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Uncovering cryptic diversity in *Loimia* (Annelida: Terebellidae), with the description of two new species from the Eastern Mediterranean

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Abstract. The genus *Loimia* Malmgren, 1866 (Annelida: Terebellidae) represents a taxonomically challenging group of tubicolous polychaetes, with many species showing high morphological conservatism and unresolved systematic boundaries. The presence of *Loimia medusa* (Savigny, 1822) along the Mediterranean coasts has historically been reported, but recent studies suggest that this species is restricted to the Red Sea and Arabian Gulf, with the Mediterranean records likely reflecting misidentifications. Here, we use an integrative taxonomic approach combining detailed morphological analyses and mitochondrial markers (COI and 16S rDNA) to reassess the diversity in *Loimia* along the coasts of Israel, Cyprus, and Lebanon. Specimens were collected at shallow waters from Akhziv, Bat Yam, and Tel Aviv beaches (Israel, 2017 and 2025), Episkopi and Larnaka Bays (Cyprus, 2024), and Bar El Mubarakh and Bar es Slaiyeb Bays (Lebanon, 2022). Our results reveal the presence of two new species: *Loimia hannae* sp. nov. and *Loimia saraiae* sp. nov., both morphologically distinct from other known species in the genus, including Indo-Pacific relatives. Phylogenetic reconstructions further support their recognition as different species, with COI genetic distances exceeding 12% from closest congeners. Furthermore, observed intraspecific variability, particularly in *L. hannae*, confirms the importance of accounting for ontogenetic morphological variation when delineating species within this genus. These findings not only expand the known diversity of *Loimia* in the Mediterranean. While our integrative approach clearly distinguishes these two new species from known Indo-Pacific congeners, their status in the Mediterranean –whether native, non-indigenous, or cryptogenic– remains uncertain and can only be resolved through broader geographic sampling and historical evidence.

Keywords. *Loimia*, integrative taxonomy, Mediterranean Sea, Terebellidae.

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Introduction

Members of the tube-dwelling genus *Loimia* Malmgren, 1866 (Annelida, Polychaeta, Terebellidae) are ecologically significant components of infaunal coastal communities (Martin *et al.* 2022) characterized by the presence of pectinate uncini, a feature unique within Terebellidae Johnston, 1846 (Wang *et al.* 2020; Hutchings *et al.* 2021, 2024, 2025). To date, *Loimia* comprises 34 valid species (Read & Fauchald 2025), many of them described in recent years primarily from tropical and subtropical areas (Martin *et al.* 2022; Hutchings *et al.* 2024). However, the systematics of this genus remains particularly challenging due to the conservative nature of some key diagnostic traits –that may also vary throughout the ontogeny– the incompleteness of some original descriptions, and the poor condition or absence of type specimens (Wang *et al.* 2020; Martin *et al.* 2022; Hutchings *et al.* 2024, 2025).

The type species of the genus, *Loimia medusa* (Savigny, 1822), originally described from the Red Sea (Savigny 1822; Martin *et al.* 2022), was historically regarded as cosmopolitan, with reports spanning global distribution (Hutchings & Glasby 1988; Hutchings & Kupriyanova 2018; Hutchings *et al.* 2021, 2024). However, integrative studies including material from the type locality strongly supported that *L. medusa* is likely restricted to the Arabian and Red Seas region (Hutchings & Glasby 1995; Lavesque *et al.* 2017; Martin *et al.* 2022), while many of the historical global records outside this range probably correspond to misidentifications or overlooked cryptic complexes (Hutchings & Glasby 1995; Wang *et al.* 2020; Martin *et al.* 2022).

In the Mediterranean, the polychaete diversity and biogeography is relatively well-studied, but significant taxonomic gaps persist, particularly within poorly explored habitats or regions such as the Levantine Basin (Coll *et al.* 2010; Langeneck *et al.* 2019; Toso *et al.* 2024). This eastern Mediterranean area is also a hotspot for non-indigenous species (NIS), many of Indo-Pacific origin, likely introduced through Lessepsian migration via the Suez Canal (Galil *et al.* 2017; Hoeksema & Yonow 2021; Galanidi *et al.* 2023). However, many of these NIS annelids present taxonomic uncertainties, often involving cryptic diversity that can only be resolved through molecular tools (Langeneck *et al.* 2024).

A recent example is *Loimia ingens* (Grube, 1878), reported as NIS for Lebanon (as *L.* cf. *ingens*), while molecular data suggest it may represent a western Indian vicariant rather than *L. ingens* s. str. (Toso *et al.* 2024). Such cases underscored the complexity of identifying Indo-Pacific species of *Loimia*, particularly in the eastern Mediterranean (Hutchings & Glasby 1988; Hutchings *et al.* 2024, 2025). On the other hand, historical records of *L. medusa* far from its type locality –such as along the Israeli Mediterranean coast, often regarded as the primary gateway for Lessepsian migrants (Zenetos *et al.* 2011)– are now considered unreliable, given the species' distribution likely restricted to the Red Sea and Persian Gulf (Hutchings & Glasby 1995; Lavesque *et al.* 2017; Martin *et al.* 2022).

Recent fieldwork along the coast of Israel, Cyprus and Lebanon have revealed the presence of previously undocumented species of *Loimia*, morphologically distinct from *L. medusa* but also from any other described congener. In this study, we describe two species using an integrative taxonomic approach that combines detailed morphological analysis with DNA barcoding to resolve their identity and clarify their systematic placement within the genus.

Material and methods

Sampling and morphological observations

Sampling in Israel was conducted by snorkeling as part of two academic field courses: "Invertebrates Zoology" –School of Zoology in Tel Aviv University (June 2017 and June 2025)– and "POLICO – Polychaetes Identification" –The Distributed European School of Taxonomy (DEST) and the Steinhardt Museum of Natural History in Tel Aviv University (June 2023). Specimens of *Loimia* were collected from two intertidal beaches: Akhziv (33.056° N, 35.102° E) and Bat Yam (32.022° N, 34.737° E), in shallow water (~1 m depth) areas with scattered small and medium rocks. One additional specimen was collected from an Artificial Reef Monitoring Structure (ARMS) in Gordon Beach in Tel Aviv by SCUBA diving (5 m depth). Specimens were carefully extracted from underneath the rocks and ARMS substrate, and immediately transferred to containers filled with ambient seawater. In the laboratory, each specimen was fixed and preserved in 85% ethanol. A mid-abdominal fragment was dissected apart and preserved in 96% ethanol for subsequent DNA extraction.

Specimens from Cyprus were obtained in the context of the EU Marine Strategy from sediment samples at depths of ~30 m, at Episkopi and Larnaca Bays (34.647° N, 32.807° E and 34.957° N, 33.690° E, respectively; August and September 2024). Specimens from Lebanon were collected during an international cooperation project focusing on environmental education from around the city of Tyre at depths of 0–5 m on artificial hard bottom (33.275° N, 35.195° E). All specimens were directly fixed in 96% ethanol in the field.

Fixed specimens were photographed with a CMEX 5 digital camera connected to a ZEISS Stemi CS-2000-C stereo microscope, and a SP100 KAF1400 digital camera connected to a Zeiss Axioplan compound microscope. Morphological terminology and character descriptions follow the standards established by Nogueira *et al.* (2010). Specifically regarding the number of ventral shields, we considered fused shields as a single unit. Moreover, since there are difficulties in determining the exact segment on which the ventral shields begin (Nogueira *et al.* 2010), we considered them as beginning on segment 2 when that segment was covered. Morphological descriptions are based on preserved specimens, unless otherwise specified as referring to live specimens. Type specimens of the new species have been deposited at the Steinhardt Museum of Natural History, Tel Aviv University (SMNHTAU) and at the Marine Biology Museum "Pietro Parenzan" of the University of Salento (PCZL).

Molecular analyses

DNA was extracted using Monarch® genomic DNA purification kit (New England BioLabs # T3010S), following the manufacturer's instructions. Tissue digestion was performed overnight. The barcode region of the mitochondrial cytochrome c oxidase I (COI) was amplified in two steps. First, a ca 1200 bp fragment was amplified using the primers LCO_1490 (Folmer *et al.* 1994) and Cox_Calc_R1 (Belinky *et al.* 2012). When no visible bands were detected on agarose gel, a semi-nested PCR was performed using LCO_1490 and HCO_2198 primers (Folmer *et al.* 1994). More recent samples (June 2025) were amplified and sequenced in a single step using newly designed primers: *Loimia*_LCO (5′-ATACTCAACAAYCAYAAAGATATTGG-3′) and *Loimia*_COIR (5′-GGTAAAATAAGAATATAAACTTCWGGRTG-3′).

The mitochondrial large ribosomal subunit (16S) was amplified using newly designed primers targeting a 674 bp fragment: 16S*Loimia*_F (5′-AAGTTAAAGGAACTCGGCAAA-3′) and 16S*Loimia*_R (5′-TACACTAAGGTCCTTTCGTAC-3′). All sequences generated in this study were deposited in the GenBank under accession numbers PV872432, PV872433, PV872434, PV872435, PV872436, PX459820, PX459821 (COI), and PV883262, PV883263, PV883264 (16S; Table 1).

Table 1 (continued on next page). GenBank accession numbers and voucher references for the sequences of the species of *Loimia* Malmgren, 19866 used in the phylogenetic analysis. “Direct submission” refers to sequences submitted directly to GenBank without an accompanying published reference.

Species	Locality	Region	Voucher	Accesion	Reference
L. aimehoensis	French Polynesia: Society Islands	S Pacific	NTM_W029897	PQ487814	Hutchings *et al.* 2025
L. arborea	China?		–	PP718025	direct submission
L. arborea	Off Shanghai, China	NW Pacific	MBM286581	MN133250	Wang *et al.* 2020
L. arborea	Yellow Sea, China	NW Pacific	MBM286582	MN133249	Wang *et al.* 2020
L. bandera	Taiwan Strait, China	NW Pacific	MBM286584	MN133252	Wang *et al.* 2020
L. bandera	Taiwan Strait, China	NW Pacific	MBM286583	MN133251	Wang *et al.* 2020
L. bermudensis	Belize	W Atlantic	SIO:BIC:A9451	MT167000	Stiller *et al.* 2020
L. borealis	Shandong Peninsula, China	NW Pacific	MBM286591	MN133237	Wang *et al.* 2020
L. borealis	Shandong Peninsula, China	NW Pacific	MBM286593	MN133238	Wang *et al.* 2020
L. borealis	Shandong Peninsula, China	NW Pacific	MBM286592	MN133239	Wang *et al.* 2020
L. borealis	Shandong Peninsula, China	NW Pacific	MBM286585	MN133240	Wang *et al.* 2020
L. davidi	São Miguel Island, Açores	NE Atlantic	CEAB A.P. 935C	MZ382866	Martin *et al.* 2022
L. davidi	São Miguel Island, Açores	NE Atlantic	CEAB A.P. 935C	MZ382868	Martin *et al.* 2022
L. gigantea (*ramzega*)	Brittany, English Channel	NE Atlantic	MNHN–IA–TYPE 1788	KY555063	Lavesque *et al.* 2017
L. gigantea (*ramzega*)	Brittany, English Channel	NE Atlantic	MNHN–IA–TYPE 1789	KY555062	Lavesque *et al.* 2017
L. gigantea (*ramzega*)	Brittany, English Channel	NE Atlantic	MNHN–IA–TYPE 1790	KY555061	Lavesque *et al.* 2017
L. hannae sp. nov.	Israel, Bat Yam	Mediterranean	SMNHTAU:Vr.25367	PV872433	present study
L. hannae sp. nov.	Israel, Bat Yam	Mediterranean	SMNHTAU:Vr.25400	PV872434	present study
L. hannae sp. nov.	Israel, Akhziv	Mediterranean	SMNHTAU:Vr.25544	PV872435	present study
L. hannae sp. nov.	Israel, Akhziv	Mediterranean	SMNHTAU:Vr.25545	PV872436	present study
L. cf. *ingens*	Lebanon, Tyre	Mediterranean	PCZL. T.LO.2.1 – *Loimia hannae*:	PP808834	Toso *et al.* 2024
L. ingens	Linqiangshidao, Island, China	NW Pacific	MBM286604	MN133248	Wang *et al.* 2020
L. ingens	Weizhoudao, Island, China	NW Pacific	MBM286603	MN133247	Wang *et al.* 2020
L. ingens	Linqiangshidao, Island, China	NW Pacific	MBM286602	MN133246	Wang *et al.* 2020
L. ingens	Weizhoudao, Island, China	NW Pacific	MBM286601	MN133245	Wang *et al.* 2020
L. ingens	Weizhoudao, Island, China	NW Pacific	MBM286600	MN133244	Wang *et al.* 2020
L. ingens	Ko Sichang, Thailand	CW Pacific	MBM286599	MN133243	Wang *et al.* 2020

Table 1 (continued). GenBank accession numbers and voucher references for the sequences of the species of *Loimia* Malmgren, 19866 used in the phylogenetic analysis. "Direct submission" refers to sequences submitted directly to GenBank without an accompanying published reference.

Species	Locality	Region	Voucher	Accesion	Reference
L. lanai	Australia	SW Pacific	AM-W54019	OR345062	Hutchings *et al.* 2024
L. lanai	Australia	SW Pacific	AM-W5145	OR345063	Hutchings *et al.* 2024
L. lanai	USA	–	SIO-BICA15677	OR345064	Hutchings *et al.* 2024
L. macrobranchia	Fangchenggang City, China	NW Pacific	MBM286579	MN133241	Wang *et al.* 2020
L. macrobranchia	Fangchenggang City, China	NW Pacific	MBM286580	MN133242	Wang *et al.* 2020
L. medusa	Virginia, USA	NW Atlantic	USNM:IZ:1446109	MK308193	direct submission
L. medusa	100% identical in blastn to sequence MN684034 of Polychaeta sp. larvae from Panama: Bocas Del Toro	NW Pacific	–	AY040704	Siddall *et al.* 2001
L. medusa	Virginia, USA	NW Atlantic	USNM:IZ:1499384	OQ322738	direct submission
L. minuta	Puerto Rico	W Atlantic	–	PV676596	direct submission
L. minuta	Puerto Rico	W Atlantic	–	PV672920	direct submission
L. minuta	Belize	W Atlantic	SIO:BIC:A9452	MT167001	Stiller *et al.* 2020
L. poraporaensis	French Polynesia: Bora-Bora	S Pacific	AM-W51451	PQ487812	Hutchings *et al.* 2025
L. saraiae sp. nov.	Israel, Akhziv	Mediterranean	SMNHTAU:Vr.25467	PV872432	present study
L. saraiae sp. nov.	Cyprus	Mediterranean	PCZL. T.LO.1.2 – *Loimia saraiae*	PX459821	present study
L. saraiae sp. nov.	Cyprus	Mediterranean	PCZL. T.LO.1.1 – *Loimia saraiae*	PX459820	present study
Polychaeta sp.	Saudi Arabia	Red Sea	KSA_9081	RSARM2385-20	BOLD
L. tuberculata	Australia: Exmouth	SW Pacific	WAM V12218	PQ596296	Hutchings *et al.* 2025
L. tuberculata	New Caledonia: Noumea	SW Pacific	MNHN_IA_2022_2095	PQ487811	Hutchings *et al.* 2025
Loimia sp.1	Vellar Estuary, Tamil Nadu, India	Bengal Gulf, Indian Ocean	VB-2018	MG251651	direct submission
Loimia sp.1	Bardez, Goa, India	Arabian Sea, Indian Ocean	GP0288	KX525511	direct submission
Loimia sp.1	Bardez, Goa, India	Arabian Sea, Indian Ocean	GP0287	KX525510	direct submission
Loimia sp.1	Bardez, Goa, India	Arabian Sea, Indian Ocean	GP0286	KX525509	direct submission
Loimia sp.1	Bardez, Goa, India	Arabian Sea, Indian Ocean	GP0285	KX525508	direct submission
Loimia sp.1 ("*ingens*")	Phuket, Thailand, Andaman Sea	E Indian Ocean	–	AF342685	Colgan *et al.* 2001

A phylogenetic tree was reconstructed using the newly generated COI sequences along with sequences of *Loimia* spp. retrieved from GenBank (Table 1) –including those from Martin *et al*. (2022) and the most recent additions–, using *Lanice conchilega* (Pallas, 1766) as outgroup. A COI sequence of Polychaeta sp., found to be identical to one of our species in a BOLD search, was also included in the analysis. Sequences were aligned with MAFFT 7.304 (Katoh & Standley 2013) using E-INS-i algorithm. Maximum Likelihood phylogenies were inferred using IQtree2 (Minh *et al.* 2013), with branch support evaluated via 1000 ultrafast bootstrap replicates (UFBoot; Minh *et al.* 2013). Pairwise evolutionary divergence between species was estimated in MEGA 12 using the p-distance model (Kumar *et al.* 2024).

Results

Taxonomy

Class Polychaeta Grube, 1850
Order Terebellida Rouse & Fauchald, 1977
Family Terebellidae Johnston, 1846
Subfamily Terebellinae Johnston, 1846

Genus ***Loimia*** Malmgren, 1866

Type species

Loimia medusa Savigny, 1822, by monotypy.

Diagnosis (after Hutchings *et al.* 2021)

Prostomium transversed, attached to dorsal surface of upper lip; basal part thick and crested; eye spots present or absent. Peristomium limited to lips; upper lip short, button-like; lower lip mid-ventral. Lateral lobes well-developed on segments 1, 3, and sometimes 4. Three pairs of arborescent branchiae on segments 2–4. Notopodia on segments 4–20; neuropodia from 5 to pygidium. Neurochaetae short-handled uncini, initially in single- rows, then in partially intercalated back-to-back double rows on segments 11–20, and then in single rows to pygidium. Uncini with pectinate crest and several minute lateral teeth. Nephridial papillae on segment 3, genital papillae on segments 6–8, posterior to notopodia. Pygidium smooth to papillate.

Loimia hannae sp. nov.
urn:lsid:zoobank.org:act:04FFF26A-91C7-44C5-AFD8-D8B2F73DF057
Figs 1–4

Loimia cf. *ingens* – Toso *et al*. 2024: fig. 2a, s31–s33, fig. s22.

Diagnosis

Species of *Loimia* with two pairs of lateral lobes on segments 1 and 3; first pair ventrolateral, with margins contacting mid-ventrally; second pair smaller, lateral. Branchiae decreasing in size from segment 2 to 4. Ventral shields over 15 segments (2–17), trapezoidal from 2 to 13, rounded posteriorly; all beige (in life: margins dark red on segments 2–11, entirely blood red from segment 13); with transverse grooves on segments 12–17. Uncini with a single row of 3–5 (thoracic) and 4 (abdominal) teeth over main fang. Thoracic capillary notochaetae alimbate and bilimbate. Pygidium with 7–8 papillae in life, appearing as globular papillae when preserved.

Etymology

The specific epithet is dedicated to Hanna Dattner Feldstein, mother of the second author, in tribute to her legacy as a holocaust survivor, an exceptional mother and a brilliant scientist with endless curiosity.

Holotype

ISRAEL – **Bat Yam Beach** • complete spec.; 32.022° N, 34.737° E; 1 m depth; 12 Jun. 2023; L. Goren and T. Feldstein leg.; fixed and preserved in 96% ethanol; SMNHTAU Vr.25367.

Paratypes

ISRAEL – **Akhziv** • 1 spec. (in two fragments, small abdominal segment taken for tissue collection); 33.056° N, 35.102° E; 1 m depth; Jun. 2025; L. Goren leg.; fixed and preserved in ethanol 96%; SMNHTAU Vr. 25544 • 1 spec. (complete); 1 m depth; May 2025; T. Morav leg.; fixed and preserved in ethanol 96%; SMNHTAU Vr. 25545 • 1 spec. (complete); T. Morav leg.; SMNHTAU Vr. 25549 • 1 spec. (complete); same collection data as for preceding; SMNHTAU Vr.25550. – **Bat Yam Beach** • 1 spec. (complete, bad condition); same collection data as for holotype; fixed and preserved in 85% ethanol; SMNHTAU Vr.25400 • 1 spec. (complete); same collection data as for holotype; fixed and preserved in 85% ethanol; SMNHTAU Vr.25547 • 1 spec. (poor condition); same collection data as for holotype; fixed and preserved in 96% ethanol; SMNHTAU Vr.25551 • 2 specs (incomplete); same collection data as for holotype; SEM mount; SMNHTAU Vr.25552. – **Gordon Beach, Tel Aviv** • 1 spec.; 32.088° N, 34.762° E; 5 m depth in artificial reef monitoring structure; 8 Jun. 2022; Zirler. R leg.; fixed and preserved in 96% ethanol; SMNHTAU Vr.25448.

LEBANON **– Bar El Mubarakh Bay** • 1 spec. (complete); 33.275° N, 35.195° E; 0–5 m depth; on artificial hard bottom; 17 Nov. 2022; fixed and preserved in ethanol 96%; PCZL. T.LO.2.1 • 1 spec. (incomplete, lacking posterior end); same collection data as for preceding; sample TR4; PCZL. T.LO.2.3 – **Bar es Slaiyeb Bay** • 1 spec. (complete); 33.267° N, 35.196° E; 0–3 m depth, on artificial hard bottom; 6 Jun. 2022; fixed and preserved in ethanol 96%; PCZL. T.LO.2.2.

Description

Holotype complete, 59 mm long (excluding buccal tentacles), 4 mm maximum width, with about 54 abdominal segments. Paratypes 42–128 mm long and 4–7 mm wide. Color in life pale, with pink tint; varying from pale beige to brown in paratypes (Fig. 1A–B), sometimes with dark pigmentation on dorsal side of posterior abdomen (Fig. 2D). Thorax with ill-defined dorsal segmentation, well-marked abdominally (Fig. 1A). Tentacles long, beige with pale brown bands, with a deep, dark pigmented groove –in life: clear, with purple to brown bands and bright spots. Eyespots only present in specimens SMNHTAU Vr. 22547 and Vr. 25548. Upper lip hood-like, wider than long, pale beige, non-projecting over first pair of lateral lobes (Fig. 1F) –in life: conical, with blunt tip, as long as wide, pale brownish, well projecting forward (Fig. 1B). Lower lip small, hidden by first pair of lobes (Fig. 1E–F) –in life: not covered by first pair of lobes (Fig. 1A). First pair of lobes on segment 1, joining ventrally (Fig. 1B–E); second pair on middle of segment 3 (Fig. 1B–E). Three pairs of branchiae in segments 2–4; first pair largest, second intermediate, third smallest. Nephrididal papillae digitiform, in segment 3 posterior and dorsal to lateral lobe (Fig. 1F, F1). Genital papillae bulbous, in segments 6–8, inserted posterior to notopodia (Fig. 1F, F2). Ventral shield on segments 2–15 (Fig 1B, D, G), those on segments 2–3 fused to form a single crenulated structure, trapezoidal on segments 2–11, round on 12–15; shields pale beige –in life: margins dark red on segments 2–10, with paler to brown center; entire blood red from segment 11–; divided transversely in two on segments 11, in three on segments 13, and in four on segments 14–15. Notopodia from segments 4–20 short, rectangular, first pair slightly shorter. Neuropodia from segment 5 as low, almost sessile ridges until segment 20, then elongate, thin, rectangular pinnules. Notochaetae of two types: smooth short capillaries and narrowly bilimbate (Fig. 3A–C). Thoracic uncini pectinate, arranged in single row from segments 5–10, then after back-to-back in double rows. Uncini with 3–5

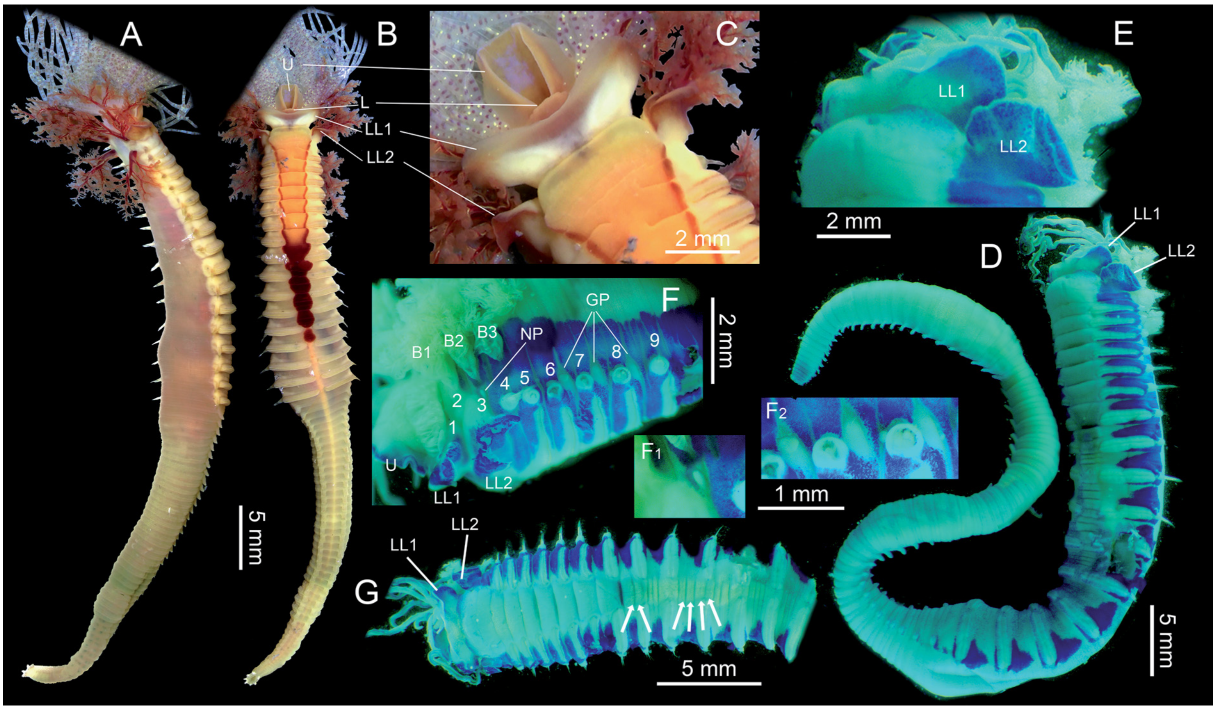

Fig. 1. *Loimia hannae* sp. nov. **A**–**C**. Paratype SMNHTAU Vr.25549, living. **E**–**G**. Holotype SMNHTAU Vr.25367 preserved and stained with Methylene blue. **A**. Entire body, dorsal view. **B**. Entire body, ventral view. **C**. Close-up on anterior end, ventral view. **D**. Entire body, lateral view. **E**. Close-up on anterior end, ventral view. **F**. Anterior part, lateral view, with close-up on nephridial (F1) and genital (F2) papillae. **G**. Thorax, ventral view. Numbers = segments. Abbreviations: B1–3 = branchiae 1–3; GP = genital papillae; L = lower lip; LL1 = lateral lobe on segment 1; LL2 = lateral lobe on segment 3; NP = nephridial papillae; U = upper lip. Arrows indicate transverse division of ventral shields.

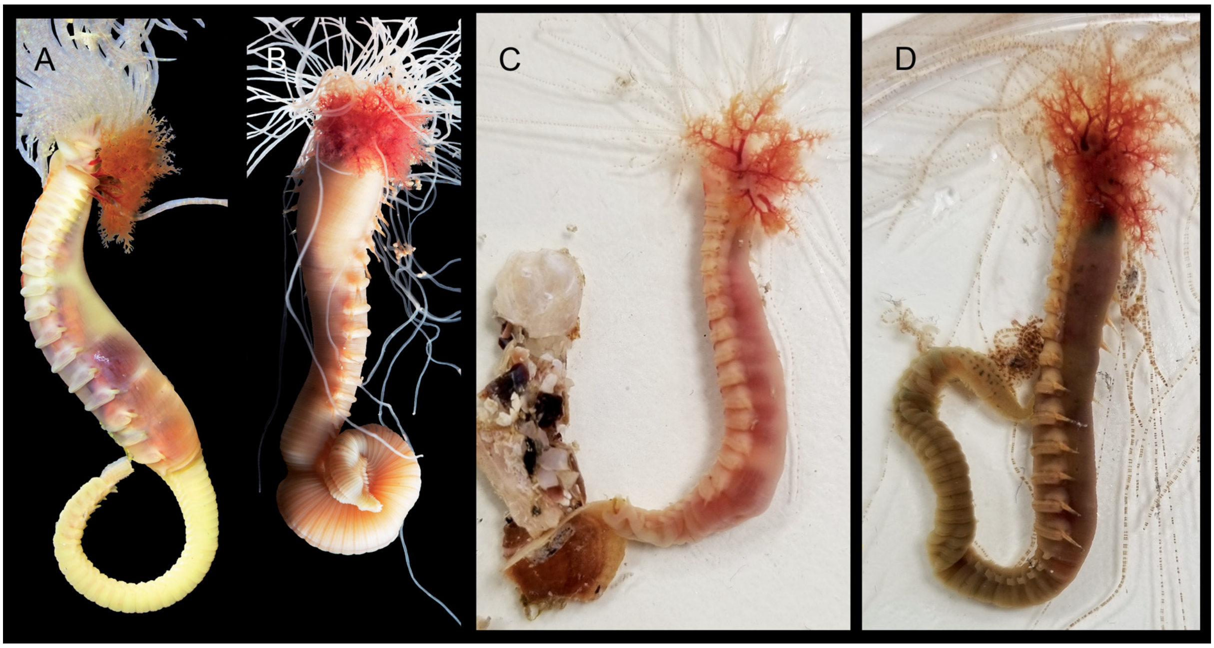

Fig. 2. *Loimia hannae* sp. nov. Color variability in life. **A**. Paratype SMNHTAU Vr.25448. **B**. Paratype SMNHTAU Vr.25399. **C**. Paratype SMNHTAU Vr.25544. **D**. Paratype SMNHTAU Vr.25549.

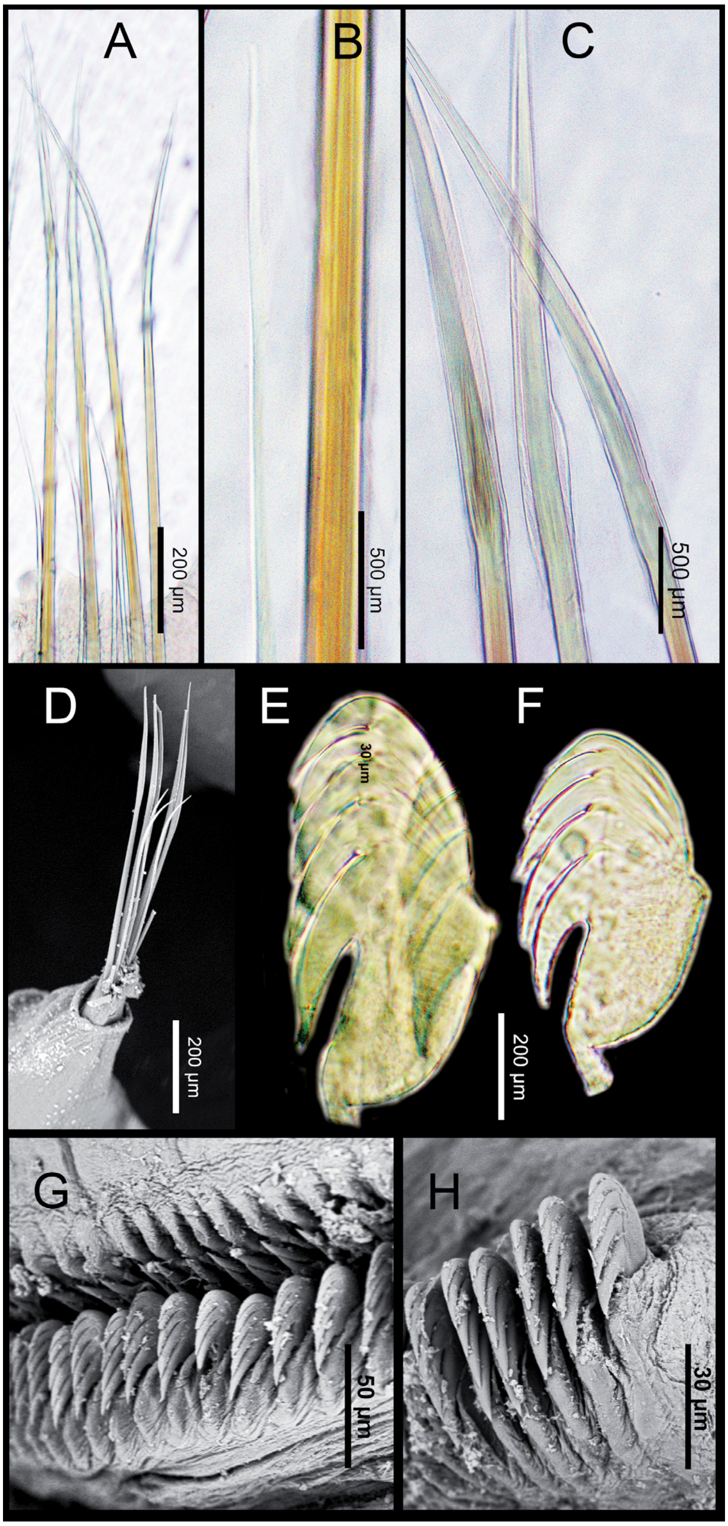

Fig. 3. *Loimia hannae* sp. nov. **A–C, E–F**. Holotype SMNHTAU Vr. 25367. **D, G, H**. Paratype SMNHTAU Vr. 25552. **A**. Arrangement of alimbate and bilimbate capillary chaetae (segment 15). **B**. Alimbate capillary chaeta (left) and bilimbate capillary chaeta (right). **C**. Tip of alimbate capillary chaeta. **D**. SEM image of notopodia with capillary chaetae. **E**. Single thoracic uncinus (segment 15). **F**. Single abdominal uncinus (segment 36). **G**. Thoracic uncini (segment 14). **H**. Abdominal uncini (segment 35).

denticles over main fang, anterior filament long, heel reduced, lacking dorsal button (Fig. 3E). Abdominal uncini with four denticles over main fang, with short anterior filament, marked heel, and no dorsal button (Fig. 3D). Pygidium with 7–8 papillae in life, visible as 7–8 pads when preserved (Fig. 4).

Methylene blue staining strong on a narrow area at border of upper lip, wider on first lateral lobe –but leaving most ventral part and ventral joining area unstained– fully covering second lateral lobe, and laterally on thoracic parapodia with notopodia (leaving uncinal tori unstained), then drastically reducing abdominally (Fig. 1D–G); nephridial papilla not stained (Fig. 1F, F1); genital papillae and closely surrounding areas not stained (Fig. 1F, F2).

Reproduction

Specimens SMNHTAU Vr. 25551 and SMNHTAU Vr. 25547 are gravid females, with oocytes measuring ~0.1–0.15 mm in diameter. Genital papillae were not observed in these specimens, although it remains unclear whether this absence reflects a true lack of these structures or results from the preservation condition of the material.

Variability

Number of ventral shields not size-related. Fused shields on segments 2–3 only, or on 2–3 and 4–5, with the number of ventral shields being 14 or 13, respectively. Specimens with more segments covered by ventral shields having trapezoidal shields reaching segment 12–13 and round shields on segments 13(14)–17. Most specimens having two transverse divisions on segments 11, three on segment 12, and four on subsequent segments, except for those having two divisions on segments 12–13, three on 14–16,

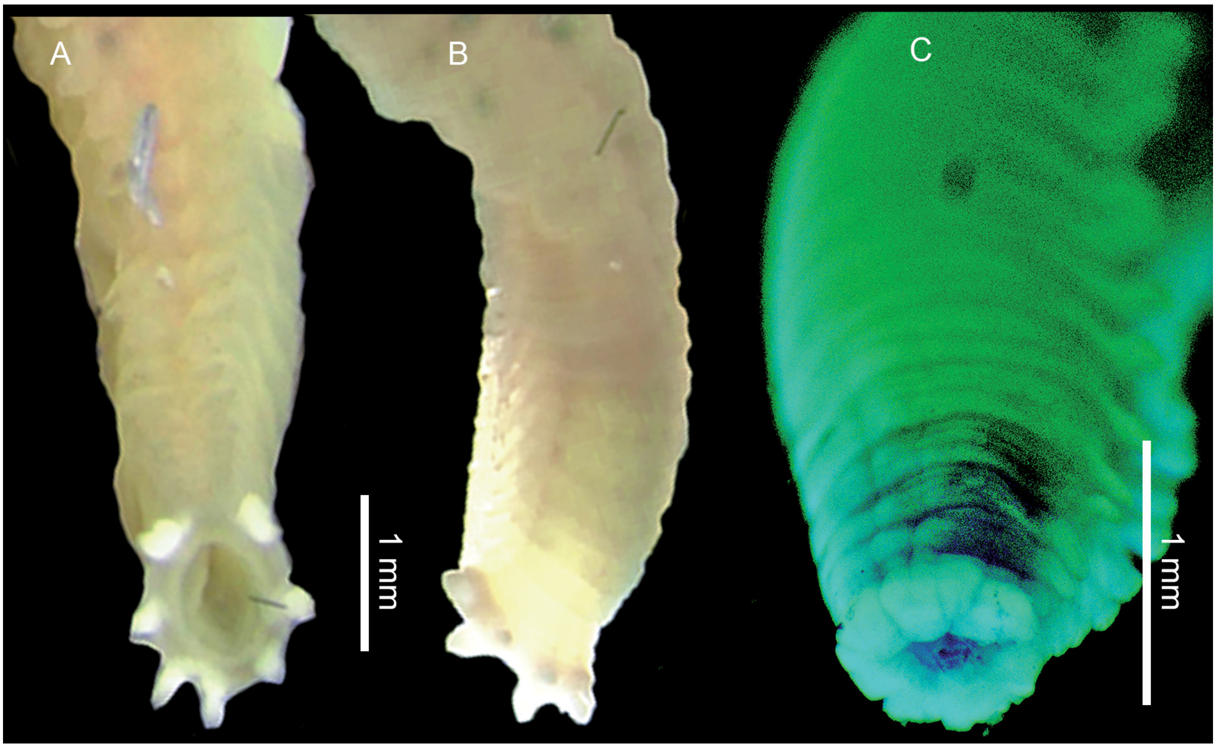

Fig. 4. *Loimia hannae* sp. nov., pygidium. **A**–**B**. Paratype SMNHTAU Vr.25549. **C**. Holotype SMNHTAU Vr.25367. **A**. Ventral view in life. **B**. Lateral view in life. **C**. Preserved in 96% ethanol, stained with Methylene blue.

and four on segment 17. In life, blood red region starting on segment 11, with only margins of more anterior shields being red.

Lebanese specimens fully agree with holotype description, with slight variation in segments with ventral shields (2–17) and number of denticles over main fang (five in thoracic uncini and four in abdominal; Toso *et al*. 2024).

Remarks

The only species of *Loimia* previously reported from the Mediterranean Sea is *L. medusa*, which differs from *L. hannae* sp. nov. in having 12 ventral shields (13–14 in *L. hannae* sp. nov.; Supp. file 1: Table S1), uncini with 4–5 denticles (4–6 in *L. hannae*), a non-papillated pygidium (papillated in *L. hannae*), and lateral lobes joined mid-ventrally by a membrane (not joined in *L. hannae*). Four other species of *Loimia* are known to have the 1st pair of lateral lobes fused to form a collar: *L. batilla* Hutchings & Glasby, 1988*, L. crassifilis* (Grube, 1878)*, L. borealis* Wang, Sui, Kou & Li, 2020 and *L. ingens* (Table 2). *Loimia batilla* differs from *L. hannae* in having the 2nd pair of lateral lobes round and covering the ventrum (not as big in *L. hannae*), the 1st pair of branchiae being the biggest (decreasing from 1 to 3 in *L. hannae*), and 10 ventral shields (13–14 in *L. hannae*). *Loimia borealis* also has 10 ventral shields, its branchiae are equal in size, and apparently has only one type of notochaetae (two types in *L. hannae*). *Loimia crassifilis* differs from *L. hannae* in having the 2nd pair of lateral lobes with low rounded ends and much thicker branchial stems (up to 1 mm). Moreover, these species are distributed in the Philippines (*L. batilla*), China (*L. borealis*), and Australia (*L. crassifilis*), hence far from the Mediterranean.

Loimia hannae sp. nov. resembles *L. ingens* in having the first pair of the lateral lobes connected ventrally and the same number of uncinal teeth (Supp. file 1: Table S1). However, it differs in having the second pair of lobes in the middle of segment 3 vs between segments 2–3 in *L. ingens* (Grube 1878; Hutchings & Glasby 1988; Wang *et al*. 2020), 13–14 ventral shields –as in *L. ingens* in Grube (1878), but 11–12 in *L. ingens* sensu Hutchings & Glasby (1988) and Wang *et al.* (2020), eyespots in at least two specimens (unknown in *L. ingens*), and branchiae decreasing in size from 1st to 3rd, as in *L. ingens* sensu Grube (1878), while only 3rd being small in Chinese specimens or all being similarly sized in Australian specimens (Hutchings & Glasby 1988; Wang *et al.* 2020).

Molecular analyses

The analyses based on the COI barcode supports the erection of *L. hannai* sp. nov. (Fig. 5), clearly distinguishing it from all other species of the genus with available sequences –which include species of the *L. ingens* complex, except for the type locality of that species. A similar topology was recovered for the 16S gene (Supp. file 2: Fig. S2). Our molecular results also support our morphological observations, as the Lebanese sequence in Toso *et al.* (2024) (GenBank accession number PP808834) clustered together with the Israeli sequences of the new species.

Uncorrected p-distances between *L. hannae* sp. nov. and its two closest relatives within the *L. ingens* complex were 12.6% and 14.8% (K2P distances 15.6% and 19.2%, respectively; Table 3).

Habitat

Found under rocks and on artificial hard substrates, from intertidal to 5 m depth. Its tubes are usually attached under small to medium rocks and are made of many small stones mixed with shell debris.

Distribution

Israeli and Lebanese coasts (Toso *et al.* 2024; this paper).

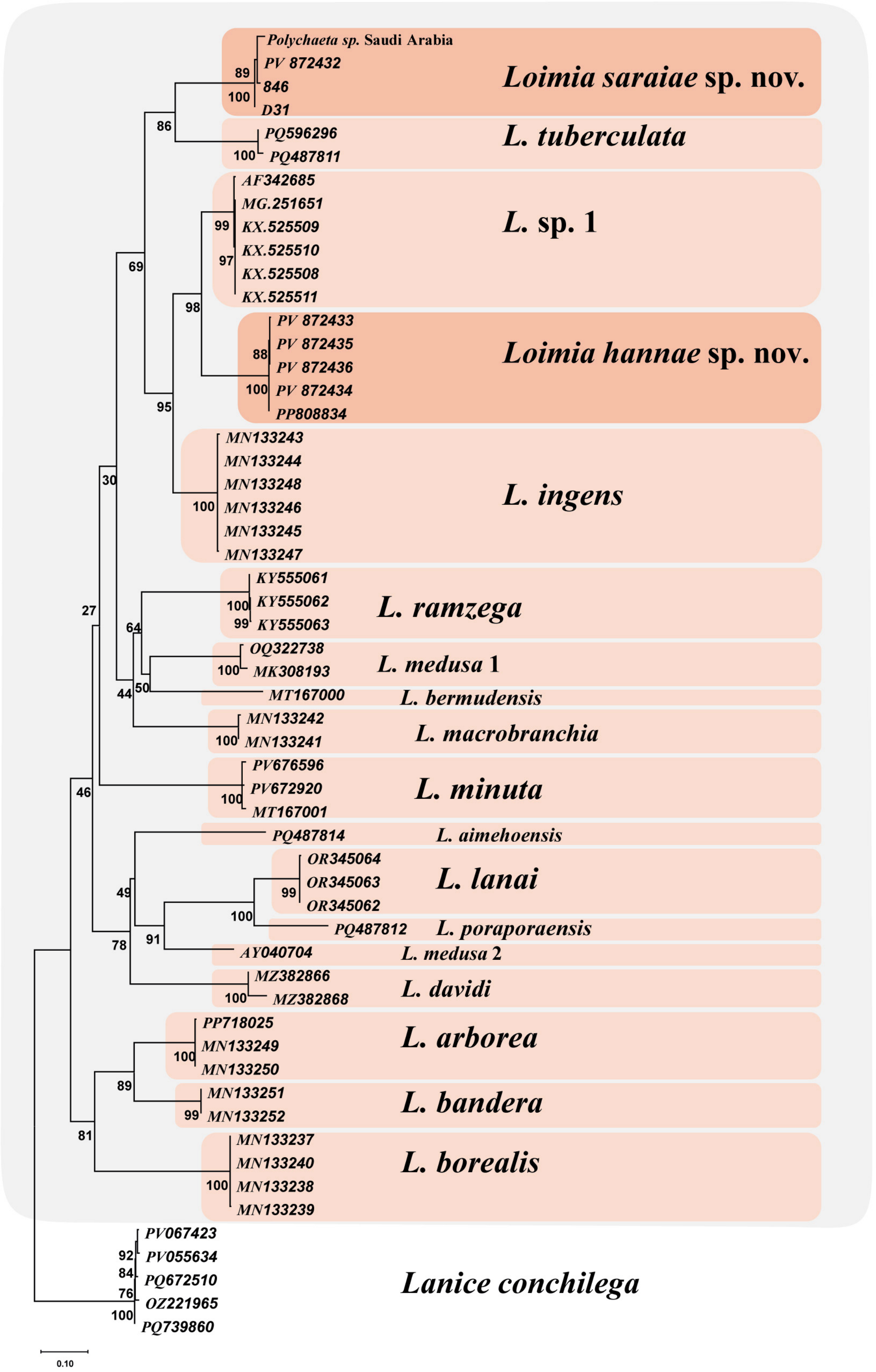

Fig. 5. Phylogenetic relationships within the genus *Loimia* Malmgren, 1866, inferred from a Maximum Likelihood analysis of the COI barcode region (603 bp). Numbers above nodes = ultrafast bootstrap supports (%).

Table 2. A comparison of the main morphological characters between species of *Loimia ingens* complex and *L. hannae* sp. nov.

Character	***Loimia ingens*** **(Grube, 1878)**	***Loimia ingens*** **sensu Hutchings & Glasby1988**	***Loimia ingens*** **sensu Wang *et al.* 2020**	***Loimia hannae*** **sp. nov.**
1st lateral lobe	Well developed	Well developed, connected mid-ventrally	Rounded, connected mid-ventrally	Well developed, connected mid-ventrally
2nd lateral lobe	Arises from the junction S2 and S3	Arises from the junction S2 and S3, not extending ventrally	Prominent and rounded, arises from the junction S2 and S3, not extending ventrally	Ear-shaped, rounded, in segment 3, not extending ventrally
Type locality	Bohol, Philippines	Australia	China	Israel
Distribution	Philippines	South Pacific	China	East Med – Israel and Lebanon
Pigmentation	White lateral bands on the thorax and anterior abdomen	Ranges from lack of pigmentation to banded buccal tentacles and body pigmentation	Beige to pinkish with banded buccal tentacles and blood red region on ventral shields	Variable – beige to pinkish, with some darker spots on the posterior dorsum
Eyespots	NA	Absent	Absent/present	Absent/present
Branchiae	3 pairs, 2–4 seg. Decreasing in size from 1st to 3rd. Short stalk	3 pairs, 2–4 seg. Vary in size	3 pairs, 2–4 seg. 1st and 2nd same size, 3rd smallest. Long basal stem	3 pairs, 2–4 seg. decreasing in size. Short basal stem
Ventral shields	Segments 2–15	NA	Segments 3–14, rectangular to trapezoidal	Segments 2–15 (holotype) 2–17 (other material), rectangular and trapezoidal
Abdominal mid ventral groove	NA	NA	Present	Present
Uncini no. of teeth	3	3–5	3–7	4–6
Pygidium	NA	NA	Not seen	Pygidium with 7–8 papillae
Source	Grube 1878	Hutchings & Glasby 1988	Wang *et al.* 2020	This study

Loimia saraiae sp. nov.

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Figs 6–7

Diagnosis

Species of *Loimia* with visible dorsal pigmentation consisting on dark spots concentrated posteriorly on each segment, on thoracic notopodia, ventral pads, and pygidium –in life: more conspicuous, with white dorsal spots in abdomen. Second pair of branchiae largest. Two pairs of lateral lobes on segments 1 and 3; first pair ventrolateral, with margins contacting mid-ventrally; second pair smaller, lateral. 14–15 ventral shields from segment 2, fused on segments 2–3; brown, gradually narrowing forming an overall triangular outline; with transverse grooves on segments 11–16. Uncini with a single row of 4–5 (thoracic) and 5–6 (abdominal) teeth over main fang. Pygidium crenulated, with dark pigmentation non-fading when preserved.

Table 3. Estimates of evolutionary divergence over sequence pairs between select species of *Loimia* Malmgren, 1866, showing the number of base substitutions per site averaged over all sequence pairs between groups. Analyses were conducted using the Kimura 2-parameter (K2P) model in the upper-right corner and p-distances in the lower-left corner. Grey cells indicate average distances within groups.

p-distance\K2P	***Loimia* sp. 1**	***L. ingens***	***L. hannae***	***L. tuberculata***	***L. saraiae***	***L. minuta***
Loimia sp. 1	0.002	0.162	0.156	0.232	0.260	0.289
L. ingens	0.130	0.002	0.192	0.222	0.257	0.295
L. hannae	0.127	0.150	0.002	0.220	0.253	0.259
L. tuberculata	0.175	0.169	0.169	0.010	0.218	0.222
L. saraiae	0.189	0.185	0.185	0.164	0.006	0.252
L. minuta	0.205	0.208	0.190	0.170	0.187	0.013

Etymology

The specific epithet honors Sarai Peled Goren, wife of the first author, in tribute to her passion for the sea, and her lifelong dedication to helping others as a clinical social worker.

Type material

Holotype

ISRAEL – **Akhziv beach** • complete spec.; 33.056° N, 35.102° E; 1 m depth; Jun. 2017; L. Goren and T. Feldstein leg.; fixed and preserved in 96% ethanol; SMNHTAU Vr.25467.

Paratypes

CYPRUS – **Episkopi Bay** • 1 spec. (complete, in four fragments); 34.647° N, 32.807° E; stn SS22; 28.2 m depth; 2 Sep. 2024; fixed and preserved in ethanol 96%; PCZL. T.LO.1.1. – **Larnaca Bay** • 1 spec. (posterior fragment); 34.957° N, 33.690° E; stn SS48; 32.2 m depth; 8 Aug. 2024**;** fixed and preserved in ethanol 96%; PCZL. T.LO.1.2.

Description

Holotype complete, 90 mm long (excluding buccal tentacles), 12 mm maximum width, with about 77 abdominal segments; posterior end regenerating; body and tentacles pale beige, with dorsal dark pigmentation still visible and white spots absent (Fig. 7D) –in life: greenish brown, with colorless buccal tentacles having pale pink spots all along their length (Fig. 7A), second lateral lobe with dark pigmentation at dorsal basis and on ventral joining point (line shaped), dark dorsal spots, concentrating as rows on posterior region of each segment thickening posteriorly on parapodia, gradually becoming more irregular dorsally on abdominal segments; white spots concentrating along with dark ones on posterior region of each segment (Fig. 7A, D); larger dark spots on dorsal side of thoracic notopodia; dark spots on posterior corner of each ventral pad (Fig. 7D); pygidium with a dark circle (Fig. 7F). Peristomium forming two lips: upper hood-like, lower small, difficult to distinguish. Branchiae thick with short basal stem, on segments 2–4; first and third pairs smaller than second. Lateral lobes with borders slightly damaged, on segments 1 and 3; first ones with dorsal margin inserted laterally to first pair of branchiae, clearly separated ventrally to expose small lower lip. Eyes not seen. Ventral shield dark pigmented on segments 2–15, with traces on segment 16; shields 1–2 almost joined; all shields trapezoidal, with one division in 10, two in 11–12, three in 13–15, and two entering 16. Notopodia on segments 4–20, with two types of notochaetae (all broken); uncini with marked hill, 4–5 denticles over main fang (Fig. 7B), and dorsal button absent. Abdominal uncini with 5–6 denticles over main fang, very marked hill, dorsal button absent, long anterior filament, and main fang thicker than in thoracic uncini (Fig. 7C). Pygidium crenulated, with dark pigmentation remaining after preservation (Fig. 6H). Tube mucous aggregating small stones and shell fragments (Fig. 6B). Methylene_blue staining more or less continuous on dorsal side of each parapodia on segments 4–14, entirely covering dorsal part of segment 4, reducing to small line on segment 14 (Fig. 7C, E), present on both sides of hooks, but not medially, on lateral lobes, border of upper lip, and basis of branchiae. Abdomen not stained.

Variation

The complete Cypriot specimen (PCZL. T.LO.1.1) was fragmented in four parts (with 24 (76 mm), 3 (6 mm), 15 (20 mm), and 35 (14 mm) chaetigers, totaling 77 chaetigers for 116 mm), the maximum width was 9 mm, the thorax had 15 chaetigers, and the abdomen 62. An intermediate section might be missing, but the posterior end of the anterior fragment was too damaged to be sure. Posterior-most

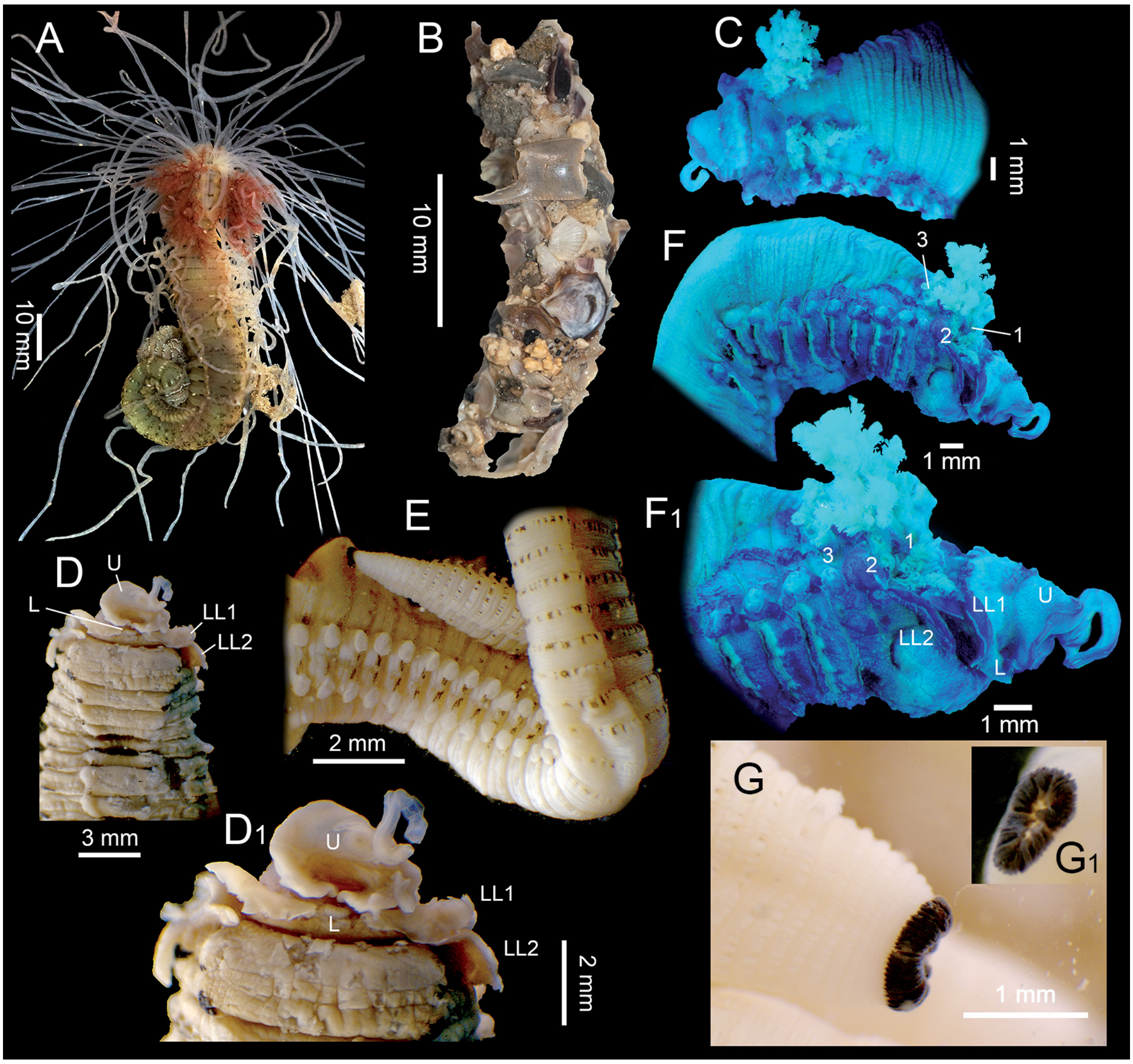

Fig. 6. *Loimia saraiae* sp. nov., holotype (SMNHTAU Vr.25467). **A**–**B**. In life. **C**–**G**. Preserved. **A**. Entire body, dorsal view. **B**. Part of the tube. **C**. Anterior part of body, dorsal view, stained with Methylene blue. **D**. Anterior, ventral view, with close up view of the anterior end (D1). **E**. Posterior, ventral view. **F**. Lateral view, stained with Methylene blue, with close up view of the anterior end (F1). **G**. Pygidium, lateral view and frontal view (G1). Abbreviations: B1–3 = branchiae 1–3; L = lower lip; LL1 = lateral lobe on segment 1; LL2 = lateral lobe on segment 3; U = upper lip.

chaetigers were very short, difficult to count. Ventral shields were present at least to segment 16, with evident dark edges on segments 10–15. There were 15 notopodia on segments 4–18 (instead of 17 on segments 4–20 in the Israeli material), three pairs of branchiae on segments 2–4, and dark brown pigmentation in transverse stripes throughout the body, more evident in posterior-most segments.

The incomplete posterior end of specimen (PCZL.T.LO.1.2) measured 8 mm for 19 chaetigers plus pygidium and was overall well preserved. The pygidium showed a clearly crenulated edge, but the dark

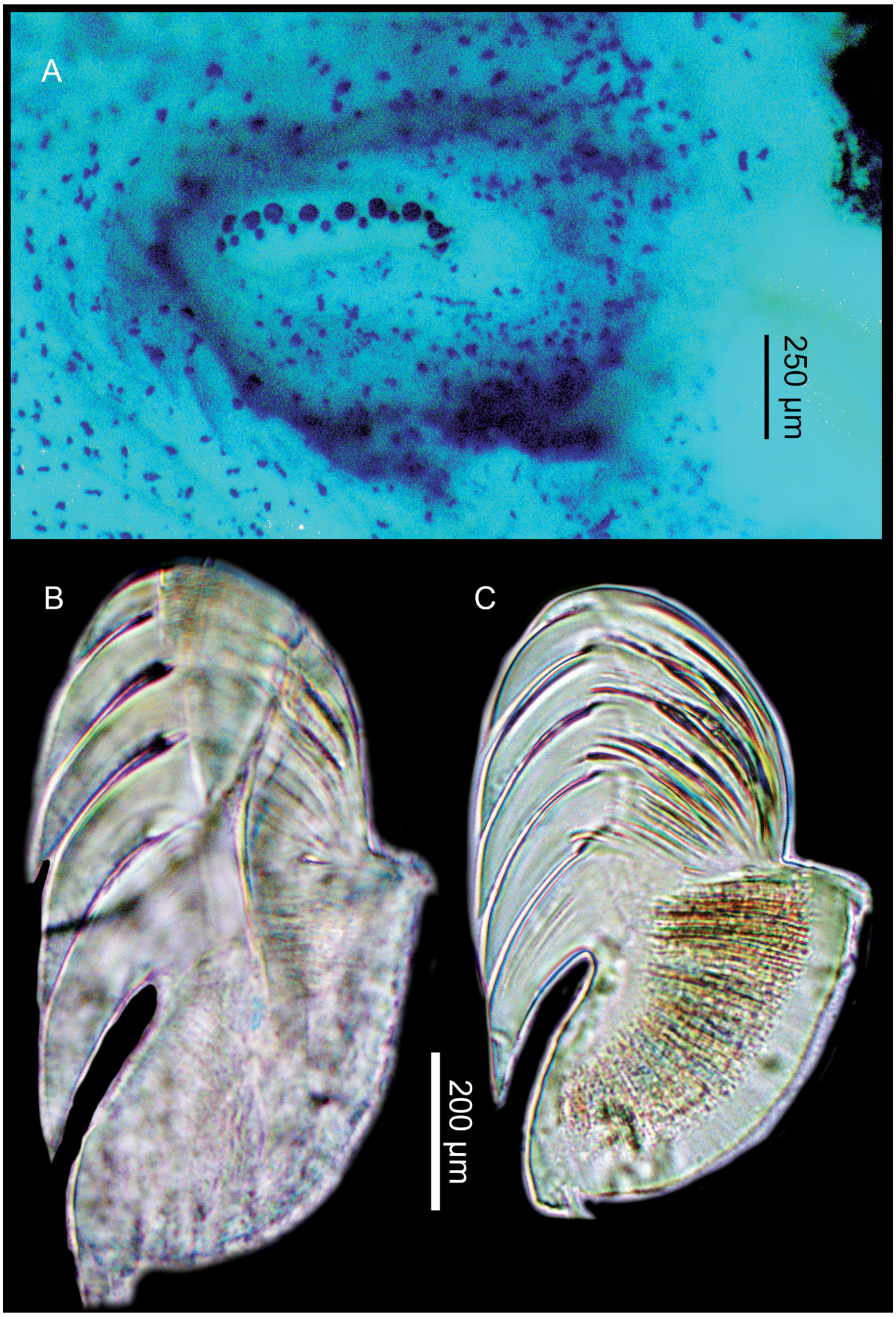

Fig. 7. *Loimia saraiae* sp. nov., holotype (SMNHTAU Vr.25467). **A**. Notopodium from segment 16, showing the bases of broken notochaetae, stained with Methylene blue. **B**. Thoracic uncinus (segment 18). **C**. Abdominal uncinus (segment 30).

pigmentation was less developed than in the Israeli specimen, not reaching the internal anal edge. Dark spots were also evident on the dorsal side of chaetigers.

Remarks

Loimia saraiae sp. nov. differs from all species of *Loimia* by its distinct and stable pigmentation (persisting after preserved in alcohol) and by its crenulated pygidium. Only five species of *Loimia* show a crenulated pygidium, while in eleven this character remains undescribed (Supp. file 1: Table S1); for none of them, however, a persistent pigmentation is mentioned. *Loimia saraiae* differs from these eleven species also in the arrangement of the lateral lobes (two pairs on segments 1 and 3) and branchiae (three pairs on segments 2–4, the 3rd being the largest): *Loimia ochracea* (Grube, 1877) and *L. bandera* Hutchings, 1990 possess three pairs of lateral lobes, while *L. bermudensis* Verrill, 1900 has lobes on segments 1–2, and *L. batilla*, *L. decora* Pillai, 1961, *L. grubei* Holthe, 1986, and *L. ingens* have lobes arising from segments 2–3. *Loimia armata* Carrerette & Nogueira, 2015, *L. contorta* (Ehlers, 1908), *L. crassifilis*, *L. minuta* Treadwell, 1929, and *L. ingens* share the mid-ventrally connected 1st pair of lateral lobes and branchiae decreasing from 1 to 3 (lateral lobes ventrally separated and 2nd pair of branchiae being the largest in *L. saraiae*). *Loimia contorta* and *L. savignyi* McIntosh, 1885 further differ in having uncini with a dorsal button, and *L. verrucosa* Caullery, 1944 in having dorsal tubercles on the abdominal segments.

Among the species with crenulated pygidium, *L. keablei* Nogueira, Hutchings & Carrerette, 2015, *L. juani* Nogueira, Hutchings & Carrerette, 2015, *L. aimehoensis* Hutchings, Daffe, Glasby & Lavesque, 2025, and *L. poraporaensis* Hutchings, Daffe, Glasby & Lavesque, 2025 are not pigmented and have uncini with dorsal buttons, contrary to *L. saraiae* sp. nov. Pigmentation on pygidium and thoracic notopodia also distinguishes *L. saraiae* from *L. tuberculata* Nogueira, Hutchings & Carrerette, 2015, which possesses unique big papillae (tubercules) on posterior dorsal body end (absent in *L. saraiae*), a different number of denticles in the uncini, and the first pair of branchiae being the largest (second in *L. saraiae*).

Molecular analyses

COI barcode and 16S analyses (Fig. 5; Supp. file 2: Fig. S2) clearly support the erection of *L. saraiae* sp. nov. –including both the Israeli and Cypriot sequences– with the most closely related species –also morphologically– being *L. tuberculata*. However, *L. saraiae* sp. nov. and *L. tuberculata* differ by 16.3% uncorrected p-distance.

Discussion

The description of two new species of *Loimia* from the Mediterranean coasts significantly contributes to resolving the taxonomy of this challenging annelid genus in the region. Our findings reinforce a growing consensus that many widely reported species of *Loimia* likely represent species complexes or misidentifications, emphasizing the importance of integrative taxonomic studies (Wang *et al.* 2020; Martin *et al.* 2022; Hutchings *et al.* 2024, 2025). The taxonomy of the genus in the Mediterranean has long been debated and is still unresolved (Rullier 1963; Ben-Eliahu 1976; Zenetos *et al.* 2011; Dorgham *et al.* 2013; Lavesque *et al.* 2017; Martin *et al.* 2022). Until recently, the only species formally recorded was *L. medusa* –regarded as a NIS (Zenetos *et al*. 2017). However, Mediterranean records are scarce and lack comprehensive descriptions (Toso *et al*. 2024), likely representing native, yet undescribed, species rather than true *L. medusa* (Lavesque *et al*. 2017). Our findings support previous revisions suggesting that most reports of this species outside its native range in the Arabian Sea and the Red Sea likely reflect misidentifications (Hutchings & Glasby 1995; Wang *et al.* 2020; Martin *et al.* 2022; Hutchings *et al.* 2024, 2025), with the description of two regionally distinct species –*L. hannae* sp. nov. and *L. saraiae* sp. nov.– further undermining the validity of earlier identifications based solely on superficial morphological similarity. However, we cannot rule out *L. medusa* specimens –which is indeed the type species of the genus– being present in the Mediterranean because it has never been the object of a "modern" redescription –except for that in Hutchings & Glasby (1995). Therefore, we would like to stress that a redescription of *L. medusa* based on topotypic specimens and including molecular data is paramount not only to further disentangle the distribution of the species and whether it is a Mediterranean NIS, but also the real diversity of the genus.

Taking this into account, this study also contributes to a broader understanding of Lessepsian migration and the distribution of eastern Mediterranean NIS. The Levantine basin is a known hotspot for biological invasions via the Suez Canal (Zenetos *et al.* 2022; Toso *et al.* 2024), and newly discovered taxa in this region are often presumed to be NIS or Lessepsian migrants. *Loimia hannae* sp. nov. closely resembles members of the *L. ingens* complex (Fig. 6), while *L. saraiae* sp. nov. appears closely related to *L. tuberculata*, both being Indo-Pacific species (Nogueira *et al.* 2015; Wang *et al.* 2020; Toso *et al.* 2024; Hutchings *et al.* 2025). Such resemblance could lead to erroneous classification as NIS Lessepsian migrants. While our integrative approach clearly distinguishes them from known Indo-Pacific congeners, the possibility that they represent non-indigenous or cryptogenic elements in the Mediterranean fauna cannot be ruled out. Indeed, their closest molecular relatives are currently found outside the basin and there is a COI sequence from Saudi Arabia identical to *L. saraiae*, suggesting either historical introduction, recent colonization, or unrecognized native persistence. Comparable cases –such as the mytilid bivalve *Brachidontes pharaonis* (P. Fischer, 1870), long regarded as a Lessepsian migrant of Indo-Pacific origin, but now suspected to represent a cryptic native Mediterranean lineage– underscore the pitfalls of relying solely on biogeographic expectations. We therefore caution against premature classification and advocate treating these species as cryptogenic pending broader geographic sampling and historical data.

Another key aspect emerging from our study –consistent with recent research on *Loimia*– is the pronounced intraspecific morphological variability, particularly in relation to body size (Martin *et al.* 2022; Hutchings *et al.* 2025). For example, large and small morphotypes of *Loimia davidi* Martin, Capa, Martínez & Costa, 2022 from the Açores were initially thought to represent different species, but genetic analysis confirmed they belong to the same taxon (Martin *et al.* 2022). Both *L. saraiae* sp. nov. and *L. hannae* sp. nov. exhibited differences in the number of ventral shields –apparently not size-related–, while *L. saraiae* showed size-related differences in number of notopodia. This kind of variation –where some individuals may show additional, more numerous, or larger structures such as branchiae, capillary chaetae, or uncini– can easily lead to taxonomic confusion if not properly accounted for. Our results thus underscore the need for examining multiple specimens across developmental stages and size ranges when describing new species of *Loimia* (Martin *et al.* 2022; Hutchings *et al.* 2025).

In conclusion, the discovery of two new species of *Loimia* from the Eastern Mediterranean coast highlights the underestimated diversity of this genus in the region and underscores the importance of integrative taxonomy in resolving longstanding identification issues. Our findings clarify misattributions to *L. medusa* and emphasize that superficial similarity to Indo-Pacific species should not be uncritically taken as evidence of Lessepsian origin. Furthermore, the observed size-related morphological variation reinforces the need to account for intraspecific variability when describing new taxa.

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Supplementary files

Supp. file 1. Table S1. Comparison of taxonomic characters between species of *Loimia* Malmgren, 1866. https://doi.org/10.5852/ejt.2026.1048.3233.14325

Supp. file 2. Fig. S2. Phylogenetic relationships within the genus *Loimia* Malmgren, 1866, inferred from a Maximum Likelihood analysis of the 16S. Numbers above nodes = ultrafast bootstrap supports (%). https://doi.org/10.5852/ejt.2026.1048.3233.14327