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First Record of a Rare New Species of *Dracognomus* (Nematoda: Draconematidae) from the Northwest Pacific Ocean †

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Abstract: We report the discovery of a novel free-living marine nematode, *Dracognomus elongatus* sp. nov., from the genus *Dracognomus* Allen & Noffsinger, 1978 (Nematoda: Draconematidae), collected from geniculate coralline algal assemblages in the intertidal zone along the eastern coast of Korea in the Northwest Pacific Ocean. *Dracognomus elongatus* sp. nov. is distinguished from its congeners by several key features: a relatively long body length (522 µm), densely developed minute spine-like ornamentation along the margins of body annules, small pore-shaped amphids (2 µm) with membranous tubes filled with corpus gelatum extending to the fifth body annule, twelve modified cephalic adhesion tubes located posterior to the rostrum, eight pairs of modified adhesion tubes in the mid-body region, an arrangement of both normal and modified subventral adhesion tubes (three pairs of each), disc-shaped tips on sublateral adhesion tubes, absence of copulatory thorns in males, and the presence of three pairs of short setae with no protuberances on the non-annulated tail end. Morphological details and illustrations were obtained using differential interference contrast microscopy. We also provide information on the geographic distribution and comparative characteristics of species within the genus *Dracognomus*, along with a schematic ventral view of a congener illustrating the arrangement of posterior adhesion tubes and copulatory thorns. Additionally, we present a species-level pictorial dichotomous key. *Dracognomus elongatus* sp. nov. is the eighth described species of this rare genus and marks the first record of *Dracognomus* in the Northwest Pacific Ocean.

Keywords: Desmodorida; diversity; morphology; South Korea; taxonomy

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1. Introduction

The genus *Dracognomus* was first established by Allen & Noffsinger (1978) [1] and is characterized by several distinctive features: an "epsilonematid" body shape, variable and relatively inconspicuous amphid morphology (inverted U-shaped, tubular, pore-shaped, or bar-shaped), the presence of modified cephalic adhesion tubes (Mod-CAT) and modified posterior adhesion tubes (Mod-PAT), and fourth-stage larvae with four longitudinal rows of posterior adhesion tubes, whereas species in other genera within the family Draconematidae typically possess only three rows [1–3].

Currently, *Dracognomus* comprises seven recognized species: *D. americanum* (Decraemer & Gourbault, 1986) Karssen & van Aelst, 2002; *D. annae* Verschelde & Vincx, 1993; *D. dermatoglyphus* Verschelde & Vincx, 1993; *D. marioni* Allen & Noffsinger, 1978; *D. notohalensis* Allen & Noffsinger, 1978; *D. simplex* (Gerlach, 1954) Allen & Noffsinger, 1978; and *D. tinae* Jensen, 1981 [1,3–7]. These species have been recorded in different regions, including the Mediterranean, Atlantic, South Pacific, and Indian Oceans. However, for nearly 50 years, there had been no records of this genus from the Northwest Pacific since its initial description. Although nematodes remain understudied in many parts of the

world, Korea has been a key area for extensive research on the family *Draconematidae*, with thorough studies in both subtidal and intertidal zones [8–10]. Despite this focused research, the absence of *Dracognomus* in prior studies suggests that this genus may be exceptionally rare.

In this study, we report the discovery of this rare genus in the intertidal zone along the eastern coast of Korea. Through detailed morphological comparisons, we identified a new species, *Dracognomus elongatus* sp. nov., which is clearly distinguishable from other known species within the genus. This new species is described based on a male specimen collected from geniculate coralline algal assemblages, with its description supported by differential interference contrast (DIC) photomicrographs and illustrations. We also compare its characteristics with those of other members of the genus and discuss its geographic distribution. A schematic ventral view of related species, illustrating the arrangement of posterior adhesion tubes and copulatory thorns, is provided. Additionally, we present a species-level pictorial dichotomous key for all known species of *Dracognomus*. This study marks the first record of *Dracognomus* from the Northwest Pacific and adds an eighth species to this rare genus, filling a long-standing gap in its documentation.

2. Materials and Methods

2.1. Sampling Site and Sample Processing

The sampling site consisted of a sloped artificial structure built to support the docking of fishing boats within a breakwater. This structure was densely colonized by various seaweed species, including *Ulva* spp., *Sargassum* spp., and *Corallina* spp. Washing the seaweed and associated sediments revealed a diverse assemblage of nematodes, including *Prochaetosoma* sp. and *Draconema* sp., as well as representatives from the families Desmoscolecidae and Epsilonematidae.

In the field, the samples were passed through a 67 µm mesh sieve after a brief rinse with freshwater (less than one minute) to induce osmotic shock. The samples were then fixed in 5% formalin [11]. Coarse detritus was removed by decantation, and the meiobenthos was roughly extracted by flotation in Ludox (Dupont) HS 40 [12]. The *Dracognomus* specimen was isolated from the mixed meiobenthos using a LEICA M205 C stereomicroscope (LEICA, Wetzlar, Germany) under high magnification. For morphological observation, the specimen was transferred to anhydrous glycerin using the method described by Seinhorst (1959) and mounted in anhydrous glycerin between two cover slips on an HS-slide [13,14].

2.2. Morphological Identification and Microscopic Analysis

Observations, measurements, and photographs were conducted using a LEICA DM2500 LED microscope equipped with a LEICA K5C color CMOS camera (LEICA, Wetzlar, Germany). Image quality was enhanced using Adobe Photoshop 2023 (Adobe, San Jose, CA, USA). Drawings were created using a 100× objective lens with immersion oil on a LEICA DM2500 LED microscope equipped with Nomarski differential interference contrast (DIC) and a drawing tube. Line drawings were produced using tracing techniques on a Wacom Cintiq 22 tablet (Wacom, Saitama, Japan) using Adobe Illustrator (Adobe, San Jose, CA, USA).

2.3. Abbreviations

L: Total body length
CAT: Cephalic adhesion tubes
CAT*n*: Number of cephalic adhesion tubes
Mod-CAT: Modified cephalic adhesion tubes
Mod-CAT*n*: Number of modified cephalic adhesion tubes
Mod-AT: Modified adhesion tubes in the mid-body region
Mod-AT*n*: Number of modified adhesion tubes in the mid-body region
Mod-AT$l_{1, 2, \ldots}$: Length of modified adhesion tubes in the mid-body region (from anterior to posterior)

SlAT: Sublateral adhesion tubes
SlAT*n*: Number of sublateral adhesion tubes
SlAT$l_{1, 2, \ldots}$: Length of sublateral adhesion tubes (from anterior to posterior)
SvAT: Subventral adhesion tubes
SvAT*n*: Number of subventral adhesion tubes
SvAT$l_{1, 2, \ldots}$: Length of subventral adhesion tubes (from anterior to posterior)
Mod-SvAT: Modified subventral adhesion tubes
Mod-SvAT*n*: Number of modified subventral adhesion tubes
Mod-SvAT$l_{1, 2, \ldots}$: Length of modified subventral adhesion tubes (from anterior to posterior)
mbd: Maximum body diameter
(mbd): Minimum body diameter
ph: Pharynx length, measured from the anterior end of the head capsule to the posterior border of the pharyngeal bulb
t: Tail length
tmr: Length of the non-annulated tail end
spic: Length of the spicule, measured along the median line
gub: Length of the gubernaculum
a: Body length divided by maximum body diameter
b: Body length divided by pharynx length
c: Body length divided by tail length
c′: Tail length divided by anal body diameter
abd: Body diameter at the level of the anus or cloacal opening

3. Results

3.1. Systematic Accounts

Phylum Nematoda Potts, 1932
Class Chromadorea Inglis, 1983
Order Desmodorida De Coninck, 1965
Family Draconematidae Filipjev, 1922
Subfamily Prochaetosomatinae Allen & Noffsinger, 1978
Genus *Dracognomus* Allen & Noffsinger, 1978

3.2. Diagnosis of the Genus Dracognomus

Emended from Allen & Noffsinger (1978), Decraemer et al. (1997), and Tchesunov (2014) [1,2,15]. Prochaetosomatinae. The pharyngeal and posterior regions are slightly swollen, with the mid-body often appearing bubble-shaped or subtly expanded. Body cuticle ornamentation may or may not be present. The rostrum is asymmetrical and positioned obliquely on the dorsal side. There are typically eight to twelve cephalic adhesion tubes (CAT), either located on the rostrum or on the annules just behind the helmet. These CAT are usually modified (except in *D. dermatoglyphus*), featuring a fine, slender structure without a swollen base, and tapering to a narrow, open tip. The amphids are positioned from the edge of the helmet to the first few body annules. They are relatively small and exhibit variable shapes, including inverted U, bar, staple, and pore-like forms, occasionally containing membranous tubes filled with corpus gelatum. Modified adhesion tubes (Mod-AT) are found in the pharyngeal region and sometimes extend toward the anterior of the posterior adhesion tubes. Posterior adhesion tubes (PAT) are categorized into three types based on the shape of their distal ends: normal, modified, and disc-shaped. Copulatory thorns are found only in males of certain species, such as *D. americanum* and *D. simplex*. One to three pairs of short setae and protuberances are typically present at the non-annulated tail end, although they may occasionally be absent.

3.3. Type Species

Dracognomus marioni Allen & Noffsinger, 1978

3.4. Other Valid Species

Dracognomus americanum (Decraemer & Gourbault, 1986) Karssen & van Aelst, 2002 [3,4]
Dracognomus annae Verschelde & Vincx, 1993 [5]
Dracognomus dermatoglyphus Verschelde & Vincx, 1993 [5]
Dracognomus elongatus sp. nov.
Dracognomus notohalensis Allen & Noffsinger, 1978 [1]
Dracognomus simplex (Gerlach, 1954) Allen & Noffsinger, 1978 [1,6]
Dracognomus tinae Jensen, 1981 [7]

Dracognomus elongatus sp. nov. (Figures 1 and 2, Table 1)
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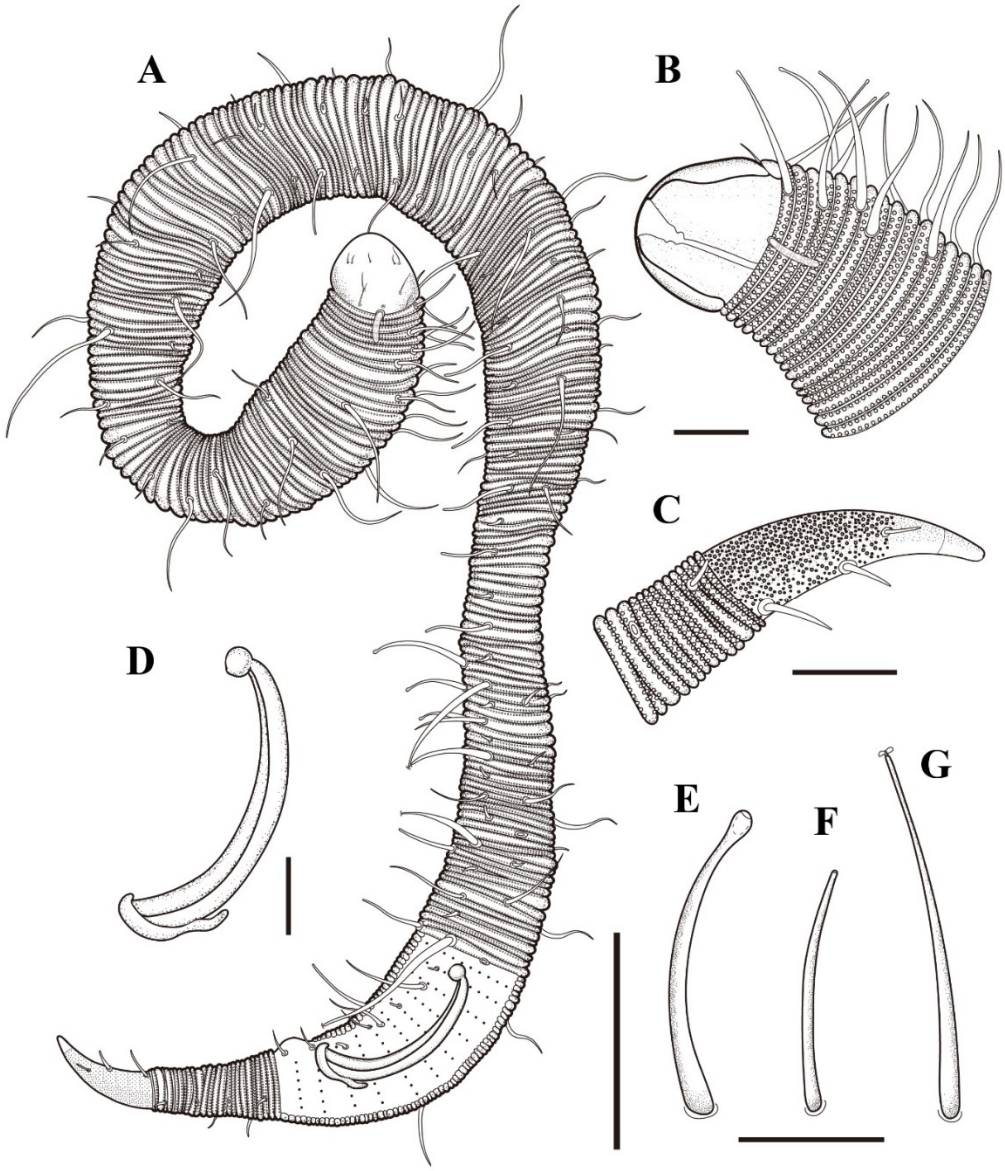

Figure 1. *Dracognomus elongatus* sp. nov., holotype male. (**A**) Habitus, lateral view; (**B**) anterior body region showing amphid with membranous tube filled with corpus gelatum, cephalic adhesion tubes, and cuticle with minute spines; (**C**) non-annulated tail end; (**D**) copulatory apparatus; (**E**) subventral adhesion tube (normal type); (**F**) subventral adhesion tube (modified type); (**G**) sublateral adhesion tube (disc-shaped type). Scale bars: (**A**) 50 µm, (**B**–**G**) 10 µm.

Table 1. Comparison of characters between *Dracognomus elongatus* sp. nov. and its congeners (Only male specimens are included; '—' indicates features not described in the original description).

Species	*D. americanum* (Decraemer & Gourbault, 1986 [4]) Karssen & van Aelst, 2002 [3]	*D. annae* Verschelde & Vincx, 1993 [5]	*D. dermatoglyphus* Verschelde & Vincx, 1993 [5]	*Dracognomus elongatus* sp. nov.	*D. marioni* Allen & Noffsinger, 1978 [1]	*D. notohalensis* Allen & Noffsinger, 1978 [1]	*D. simplex* (Gerlach, 1954 [6]) Allen & Noffsinger, 1978 [1]	*D. tinae* Jensen, 1981 [7]
Body length (µm)	325–420	397–433	383	522	400–600	300	330–380	362–406
Amphids	small, inverted U-shaped, 4–5 µm	long, straight amphids, 12 µm, pore-like apertura amphidialis	large, bar-shaped, 6 µm	pore-shaped (2 µm), membranous tube with corpus gelatum (7 µm)	inverted U-shaped	—	amphids small (3 µm long and 2 µm wide), inverted U-shaped	amphideal groove tubular
CATn	absent	absent	12	absent	absent	absent	absent	5–6 pairs
Position of CAT	absent	absent	first half of the rostrum	absent	absent	absent	absent	posterior half of the helmet on the dorsal sector
Mod-CATn	8	—	absent	12	—	—	12	absent
Position of Mod-CAT	just posterior to helmet	halfway between rostrum edge and middle of the head capsule	absent	entirely behind the helmet within the first seven body annules	the anterior half of the rostrum	the anterior half of the rostrum	partly dorsal and subdorsal on helmet edge extending till first four annules	absent
Mod-ATn	7 pairs	absent	absent	8 pairs	absent	absent	7 pairs	—
SlATn (normal)	absent	9–10 pairs	9 pairs	absent	absent	absent	absent	—
SlATn (modified)	4 pairs	absent	absent	absent	8–9 pairs	6 pairs	absent	—
SlATn (disc-shaped)	absent	absent	absent	4 pairs	absent	absent	4 pairs	—
SvATn (normal)	absent	absent	6 pairs	3 pairs	absent	absent	absent	—
SvATn (modified)	5–7 pairs	6–7 pairs	absent	3 pairs	6–8 pairs	6 pairs	6 pairs	—
Spicules (µm)	strongly curved, alae weakly developed (27–30)	arched spicules clearly sclerotized and hollow; club-shaped capitulum; spicule tips often slightly protruding in fixed specimens (31–34)	long, smoothly arched spicules with hook- to hammer-shaped capitulum, (43)	long and arcuate, with rounded proximal cephalization and well-developed ventral alae (47)	30–33	24	arcuate, proximal rounded cephalization with small ventral projection, ventral alae well developed (29–32)	pair of undifferentiated spicules, bent (26–31)
Gubernaculum	parallel to the spicules, 11–15 µm	22 µm	distal half of gubernaculum parallel to spicules, proximal half bent conspicuously, 22 µm	parallel to the distal part of the spicule and shows a distinct bend at its distal end, 17 µm	17–19 µm	9 µm	12–14 µm	as a slender rod located posterior to the spicules
Copulatory thorns	9	absent	absent	absent	absent	absent	11	absent
Setae on non-annulated tail end	2 pairs	2 pairs	1 pair	3 pairs	1 pair	1 pair	3 pairs	—

Table 1. *Cont.*

Species	*D. americanum* (Decraemer & Gourbault, 1986 [4]) Karssen & van Aelst, 2002 [3]	*D. annae* Verschelde & Vincx, 1993 [5]	*D. dermatoglyphus* Verschelde & Vincx, 1993 [5]	*Dracognomus elongatus* sp. nov.	*D. marioni* Allen & Noffsinger, 1978 [1]	*D. notohalensis* Allen & Noffsinger, 1978 [1]	*D. simplex* (Gerlach, 1954 [6]) Allen & Noffsinger, 1978 [1]	*D. tinae* Jensen, 1981 [7]
Protuberance on non-annulated tail end	2	3	3 pairs	absent	2 pairs	1 pair	absent	absent
Habitats	marine, in coarse, calcareous sandy beach interstitial water	sandbank near a *Sonneratia* bush	sandbank near a *Sonneratia* bush	intertidal sediments with geniculate coralline algal assemblages	marine, collected from sand on sand bar	marine, associated with coral on coral reef	sand or bottom debris from the intertidal zone at coarse sand beaches	32–40 m deep sand medium diameter 300–350 µm with only 0.25% or less silt-clay fractions
Type locality	Guadeloupe and Martinique, France	Kenya, Gazi, mouth of the Gazi Creeck river	Kenya, Gazi, mouth of the Gazi Creeck river	Seokho breakwater, Nagok, Uljin, Korea	Boca Raton, Florida, USA; in Palm Beach County on east coast	Pago Pago Island, American Samoa, Samoa Islands	Banyuls and Cannes, France, Mediterranean Sea	North Sea off the Belgian Coast "M 14" (51°50′50″ N, 02°51′08″ E)
References	Karssen & van Aelst (2002) [3]	Verschelde & Vincx (1993) [5]	Verschelde & Vincx (1993) [5]	This study	Allen & Noffsinger (1978) [1]	Allen & Noffsinger (1978) [1]	Karssen & van Aelst (2002) [3]	Jensen (1981) [7]

3.5. Diagnosis of the New Species

Dracognomus elongatus sp. nov. is distinguished from other congeners by the following characteristics: its extended body length (522 µm), densely developed minute spine-like ornamentations along both margins of the body annules, small pore-shaped amphids (2 µm) with membranous tubes filled with corpus gelatum, the position of twelve fine modified cephalic adhesion tubes (Mod-CAT) entirely shifted behind the rostrum, the presence of eight pairs of modified adhesion tubes (Mod-AT), the arrangement of subventral adhesion tubes (SvAT) into three pairs of normal tubes and three pairs of modified tubes, the presence of disc-shaped tube tips on four pairs of sublateral adhesion tubes (SlAT), the absence of copulatory thorns in males, and the presence of three pairs of short setae with no protuberances on the non-annulated tail end.

3.6. Type Material

A single male specimen was collected from a geniculate coralline algal bed in the intertidal zone of Uljin, Korea, on 18 May 2024. The holotype (MABIK NA00158737) has been deposited in the nematode collection at the specimen conservation room of the Marine Biodiversity Institute of Korea (MABIK).

3.7. Measurements

Male (n = 1): L = 522 µm, Mod-CATn = 12, mbd = 33 µm, (mbd) = 17 µm, ph = 43 µm, t = 59 µm, tmr = 25 µm, tmr/t = 0.4, spic = 52 µm, gub = 17 µm, a = 15.8, b = 12.1, c = 8.9, c′ = 2.9, abd = 20.6, Mod-ATn = 16, Mod-ATl_1 = 18 µm, Mod-ATl_2 = 21 µm, Mod-ATl_3 = 20 µm, Mod-ATl_4 = 17 µm, Mod-ATl_5 = 18 µm, Mod-ATl_6 = 16 µm, Mod-ATl_7 = 17 µm, Mod-ATl_8 = 15 µm, SlATn = 8, SlATl_1 = 26 µm, SlATl_2 = 16 µm, SlATl_3 = 19 µm, SlATl_4 = 34 µm, SvATn = 6, SvATl_1 = 21 µm, SvATl_2 = 15 µm, SvATl_3 = 13 µm, Mod-SvATn = 6, Mod-SvATl_1 = 14 µm, Mod-SvATl_2 = 15 µm, Mod-SvATl_3 = 16 µm.

3.8. Etymology

The specific name *elongatus* is derived from Latin, meaning "elongated," and refers to the species' long and slender body shape.

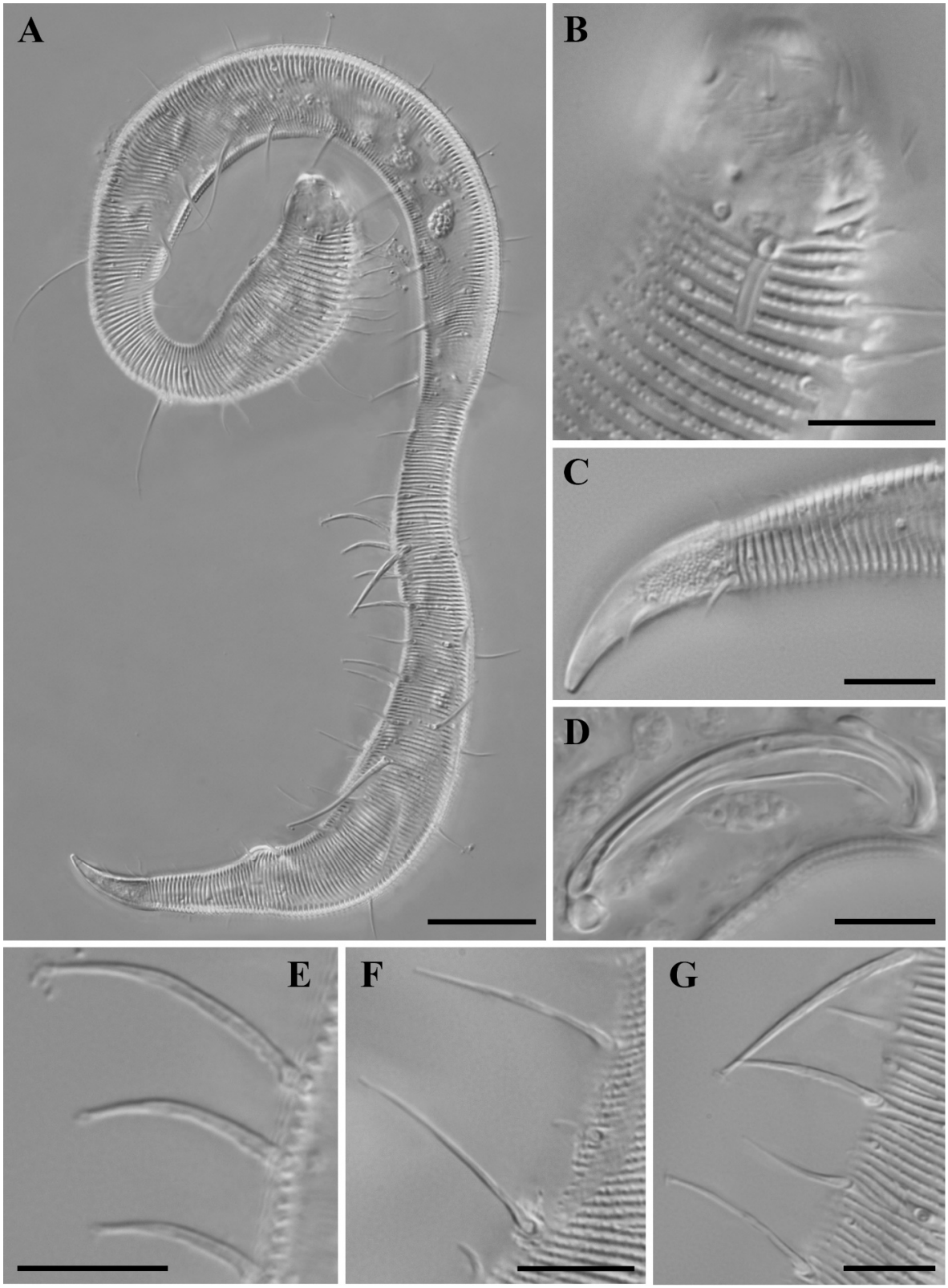

Figure 2. *Dracognomus elongatus* sp. nov., DIC photomicrographs of holotype male. (**A**) Entire view of the body, lateral view; (**B**) head region with an amphidial fovea and the anterior body cuticles covered with minute spines; (**C**) non-annulated tail end; (**D**) spicule and gubernaculum; (**E**) subventral adhesion tubes (normal type); (**F**) subventral adhesion tubes (modified type); (**G**) sublateral adhesion tubes (disc-shaped type). Scale bars: (**A**), 20 μm, (**B**–**G**) 10 μm.

3.9. Type Locality and Habitat

The type locality is the intertidal zone at a depth of 60 cm near Seokho breakwater, Nagok-ri, Buk-myeon, Uljin-gun, Gyeongsangbuk-do, Korea (37°06′47.1″ N, 129°22′32.7″ E). The specimen was collected from intertidal sediments associated with geniculate coralline algal assemblages.

3.10. Description

Male. The body is elongated, measuring 522 μm in length, and resembles the shape of the Arabic numeral 9. It consists of three slightly swollen regions: the pharyngeal region, the mid-body region (located between the posterior end of the pharyngeal region and the anterior part of the posterior adhesion tubes), and the posterior region just anterior to the cloaca. Body annules are present throughout the body except at the tail end (Figures 1A and 2A). Both margins of the body annules are covered with densely developed minute spine-like ornamentations. The head capsule is smoothly rounded and positioned obliquely on the dorsal side. Amphids are small and pore-shaped, with a diameter of 2 μm, and are situated at the edge of the rostrum. A membranous tube (7 μm) filled with corpus gelatum extends to the fifth body annule (Figure 1A,B and Figure 2B). The buccal cavity is weakly developed, featuring large dorsal teeth and minute ventral teeth. Twelve fine modified cephalic adhesion tubes (Mod-CAT) are present, located entirely behind the helmet within the first seven body annules; no Mod-CAT are found on the helmet itself. The CAT gradually taper towards the distal end, with slight swelling at both the basal insertion and the distal open tip (Figures 1B and 2B).

There are two sublateral rows of modified adhesion tubes (Mod-AT) located in the slightly swollen mid-body region, between the two body constrictions: posterior to the pharyngeal region and anterior to the posterior adhesion tubes. The Mod-AT start after three long, curved somatic setae (28–33 μm), which alternate with very short somatic setae. Each row consists of eight Mod-AT, measuring 15–21 μm in length, with a slightly swollen base (Figure 1A,F and Figure 2A,F). These tubes alternate with one or two very short somatic setae (3–4 μm). The somatic setae are arranged in six rows along the mid-body region: two dorsal, two subdorsal, and two subventral. The longest somatic setae (35 μm) are positioned subdorsally in the anterior part of the mid-body region.

The posterior adhesion tubes (PAT) are arranged in two sublateral and two subventral rows located between the last Mod-AT and the cloaca. The subventral adhesion tubes (SvAT) consist of both normal and modified types: three pairs of normal tubes and three pairs of modified tubes. The normal tubes are robust, slightly bent, and become progressively shorter towards the posterior end (13–21 μm). They have a thick basal part and taper towards the distal end, which features a swollen, hollow tip (Figure 1A,E and Figure 2A,E). The modified tubes, measuring 14–16 μm, are positioned posterior to the normal tubes. The first two pairs are not positioned directly opposite each other, whereas the third pair is aligned side by side. Each tube has a slightly expanded base and tapers gradually toward the distal end, ending in a narrow, open tip (Figure 1A,F and Figure 2A,F).

All sublateral adhesion tubes (SlAT) feature a disc-shaped structure at the tip, with a diameter of 2 μm, and are arranged in two rows of four tubes each (Figure 1A,G and Figure 2A,G). Of the four pairs, the first and last pairs are notably long (26–34 μm) and thick, while the second and third pairs are relatively short (16–19 μm). Three somatic setae are interspersed between the SlAT: two short setae (3 μm) located near each tube and one long seta (14 μm) positioned between them. No PAT are present posterior to the cloaca.

The spicules are long and arcuate, with rounded proximal cephalizations and well-developed ventral alae. The gubernaculum runs parallel to the distal part of the spicule and shows a distinct bend at its distal end (Figures 1D and 2D). Two subventral pairs of anal setae (6 μm) are present, with one pair located anterior to the anus and the other pair posterior to it. The non-annulated tail end curves ventrally and bears three pairs of short setae: two ventral (6–7 μm) and one lateral (4 μm). This region is uniformly punctate,

except at the distal end of the non-annulated tail. No protuberances are present on the non-annulated tail end (Figures 1C and 2C).

Female. Unknown.

3.11. Differential Relationships Between Dracognomus elongatus sp. nov. And Its Congeners Based on Morphological Taxonomic Key Characters

The comparison of relationships among all congeners is based on original descriptions and redescriptions, focusing exclusively on male specimens (Table 1). To facilitate a clearer comparison of the arrangement of posterior adhesive tubes (PAT) and copulatory thorns, a schematic ventral view of *Dracognomus* species is provided (Figure 3).

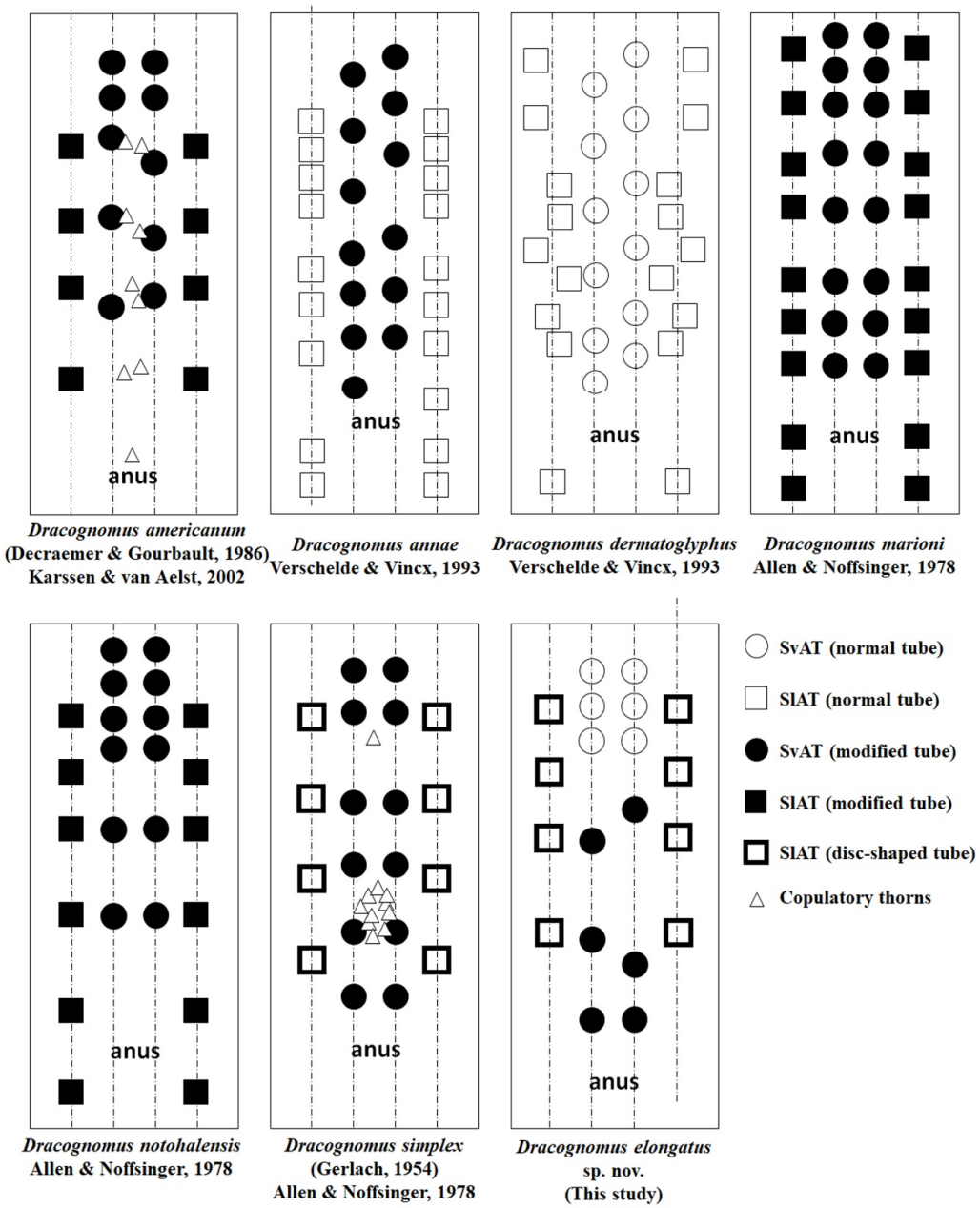

Figure 3. Schematic ventral view of the genus *Dracognomus* Allen & Noffsinger, 1978, illustrating the arrangement of posterior adhesion tubes and copulatory thorns (*D. tinae* is excluded due to insufficient description; the number and locations of tubes are inferred from the available figures and descriptions) [1,3–6].

Dracognomus simplex. *Dracognomus elongatus* sp. nov. is most similar to *D. simplex* in several key characteristics: both species possess twelve very thin modified CAT, four pairs of differentiated SlAT with disc-shaped tips, well-developed spicule alae, three pairs of non-annulated tail end setae, and lack protuberances on the non-annulated tail end. However, they differ in several specific features. *Dracognomus elongatus* sp. nov. has pore-shaped amphids containing a membranous tube filled with corpus gelatum, whereas *D. simplex* has small, inverted U-shaped amphids with a longitudinal slit. Additionally, all modified CAT in *D. elongatus* sp. nov. are entirely located posterior to the helmet edge within the first seven body annules, while in *D. simplex*, some modified CAT are positioned on the helmet edge, extending to the first four annules. Furthermore, *D. elongatus* sp. nov. has eight pairs of Mod-AT, whereas *D. simplex* has seven pairs; *D. elongatus* sp. nov. has three pairs of robust normal SvAT, whereas *D. simplex* lacks normal SvAT entirely. Lastly, *D. elongatus* sp. nov. lacks copulatory thorns, while *D. simplex* possesses 11 copulatory thorns in males. To date, *D. elongatus* sp. nov. and *D. simplex* are the only known species within the genus to exhibit disc-shaped SlAT tips. Nonetheless, the two species can be clearly distinguished by the presence of three pairs of normal SvAT in *D. elongatus* sp. nov. (absent in *D. simplex*) and the differing number of modified SvAT (three pairs in *D. elongatus* sp. nov. vs. six pairs in *D. simplex*).

Dracognomus americanum. *Dracognomus elongatus* sp. nov. also shares several characteristics with *Dracognomus americanum*: both species have a body shape resembling the Arabic numeral '9', minute spine-like ornamentations along the margins of the body annules, no posterior adhesion tubes located posterior to the anus or cloaca, and four pairs of SlAT. However, they can be readily distinguished by specific features. *Dracognomus elongatus* sp. nov. has pore-shaped amphids containing a membranous tube filled with corpus gelatum, while *D. americanum* has small, inverted U-shaped amphids measuring 4–5 µm. *Dracognomus elongatus* sp. nov. possesses twelve Mod-CAT entirely positioned behind the helmet within the first seven body annules, whereas *D. americanum* has only eight Mod-CAT located just posterior to the helmet. Additionally, *D. elongatus* sp. nov. exhibits disc-shaped tips on the SlAT, a feature absent in *D. americanum*, which lacks differentiated tips on the SlAT. *Dracognomus elongatus* sp. nov. has eight pairs of Mod-AT, compared to seven pairs in *D. americanum*. Furthermore, *D. elongatus* sp. nov. lacks copulatory thorns, whereas *D. americanum* has nine evenly distributed copulatory thorns in males. The spicules of *D. elongatus* sp. nov. are long and arcuate, with rounded proximal cephalizations and well-developed ventral alae, measuring 47 µm in length, whereas the spicules in *D. americanum* are strongly curved with weakly developed alae, measuring 27–30 µm. Lastly, *D. elongatus* sp. nov. has three pairs of short setae without protuberances on the non-annulated tail end, while *D. americanum* possesses two pairs of short setae along with two protuberances on the non-annulated tail end.

Dracognomus annae. *Dracognomus annae* and *D. elongatus* sp. nov. can be distinguished by several key features. *D. annae* has an S-shaped body with bubble-like swelling in the mid-body region, whereas *D. elongatus* sp. nov. has an elongated body measuring 522 µm, with densely developed minute spine-like ornamentations along both margins of the body annules. The amphids of *D. annae* are long, straight, and pore-like, measuring 12 µm, while *D. elongatus* sp. nov. has small, pore-shaped amphids (2 µm) containing a membranous tube filled with corpus gelatum. In terms of adhesion tubes, *D. annae* does not have a recorded number of Mod-CAT, but they are positioned halfway between the rostrum edge and the middle of the head capsule, and no Mod-AT are present. In contrast, *D. elongatus* sp. nov. possesses twelve fine Mod-CAT located entirely behind the helmet within the first seven body annules, as well as eight pairs of Mod-AT. Additionally, *D. elongatus* sp. nov. has three pairs of normal SvAT and three pairs of modified SvAT, along with four pairs of SlAT with disc-shaped tips. In contrast, *D. annae* has a slightly greater number of posterior adhesive tubes, with 9–10 pairs of SlAT and 6–7 pairs of SvAT. *Dracognomus annae* also has two pairs of short setae and three protuberances on the non-annulated tail end, whereas *D. elongatus* sp. nov. lacks protuberances and has three pairs of short setae

on the non-annulated tail end. While both species lack copulatory thorns in males, they differ in spicule structure. *Dracognomus elongatus* sp. nov. possesses distinctive long and arcuate spicules with rounded proximal cephalizations and well-developed ventral alae, measuring 47 µm, while *D. annae* has arched, clearly sclerotized and hollow spicules with a club-shaped capitulum, measuring 31–34 µm in length.

Dracognomus dermatoglyphus. *Dracognomus dermatoglyphus* also differs from *D. elongatus* sp. nov. in several key features. *Dracognomus dermatoglyphus* has an S-shaped body with a bubble-shaped mid-body and exhibits a fingerprint-like pattern on the body annules in the swollen mid-body region. It possesses large, bar-shaped amphids measuring 6 µm and twelve normal CAT positioned in the first half of the rostrum, none of which are modified. In contrast, *D. elongatus* sp. nov. lacks CAT entirely and has twelve fine Mod-CAT located entirely behind the helmet within the first seven body annules. Additionally, *D. dermatoglyphus* lacks modified PAT, with all sublateral and subventral adhesion tubes being unmodified. It has nine pairs of unmodified SlAT and six pairs of unmodified SvAT, while *D. elongatus* sp. nov. has eight pairs of Mod-AT, four pairs of SlAT with disc-shaped tips, and both normal and modified SvAT (three pairs each). Furthermore, *D. dermatoglyphus* has one pair of short setae and three pairs of protuberances on the non-annulated tail end, whereas *D. elongatus* sp. nov. lacks protuberances and has three pairs of short setae on the non-annulated tail end. Verschelde and Vincx (1993) described the CAT in *D. dermatoglyphus* as unmodified, as indicated by the swollen distal tips of the twelve very thin CAT visible through light microscopy [5]. SEM observations of *D. annae*, which was described alongside *D. dermatoglyphus*, revealed that the CAT in *D. annae* are modified, supporting the idea that the CAT in *D. dermatoglyphus* are indeed unmodified. While the SvAT in *D. dermatoglyphus* were confirmed to be unmodified, the description of the SlAT does not clarify whether they are normal or modified. However, based on detailed descriptions of adult females, which reported eleven pairs of unmodified SlAT and seven pairs of unmodified SvAT, it is presumed that no modified tubes are present in either the CAT or PAT of *D. dermatoglyphus*. Given the absence of SEM images for *D. dermatoglyphus* and the significance of modified adhesion tubes in both CAT and PAT as key characteristics of this genus, further examination of specimens is necessary to confirm the absence of modifications in both CAT and PAT of *D. dermatoglyphus*.

Dracognomus marioni. *Dracognomus marioni* can be distinguished from *D. elongatus* sp. nov. by several key features. *Dracognomus marioni* has a body shape with a bubble-shaped swelling in the mid-body region, inverted U-shaped amphids, and Mod-CAT positioned in the anterior half of the rostrum, whereas *D. elongatus* sp. nov. has no CAT and twelve Mod-CAT located entirely behind the helmet. Additionally, *D. marioni* lacks Mod-AT and normal PAT, with all PAT being modified, while *D. elongatus* sp. nov. possesses eight pairs of Mod-AT and both normal and modified SvAT (three pairs each). Furthermore, *D. marioni* has only one pair of short setae and two pairs of protuberances at the non-annulated tail end, whereas *D. elongatus* sp. nov. has three pairs of short setae and no protuberances. Although the original description by Allen & Noffsinger (1978) did not mention specific details about the shape of SvAT in *D. marioni*, it is presumed to have a unique structure [1]. Jensen (1981) described a ventral row of spine-like setae in *D. tinae* and suggested that this feature may not be unique but rather a more general characteristic of the genus, as he observed similar setae in reexamined specimens of *D. marioni* [7]. Decraemer & Gourbault (1986), in their redescription of *D. marioni* collected from Martinique, noted that its SvAT differed from those of any other draconematid species [4]. Further examination of *D. marioni* specimens is necessary to confirm the presence of additional types of tube tips beyond the disc-shaped tip, which may provide additional distinguishing features.

Dracognomus notohalensis. *Dracognomus notohalensis* can be distinguished from *D. elongatus* sp. nov. by several key features. *D. notohalensis* possesses U-shaped amphids (while the original description did not specify amphid shape, we interpret it as U-shaped based on the accompanying illustration), Mod-CAT located in the anterior half of the rostrum, and lacks Mod-AT [1]. Additionally, *D. notohalensis* lacks normal PAT, as all PAT are modi-

fied. It also has one pair of short setae and protuberances at the non-annulated tail end, whereas *D. elongatus* sp. nov. has three pairs of short setae and no protuberances at the non-annulated tail end. In terms of spicules, *D. elongatus* sp. nov. has long, arcuate spicules with rounded proximal cephalization and well-developed ventral alae, measuring 47 µm in length, while *D. notohalensis* has comparatively shorter spicules measuring 24 µm. The gubernaculum in *D. elongatus* sp. nov. also differs, showing a distinct bend at its distal end and measuring 17 µm, whereas *D. notohalensis* has a shorter gubernaculum of 9 µm. Decraemer & Gourbault (1986) suggested that *D. notohalensis* might be synonymous with *D. marioni*, as they found no significant differences between the two species in terms of male spicule shape and female Mod-AT position [4]. However, they recognized *D. notohalensis* as a valid species due to the distinctive shape of the SvAT in *D. marioni*, pending examination of additional specimens. Following this reasoning, we also consider *D. notohalensis* a valid species.

Dracognomus tinae. *Dracognomus elongatus* sp. nov. and *D. tinae* exhibit several distinct morphological differences that distinguish them within the genus. A primary difference is in the shape of the amphids: *D. elongatus* sp. nov. has pore-shaped amphids with a membranous tube filled with corpus gelatum, while *D. tinae* has groove-like tubular amphids located on the posterior half of the helmet on the dorsal sector. Additionally, *D. tinae* possesses a ventral row of spine-like setae along the posterior body, a feature absent in *D. elongatus* sp. nov. The lip region in males also shows differences, with *D. tinae* exhibiting a narrower, more elongated lip compared to the broader lip of *D. elongatus* sp. nov. Furthermore, *D. elongatus* sp. nov. has twelve Mod-CAT located entirely behind the helmet within the first seven body annules and eight pairs of Mod-AT, both of which are absent in *D. tinae*. According to Jensen's original 1981 description, *D. tinae* has five to six pairs of CAT located in the posterior half of the helmet on the dorsal sector, though Jensen did not specify whether these CAT are normal or modified. In the absence of such detail, we interpret these CAT as typical, normal tubes. The spicules also differ between the two species. *D. elongatus* sp. nov. has long, arcuate spicules with rounded proximal cephalization and well-developed ventral alae, measuring 47 µm, while *D. tinae* has a pair of undifferentiated, bent spicules measuring 26–31 µm. The gubernaculum in *D. elongatus* sp. nov. is parallel to the distal part of the spicule and shows a distinct bend at its distal end, measuring 17 µm, whereas in *D. tinae*, the gubernaculum is a slender rod located posterior to the spicules. The tail morphology of *D. elongatus* sp. nov. includes three pairs of short setae without protuberances on the non-annulated tail end, while information on the tail morphology of *D. tinae* remains limited.

4. Discussion

4.1. Redefining Modified Adhesion Tubes in Dracognomus: A Comparative Analysis and Proposal for a Practical Identification Key

The presence of modified adhesion tubes (Mod-AT) in the pharyngeal region is a unique trait of *Dracognomus* and has not been observed in other members of the family Draconematidae [1,2]. Through a literature review, we identified two distinct types of Mod-AT in the mid-body region of *Dracognomus*, both previously referred to under the same term, 'Mod-AT' (tube-like setae in *D. annae* and *D. dermatoglyphus*). The first type of Mod-AT extends from the pharyngeal region to just anterior to the posterior adhesion tubes, forming seven to eight pairs. These tubes have been reported in *D. americanum*, *D. simplex*, and *D. elongatus* sp. nov. and are present in both males and females (though females of *D. elongatus* sp. nov. remain unknown).

The second type of Mod-AT has a more restricted distribution, extending from just posterior to the rostrum to the pharyngeal region and forming four to five pairs. This type has been observed in *D. annae*, *D. dermatoglyphus*, *D. marioni*, *D. notohalensis*, and *D. tinae*. It exhibits sexual dimorphism, being present only in females, and is relatively short, measuring 6–10 µm in *D. marioni* and *D. notohalensis*. In contrast, the first type of

Mod-AT in *D. americanum* (11–17 μm), *D. simplex* (10–15 μm), and *D. elongatus* sp. nov. (15–21 μm) is notably longer.

Since we have not examined type specimens for the second type of Mod-AT, we cannot confirm whether these structures are truly modified tubes or merely tube-like setae. However, using the term 'Mod-AT' for both types may cause confusion. To address this, we tentatively propose revised terminology in this paper, distinguishing between the two types: 'long Mod-AT' refers to the elongated modified tubes that extend from the pharyngeal region to the posterior adhesion tubes in both sexes (*D. americanum*, *D. simplex*, and *D. elongatus* sp. nov.), while 'short Mod-AT' refers to the shorter modified tubes limited to the pharyngeal region in females (*D. annae*, *D. dermatoglyphus*, *D. marioni*, *D. notohalensis*, and *D. tinae*).

As highlighted by Karssen & van Aelst (2002), species within this genus are especially important for observations made through scanning electron microscopy (SEM) [3]. However, obtaining sufficient numbers of individuals for SEM analysis of this rare taxon presents challenges. To facilitate species-level identification, we propose a more accessible taxonomic approach, including a pictorial dichotomous key (Figure 4). This updated key incorporates critical features such as the presence of short Mod-AT, Mod-CAT, copulatory thorns, non-annulated tail end protuberances, amphid shape, and differentiated tip structures like disc-shaped or spine-shaped ends. The key is designed to be used effectively with differential interference contrast (DIC) microscopy, offering a practical alternative to exclusive SEM use. We anticipate that further SEM observations and reexamination of additional specimens from other species within the genus will help elucidate the unique characteristics of this enigmatic genus.

4.2. Biogeographic Significance and Ecological Adaptability of Dracognomus elongatus sp. nov. And Its Congeners: Expanding the Known Range of Dracognomus in the Northwestern Pacific

The habitat and distribution of *Dracognomus elongatus* sp. nov. and its congeners demonstrate a broad geographic range and ecological versatility within the genus (Figure 5). *Dracognomus elongatus* sp. nov. was found in intertidal sediments associated with geniculate coralline algal assemblages at Seokho breakwater, Nagok, Uljin, Korea, marking the first record of the genus *Dracognomus* in the northwestern Pacific. This finding expands the known range of *Dracognomus* and contributes valuable information on the biogeographic distribution of the genus.

Dracognomus americanum has been documented in coarse, calcareous sandy beach interstitial water in Guadeloupe and Martinique. Its habitat in Caribbean sandy, interstitial environments highlights the adaptability of the genus to different substrate types, such as calcareous sand. Similarly, *D. simplex*, which has been collected from sand or bottom debris along coarse sand beaches in the Mediterranean Sea, and *D. marioni*, found on sandbars in Florida, USA, support the genus's association with sandy or coarse marine substrates.

Dracognomus annae and *D. dermatoglyphus*, both found near the mouth of the Gazi Creek in Kenya, inhabit sandbanks near *Sonneratia* bushes. This habitat suggests that the genus *Dracognomus* can thrive in shallow, sheltered coastal environments, potentially benefiting from organic matter and nutrients associated with mangrove ecosystems.

In contrast, *D. tinae* was collected from deeper waters (32–40 m) off the coast of Belgium in the North Sea. Its presence at these depths, where sand fractions dominate with minimal silt-clay content, demonstrates the genus's ability to occupy various depths and sediment types. *D. notohalensis*, found in association with coral reefs in Pago Pago, American Samoa, further illustrates the genus's adaptability to structurally complex reef environments.

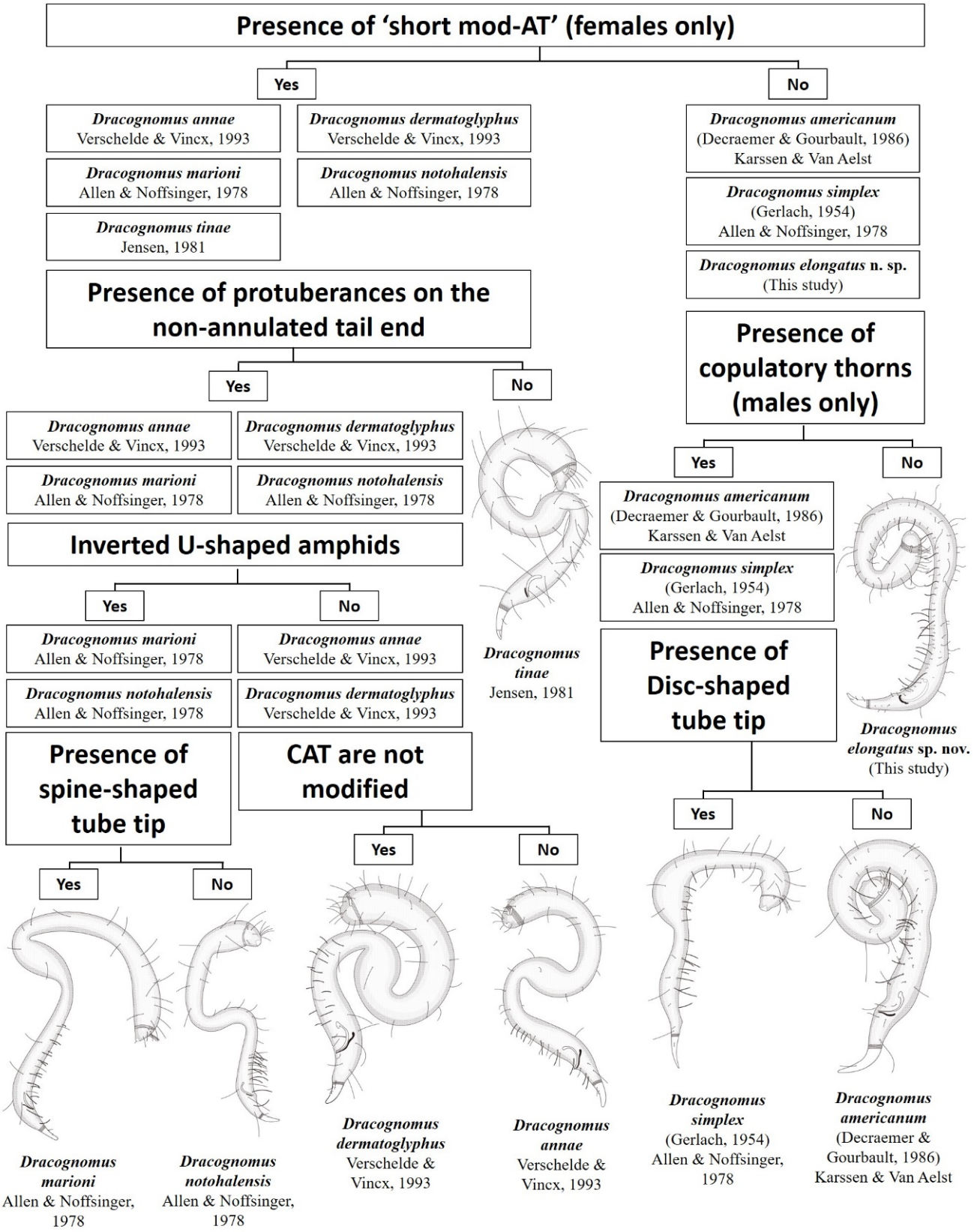

Figure 4. Pictorial dichotomous key for species identification within the genus *Dracognomus* [1,3–7].

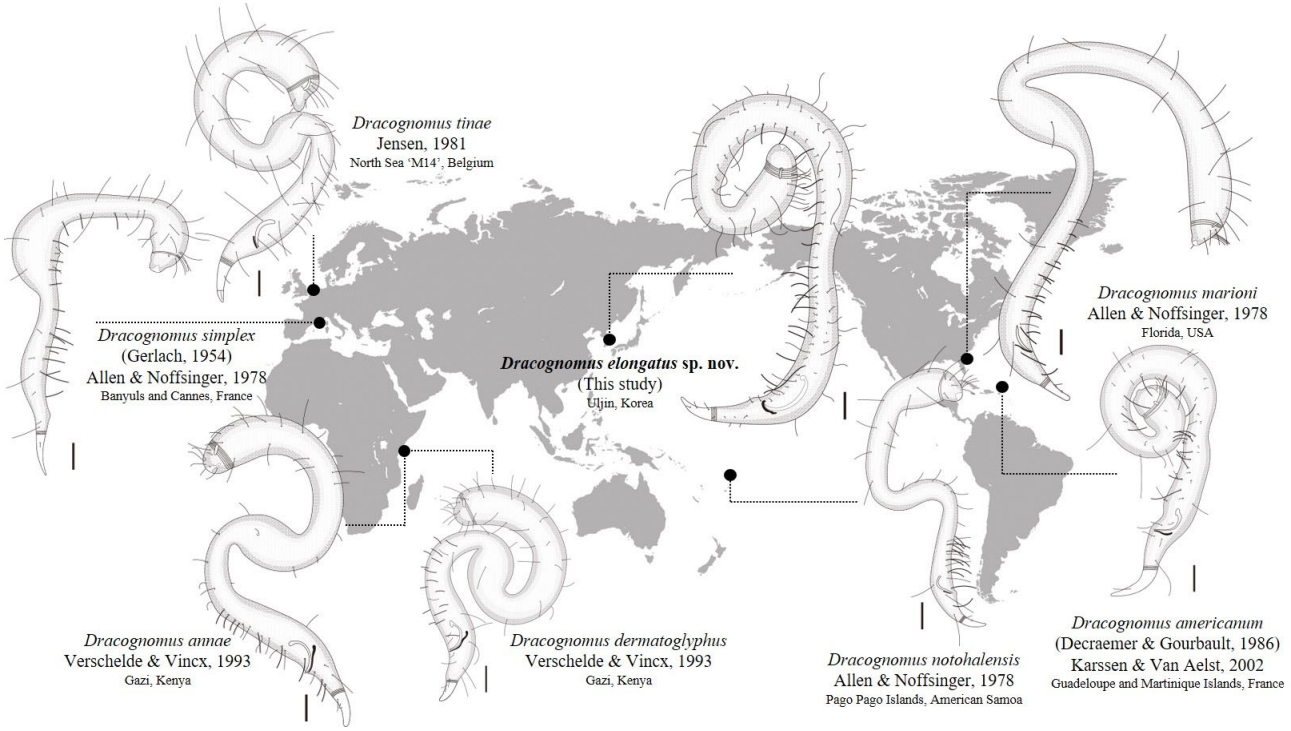

Figure 5. Biogeographical distribution of species in the genus *Dracognomus* (Scale bars: 20 µm) [1,3–7].

These findings collectively suggest that the genus *Dracognomus* exhibits significant ecological flexibility, occupying a range of marine habitats from shallow intertidal zones to deeper offshore waters and from sandy substrates to coral reef ecosystems. The discovery of *D. elongatus* sp. nov. in the northwestern Pacific is particularly noteworthy, as it significantly broadens the known distribution of the genus. This expansion not only highlights the adaptability of *Dracognomus* to new environments but also suggests the potential for discovering additional, unrecorded species in unexplored regions. The genus's wide distribution, spanning the Caribbean, Mediterranean, Pacific Islands, and East Asian waters, implies that *Dracognomus* may be widely dispersed across oceanic regions.

5. Conclusions

In this study, we describe *Dracognomus elongatus* sp. nov., the eighth documented species of the genus *Dracognomus* and the first discovered in the Northwest Pacific. This species is defined by key morphological traits, including its long body, minute spine-like ornamentations densely arranged along both margins of body annules, pore-shaped amphid containing membranous tube with corpus gelatum, differentiated tips on the sublateral adhesion tubes, and the absence of copulatory thorns in males. These findings, observed through differential interference contrast (DIC) microscopy, provide new insights into the genus *Dracognomus*. To address inconsistencies in previous descriptions, we distinguish between two types of Mod-AT: 'long Mod-AT' and 'short Mod-AT,' refining the taxonomic framework for the genus. The newly developed dichotomous key serves as a practical tool for species identification using DIC microscopy, offering an alternative to relying solely on scanning electron microscopy (SEM). The discovery of *D. elongatus* sp. nov. significantly extends the known geographic range of the genus and highlights its ecological adaptability across varied marine habitats, from shallow intertidal zones to deeper offshore waters. This finding suggests the potential for discovering additional, unrecorded species in unexplored regions. Future research, including SEM analysis and further specimen collection, will be essential to refining species-level distinctions and understanding phylogenetic relationships within this genus.

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