium), (ii) low or absence of sediment levels, and (iii) isolation of the islands from the mainland. One may also consider biotic factors herein, but I did not observe fish or larger invertebrates during the sampling from the type locality. For example, no fish was seen in the lakes and other water bodies sampled on the islands. Eventually, one may consider biotic factors are less or no importance on the absence of ostracods.

In terms of improper aquatic conditions, as indicated above, bromide level (29.3 mg/L) of the waters collected during the present study was comparatively found higher (Table 2) than the freshwater systems (ca. 0.5 mg/L) (WHO 2009) but it was even low for the seawater where the range was generally known from 65 mg/L to well over 80 mg/L (Al-Mutaz 2000). Such a level of bromide can be expected since occurrence of bromide in natural aquatic sites coincides with NaCl due to similar physicochemical characteristics of 10 marine sampling sites. In contrast calcium and magnesium followed by Na and Cl were dominant in the 22 freshwater sites (Fig. 4). Meanwhile, we do not know if (or how) the bromide and ostracods are related. Thus, this part of the study is open for further discussion. On the other hand, finding the species from a very cold and saline water challenges our knowledge about ostracod tolerance level. For example, it is known that several species of freshwater ostracods can tolerate very high (up to 55 °C) (Külköylüoğlu et al. 2003) and very low (ca. 0.5–1.0 °C) temperature levels (Delorme 1991; Kiss 2007) but in seawater this seems to be much lower (0.3 °C this study). Now, we may not explain how ostracod tolerate such extreme conditions due to lack of studies. Further studies are needed.

Second possible explanation of the absence of ostracods from the sampling sites was inadequate levels of sediments. According to field observation by the author, except lake samples, all other water bodies showed very scarce and/or no sediment enough to support ostracods on the bottom of the

water bodies, including the type locality. This also applies to samples taken from the littoral zone of the seawater. According to the previous studies (Adams et al. 1992; Boyd 2015), sediments as source of different chemicals play critical role in aquatic ecosystems. Considering most of the ostracods are bottom dependent, a few swimming species may prefer living in or around the macrophytes. They mostly inhabit parts in and/or just above the sediment where ostracods find possibilities to feed and survive on several different organisms and organic matter (Puri 1966). Implication of this approach is that lack of sediments reduces the chance of finding suitable habitat for ostracods, which may be the case in the present study.

Isolation of the islands may be another explanation of the absence of ostracods from many sites sampled during the present study. Antarctica has a long geological history going back to about Precambrian age. It has mainly two parts East and West Antarctica. The sampling sites (Table 1) were located on the western part of the continent. According to Nazik et al. (2022), species found from the sites closer to the present sampling location are known from about Oligocene to Recent. Indeed, Williams et al. (2008) reported well-preserved non-marine ostracods from the Miocene, indicating a lake setting (Palaeolake Boreas) probably suitable for the ostracods. Implication of this information is that the separation of the continent from the mainland is a long story. Hence, such a long-term isolation may cause absence (or low) freshwater ostracod species living on the islands.

In addition to these possibilities, the lack of species may be due to the lack of studies on the islands. Although several different species of different taxonomic groups have been reported from the waters on the islands (Majewski and Olempska 2005; Dartnall 2017), scarcity of ostracods may not be well explained. Hence, this may be challenging for future studies. Herein, one may argue about earlier ostracod species reported alive from the islands. For example, Dartnall (2017), listing several different aquatic species, reported nine freshwater ostracods (*Candona* sp. from South Georgia islands (Dartnall 2017); *Eucypris pestai* [recently accepted name *Amphicypris pestai* (Graf 1931)] from South Georgia islands (Graf 1931); *Cypretta* sp. (recently *Cypretta* cf. *seurati*) from Macquarie Island (Lofthouse 1967); *Eucypris corpulenta* [recently known as *Ramotha corpulenta* (Sars 1895)] from Îles Kerguelen and the Poincaré peninsula (Lofthouse 1967); *Eucypris fontana* [recently known as *Argentocypris sarsi* see Díaz and Martens 2014 (Graf 1931)] from South Orkney and South Georgia islands (Graf 1931; De Deckker 1981a); *Eucypris virens* (Jurine 1820) from Macquarie Island and Îles Kerguelen (Dartnall 2017); *Ilyodromus kerguelensis* Müller 1906 from Possession Island, Îles Kerguelen, Îles Crozet, and Prince Edward Islands (Lofthouse 1967; Dartnall 2017); *Cypridopsis frigogena* (recently known as *Neocypridopsis*

frigogena, see Martens and Behen 1994) (Graf 1931) from South Orkney and South Georgia islands (Graf 1931, De Deckker 1981b; and *Tanycypris* sp., Dartnall 2017 from South Georgia) from the Antarctic islands. However, from a careful detailed search on the locations listed in Dartnall (2017), I found out that except two species some of these ostracods previously reported did not belong to the area within the 60° S of Antarctica. For example, Graf (1931) listed *A. fontana* and *N. frigogena* from the samples provided by Dr. W. König in 1926 but König's samples were collected from Grytviken (S. Georgia Island) which is located north of 60° S. On the other hand, De Deckker (1981a, b) identified two species (*N. frigogena*, *A. sarsi*) from the lakes on Singy Island (S. Orkney Islands) located at the border of 60° S latitude. Therefore, at the moment, except these two species, there is no other freshwater ostracods from the islands as far as the present study shows.

Finally, it should be stated that the new species includes several characters different from the other species of the genus *Xestoleberis*. Comparing the characters provided in Athersuch et al. (1989), it may also be a new genus of the family. However, due to lack of specimens, description of the species is tentatively done in here. Thus, its taxonomic status can possibly be verified with providing more specimens.

Conclusion

Based on the differences in soft body parts and carapace introduced above, *Xestoleberis nansenensis* n. sp. is proposed as a new species from the Nansen Island, Antarctica. This is the first ostracod species found from this island. Absence of ostracods from other islands sampled during the study are discussed based on improper aquatic conditions (e.g., low-temperature values) and historical background of the area. Although marine and brackish water ostracods are known from the continent, the known literature reveals that there appears to be only two non-marine living ostracod species from the freshwater habitats within the 60° S in Antarctica. This result suggests that non-marine ostracods can be found in all six continents, but future studies are thought to clarify the issue.

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Author contributions The corresponding author O.K. collected the samples from each location, identified the species, and wrote the main manuscript.

Data availability All data on the measured environmental variables used in this study are included within this paper and they can be available upon request.

Declarations

Conflict of interest The author declares that he has no conflicts of interest.

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