

Research Article

Description of the Postlarval Stages of *Dactylochelififer gracilis* Beier, Pseudoscorpiones: Cheliferidae

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A study of the free-living developmental stages of *Dactylochelififer gracilis* Beier, 1951, is presented based on 68 specimens of all nymphal and adult stages, collected from two locations in Iran. Basic differences of all stages are characterized by size, pedipalpal ratios, and the addition of trichobothria and setae during development.

1. Introduction

Pseudoscorpions are small arachnids usually 2–8 mm in length (e.g., [1]). They are generally confined to habitats such as leaf litter, under stones, under trees or log barks, bird's nests, and mammal's lairs (e.g., [2]). Their life cycle is ovoviviparous and consists of four phases (e.g., [3]): (1) eggs which are attached to the female's abdomen and carried by her in a brood sac, (2) two larval instars that also remain in the brood sac, (3) three nymphal instars, and (4) adults. Nymphs are very similar to adults but are smaller (Figures 8, 9, and 10) and lack genital organs (Figure 11). The three nymphal instars are termed protonymph, deutonymph, and tritonymph and can be easily recognized by the unique number of trichobothria of each stage [4]. In addition to the differences in the sexual organs, adult females are generally slightly larger than males.

The present study is focused on the external morphology of the postlarval stages of a species of *Dactylochelififer* Beier from Iran. This genus is a member of the family Cheliferidae [5, 6], which belongs to the Cheliferoidea along with Atemnidae, Chernetidae, and Withiidae [7, 8]. *Dactylochelififer* is widely distributed in the Holarctic region [6] and can

be recognized by the following combination of features: presence of coxal sacs situated within the coxae of the fourth pair of legs of males, each sac with a well-developed atrium (Figure 7(a)); tarsus with simple subterminal seta (Figures 7(c) and 7(d)); presence of a median seta on each half tergite; tarsal claws not divided; and female with one cribriform plate (Figure 11(e)) [9].

The first pseudoscorpion reported from Iran, *Chelififer spinipalpis* Redikorezev, 1918, now placed in the genus *Strobilochelififer*, was described from Bazman, Southeastern Iran [10]. The most substantial contributions were by Beier [11, 12]. There are currently nine families, 21 genera, and 39 species known from the country [6].

There are currently 44 species belonging to the genus *Dactylochelififer* of which 28 are represented in the Middle East and Central Asia [6]. Although many Asian species are poorly known with brief published descriptions and few illustrations, recent revisionary work on the Central Asian fauna (e.g., [9, 13]) has helped clarify the status and distribution of several species. The present study was designed to complement previous work by providing detailed descriptions of all postembryonic life stages of a species of *Dactylochelififer* found in Kerman Province, Iran.

2. Material and Methods

The 68 specimens utilized in this study were collected from three sites in Kerman Province, Iran. Specimens were separated from dry leaf litter using a sieve. They were preserved in 70% ethanol and prepared for study as follows. The pedipalps and chelicera, first and fourth legs were dissected, cleared with 60% lactic acid, and mounted on glass microscope slides in Hoyer's medium (a mixture of distilled water, chloral hydrate, Arabic gum, and glycerin). The duration of the clearing phase was dependent on the degree of sclerotization. The specimens were examined and illustrated with an Olympus BH-2 compound microscope and drawing tube attachment. All specimens are lodged in collection of the Acarology Laboratory, Shahid Bahonar University of Kerman (SBUK), Iran.

Morphological terminology follows Chamberlin [14], Harvey [7], and Judson [15]. The following trichobothria abbreviations are employed (Figure 9): eb: external basal; esb: external subbasal; ib: internal basal; isb: internal subbasal; ist: internal subterminal; est: external subterminal; it: internal terminal; et: external terminal; t: terminal; sb: subbasal; st: subterminal. In addition, the following abbreviations are used: mm: millimeter; L: length; W: width; and H: height.

3. Taxonomic Results

The specimens used in this study were compared with published descriptions of all species of *Dactylochelifer*. They compare very favorably with several Asian species of *Dactylochelifer*. However, they are most similar to *D. gracilis* Beier, 1951, which was described from a single male collected from an unspecified locality in Kerman Province, Iran, as part of the Österreichischen Iran-Expedition 1949/1950 [11]. Although the expedition collected at multiple sites within Kerman Province (e.g., [11, 16]), there is, regrettably, no precise collection site other than the name of the province. The specimens used in this study also come from Kerman Province.

This species was later reported from Turkey [17, 18], but no further morphological records or descriptions have been published. The morphology of the male tarsus I and tarsal claws is similar to that of some other Asian species of the genus, including *D. brachialis* Beier, 1952, originally described from Afghanistan [19], but later recorded throughout Central Asia (e.g., [9, 13, 20]). *Dactylochelifer changaiensis* was described by Krumpál and Kiefer [21] from male and female specimens collected in Arkhangai Province, Mongolia, and treated as a junior synonym of *D. brachialis* by Dashdamirov and Schawaller [9], who noted similarities in the shape of the male tarsus I. While the published descriptions of *D. gracilis*, *D. brachialis*, and *D. changaiensis* suggest that they are all very similar to each other, we refrain from making any further taxonomic changes until a more detailed study of variation across a wide range of samples can be undertaken. So, we, therefore, attribute the Iranian material to *D. gracilis* with reference to geographical characters of previous reports [11].

The specimens reported in this study are slightly larger than the dimensions reported for the holotype of *D. gracilis* by Beier [11]. For example, the pedipalpal femur of the male holotype of *D. gracilis* was reported to be 0.66/0.16 mm [11],

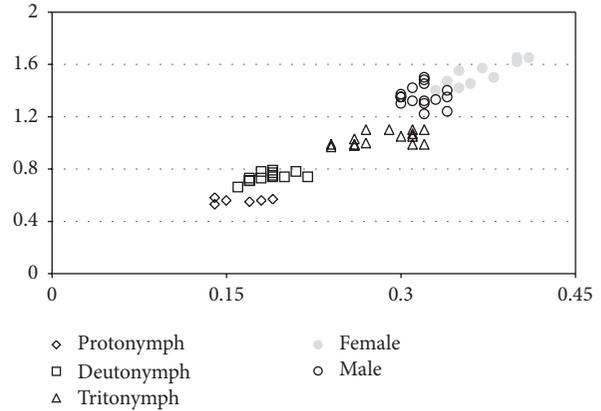


FIGURE 1: Chelal growth of all postlarval stages of *Dactylochelifer gracilis*.

whereas the males used in this study are 0.85–1.06/0.20–0.23 (male) and 0.92–1.18/0.22–0.26 mm (female).

Family Cheliferidae.

Genus *Dactylochelifer* Beier [22].

Dactylochelifer gracilis Beier [11].

Dactylochelifer gracilis Beier [11]: 100-101, Figure 1(f).

4. Material Examined

The materials collected for examination from Iran: Kerman Province were as follows: 11 males, 5 females, 4 protonymphs, 9 deutonymphs, and 10 tritonymphs, Rayen (29°35'29"N, 57°26'06"E; altitude 2800 m), May 2011, M. Nassirkhani (SBUK); 4 males, 4 females, and 8 tritonymphs, Lale-zar (29°30'55"N, 56°49'22"E; altitude 3000 m), June 2011, M. Nassirkhani (SBUK); 5 male, 1 female, 3 protonymphs, and 4 deutonymphs, Dalfard (28°59'38"N, 57°36'30"E; and altitude 2060 m), June 2011, M. Nassirkhani (SBUK).

5. Diagnosis

Dactylochelifer gracilis can be readily identified by the shape of male genital organ (Figure 11(d)), the ratio of male tarsus I (2.00–2.30), and the shape of male tarsus I (Figure 7(c)), that is, robust and highly modified with a distinct dorsal indentation and subdistal concavity.

6. Description

6.1. Protonymph: Figure 3; Tables 1, 2, and 3

Carapace. It is present as follows: light brown to dark yellow; darker than abdomen; lateral margins (around eyes) darker; wider than long; with 2 small eyes; setae short with terminal denticulations; surface usually not granulate, region around eyes granulate; anterior transverse furrow shallow, narrow, and slightly curved posteriorly; and posterior furrow absent.

Tergites. They are present as follows: not sclerotized, lighter in color than carapace, dark yellow, most tergal setae short with

TABLE 1: Morphological measurements (mm), numbers, and setation in *Dactylochelififer gracilis*.

Characters	Male (n = 20)	Female (n = 10)	Tritonymph (n = 18)	Deutonymph (n = 13)	Protonymph (n = 7)
Body length	2.52–3.15	3.30–3.82	2.00–2.72	1.57–1.92	1.15–1.55
Carapace L.	0.82–0.97	0.94–1.07	0.67–0.77	0.50–0.59	0.40–0.47
Carapace W.	0.60–0.82	0.68–0.95	0.58–0.73	0.45–0.55	0.38–0.45
Pedipalp					
Trochanter L.	0.42–0.52	0.44–0.55	0.29–0.36	0.21–0.27	0.16–0.17
Trochanter W.	0.22–0.27	0.23–0.28	0.16–0.24	0.12–0.16	0.10–0.12
Femur L.	0.85–1.06	0.92–1.18	0.57–0.72	0.39–0.47	0.30–0.32
Femur W.	0.20–0.23	0.22–0.26	0.16–0.23	0.12–0.15	0.10–0.15
Patella L.	0.79–0.95	0.85–1.00	0.52–0.63	0.35–0.40	0.23–0.28
Patella W.	0.25–0.27	0.25–0.28	0.19–0.26	0.14–0.19	0.12–0.16
Chela with pedicel L.	1.22–1.50	1.40–1.65	0.97–1.10	0.66–0.79	0.53–0.58
Chela without pedicel L.	1.17–1.40	1.27–1.65	0.90–1.05	0.62–0.73	0.50–0.55
Hand with pedicel L.	0.69–0.84	0.78–0.94	0.51–0.62	0.36–0.43	0.28–0.30
Chela W.	0.30–0.34	0.33–0.41	0.24–0.31	0.16–0.22	0.14–0.19
Movable finger L.	0.60–0.71	0.68–0.78	0.42–0.59	0.32–0.38	0.26–0.29
Fixed finger teeth	43–50	46–50	36–42	32–35	29–31
Movable finger teeth	45–50	47–50	38–44	34–36	32–33
Chelicera					
Movable finger L.	0.16–0.20	0.19–0.22	0.14–0.17	0.11–0.13	0.10–0.11
Rami N.	1–3	5–6	3–5	3–4	3–4
Rallum blades N.	16–19	17–21	14–17	13–15	11–12
Leg I					
Trochanter L.	0.14–0.17	0.18–0.21	0.11–0.15	0.08–0.10	0.06–0.07
Trochanter W.	0.14–0.17	0.14–0.16	0.10–0.13	0.07–0.09	0.05–0.06
Femur L.	0.27–0.33	0.27–0.33	0.19–0.23	0.13–0.15	0.10–0.13
Femur W.	0.14–0.17	0.15–0.17	0.11–0.14	0.07–0.09	0.07–0.08
Patella L.	0.36–0.43	0.35–0.47	0.25–0.31	0.16–0.20	0.14–0.15
Patella W.	0.13–0.16	0.11–0.13	0.10–0.12	0.06–0.08	0.06–0.07
Tibia L.	0.33–0.39	0.37–0.43	0.23–0.26	0.15–0.20	0.12–0.13
Tibia W.	0.12–0.14	0.08–0.11	0.07–0.10	0.06–0.08	0.05–0.07
Tarsus L.	0.31–0.36	0.38–0.45	0.27–0.37	0.19–0.22	0.15–0.16
Tarsus W.	0.14–0.15	0.07–0.08	0.07–0.09	0.05–0.06	0.04–0.06
Leg IV					
Trochanter L.	0.24–0.32	0.26–0.40	0.15–0.24	0.15–0.16	0.11–0.13
Trochanter W.	0.12–0.15	0.13–0.17	0.11–0.14	0.07–0.09	0.07–0.08
Femur L.	0.18–0.28	0.25–0.31	0.16–0.21	0.13–0.16	0.11–0.12
Femur W.	0.12–0.14	0.13–0.16	0.11–0.15	0.08–0.13	0.07–0.09
Patella L.	0.54–0.68	0.63–0.73	0.38–0.48	0.26–0.30	0.19–0.23
Patella W.	0.16–0.18	0.17–0.20	0.13–0.20	0.09–0.13	0.08–0.12
Tibia L.	0.55–0.70	0.63–0.73	0.38–0.45	0.25–0.29	0.19–0.23
Tibia W.	0.09–0.11	0.10–0.11	0.08–0.11	0.06–0.09	0.07–0.08
Tarsus L.	0.38–0.48	0.46–0.52	0.31–0.35	0.22–0.25	0.17–0.20
Tarsus W.	0.07–0.08	0.07–0.08	0.07–0.11	0.05–0.07	0.05–0.07
Setation					
Trichobothria of fixed finger	8	8	7	6	3
Trichobothria of movable finger	4	4	3	2	1
Galeal seta	Present	Present	Present	Present	Absent
Carapace, anterior margin	6(2)–8(1)	6(1)–8(2)	4–8	6	4

terminal denticulations, tergite XI with 2 long and simple setae, tergites incompletely divided with narrow median line; tergite XI not divided, and tergal chaetotaxy is shown in Table 3.

Sternites. They are present as follows: sternite II without setae or lyrifissures; sternite X and IX with 2 long medial setae and 2 short lateral setae; sternal setae simple and longer than tergal setae; sternites not divided; and sternal chaetotaxy is shown in Table 3.

Pleurite. It is present as follows: striated and spiracle equal in size.

Chelicera. It is present as follows: light brown; hand with 4 setae; galea with 3 or 4 distal rami; rallum with 3 blades; serrula exterior with 11-12 blades; movable finger without galeal seta; and fixed finger with 5 teeth, 2 small and acute terminal teeth, and 3 large and blunt basal teeth.

Pedipalps. They are present as follows: brown; darker than carapace; femur, patella, and chela not granulate; trochanter, femur, and patella with short setae with terminal denticulations; chelal fingers and terminal base of hand with simple setae; trochanter with one dorsal projection; surface of projection granulate; femur without pedicel; retrolateral margin of femur projected; patella shorter and somewhat wider than femur; femur 1.11–1.30 longer than patella; prolateral margin of patella convex; movable finger as long as hand with pedicel; fixed finger with 3 trichobothria and movable finger with 1 trichobothrium; fixed finger with 29–31 and movable finger with 32–33 teeth; and nodus ramosus present in both fingers, slightly longer in movable finger than fixed finger, situated medially in movable finger and posterior to et in fixed finger.

Legs. They are present as follows: leg I: trochanter not granulated, with 1 seta; femur, patella, tibia, and tarsus not granulate; setae arranged same as adults; femur joined widely with patella; and patella 1.15–1.40 longer than femur. Leg IV: trochanter not granulated, with 0-1 seta; patella, tibia, and tarsus not granulate; setae arranged same as adults; tibia as long as patella; and patella 1.66–1.75 longer than femur.

6.2. Deutonymph: Figure 4, Tables 1, 2, and 3

Carapace. It present as follows: light brown; lighter in color than deutonymph, darker than abdomen; lateral margins darker and granulate with small granules; longer than wide; with 2 distinct eyes situated very close to anterior margin, completely swell; setae short with terminal denticulations; anterior margin narrower than posterior margin; 2 transverse furrows present; anterior furrow situated medially, narrow, and extending to lateral margins; and posterior furrow shorter, wider, and slightly V-shaped medially.

Tergites. They are present as follows: more sclerotized than protonymph; lighter in color than carapace, mostly cream with dark spots; most setae short with terminal denticulations; tergites VII to XI with longer median setae; tergite XI with 2 very long and simple tactile setae; tergites I and

II divided with narrow median line; tergites X and XI not divided; and tergal chaetotaxy is shown in Table 3.

Sternites. They are present as follows: pale brown; not granulate; sternites X and XI with 2 long median tactile setae; sternal setae simple and longer than tergal setae; and sternal chaetotaxy is shown in Table 3.

Pleurite. It is present as follows: striated; spiracles equal in size; and anus situated between last tergite and last sternite.

Chelicera. It present as follows: light brown, darker in color than legs; hand with 5 setae; galeal seta present; galea with 3 or 4 distal rami; rallum with 3 blades; serrula exterior with 13–15 blades; and fixed finger with 5 teeth, 2 terminal teeth small and acute, and 3 basal teeth are large and blunt, these teeth larger than teeth of protonymph.

Pedipalps. They are present as follows: larger and stouter than protonymph; brown; darker than carapace; trochanter, femur, patella, and chelal hand slightly granulate; most pedipalpal setae short with terminal denticulations; chelal fingers and base of hand with simple setae; trochanter with a dorsal projections; femur with short pedicel; retrolateral margin of femur semiswollen; prolateral margin of femur more granulate than retrolateral margin; patella shorter and somewhat wider than femur; prolateral margin of patella slightly swollen and more granulate than retrolateral margin; femur 1.10–1.17 longer than patella; chela weakly granulate; chela less granulate than femur; movable finger as long as or slightly shorter than hand with pedicel; hand 1.02–1.17 longer than movable finger; fixed finger with 6 and movable finger with 2 trichobothria; fixed finger with 32–35 and movable finger with 34–36 teeth; and nodus ramosus present in both fingers, longer in movable finger than fixed finger, situated posterior of t in movable finger, and between et and est in fixed finger.

Legs. They are present as follows: leg I: stouter than protonymph; not granulate; setae arranged same as adults setae; patella 1.20–1.36 longer than femur; and femur joined widely with patella. Leg IV: stouter than protonymph; not granulate; setae arranged same as adults setae; and patella 1.88–2.15 longer than femur.

6.3. Tritonymph: Figure 5; Tables 1, 2, and 3

Carapace. It present as follows: brown, darker than abdomen, anterior margin darker than posterior margin; lateral and anterior margins more granulate than other areas; longer than wide; with 2 obvious eyes; setae short with terminal denticulations; 2 transverse furrows present; anterior furrow situated medially, narrow, U-shaped, and extending to lateral margins; and posterior furrow slightly curved posteriorly, wide medially, and narrow laterally.

Tergites. They are present as follows: more sclerotized and granulate than deutonymph; lighter in color than carapace, dark cream with 2 brown spots; most tergal setae short with terminal denticulations; tergites IX to XI with longer median setae; and tergite XI with 2 very long and simple tactile setae;

tergal setae situated irregularly, tergites I to III with serial setae (in one row), each half-tergite of segments IV to X with 1 median seta, tergite XI with dispersed setae; tergites I–IX divided by narrow median line; tergites X and XI not divided; and tergal chaetotaxy is shown in Table 3.

Sternite. It is present as follows: sternites III to X are divided by narrow median line; sternites IX to XI are not divided; sternites X and XI with 2 long median tactile setae; sternal setae simple and longer than tergal setae; and sternal chaetotaxy is shown in Table 3.

Pleurite. It is present as follows: striated; spiracles equal in size; anus with 4 circum-anal setae; and anus situated between last sternite and last tergite.

Chelicera. It is present as follows: light brown, darker in color than legs; dorsal side of movable finger darker than hand; galeal seta present; hand with 5 simple setae; external seta longer than fixed finger; galea with 3 to 5 distal rami; rallum with 3 blades; serrula exterior with 14–17 blades; and fixed finger with 6 teeth, 3 terminal teeth small and acute, and 3 basal teeth large and blunt, these teeth are as large as those of deutonymph.

Pedipalps. They are present as follows: larger and stouter than deutonymph; brown, darker than carapace; lateral margins dark brown; trochanter, femur and patella granulate; chelal hand weakly granulate; most setae short with terminal denticulations; chelal fingers and distal base of hand with simple and long setae; trochanter with 2 small dorsal projections; femur with distinct pedicel; both sides of femur straight and granulate; patella shorter and somewhat wider than femur; femur 1.09–1.19 longer than patella; patella with distinct curved and short pedicel; chelal hand granulate; chelal hand less granulate than femur; chela with distinct short pedicel; movable finger slightly shorter than hand with pedicel; hand 1.04–1.28 longer than movable finger; fixed finger with 7 and movable finger with 3 trichobothria; fixed finger with 36–42 and movable finger with 49–46 same teeth; and nodus ramosus present in both fingers, clearly longer in movable finger than fixed finger, situated anterior of t or rarely st in movable finger (Figures 5(e) and 10(b)), and between et and it in fixed finger.

Legs. They are present as follows: leg I: stouter and larger than deutonymph; lighter in color than body; setae arranged same as adults setae; femur, patella, tibia, and tarsus not granulate; femur joined widely with patella; patella 1.27–1.40 longer than femur. Leg IV: stouter and larger than deutonymph; setae arranged same as adults setae; trochanter, patella, tibia, and tarsus not granulate; femur joined widely with patella; patella 1.95–2.55 longer than femur; and tibia slightly shorter or slightly longer than patella (0.93–1.02).

6.4. Female: Figure 6; Tables 1, 2, and 3

Carapace. It is present as follows: dark brown, darker than other stages; less granulate than male; distinctly longer and

stouter than in male; with 2 well developed eyes, larger, wider, and less swollen than those of male; setae short, with terminal denticulations; anterior margin with 10 setae and posterior margin with 8 setae; anterior margin with 2 very short setae in front of each eye and 8 long setae on border; 2 transverse furrows present; anterior furrow narrow, U-shaped, and situated medially, extending to lateral margins; and posterior furrow slightly curved posteriorly, wider medially, and narrow laterally.

Tergites. They are present as follows: lighter in color than carapace, brown with 2 dark brown and extensive stripes, each half-tergite with a darker and larger area than tritonymph; most tergal setae short with terminal denticulations; tergite XI with 2 long tactile setae; tergites I, II, and XI are not divided, tergites III to XIII divided by narrow and obvious median line, tergite IX incompletely divided; and tergal chaetotaxy is shown in Table 3.

Sternites. They are present as follows: sternites III to X are divided by narrow median line; sternite XI not divided; sternites II and III are deformed and made anterior operculum and posterior operculum; cribriform plate single, brown in color with darker borders, bean-like in shape; sternal setae simple and longer than tergal setae; and sternal chaetotaxy is shown in Table 3.

Pleurite. It is present as follows: striated; spiracles equal in size; and anus between last tergite and last sternite, with 4 circum-anal setae.

Chelicera. It is present as follows: darker in color than male; movable finger longer than male; galea with 5–6 distal rami; galeal seta present; hand with 5 simple setae; rallum with 3 blades, distal blade longest, with lateral denticulations; serrula exterior with 18–20 blades; and fixed finger with 6 teeth, 3 terminal acute teeth and 3 basal teeth large and blunt, these teeth are larger and stouter than teeth of tritonymph.

Pedipalps. They are present as follows: distinctly larger and stouter than tritonymph and male; dark brown, darker than carapace; lateral margins darker and more granulate than others; trochanter, femur, and patella completely granulate; dorsal and ventral margin of chelal hand not granulate; pedipalp less granulated than male; most pedipalpal setae short with 1 lateral and few terminal denticulations; chelal fingers and base of hand with simple and long setae; trochanter with 2 dorsal projections; femur with distinct pedicel; retrolateral margin of femur slightly curved basally and prolateral margin straight; patella shorter and somewhat wider than femur; femur 1.05–1.23 longer than patella; patella with obvious curved and short pedicel; retrolateral margin of patella distinctly curved basally and prolateral margin slightly curved distally; femur more granulate than chelal hand; chela with distinct and moderate pedicel; movable finger shorter than hand with pedicel; hand 1.14–1.27 longer than movable finger; fixed finger with 8 trichobothrium and movable finger with 4 trichobothrium setae or fixed finger with 8 and movable finger with 4 trichobothrial setae; fixed finger with trichobothrium et situated distal to it, ist situated posterior,

and it anterior to est, eb-esb-ib-isb aggregated basally; movable finger with trichobothrium st situated between t and sb, sb situated close to b; fixed finger with 44–50 and movable finger with 45–54 similar-shaped teeth; and nodus ramosus present in both fingers, clearly longer in movable finger than fixed finger, situated slightly posterior to st and st in movable finger, and between est and ist in fixed finger.

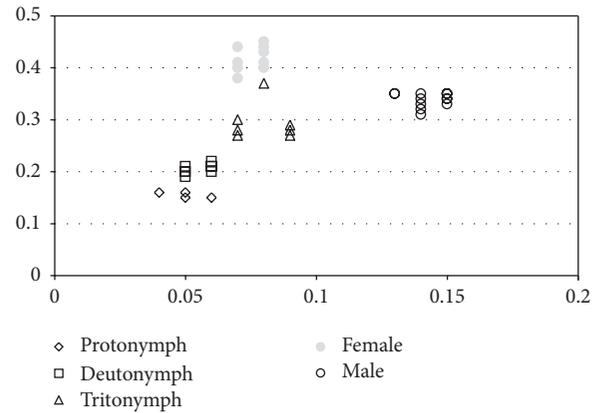
Legs. They are present as follows: leg I: light brown; lighter in color than body; trochanter weakly granulate; femur and patella granulate; patella joined with femur widely; patella 1.29–1.46 longer than femur; tibia granulate, prolateral margin curved distally; tibia slightly shorter and distinctly narrower than patella; tarsus weakly granulate; most setae with one lateral and few terminal denticulations; tibia with simple and long terminal seta; retrolateral margin of tarsus with denticulate setae (except terminal and subterminal setae) and prolateral margin with simple setae; claws symmetric and without teeth; and arolium shorter than claws. Leg IV: stouter and larger than tritonymph; trochanter weakly granulate; femur not granulate; lateral margins of patella more granulate than ventral and dorsal margins; patella 2.39–2.70 longer than femur; tibia slightly curved basally, as long as patella or slightly shorter than patella (0.97–1.00); tarsus clearly shorter than tibia, with weak granules; most setae with one lateral and few terminal denticulations, patella with one simple median seta, tibia with simple and long terminal setae, tarsus with basal denticulate setae.

6.5. Male: Figure 7; Tables 1, 2, and 3

Carapace. It is present as follows: brown to dark brown, slightly lighter in color than female but distinctly darker than other stages, darker than abdomen, similar to pedipalps; completely granulate, lateral and anterior margins more granulate; usually longer than wide, granules of furrows with smaller in diameter; with 2 well-developed corneate eyes, larger, wider, and less swollen than in tritonymph; 2 transverse furrows present; anterior furrow situated medially, narrow, and extending to the lateral margins; posterior furrow wider than anterior furrow and extending to proximity of the lateral margins; setae short with terminal denticulations, anterior margin with longer setae than posterior margin, 1 or 2 small setae situated very close to median zone of anterior margin; and anterior margin curved anteriorly and posterior margin straight.

Tergites. They are present as follows: sclerotized and granulate; lighter in color than carapace, brown with 2 darker spots, each half-tergite with a darker and larger spots than tritonymph and lighter in color than female; most tergal setae short with terminal denticulations; half-tergites IV to XI with lateral and median setae; 2 median setae present, one seta situated on exterior side of half-tergites and one seta situated on middle zone of each half-tergite; tergite XI with 2 long tactile setae situated laterally; tergites I and XI are not divided; and tergal chaetotaxy is shown in Table 3.

Sternites. They are present as follows: lighter in color than tergites; less granulate than tergites; sternites II and III



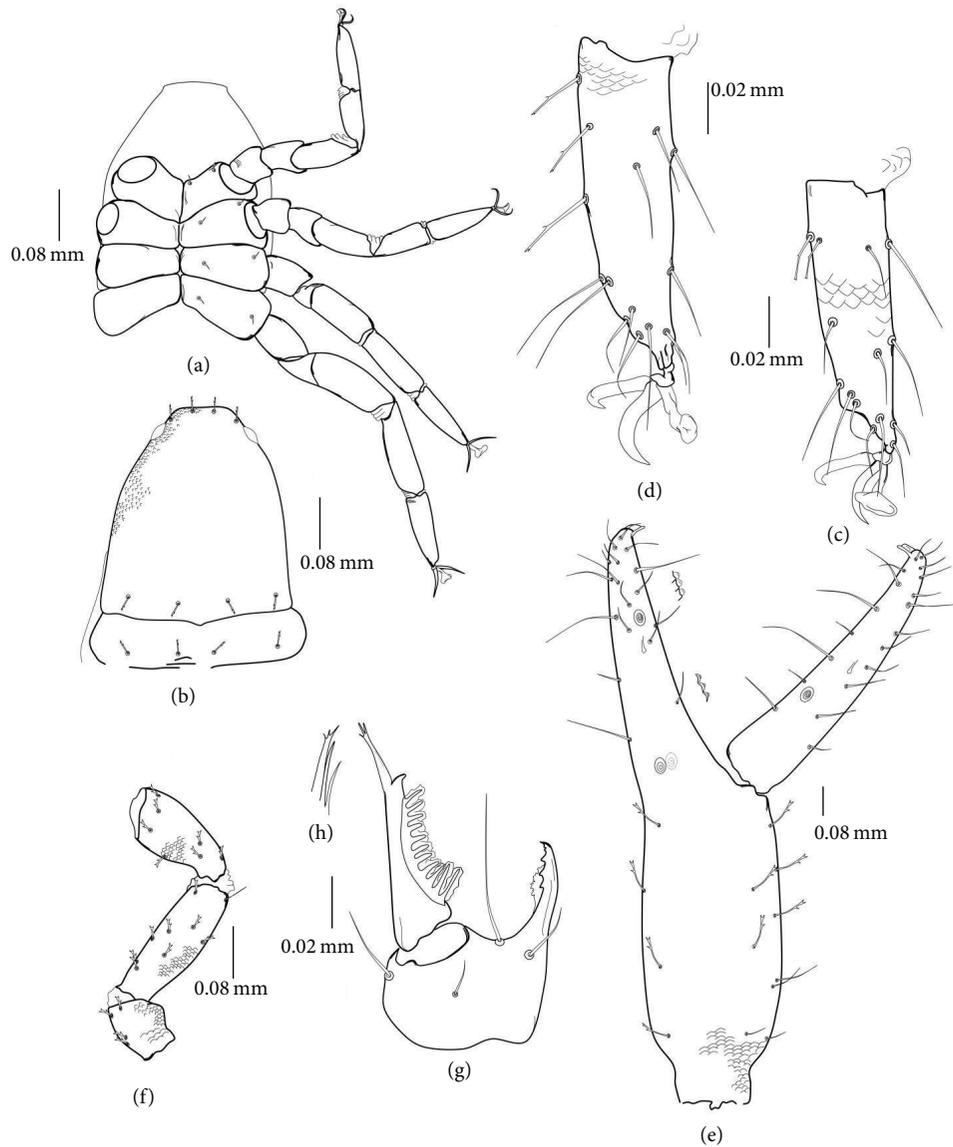


FIGURE 3: Protonymph: (a) legs and ventral view of carapace, (b) dorsal side of carapace, (c) tarsus of leg I, (d) tarsus of leg IV, (e) right chela, (f) pedipalp, (g) chelicera, and (h) rallum.

to ist than it, eb-esb-ib-isb aggregated basally; movable finger with trichobothrium st situated between t and sb, sb situated close to b; fixed finger with 43–50 and movable finger with 45–52 similar-shaped teeth; and nodus ramosus present in both fingers, clearly longer in movable finger than fixed finger, situated slightly anterior to st in movable finger, and between est and it in fixed finger.

Legs. They are present as follows: leg I: light brown, lighter in color than body; trochanter weakly granulate; femur slightly granulate, stouter than patella and joint widely; patella granulate and longer than femur; patella 1.23–1.37 longer than femur; tibia granulate, slightly shorter and narrower than patella, prolateral margin curved distally; tarsus much stouter and larger than in tritonymph, clearly shorter and stouter than in female; tarsus modified, stout and smooth,

retrolateral margin curved dorsally and prolateral margin slightly curved ventrally, and terminal margin concave; most setae with one lateral and few terminal denticulations; retrolateral margin of tarsus with denticulate setae, except for terminal and subterminal setae situated on dorsal terminal ridge, and prolateral margin with denticulate setae except distally; 2 terminal pseudotactile setae present on retrolateral margin; subterminal setae curved; claws asymmetric, posterior claw with 3–4 teeth; and arolium shorter than claws. Leg IV: stout and larger than tritonymph, distinctly shorter and narrower than in female; light brown, lighter in color than leg I; coxal sac present, with well-developed atrium; trochanter slightly granulate on dorsal side; femur smooth; lateral margins of patella more granulate than ventral and dorsal margins; patella 2.62–3.33 longer than femur; tibia slightly curved basally, as long as or slightly longer than patella, tibia

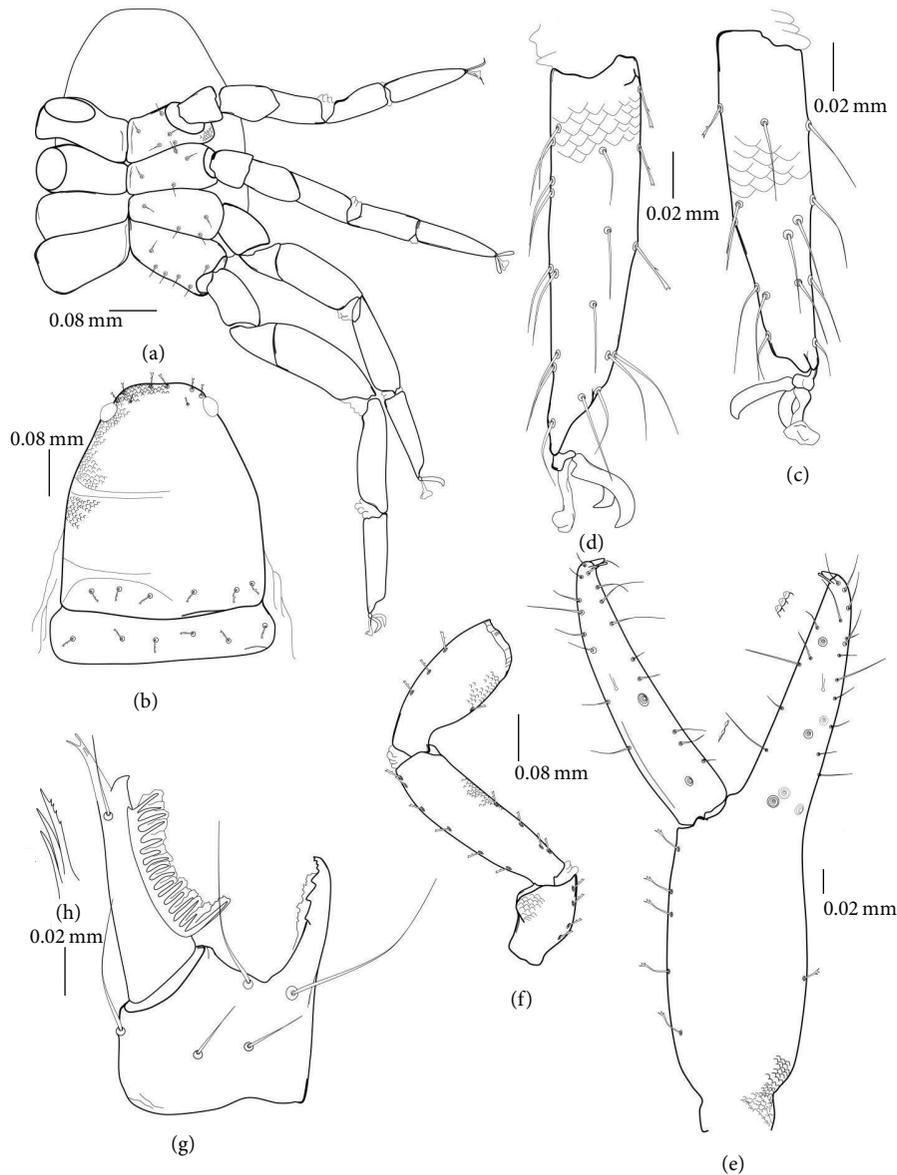


FIGURE 4: Deutonymph: (a) legs and ventral view of carapace, (b) dorsal side of carapace, (c) tarsus of leg I, (d) tarsus of leg IV, (e) left chela, (f) pedipalp, (g) chelicera, and (h) rallum.

1.00–1.04 longer than patella; tarsus clearly shorter than tibia, with small granules; most setae with one lateral and a few terminal denticulations; tarsus with simple distal setae and 2 pseudotactile setae; subterminal setae curved; claws symmetric, without teeth; and arolium simple and shorter than claws.

7. Distribution

Dactylochelifer gracilis has only been recorded from Iran and Turkey [17, 18].

8. Discussion

Many differences are apparent between each stage of *D. gracilis*, including size, pedipalpal ratios (Table 2, Figures 1

and 2), density of granules on the pedipalps and tergites, and the number of trichobothria on the pedipalpal fingers.

The body lengths of deutonymphs are longer than protonymphs and tritonymphs are longer than deutonymphs. Male body lengths are shorter than females. The carapace of protonymphs is slightly longer than wide whereas in the other stages, it is noticeably longer than wide (Figures 3(b), 4(b), 5(b), 7(b), and 8).

The body and carapace of protonymphs are smooth and poorly sclerotized. The sclerotization of the body and carapace begins at the deutonymphal stage and increases gradually to adults. Males are more sclerotized and granulated than females (Figure 8).

The ratios and the degree of granulation of the pedipalps increase during development. Protonymphs have small and

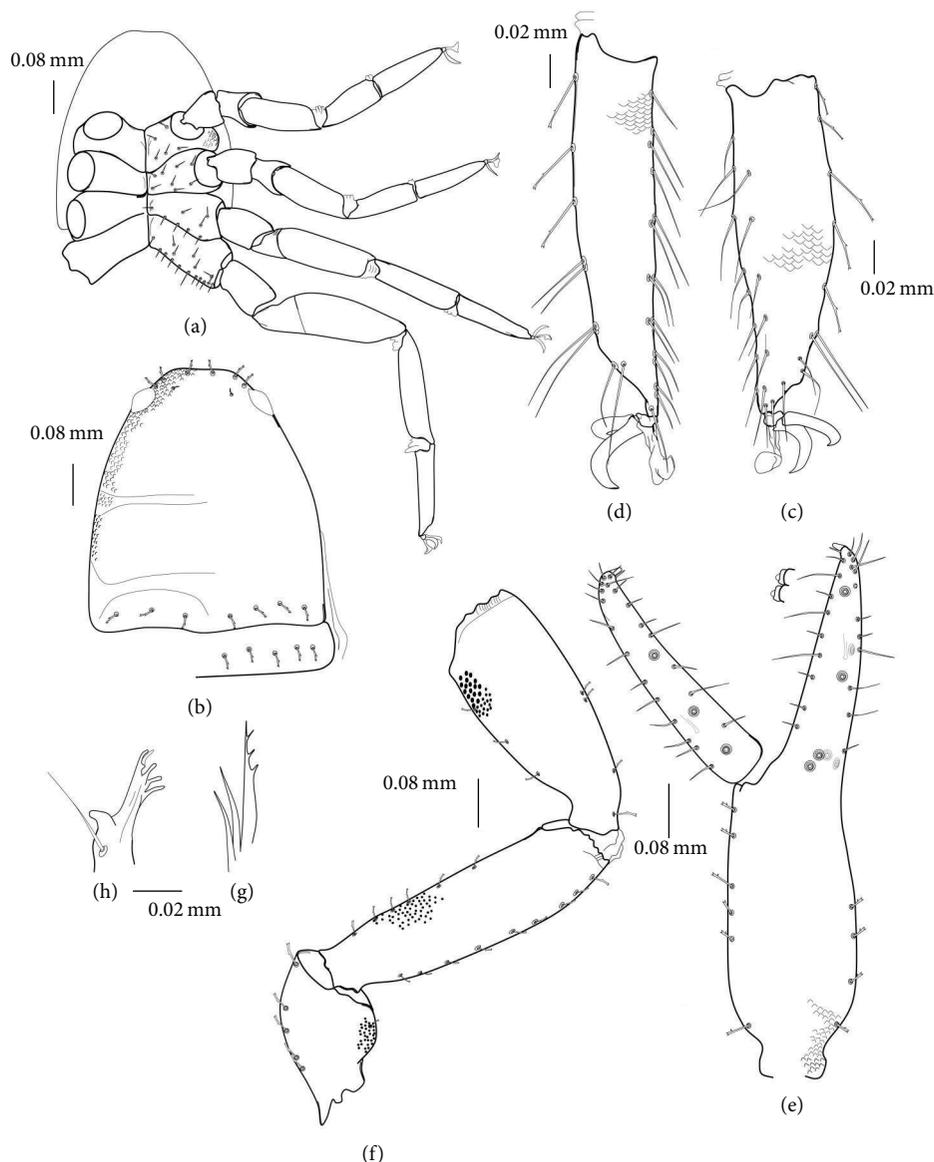


FIGURE 5: Tritonymph: (a) legs and ventral view of carapace, (b) dorsal side of carapace, (c) tarsus of leg I, (d) tarsus of leg IV, (e) left chela, (f) pedipalp, (g) rallum, and (h) galea.

smooth pedipalps. The pedipalpal femur of protonymphs is without an obvious pedicel and is 1.21–1.56 times shorter than that of deutonymphs. The tritonymphs have stouter and longer pedipalps than deutonymphs, and adults have the longest and widest pedipalps. The pedipalps of males are slightly shorter and thinner than females but they are more granular and slightly stouter (Figure 9; Table 1).

The chela and the leg I gradually become longer (Figures 1 and 2). The chelae of deutonymphs are 1.24–1.49 times longer than those of protonymphs and the chelae tritonymphs are 1.23–1.66 times longer than those of deutonymphs. The chelae of males are 1.23–1.54 times longer than those of tritonymphs but 1.10–1.35 times shorter than those of females (Figures 1 and 10).

Only two other species of *Dactylochelifer* have had all of their developmental stages documented, *D. latreillii* [23] from

England and *D. vtorovi* Mahnert, 1977 from Kyrgyzstan [24]. The data presented for *D. latreillii* suggests that the segments become progressively more slender; for example, the pedipalpal femur ratios are protonymphs 2.41–2.76, deutonymphs 2.66–2.99, tritonymphs 2.73–3.21, males 3.24–3.78, and females 3.06–3.53. The femur ranges of *D. vtorovi* followed by ratios in parentheses are protonymphs 0.26 mm (2.88), deutonymphs 0.34–0.35/0.11–0.12 mm (2.91–3.09), tritonymphs 0.51–0.53/0.14–0.15 mm (3.53–3.64), female 0.66–0.77/0.17–0.20 mm (3.85–3.88), and male 0.66–0.67/0.15–0.17 mm (3.94–4.40). The pedipalpal femur ratios for *D. gracilis* are protonymphs 2.06–3.00, deutonymphs 2.61–3.41, tritonymphs 3.13–3.87, males 4.09–4.81, and females 4.12–4.66.

By comparing tergal and sternal chaetotaxy, a fair difference was confirmed between *D. gracilis*, *D. latreilli*, and

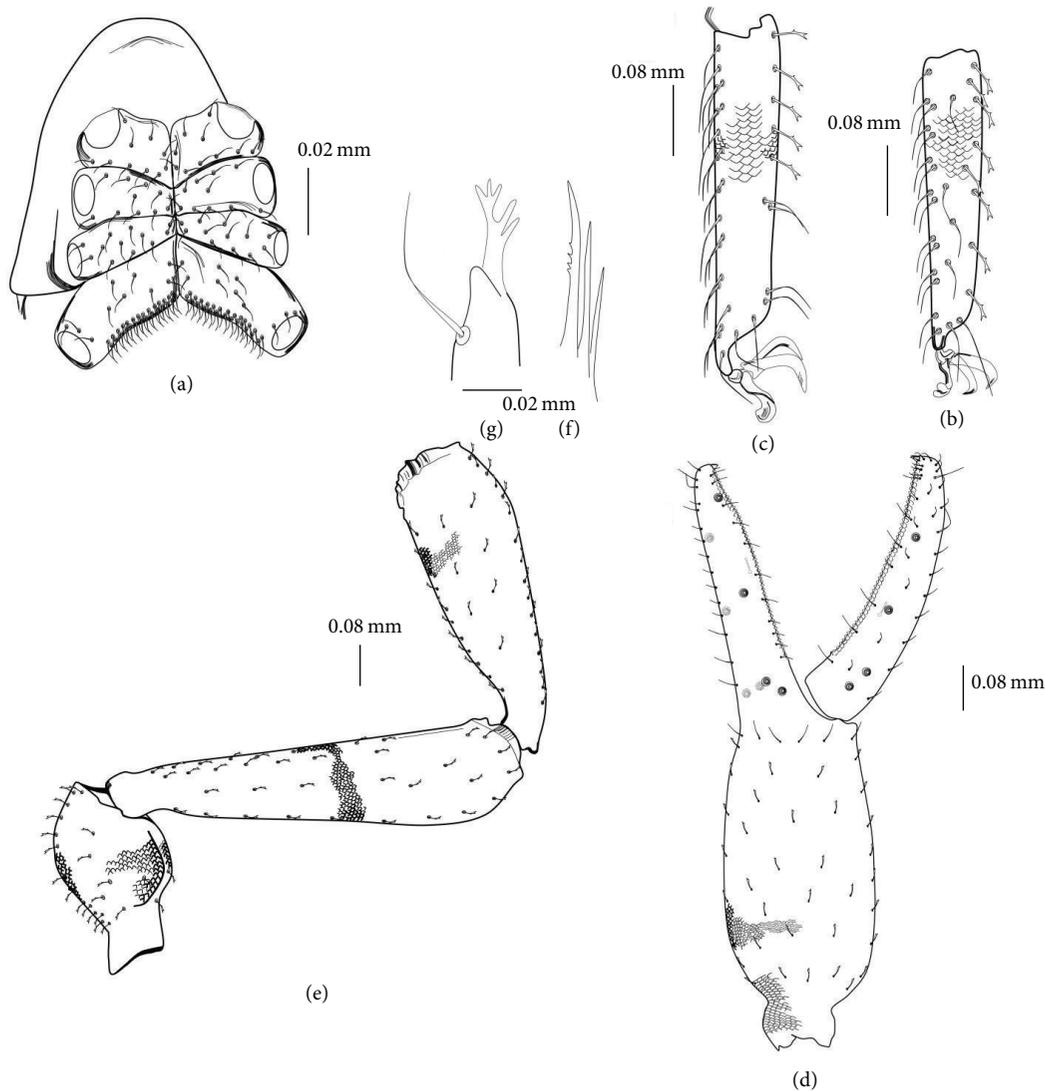


FIGURE 6: Female: (a) ventral side of carapace, (b) tarsus of leg I, (c) tarsus of leg IV, (d) right chela, (e) pedipalp, (f) rallum, and (g) galea.

D. vtoromi. The most important differences can be distinguished by consideration of anterior operculum. The more setae can be counted on anterior operculum of *D. latreillii* which are measured more than 50 for males and more than 25 for females, the numbers less than what are mentioned before will belong to one of the three mentioned species. Tergal setae is arranged widely variable, but the most tergal setae (20 setae) may be counted in *D. gracilis*. Tergal chaetaxy of nymphal stages are very similar in all three mentioned before species. It is worth mentioning that there are small differences confirmed in sternal chaetotaxy of nymphal stages, where the most cleared difference is being recognized in protonymphs of *D. gracilis* which can be identified by presence of 2 setae on sternite IV but there are 4 setae on Sternite IV of *D. latreilli* and *D. vtoromi* protonymphs.

The sequence of the appearance of individual trichobothria on the fixed and movable fingers during development

of pseudoscorpions has been well documented (e.g., [4, 7]). The developmental sequence in *D. latreillii* and *D. vtorovi* is identical to the pattern of *D. gracilis* [24, 25].

The chela of *D. gracilis* is relatively longer than that of *D. latreillii* in all developmental stages. The length of the chela with pedicel of *D. latreillii* is 0.64–0.70 mm (deutonymph), 0.89–0.97 mm (tritonymph), 1.21–1.31 mm (female), and 1.10–1.25 mm (males) [25]. The length of chela with pedicel of *D. gracilis* is 0.53–0.58 mm (protonymph), 0.66–0.79 mm (deutonymph), 0.97–1.10 mm (tritonymph), 1.40–1.65 mm (female), and 1.22–1.50 mm (male) (Figure 10). The protonymphs of both species have short, narrow chelae with three trichobothria on the fixed finger (et, ist, and eb) and one trichobothrium (t) on the movable finger (Figures 3(e) and 10(a)). The deutonymphs of both species carry six trichobothria on the fixed finger and two trichobothria on the movable finger. The trichobothria added at this stage are

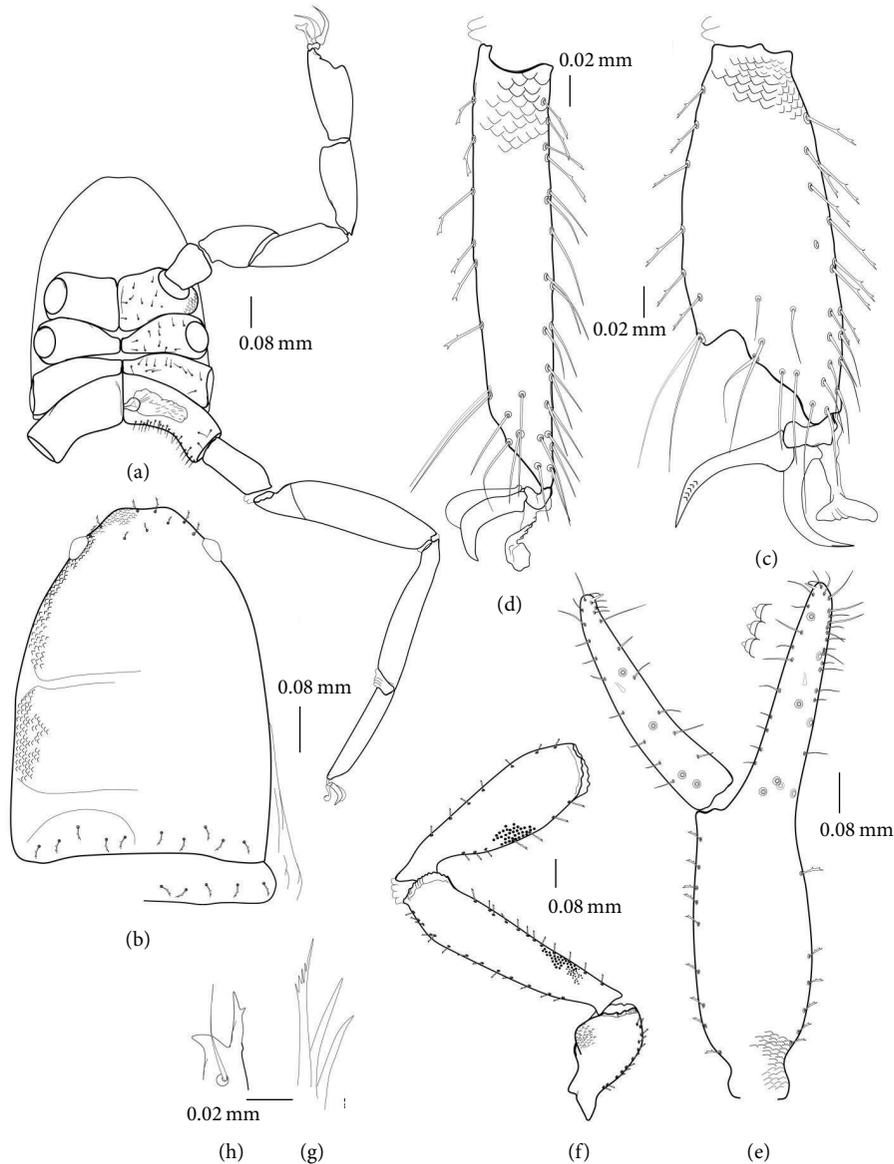


FIGURE 7: Male: (a) legs and ventral side of carapace, (b) dorsal side of carapace, (c) tarsus of leg I, (d) tarsus of leg IV, (e) left chela, (f) pedipalp, (g) rallum, and (h) galea.

it, ib, and est on the fixed finger and b on the movable finger (Figures 4(e) and 10(b)). Trichobothrium t is situated basally in the protonymph but is situated medially after molting to the deutonymph stage. Tritonymphs have seven trichobothria on the fixed finger and three on the movable finger, with trichobothrium esb being added to the fixed finger and st to the movable finger (Figures 5(e) and 10(c)). Adults have eight trichobothria on the fixed finger and four trichobothria on the movable finger; trichobothrium isb is added to the fixed finger and sb is added to the movable finger (Figures 6(d), 7(e), and 10(d)).

Significant differences exist between *D. latreillii*, *D. vtorovi*, and *D. gracilis* in the shape of male tarsus I. Rarely, the proportion of male tarsus I of *D. gracilis* and *D. latreilli* are

measured similar. The male tarsus I of *D. gracilis* is curved and shaped an irregular concaved subdistal margin (Figure 7(c)) but the male tarsus I of *D. latreilli* is being seen in a convex shape with a smooth subdistal margin [25]. The mentioned irregular concaved shape (Figure 7(c)) can be used as a distinct factor for identification. Gabbutt [25] reported the following ratios for male of *D. latreillii* 2.91–3.10 and Mahnert [24] reported the following ratios of *D. vtorovi*: protonymphs 3.66, deutonymphs 3.55–3.71, tritonymphs 3.30–3.48, males 2.70–3.00, and females 4.99–5.63. The tarsus I ratios of *D. gracilis* are noticeably more slender: protonymphs 2.50–3.20, deutonymphs 3.00–4.00, tritonymphs 3.00–4.62, males 2.20–2.57, and females 5.00–6.28 (Figures 3(c), 4(c), 5(c), 6(b), and 7(c)).

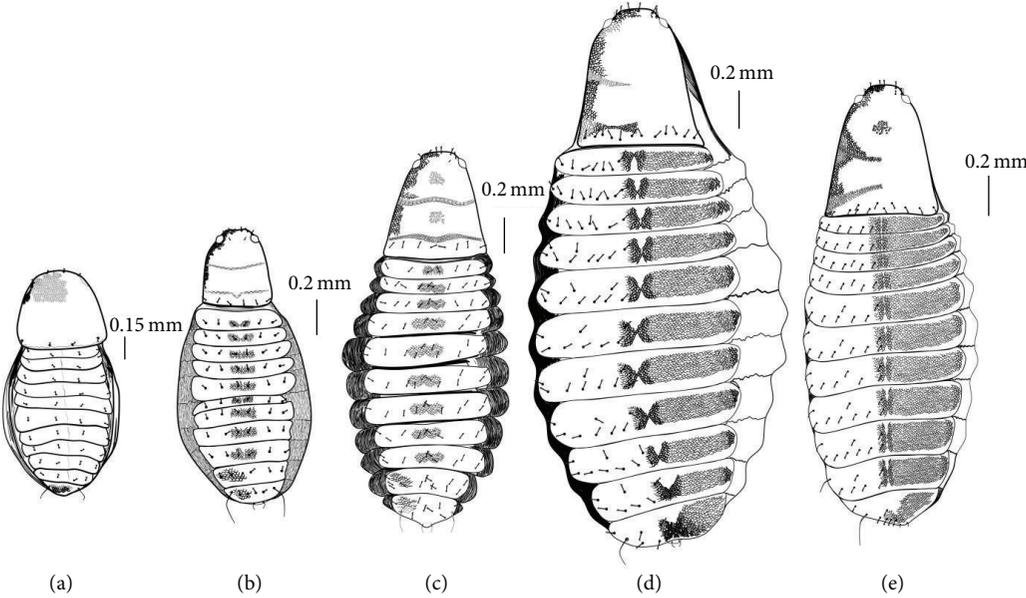


FIGURE 8: Ventral view of body: (a) protonymph, (b) deutonymph, (c) tritonymph, (d) female, and (e) male.

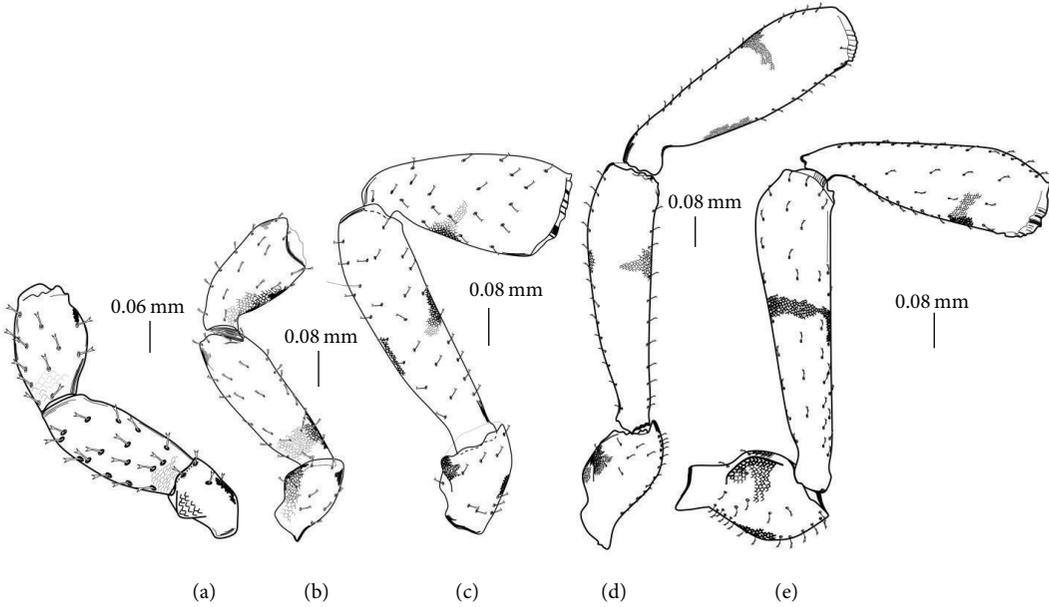


FIGURE 9: Pedipalps of *Dactylochelifera gracilis*: (a) protonymph, (b) deutonymph, (c) tritonymph, (d) male, and (e) female.

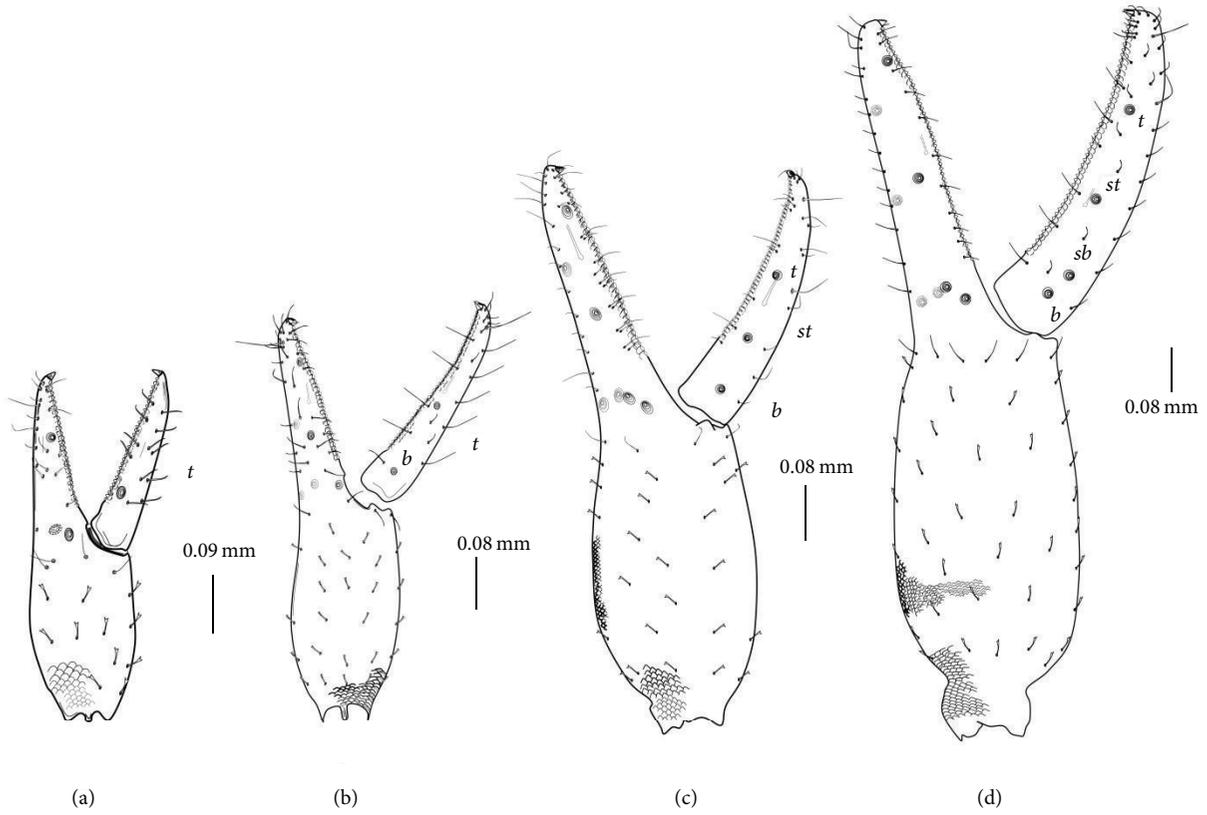


FIGURE 10: Right chela of *Dactylochelifer gracilis*: (a) protonymph, (b) deutonymph, (c) tritonymph, and (d) female.

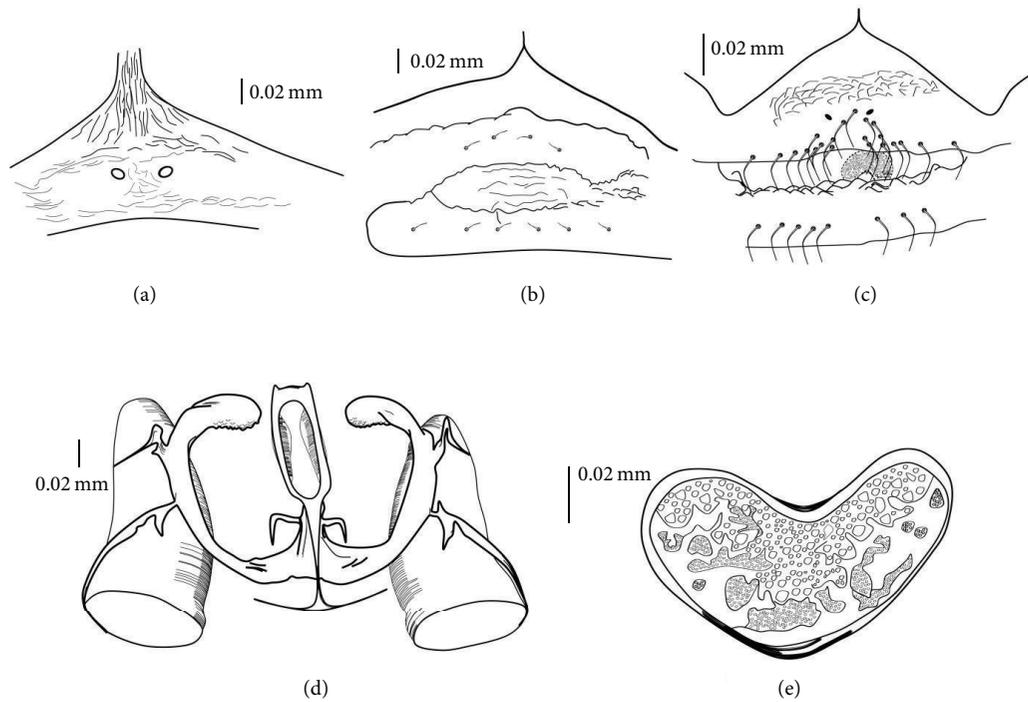


FIGURE 11: The genital organs of *Dactylochelifer gracilis*: (a) anterior operculum of deutonymph, (b) anterior and posterior operculum of tritonymph, (c) anterior and posterior operculum of female, (d) genital organs of male, and (e) cribriform plate.

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