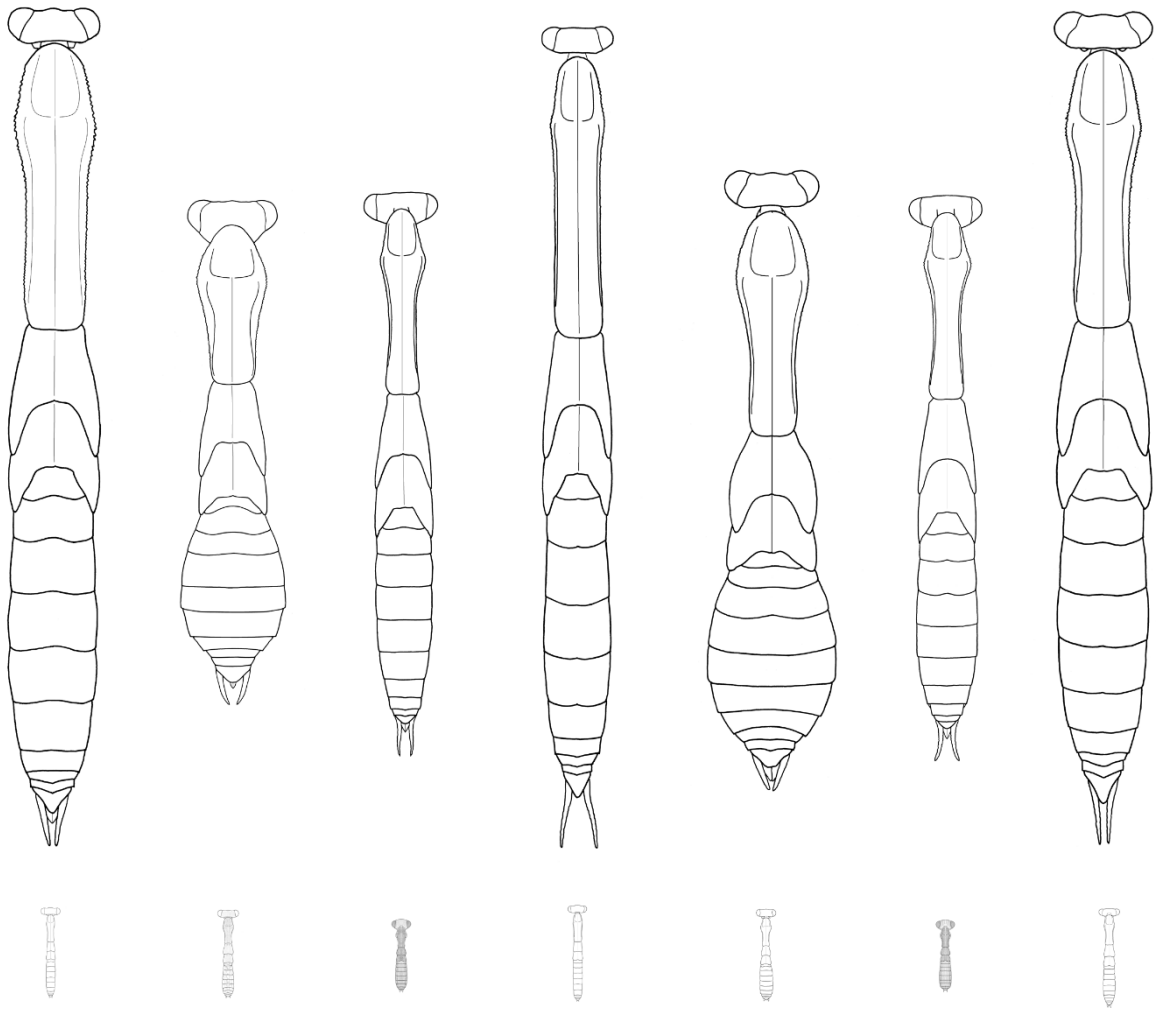


日本産カマキリ目の若虫と雌外部生殖器の  
形態および分類学的研究



2021年  
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## 第1章

### 緒言

カマキリ目 Mantodea は、ゴキブリ目 Blattodea とともに網翅類 Dictyoptera を構成する昆虫の一群で、世界の熱帯と亜熱帯を中心に分布する。世界から 29 科 (Schwarz & Roy 2019), 約 2,400 種が記載されており (Otte *et al.* 2020), 日本からは、1 移入種を含む、3 科 13 種が記録されている (中峰 2020)。

カマキリ目の形態学的研究および分類学的研究は、雄成虫と卵鞘を中心に進められている (Roberto *et al.* 2010; Zhu *et al.* 2012; Rivera & Svenson 2016; Brannoch *et al.* 2017; Song 2020)。若虫では、化石種の記載 (Grimaldi 1997) や聴覚器官の形態比較 (Yager 1996), 擬態モデルとの形態比較 (Haug *et al.* 2020) などが行なわれているものの、分類や同定に関する研究は付屬的にしか行なわれてない (岡田 2001; Leong 2009; O' Hanlon *et al.* 2013; Wieland 2013; Fatimah *et al.* 2016) ことが多く、若虫そのものを対象にした研究は成虫のものと比較して少数である。

若虫の基本的な構造は、Steinmann & Zombori (1984) と Nickle (1987) によって記述されている。これを皮切りに、同一種における全齢期をとおしての形態形質の報告はある (Suckling 1984; Iwasaki 1992; Ranade *et al.* 2004) もの、種数は限られる上、いずれも体長や頭幅などの計測値や体色の記述に留まっている。各部位を詳細に記載し、種同定や齢期、雌雄の判別に利用可能な研究はごく僅かであり (岡田 2004; Nakamine *et al.* 2016; Raut & Gaikwad 2016), 多くの種において若虫の種同定などに有用な形態形質は未解明である。

一方で、雌成虫における形態学および分類学的な解明度も不十分である。カマキリ類の成虫のより正確な種同定には、場合によって外部生殖器を観察する必要がある。従来の外部生殖器による種同定は、おもに雄生殖器の形態形質を用いており (Wang 1993; Battiston & Fontana 2005; Jensen 2009; 中峰 2016; Agudelo & Rafael 2016), 雌生殖器の形態形質を用いた例はほぼ皆無である。したがって、雄個体同士の種同定は外部生殖器によって可能であるが、雌個体同士では正確に種を同定できない可能性が考えられる。また、一部のカマキリ類には、形態に顕著な性的二型を有する種が知られるため (Zhu *et al.* 2012; Svenson *et al.* 2016; Rodrigues *et al.* 2017; Agudelo *et al.* 2019), 種同定に有用な形態形質は、雌雄ともに詳細に記載する必要があると考えられる。

国内におけるカマキリ類は、多くの種が人家付近や都市公園でも見つかる馴染みの深い昆虫であるにもかかわらず、形態・分類・生態に未知な部分が残されている。とくに南西諸島においては、ハラビロカマキリ *Hierodula patellifera* (Audinet-Serville, 1838) の化性が年一化である (東 2013) ことが分かっている以

外は、各種の生活史が不明である（岡田 2001；中峰 2016）ほか、各種の月ごとの発育段階や正確な分布域についてもほとんど未解明であり（山下 2018）、これらの解明に向けた継続的なファウナ調査が求められる。南西諸島におけるファウナ調査では、成虫や卵鞘に加えてさまざまな齢期の若虫が同時期に得られることが多い（大島 2018；大島・瑤寺 2019；大島ら 2020）。したがって、全齢期における正確な種同定や同一種における齢期判別などが必要である。しかし、若虫の形態については、ごく限られた齢期しか調べられていないため、種の同定や齢期、雌雄の判別は困難である。

カマキリ類は、国内外問わず生体や卵鞘が物流とともに運ばれ、外来種として報告されることがある（柏崎 1999; Battiston *et al.* 2018, 2020; 櫻井ら 2018; Shcherbakov & Govorov 2020）。外来種の分布状況や在来種との競合の実態を把握するためには、すべての発育段階ならびに性別における正確な種同定が必要であると考えられる。しかし、得られた標本が若虫または雌成虫のみであった場合、正確に種を同定できない可能性があり、外来種の若虫の誤同定も実際に生じている（Harris 2007）。こういった事態を回避し、すべての発育段階ならびに性別において正確な種同定を可能にするため、若虫および雌生殖器の形態が同定形質として有用であるかを検討する必要がある。

本研究では、カマキリ目の若虫の形態形質を用いた種同定、齢期判別、雌雄判別の確立および雌外部生殖器の形態形質を用いた種の同定方法の確立を目的とし、日本産 13 種のうち、7 種の若虫および 11 種の雌外部生殖器を形態学的ならびに分類学的に検討した。また、南西諸島のファウナ調査によって得られた、分類学的な問題があると思われる沖縄県大東諸島のハラビロカマキリについて検討した。

## 第2章

### 日本産カマキリ科の若虫の形態および分類学的研究

#### 2-1 *Tenodera* 属 3 種の若虫期における形態

##### 2-1-1 緒言

*Tenodera* 属は、日本からはマエモンカマキリ *T. fasciata* (Olivier, 1792) (以下, マエモン), チョウセンカマキリ *T. angustipennis* Saussure, 1869 (以下, チョウセン), オオカマキリ *T. sinensis* Saussure, 1871 (以下, オオ) の3種が知られる(岡田 2001; 中峰 2016). これら3種のうち, 本州~屋久島には, チョウセンとオオが, 徳之島~先島諸島には, チョウセンとマエモンが分布し, それぞれが同所的に採集されることがある. 3種の形態はそれぞれ類似しているが, 雄外部生殖器の形状や後翅の斑紋の有無, 前脚基節窩間の色を比較することで成虫では容易に判別できる(岡田 2001; 中峰 2016). 若虫においては, 亜終齢と終齢では前脚腿節の黒褐色斑の有無によって各種が同定できる(岡田 2004)が, 亜終齢未満の若虫での同定方法は確立されていない. したがって, 種の分布が重なる地域で亜終齢未満の若虫が得られても, 形態による種同定は困難である. また, 全齢期を通しての形態的特徴の記載は, Iwasaki (1992) によってオオとチョウセンの体長と体色について行なわれたのみであり, 同一種の齢期や雌雄の判別でさえ困難である.

そこで, これら3種的全齢期における若虫の形態を記載し, 分布域が重なる2種間で比較した結果, 全齢期において, 若虫期に種を同定するための有用な形態的特徴を見いだした. また, 3種すべてにおいて外部形態による齢期ごとの特徴および2齢以降の雌雄の特徴を見だし, 種, 齢期, 雌雄を判別可能な検索表を作成した.

##### 2-1-2 材料および方法

###### 1) 若虫の採集と飼育方法

観察した若虫は, すべて人工管理下で孵化させたものを用いた. マエモンは, 2017年3月11日に沖縄県伊平屋村我喜屋において採集した卵鞘を気温 30°C, 湿度 60-80%の条件下で管理し, 孵化させた. チョウセンは, 2017年7月21日に沖縄県伊是名村伊是名と勢理客において採集した雌雄を交配させ, 産下させた卵鞘を気温 30°C, 湿度 60-80%の条件下で管理し, 孵化させた. オオは, 2017

年 10 月 9 日に東京都昭島市拝島町において採集した雌が産下した卵鞘を気温 27°C、湿度 60–80%の条件下で孵化まで管理し、孵化させた。

得られた卵鞘は、プラスチック製ケース（縦 181 mm、横 124 mm、深さ 112 mm）に入れ管理した。孵化した若虫はすべて、気温 30°C、湿度 60–80%、日長 15L:9D の条件下で飼育した。1 齢から 5 齢若虫の飼育には、プラスチック製プリンカップ（口径 102 mm、深さ 80 mm）、6 齢と 7 齢若虫には同製プリンカップ（口径 129 mm、深さ 97 mm）を用いた。カップの蓋には容器内の蒸れを防ぐために複数の小さな穴をあけた。8 齢と 9 齢若虫には体長によって、プラスチック製ケース（縦 181 mm、横 124 mm、深さ 112 mm）または、さらに大きな同ケース（縦 235 mm、横 155 mm、深さ 142 mm）を用いた。飼育に用いた各容器には、若虫の足場として園芸用の鉢底ネットをアーチ状にして配置し、底には乾燥防止用に水を含ませたティッシュペーパーを置いた。

餌は以下の要領で与えた。1 齢と 2 齢若虫には、キイロショウジョウバエ *Drosophila melanogaster* Meigen, 1830（ショウジョウバエ科）をそれぞれ 3 頭と 5 頭与えた。3 齢以降の若虫には、体長に適したサイズのレッドローチ *Shelfordella lateralis* (Walker, 1868)（ゴキブリ科）をそれぞれ 1 頭与えた。給餌は週 5 回行なったが、脱皮直前または直後の場合や、捕食を拒否した場合は給餌を見送った。また、脱皮前の数日間は消化能力が低下するため、餌の量を減らすか、または見送った。

## 2) 若虫の観察方法

マエモンとチョウセンは、2 齢以降の各齢において 3–5°C の低温に 30 分以上晒し、麻酔をかけた状態で観察した。オオは、2 齢以降の各齢においてクロロホルムに数分間晒し、麻酔をかけた状態で観察した。1 齢若虫は軽度の麻酔でも死亡してしまうため、死後数時間以内の新鮮な標本を観察に用いた。各種各齢における検視個体数は Table 1–3 にまとめた。

各種各齢の若虫において、体長、前胸背板、前脚基節窩間、有翅胸節（翅芽）、前脚基節、基節背縁突起、前脚腿節、内縁刺、外縁刺、中列刺、腹部第 VII–IX 腹板、尾角を実態顕微鏡（SZ60; Olympus, 東京）とデジタルマイクロスコープ（VHX-1000; Keyence, 大阪）を用いて観察した。撮影には同デジタルマイクロスコープとデジタルカメラ（WG-4; Ricoh, 東京）を使用し、トレス法で作図した。また、各部位の計測には定規を用いた。各種各齢の若虫における各部位の形態的特徴を記載し、種、齢、雌雄の判別方法を検証した。

各部位名称は、Roberto *et al.* (2010) と Brannoch *et al.* (2017) に従ったが、雌生殖器の一部では Matsuda (1976) に従った。日本語名称については、おもに中峰 (2016) に従ったが、前脚腿節の刺については岡田 (2001) に従った。また、日

本語名称のない部位は和訳した。なお、本論文では、各種の記載については英文で行なった。各部位名称の和英対応および計測箇所は以下のとおりである：体長 body length；前胸背板 pronotum；中央隆起 medial keel；前脚基節窩間 Prosternum between coxal cavities；有翅胸節（翅芽） pterothrax (wing pad)；前脚基節 procoxa；基節背縁突起 marginal spine；前脚腿節 profemur；内縁刺 anteroventral-femoral spine；外縁刺 posteroventral-femoral spine；中列刺 discoidal spine；膝距 genicular spur；腹部腹板 sternite；腹部背板 tergite；陰具片 gonapophysis；生殖片 gonoplac；尾突起 stylus；下陰基板突起 posterior process；尾角 cercus：

- (1) 体長 Body length: 前胸背板の前縁から腹部第 X 背板の後縁までの最大長；
- (2) 前胸背板長 Pronotum length: 前胸背板の前縁から後縁までの最大長；
- (3) 前胸背板幅 Pronotum width: 前胸背板の横幅のもっとも広い部分の長さ；
- (4) 前翅芽長 Fore wing pad length: 肩部から前翅芽の末端までの最大長；
- (5) 前脚腿節長 Profemur length: 前脚腿節の前縁から後縁までの最大長；
- (6) 前脚腿節幅 Profemur width: 前脚腿節の背縁から第 II 内縁刺の基部までの最大長；
- (7) 尾角長 Cercus length: 尾角の基部から末端までの最大長。

### 2-1-3 結果および考察

#### マエモンカマキリ

#### *Tenodera fasciata* (Olivier, 1792)

各齢期における各部位の測定値を Table 1 にまとめた。成虫になるまでの齢数は、雄で 7 齢または 8 齢，雌で 8 齢または 9 齢である。羽化までの脱皮回数が少ない個体（雄：7，雌：8）と多い個体（雄：8，雌：9）は、同じ飼育条件下において発生した。以下に記載した形態的特徴を用いて、本種の幼虫期における齢、性別、種の判別が可能である。

#### 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 8.1–8.8 mm in long (Figs. 3a, 4a), generally wholly brownish.

Pronotum (Fig. 9a) approximately 3.2 times as long as its maximum width. Prosternum between coxal cavities (Fig. 12a) dull, same in color as rest of body. Posterolateral angles of pterothoracic segments (Figs. 15a, 16a) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 21a, j) approximately 6 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half



interolaterally, on tibial spur groove, and along anteroventral (internal) -femoral spines. Four discoidal spines basal spine longest; proportional length of basal to apical spines 3.5: 1.4: 1: 1.7. Mesofemur and Metafemur with or without genicular spur. Posterior margin of abdominal sternite VII and VIII (Figs. 24a, 25a) straight in medial region. Sternite IX with a pair of immature gonoplags (in prospective adult female) or immature styles (in prospective adult male); immature gonoplags and styles conical and same in shape and size between the sexes. Cerci unsegmented, 0.03 times as long as body length.

**2nd instar.** Female: body 13.8–14.5 mm in long (Fig. 3b), generally wholly brownish or greenish. Pronotum (Fig. 9b, j) approximately 4.5 times as long as its maximum width. Prosternum between coxal cavities (Fig. 12b) dull, same in color as rest of rest of body. Posterolateral angles of pterothoraces (Fig. 15b) rounded, lacking wing pads. Procoxa (Fig. 12j) lacking marginal spines. Profemur (Fig. 21b) approximately 6 times as long as its width, mottled with small to large, irregular black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines. Four discoidal spines, subapical spine longest; proportional length of basal to apical spines 1.4: 2.6: 4.7: 1. Mesofemur and Metafemur with genicular spur. Posterior margin of abdominal sternite VII and VIII straight in medial region. Posterior margin of sternite IX rounded between immature gonoplags. Immature gonoplags conical. Margin between immature gonoplags with or without short groove (Fig. 24b, c). Cerci at least 5-segmented, length 0.04 times as long as body length.

Male: similar to female. Body length 13.5–14.5 mm (Fig. 4b). Immature styles (Fig. 25b) same shape and size as immature gonoplags.

**3rd instar.** Female: body 18.6–20.3 mm in long (Fig. 3c), generally wholly brownish or greenish. Pronotum (Fig. 9c) approximately 4.3 times as long as its maximum width. Prosternum between coxal cavities (Fig. 12c) polished, milky white in color. Posterolateral angles of pterothoraces (Fig. 15c) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 21c) approximately 6.3 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; anteroventral-femoral spines and posteroventral (external) -femoral spines weakly

darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII weakly extended posteriorly; posterior margin rounded evenly, straight or slightly concave at middle part. Sternite VIII with or without a pair of immature gonapophyses VIII (Fig. 24d, e) at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplacs. Immature gonoplacs conical. Cerci at least 7-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 18.5–20.7 mm (Fig. 4c). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 25c). Posterior margin of sternite IX rounded between immature styles. Immature styles narrowed apically.

**4th instar.** Female: body 26.5–30.4 mm in long (Fig. 3d), generally wholly brownish or greenish. Pronotum (Fig. 9d) approximately 5 times as long as its maximum width, with lateral margins minutely serrate throughout its length (Fig. 9k). Prosternum between coxal cavities (Fig. 12d) polished, milky white in color. Posterolateral angles of pterothoraces (Fig. 15d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.09 times as long as body length. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 21d, k) approximately 6.3 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 24f) extended posteriorly, posterior margin shallowly notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci at least 9-segmented, 0.06 times as long as body length.

Male: similar to female. Body length 26.0–31.5 mm (4d). Posterior margin of abdominal sternites VII and VIII straight in middle region (Fig. 25d). Posterior margin of sternite IX slightly rounded between immature styles. Immature styles short, papillate.

**5th instar.** Female: body 34.7–40.8 mm in long (Fig. 3e), generally wholly brownish or greenish. Pronotum (Fig. 9e) approximately 5.8 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Prosternum between coxal cavities (Fig. 12e) polished, milky white in color. Wing pads (Fig. 15e) 0.09 times as long as body length, with or without slightly developed veins. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 21e) approximately 6.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interlaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest; basal and subapical spines of discoidal spines with or without single indistinct black spot. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 24g) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplags elongated, with apex blunt. Cerci at least 10-segmented, 0.07 times as long as body length.

Male: similar to female. Body length 35.4–40.9 mm (4e). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 25e). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**6th instar.** Female: body 42.0–51.6 mm in long (5f), generally wholly brownish or greenish. Pronotum (Fig. 9f) approximately 5.9 times as long as its maximum width, with lateral margin minutely but distinctly serrate throughout its length (Fig. 9l). Prosternum between coxal cavities (Fig. 12f) polished, milky white in color. Wing pads (Fig. 15f) provided with slightly developed veins, 0.09 times as long as body length. Procoxa (Fig. 12l) with a few slightly developed marginal spines. Profemur (Fig. 21f, l) approximately 7.1 times as long as its width, mottled with small, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines weakly darkened apically, with subapical spine longest; basal and subapical spines of discoidal spines with or without single indistinct

black spot. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 24f) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with obtuse apices. Immature gonoplacs elongated, with blunt apices. Cerci at least 12-segmented, 0.08 times as long as body length.

Male antepenultimate instar: similar to 6th-instar female. Body length 45.0–52.4 mm (Fig. 4f). Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 25f). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Penultimate instar male: similar to male antepenultimate instar. Body length 44.2–55.6 mm (Fig. 4g). Wing pads (Fig. 16g) provided with clearly developed veins, 0.11 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Profemur approximately 7.5 times longer than wide. Abdominal sternite IX extended posteriorly, covering supra-anal lobe. Cerci at least 13-segmented.

**7th instar.** Female antepenultimate instar: body 48.8–59.2 mm in long (Fig. 3g), generally wholly brownish or greenish. Pronotum approximately 5.6 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length. Prosternum between coxal cavities polished, milky white in color. Wing pads (Fig. 15g) provided with developed veins, 0.09 times as long as body length. Procoxa with slightly developed marginal spines. Profemur approximately 7.1 times as long as its width, mottled with small, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically, with or without single indistinct black spot of anteroventral-femoral spines interolaterally; discoidal spines darkened apically, with subapical spine longest; basal, subbasal and subapical spines of discoidal spines with or without single distinct black spot. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 13-segmented, 0.09 times as long as body length.

Penultimate instar female: similar to female antepenultimate instar. Body length 49.3–60.0 mm. Wing pads (Fig. 15h) provided with clearly developed veins, 0.11 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 24i) extended posteriorly, covering most of sternite VIII, with posterior margin stoutly notched and tucked at middle.

Penultimate instar male: similar to female antepenultimate instar. Body length 53.8–60.0 mm (Fig. 3h). Profemur approximately 7.5 times longer than wide. Posterior margin of abdominal sternites VII and VIII straight in the middle (Fig. 25g). Sternite IX extended posteriorly, covering supra-anal lobe; posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Last instar male: similar to penultimate instar male. Body length 55.0–65.2 mm (Fig. 4i). Fore-wing pads (Fig. 16i) provided with clearly developed veins and jugal field (including anal veins), 0.14 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Profemur approximately 7.7 times longer than wide. Anteroventral-femoral spines and posteroventral-femoral spine with or without single distinct black spot interlaterally. Basal, subbasal and subapical spines of discoidal spines with single distinct black spot. Abdominal sternite IX (Fig. 25h) extended posteriorly, post posterior margin of tergite X. Immature posterior process extended behind sternite IX. Cerci at least 14-segmented, 0.1 times as long as body length.

**8th instar.** Penultimate instar female: body 59.0–66.5 mm in long (Fig. 3i), generally wholly brownish or greenish. Pronotum approximately 5.3 times as long as its maximum width, with lateral margin minutely and distinctly serrate throughout its length. Prosternum between coxal cavities polished, milky white in color. Wing pads (Fig. 15i) provided with clearly developed veins, 0.11 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Procoxa with slightly developed marginal spines. Profemur approximately 7.1 times as long as its width, mottled with small, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically, with single distinct black spot of anteroventral-femoral spines interlaterally; discoidal spines darkened apically, with

subapical spine longest; basal, subbasal and subapical spines of discoidal spines with or without single distinct black spot. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 24j) extended posteriorly, covering sternite VIII for the most part, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, with blunt apices. Cerci at least 14-segmented, 0.09 times as long as body length.

Last instar female: similar to penultimate instar female. Body length 61.4–73.5 mm (3j). Fore-wing pads (Fig. 15j) provided with clearly developed veins and jugal field (including anal veins), 0.14 times as long as body length; apex of hind wing pads strongly extended behind posterior edge of abdominal tergite I. Abdominal sternite VII (Fig. 24k) extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at middle, extended to posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Cerci at least 15-segmented.

Last instar male: similar to last instar female. Body length 60.6–70.8 mm (Fig. 4j). Pronotum approximately 5.6 times as long as its maximum width. Profemur approximately 7.7 times longer than its wide. Posterior margin of abdominal sternite VII and VIII straight in medial region (Fig. 25i). Sternite IX extended to level of posterior margin of tergite X; posterior margin of sternite IX straight between immature styles, which are short and papillate. Immature posterior process extended to sternite IX. Cercus length 0.1 times as long as body length.

**9th instar.** Last instar female: body 70.0–78.4 mm in long (Fig. 3k), generally wholly brownish or greenish. Pronotum (Fig. 9i) approximately 5.3 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout their length. Prosternum between coxal cavities (Fig. 12i) polished, milky white in color. Fore-wing pads (Fig. 15k) provided with clearly developed veins and jugal field (including anal veins), 0.14 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Procoxa with slightly developed marginal spines. Profemur (Fig. 21i) approximately 7.1 times as long as its width, mottled with small, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and

posteroventral-femoral spines darkened apically, with single indistinct black spot interolaterally near anteroventral spines interolaterally; discoidal spines darkened apically, with subapical spine longest; distinct black spots near basal, subbasal and subapical spines of discoidal spines. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 24l) extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at middle and reaching posterior margin of tergite X. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, apices blunt. Cerci at least 15-segmented, 0.09 times as long as body length.

### 若虫の齡期判別

1 齡若虫は、体長 10 mm 未満であること (Figs. 3a, 4a) や中列刺のうち第 I 刺がもっとも長いこと (Fig. 21a, j) から、ほかの齡と判別できる。2 齡から 4 齡の判別には、体長が有用である (Figs. 3, 4) : 2 齡は体長 14 mm 内外 ; 3 齡は体長 19 mm 内外 ; 4 齡は体長 28 mm 内外。5 齡と 6 齡の判別には、体長や尾角の節数が有用である : 5 齡は体長 41 mm 未満, 尾角は最低 10 節 ; 6 齡は体長 42 mm 以上, 尾角は最低 12 節。前亜終齡 (雌 : 6 齡, 7 齡 ; 雄 : 6 齡), 亜終齡 (雌 : 7 齡, 8 齡 ; 雄 : 6 齡, 7 齡), 終齡 (雌 : 8 齡, 9 齡 ; 雄 : 7 齡, 8 齡) の判別には、とくに後翅芽の伸長度合いが有用である : 前亜終齡は後翅芽の末端が腹部第 I 背板の後縁に達しない (Figs. 3g, 4f) ; 亜終齡は後翅芽の末端が第 I 背板の後縁に達するかまたは僅かに超える (Figs. 3h, i, 4g, h) ; 終齡は後翅芽の末端が第 I 背板の後縁を大きく超える (Figs. 3j, k, 4i, j)。また、亜終齡と終齡は、雌は腹部第 VII 腹板, 雄では第 IX 腹板と下陰基板突起の発達度合いでも判別できる : 亜終齡の雌は、第 VII 腹板の後縁が第 I 背板の後縁に達しないが、終齡の雌では第 VII 腹板の後縁が第 I 背板の後縁を超える (Fig. i-l) ; 亜終齡の雄は、第 IX 腹板の後縁が第 I 背板の後縁に達せず、下陰基板突起は第 IX 腹板から露出しないが、終齡の雄では、第 IX 腹板の後縁が第 I 背板の後縁を超え、下陰基板突起は第 IX 腹板から露出する (Fig. g-i)。

以上の特徴から、マエモンカマキリは外部形態による齡期判別が可能である。

### 若虫の雌雄判別

1 齡若虫では、外部形態における雌雄差は確認できなかった。2 齡では、雌は腹部第 IX 腹板の後縁 (生殖片の間) に小さな切れ込みが生じる (Fig. 24c) のに対し、雄の腹部第 IX 腹板の後縁 (尾突起の間) はほぼ平坦である (Fig. 25b) ことから雌雄が判別できる。ただし、一部の雌個体は雄に似た特徴を表すことがあ

る (Fig. 24b). 3 齢から終齢では, 3 つの形質から判別できる (Figs. 24, 25) : (1) 雌は第 VII 腹板の後縁が湾曲しながら後方に拡張し, 加齢に伴い亜生殖板を形成するのに対し, 雄の第 VII 腹板の後縁はほぼ平坦であり, 加齢に伴う形状の変化はほとんどない ; (2) 雌は 3 齢の一部の個体を除き, 第 VIII 腹板の後縁に一对の陰具片を有するのに対し, 雄の第 VIII 腹板の後縁はほぼ平坦であり, 加齢に伴う形状の変化はほとんどない ; (3) 雌は第 IX 腹板に一对の陰具片と生殖片を有し, それらの形状が加齢に伴い変化するのに対し, 雄の第 IX 腹板の尾突起には加齢に伴う形状の変化はほとんどない. また, 7 齢と 8 齢の雌は, 同齢の雄よりも前胸背板の縦横比が大きい, 8 齢の雌は雄よりも体長と尾角の比が小さいといった性差も確認された.

以上の特徴から, マエモンカマキリは 2 齢以降に外部形態による雌雄判別が可能である.

### チョウセンカマキリ

#### *Tenodera angustipennis* Saussure, 1869

各齢期における各部位の測定値を Table 2 にまとめた. 成虫になるまでの齢数は, 雄雌ともに 8 齢または 9 齢である. 以下に記載した形態的特徴を用いて, 本種の幼虫期における齢, 性別, 種の判別が可能である.

#### 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 7.5–8.0 mm in long (Figs. 5, 6), generally wholly brownish. Pronotum (Fig. 10a) approximately 3.2 times as long as its maximum width. Prosternum between coxal cavities (Fig. 13a) dull, same in color as rest of body, with a small black marking posteriorly. Posterolateral angles of pterothoracic segments (Figs. 17a, 18a) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 22a, j) approximately 5 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interlaterally, on tibial spur groove, and along anteroventral (internal) - femoral spines. Four discoidal spines basal spine longest; proportional length of basal to apical spines 3.6: 1.9: 1: 1. Mesofemur and Metafemur with or without genicular spur. Posterior margin of abdominal sternite VII and VIII (Figs. 26a, 27a) straight in medial region. Sternite IX with a pair of immature gonoplacs (in prospective adult female) or immature styles (in prospective adult male); immature gonoplacs and styles conical and same in shape and size between the sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Female: body 11.0–11.5 mm in long (Fig. 5b), generally wholly brownish or greenish. Pronotum (Fig. 10b, j) approximately 3.6 times as long as its



maximum width; median keel developed strongly. Prosternum between coxal cavities (Fig. 13b) dull, same in color as rest of rest of body, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 17b) rounded, lacking wing pads. Procoxa (Fig. 13j) lacking marginal spines. Profemur (Fig. 22b) approximately 5.2 times as long as its width, mottled with small to large, irregular black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines. Four discoidal spines, subapical spine longest; proportional length of basal to apical spines 1.1: 1.3: 2.8: 1. Mesofemur and Metafemur with genicular spur. Posterior margin of abdominal sternite VII and VIII straight in medial region. Posterior margin of sternite IX rounded between immature gonoplacs. Immature gonoplacs conical. Margin between immature gonoplacs with or without short groove (Fig. 26b, c). Cerci at least 5-segmented, length 0.04 times as long as body length.

Male: similar to female. Body length 11.0–11.5 mm (Fig. 6b). Immature styles (Fig. 27b) same shape and size as immature gonoplacs.

**3rd instar.** Female: body 14.0–15.0 mm in long, generally wholly brownish or greenish. Pronotum (Fig. 10c) approximately 3.2 times as long as its maximum width; median keel developed strongly. Prosternum between coxal cavities (Fig. 13c) polished, white in color, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 17c) rounded or angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.09 times as long as body length. Procoxa lacking marginal spines. Profemur (Fig. 22c) approximately 5.5 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; anteroventral-femoral spines and posteroventral (external) -femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII weakly extended posteriorly; posterior margin rounded evenly, straight or slightly concave at middle part. Posterior margin of abdominal sternite VIII straight in middle region (Fig. d, e). Immature gonapophyses IX present or absent between immature gonoplacs. Immature gonoplacs conical. Cerci at least 6-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 14.0–15.0 mm (Fig. 6c). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 27c). Posterior margin of sternite IX rounded between immature styles. Immature styles narrowed apically.

**4th instar.** Female: body 20.0–24.0 mm in long (Fig. 5d), generally wholly brownish or greenish. Pronotum (Fig. 4d) approximately 4.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length (Fig. 4k);

median keel developed strongly. Prosternum between coxal cavities (Fig. 13d) polished, yellow in color, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 17e) angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.09 times as long as body length. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 22d, k) approximately 5.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interlaterally, on tibial spur groove, and along anteroventral-femoral spines; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 26f) extended posteriorly, posterior margin shallowly notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci at least 7-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 20.0–24.0 mm (Fig. 6d). Posterior margin of abdominal sternites VII and VIII straight in middle region (Fig. 27d). Posterior margin of sternite IX slightly rounded between immature styles. Immature styles short, papillate.

**5th instar.** Female: body 26.0–34.5 mm in long (Fig. 5e), generally wholly brownish or greenish. Pronotum (Fig. 10e) approximately 4.7 times as long as its maximum width, with lateral margins minutely serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities (Fig. 4e) polished, orange in color, with a zonal black marking posteriorly. Wing pads (Fig. 17f) 0.09 times as long as body length, lacking veins. Procoxa weakly darkened or wholly concolor (green) basally, with a few, slightly developed marginal spines. Profemur (Fig. 22e) approximately 5.7–5.8 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interlaterally, on tibial spur groove, and along anteroventral-femoral spines; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 26g) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, with apex blunt. Cerci at least 8-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 26.5–34.5 mm (Fig. 6e). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 27e). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**6th instar.** Female: body 34.0–40.0 mm in long (Fig. 5f), generally wholly brownish or greenish. Pronotum (Fig. 10f) approximately 4.8 times as long as its maximum width, with lateral margin minutely but distinctly serrate throughout its length (Fig. 10l); median keel developed strongly. Prosternum between coxal cavities (Fig. 13f) polished, orange in color, with a zonal black marking posteriorly. Wing pads (Fig. 17f) provided with slightly developed veins, 0.1 times as long as body length. Procoxa (Fig. 4l) darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur (Fig. 22f, l) approximately 5.7–5.8 times as long as its width, mottled with small-sized, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and along discoidal spines; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 26f) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with obtuse apices. Immature gonoplacs elongated, with blunt apices. Cerci at least 10-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 34.0–40.0 mm (Fig. 6f). Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 27f). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**7th instar.** Female antepenultimate instar: body 47.5–50.5 mm in long, generally wholly brownish or greenish. Pronotum approximately 4.2–4.3 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities polished, orange in color, with a zonal black marking posteriorly. Wing pads provided with developed veins, 0.1 times as long as body length. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur approximately 5.7–5.8 times as long as its width, mottled with small-sized, irregular, black spots on tibial spur groove, along anteroventral-femoral spines, and along discoidal spines; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 12-segmented, 0.05 times as long as body length.

Penultimate instar female: similar to female antepenultimate instar. Body length

51.5–61.5 mm (Fig. 5g). Pronotum (Fig. 10g) approximately 4 times as long as its maximum width. Wing pads (Fig. 17h) provided with clearly developed veins, 0.14 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 26i) extended posteriorly, covering most of sternite VIII, with posterior margin stoutly notched and tucked at middle. Cerci at least 13-segmented.

Male antepenultimate instar: similar to female antepenultimate instar. Body length 47.0–50.0 mm. Posterior margin of abdominal sternite VII and VIII straight at middle part. Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Penultimate instar male: similar to penultimate instar female. Body length 50.0–61.0 mm (Fig. 6g). Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 27g). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**8th instar.** Penultimate instar female: body 60.5–66.0 mm in long (Fig. 5h), generally wholly brownish or greenish. Pronotum approximately 4 times as long as its maximum width, with lateral margin minutely and distinctly serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities polished, orange in color, with a zonal black marking posteriorly. Wing pads provided with clearly developed veins, 0.13 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur approximately 5.8 times as long as its width, mottled with small-sized, irregular, black spots along anteroventral-femoral spines, and along discoidal spines; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering sternite VIII for the most part, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, with blunt apices. Cerci at least 14-segmented, 0.05 times as long as body length.

Last instar female: similar to penultimate instar female. Body length 63.0–68.0 mm (Fig. 5i). Pronotum approximately 3.8 times as long as its maximum width. Forewing pads (Fig. 17i) provided with clearly developed veins and jugal field (including anal veins), 0.16 times as long as body length; apex of hind wing pads strongly extended behind posterior edge of abdominal tergite I. Abdominal sternite VII (Fig. 26j) extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at

middle, extended to posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Cerci at least 14-segmented.

Penultimate instar male: similar to penultimate instar female. Body length 60.0–65.0 mm. Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight at middle part. Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Last instar male: similar to last instar female. Body length 62.0–66.0 mm (Fig. 6i). Pronotum approximately 4 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight in medial region (Fig. 27h). Sternite IX extended to level of posterior margin of supraanal robe; posterior margin of sternite IX straight between immature styles. Cercus length 0.06 times as long as body length.

**9th instar.** Last instar female: body 65.5–74.0 mm in long (Fig. 5j), generally wholly brownish or greenish. Pronotum (Fig. 10i) approximately 3.8 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout their length; median keel developed strongly. Prosternum between coxal cavities (Fig. 13i) polished, orange in color, with a zonal black marking posteriorly. Fore-wing pads provided with clearly developed veins and jugal field (including anal veins), 0.16 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur (Fig. 22i) approximately 5.8 times as long as its width, mottled with small, irregular, black spots along anteroventral-femoral spines, and along discoidal spines; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at middle and reaching posterior margin of tergite X. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, apices blunt. Cerci at least 15-segmented, 0.06 times as long as body length.

Last instar male: similar to last instar female. Body length 63.0–70.5 mm. Pronotum approximately 4 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight in medial region. Sternite IX extended to level of posterior margin of supraanal robe; posterior margin of sternite IX straight between immature styles.

## 若虫の齡期判別

1 齡若虫は、体長 10 mm 未満である (Figs. 5a, 6a) ことや中列刺のうち第 I 刺がもっとも長い (Fig. 22a, j) ことから、ほかの齡と判別できる。2 齡から 4 齡の判別には、体長や前脚基節窩間の発色が有用である (Figs. 5, 6, 13) : 2 齡は体長 11 mm 内外、前脚基節窩間は体色と同色 ; 3 齡は体長 15 mm 内外、前脚基節窩間は白色 ; 4 齡は体長 22 mm 内外、前脚基節窩間は黄色。5 齡と 6 齡の判別は、翅脈の有無や尾角の節数が有用である (Figs. 17, 18, 26, 27) : 5 齡は翅脈を欠き、尾角は最低 8 節 ; 6 齡は薄い翅脈を持ち、尾角は最低 10 節。前亜終齡 (7 齡)、亜終齡 (7 齡, 8 齡)、終齡 (8 齡, 9 齡) の判別には、とくに後翅芽の伸長度合いが有用である : 前亜終齡は後翅芽の末端が腹部第 I 背板の後縁に達しない ; 亜終齡は後翅芽の末端が第 I 背板の後縁に達するかまたは僅かに超える (Figs. 5g, h, 6g, h) ; 終齡は後翅芽の末端が第 I 背板の後縁を大きく超える (Figs. 5i, j, 6i, j)。また、亜終齡と終齡は、雌は腹部第 VII 腹板、雄では第 IX 腹板の発達度合いでも判別できる : 亜終齡の雌は、第 VII 腹板の後縁が第 I 背板の後縁に達しないが、終齡の雌では第 VII 腹板の後縁が第 I 背板の後縁を超える (Fig. 26i, j) ; 亜終齡の雄は、第 IX 腹板の後縁が第 I 背板の後縁に達しないが、終齡の雄では第 IX 腹板の後縁が第 I 背板の後縁を超える (Fig. 27g, h)。

以上の特徴から、チョウセンカマキリは外部形態による齡期判別が可能である。

## 若虫の雌雄判別

概ねマエモンカマキリと同様であったため、以下に要点をまとめた。

- (1) 1 齡には、外部形態における雌雄差がない。
- (2) 2 齡は、雌は一部の個体を除き、腹部第 IX 腹板の後縁に小さな切れ込みがある (Fig. 26c) が、雄の腹部第 IX 腹板の後縁はほぼ平坦である (Fig. 27b)。
- (3) 3 齡以降、雌は第 VII 腹板の後縁が加齡に伴い後方に拡張し、亜生殖板を形成する (Fig. 26d-j) が、雄の第 VII 腹板は加齡に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 27c-h)。
- (4) 3 齡以降、雌は一部の個体を除き、第 VIII 腹板の後縁に一对の陰具片を有する (Fig. 26e-j) が、雄の第 VIII 腹板は加齡に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 27c-h)。
- (5) 3 齡以降、雌は第 IX 腹板の陰具片と生殖片が加齡に伴い発達し、それらの形状が変化する (Fig. 26e-j) が、雄の第 IX 腹板の尾突起には加齡に伴う形状の変化はほとんどない (Fig. 27c-h)。
- (6) 7 齡と 8 齡は、前胸背板の縦横比が雌>雄である。
- (7) 8 齡は、体長と尾角の比が雄>雌である。

以上の特徴から、チョウセンカマキリは 2 齢以降に外部形態による雌雄判別が可能である。

## オオカマキリ

### *Tenodera sinensis* Saussure, 1871

各齢期における各部位の測定値を Table 3 にまとめた。成虫になるまでの齢数は、雄雌ともに 8 齢または 9 齢である。以下に記載した形態的特徴を用いて、本種の幼虫期における齢、性別、種の判別が可能である。

### 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 8.5–9.0 mm in long (Figs. 7, 8), generally wholly brownish. Pronotum (Fig. 11a) approximately 2.8 times as long as its maximum width. Prosternum between coxal cavities (Fig. 14a) dull, same in color as rest of body, with a small black marking posteriorly. Posterolateral angles of pterothoracic segments (Figs. 19a, 20a) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 23a, j) approximately 5 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interlaterally, on tibial spur groove, and along anteroventral (internal) - femoral spines. Four discoidal spines basal spine longest; proportional length of basal to apical spines 5: 2: 1.5: 1. Mesofemur and Metafemur with or without genicular spur. Posterior margin of abdominal sternite VII and VIII (Figs. 28a, 29a) straight in medial region. Sternite IX with a pair of immature gonoplacs (in prospective adult female) or immature styles (in prospective adult male); immature gonoplacs and styles conical and same in shape and size between the sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Female: body 13.5–14.5 mm in long (Fig. 7b), generally wholly brownish or greenish. Pronotum (Fig. 11b, j) approximately 3.6 times as long as its maximum width; median keel developed strongly. Prosternum between coxal cavities (Fig. 14b) dull, same in color as rest of rest of body, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 19b) rounded, lacking wing pads. Procoxa (Fig. 14j) lacking marginal spines. Profemur (Fig. 23b) approximately 5.2 times as long as its width, mottled with small to large, irregular black spots in basal half interlaterally, on tibial spur groove, and along anteroventral-femoral spines. Four discoidal spines, subapical spine longest; proportional length of basal to apical spines 1.4: 1.9: 3.2: 1. Mesofemur and Metafemur with genicular spur. Posterior margin of abdominal sternite VII and VIII straight in medial region. Posterior margin of sternite IX rounded between immature gonoplacs. Immature gonoplacs conical. Margin between immature gonoplacs

with or without short groove (Fig. 28b). Cerci at least 5-segmented, length 0.04 times as long as body length.

Male: similar to female. Body length 13.5–14.5 mm (Fig. 8b). Immature styles (Fig. 29b) same shape and size as immature gonoplacs.

**3rd instar.** Female: body 16.5–20.0 mm in long (Fig. 7c), generally wholly brownish or greenish. Pronotum (Fig. 11c) approximately 3.8 times as long as its maximum width; median keel developed strongly. Prosternum between coxal cavities (Fig. 14c) polished, white in color, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 19c) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 23c) approximately 5.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; anteroventral-femoral spines and posteroventral (external) -femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII weakly extended posteriorly; posterior margin rounded evenly, straight or slightly concave at middle part. Sternite VIII with or without a pair of immature gonapophyses VIII (Fig. 28c, d) at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplacs. Immature gonoplacs conical. Cerci at least 6-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 16.5–20.0 mm (Fig. 8c). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 29c). Posterior margin of sternite IX rounded between immature styles. Immature styles narrowed apically.

**4th instar.** Female: body 22.0–26.5 mm in long (Fig. 7d), generally wholly brownish or greenish. Pronotum (Fig. 11d) approximately 4.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length (Fig. 11k); median keel developed strongly. Prosternum between coxal cavities (Fig. 14d) polished, white in color, with a small black marking posteriorly. Posterolateral angles of pterothoraces (Fig. 19d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.1 times as long as body length. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 23d, k) approximately 5.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 28e) extended posteriorly, posterior margin shallowly notched at middle. Sternite VIII



with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci at least 7-segmented, 0.05 times as long as body length.

Male: similar to female. Body length 22.0–26.5 mm (Fig. 8d). Posterior margin of abdominal sternites VII and VIII straight in middle region (Fig. 29d). Posterior margin of sternite IX slightly rounded between immature styles. Immature styles short, papillate.

**5th instar.** Female: body 29.0–34.5 mm in long (Fig. 7e), generally wholly brownish or greenish. Pronotum (Fig. 11e) approximately 4.5 times as long as its maximum width, with lateral margins minutely serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities (Fig. 14e) polished, yellow in color, with a zonal black marking posteriorly. Wing pads (Fig. 19e) 0.1 times as long as body length, lacking veins. Procoxa with a few, slightly developed marginal spines. Profemur (Fig. 23e) approximately 5.8 times as long as its maximum width, mottled with or without small to medium-sized, irregular, black spots in basal half interlaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 28f) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, with apex blunt. Cerci at least 8-segmented, 0.07 times as long as body length.

Male: similar to female. Body length 29.0–34.5 mm (Fig. 8e). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 29e). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**6th instar.** Female: body 36.0–42.0 mm in long (Fig. 7f), generally wholly brownish or greenish. Pronotum (Fig. 11f) approximately 4.2 times as long as its maximum width, with lateral margin minutely but distinctly serrate throughout its length (Fig. 11l); median keel developed strongly. Prosternum between coxal cavities (Fig. 14f) polished, yellow in color, with a zonal black marking posteriorly. Wing pads (Fig. 19f) provided with slightly developed veins, 0.1 times as long as body length. Procoxa (Fig. 4l) darkened or wholly concolor (green) basally, with slightly developed marginal spines. Profemur (Fig. 23f, l) approximately 5.8 times as long as its width, mottled with medium-sized, irregular, black spots on tibial spur groove and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur and Metafemur with

genicular spur. Abdominal sternite VII (Fig. 28g) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with obtuse apices. Immature gonoplacs elongated, with blunt apices. Cerci at least 10-segmented, 0.07 times as long as body length.

Male: similar to female. Body length 36.0–42.0 mm (Fig. 8f). Pronotum approximately 4.5 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 29d). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**7th instar.** Female antepenultimate instar: body 42.0–50.0 mm in long (Fig. 7g), generally wholly brownish or greenish. Pronotum approximately 4.0 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities polished, yellow in color, with a zonal black marking posteriorly. Wing pads (Fig. 19g) provided with developed veins, 0.11 times as long as body length. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur approximately 5.8 times as long as its width, mottled with medium-sized, irregular, black spots on tibial spur groove and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII (Fig. 28h) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 12-segmented, 0.08 times as long as body length.

Penultimate instar female: similar to female antepenultimate instar. Body length 45.0–61.5 mm (Fig. 7h). Wing pads (Fig. 19h) provided with clearly developed veins, 0.12 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 28i) extended posteriorly, covering most of sternite VIII, with posterior margin stoutly notched and tucked at middle. Cerci at least 13-segmented.

Male antepenultimate instar: similar to female antepenultimate instar. Body length 42.0–50.0 mm (Fig. 8g). Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight at middle part. Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Penultimate instar male: similar to penultimate instar female. Body length 45.0–60.0 mm (Fig. 8h). Pronotum approximately 4.2 times as long as its maximum width.

Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 29g). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**8th instar.** Penultimate instar female: body 53.0–63.0 mm in long (Fig. 7i), generally wholly brownish or greenish. Pronotum approximately 4 times as long as its maximum width, with lateral margin minutely and distinctly serrate throughout its length; median keel developed strongly. Prosternum between coxal cavities polished, yellow in color, with a zonal black marking posteriorly. Wing pads (Fig. 19i) provided with clearly developed veins, 0.12 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur approximately 5.8 times as long as its width, mottled with or without medium-sized, irregular, black spots on tibial spur groove and on femoral brushes; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering sternite VIII for the most part, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, with blunt apices. Cerci at least 14-segmented, 0.08 times as long as body length.

Last instar female: similar to penultimate instar female. Body length 62.5–74.5 mm (Fig. 7j). Pronotum approximately 3.8 times as long as its maximum width. Forewing pads (Fig. 19j) provided with clearly developed veins and jugal field (including anal veins), 0.16 times as long as body length; apex of hind wing pads strongly extended behind posterior edge of abdominal tergite I. Abdominal sternite VII (Fig. 29j) extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at middle, extended to posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Cerci at least 14-segmented, 0.09 times as long as body length.

Penultimate instar male: similar to penultimate instar female. Body length 54.5–62.0 mm (Fig. 8i). Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight at middle part (Fig. 29h). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

Last instar male: similar to last instar female. Body length 60.0–70.5 mm (Fig. 8j). Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight in medial region (Fig. 29i). Sternite IX extended to level of posterior margin of supraanal robe; posterior margin of sternite IX straight between immature styles.

**9th instar.** Last instar female: body 66.0–76.0 mm in long (Fig. 7k), generally wholly brownish or greenish. Pronotum (Fig. 11i) approximately 3.8 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout their length; median keel developed strongly. Prosternum between coxal cavities (Fig. 14i) polished, yellow in color, with a zonal black marking posteriorly. Fore-wing pads (Fig. 19k) provided with clearly developed veins and jugal field (including anal veins), 0.16 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Procoxa darkened or wholly concolor (green) basally, with wholly developed marginal spines. Profemur (Fig. 23i) approximately 5.8 times as long as its width, mottled with or without medium-sized, irregular, black spots on tibial spur groove and on femoral brushes; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur and Metafemur with genicular spur. Abdominal sternite VII extended posteriorly, covering most of sternite VIII; posterior margin of sternite VII incised at middle and reaching posterior margin of tergite X. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, apices blunt. Cerci at least 15-segmented, 0.09 times as long as body length.

Last instar male: similar to last instar female. Body length 63.0–70.5 mm (Fig. 8k). Pronotum approximately 4.2 times as long as its maximum width. Posterior margin of abdominal sternite VII and VIII straight in medial region (Fig. 29j). Sternite IX extended to level of posterior margin of supraanal robe; posterior margin of sternite IX straight between immature styles.

### 若虫の齡期判別

1 齡若虫は、体長 10 mm 未満であること (Figs. 7, 8) や中列刺のうち第 I 刺がもっとも長いこと (Fig. 23a, j) から、ほかの齡と判別できる。2 齡から 4 齡の判別には、体長や前脚基節窩間の発色が有用である (Figs. 7, 8, 14) : 2 齡は体長 14 mm 内外, 前脚基節窩間は体色と同色 ; 3 齡は体長 18 mm 内外, 前脚基節窩間は白色 ; 4 齡は体長 24 mm 内外, 前脚基節窩間は薄い黄色。5 齡と 6 齡の判別は、翅脈の有無や尾角の節数が有用である (Figs. 19, 20, 28, 29) : 5 齡は翅脈を欠き, 尾角は最低 8 節 ; 6 齡は薄い翅脈を持ち, 尾角は最低 10 節。前亜終齡 (7 齡), 亜終齡 (7 齡, 8 齡), 終齡 (8 齡, 9 齡) の判別には、とくに後翅芽の伸長度合いが有用である : 前亜終齡は後翅芽の末端が腹部第 I 背板の後縁に達しない (Figs. 7g, 8g) ; 亜終齡は後翅芽の末端が第 I 背板の後縁に達するかまたは僅かに超える (Figs. 7h, i, 8h, i) ; 終齡は後翅芽の末端が第 I 背板の後縁を大きく超える

(Figs. 7j, k, 8j, k). また、亜終齢と終齢は、雌の腹部第 VII 腹板の発達度合いでも判別できる：亜終齢の雌は、第 VII 腹板の後縁が第 I 背板の後縁に達しないが、終齢の雌では第 VII 腹板の後縁が第 I 背板の後縁を超える (Fig. 28i, j).

以上の特徴から、オオカマキリは外部形態による齢期判別が可能である。

### 若虫の雌雄判別

概ねマエモンカマキリと同様であったため、以下に要点をまとめた。

- (1) 1 齢は、外部形態における雌雄差がない。
- (2) 2 齢は、雌は一部の個体を除き、腹部第 IX 腹板の後縁に小さな切れ込みがある (Fig. 28b) が、雄の腹部第 IX 腹板の後縁はほぼ平坦である (Fig. 29b)。
- (3) 3 齢以降、雌は第 VII 腹板の後縁が加齢に伴い後方に拡張し、亜生殖板を形成する (Fig. 28c-j) が、雄の第 VII 腹板は加齢に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 29c-j)。
- (4) 3 齢以降、雌は一部の個体を除き、第 VIII 腹板の後縁に一对の陰具片を有する (Fig. 28d-j) が、雄の第 VIII 腹板は加齢に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 29c-j)。
- (5) 3 齢以降、雌は第 IX 腹板の陰具片と生殖片が加齢に伴い発達し、それらの形状が変化する (Fig. 28d-j) が、雄の第 IX 腹板の尾突起には加齢に伴う形状の変化はほとんどない (Fig. 29c-j)。
- (6) 7 齢と 8 齢は、前胸背板の縦横比が雌>雄である。
- (7) 8 齢は、体長と尾角の比が雄>雌である。

以上の特徴から、オオカマキリは 2 齢以降に外部形態による雌雄判別が可能である。

### 若虫期における種同定

マエモンとチョウセンの若虫において、2 種を判別するうえで有用な形態は、体長 (Figs. 3-6)、前胸背板の縦横比と側縁の突起の発達度合い (Figs. 9, 10)、前脚基節窩間の発色 (Figs. 12, 13)、前脚基節基部の発色 (おもに褐色型個体) (Figs. 12, 13)、基節背縁突起の発達度合い (Figs. 12, 13)、前脚腿節の縦横比 (Figs. 21, 22)、内縁刺と中列刺の黒紋の有無 (Figs. 21, 22)、体長と尾角長の比であった。2 種は以下の特徴で判別できる：(1) 体長は 1 齢から 6 齢の各齢において、マエモン>チョウセンである；(2) 前胸背板の縦横比は 2 齢以降の各齢においてチョウセン>マエモンであり、前胸背板側縁の突起の発達は 7 齢以降においてチョウセン>マエモンである；(3) 前脚基節窩間の発色は、マエモンは全齢において体色とほぼ同色であるが、チョウセンは 3 齢と 4 齢において黄色、5 齢以降は橙色である；(4) 前脚基節基部の発色は、マエモンは全齢において体色とほぼ同色であ

るが、チョウセンは5歳以降のおもに褐色型の個体において黒色である；(5) チョウセンの基節背縁突起は、6歳以降においてマエモンより強く発達する；(6) 前脚腿節の縦横比は全齢においてチョウセン>マエモンである；(7) マエモンの前脚腿節の内縁刺と中列刺は、7歳以降において側面に黒紋を有するが、チョウセンは全齢において同箇所黒紋を基本的に欠く；(8) 体長と尾角長の比は4歳以降においてマエモン>チョウセンである。

オオとチョウセンの若虫において、2種を判別するうえで有用な形態は、体長 (Figs. 5–8), 前胸背板の縦横比 (Figs. 10, 11), 前脚基節窩間の発色 (Figs. 13, 14), 前脚腿節の内縁刺基部付近の黒紋の有無 (Figs. 22, 23), 体長と尾角長の比であった。2種は以下の特徴で判別できる：(1) 体長は1歳から3歳の各齢において、オオ>チョウセンである(2) 前胸背板の縦横比は1歳においてオオ>チョウセンである；(3) 前脚基節窩間の発色は、オオは3歳と4歳において白色、5歳以降は薄い黄色であるが、チョウセンは3歳と4歳において黄色、5歳以降は橙色である；(4) チョウセンの前脚腿節の内縁刺基部付近には、全齢において黒紋を有するが、オオは7歳以降において同箇所黒紋を基本的に欠く；(5) 体長と尾角長の比は5歳以降においてオオ>チョウセンである。

3種とも翅芽と腹部腹板には種の同定に有用な差異は確認できなかった。また、岡田 (2004) が示した前脚腿節の黒紋の有無と各刺末端部の発色による各種の特徴は、3種とも亜終齢と終齢において一致した。亜終齢未満の齢期における黒紋の有無は個体変異が大きく、安定した特徴を現わさなかったため、岡田 (2004) による種同定は亜終齢と終齢において有用である。

## 今後の展望

本州において、チョウセンとオオは生息環境が異なることが知られている (井上・松良 1975；松良 1984；岩崎 1995, 2002) が、琉球におけるチョウセンとマエモンの棲み分けについては明らかにされていない。琉球における採集調査では、チョウセンが開放性の低い林縁の草地から多く得られたのに対し、マエモンは開放性の高い開けた草地から多く得られ、2種が同時に見つかることが少なかったことから、琉球におけるチョウセンとマエモンも本州に産する2種と同様に棲み分けを行なっている可能性が高く、今後の調査が望まれている (大島・瑤寺 2019；大島ら 2020)。また、奄美群島以南に分布するカマキリ類は、ハラビロカマキリ *Hierodula patellifera* (Audinet-Serville, 1839) を除いて化性が不明であり (岡田 2001；東 2013；中峰 2016；山下 2018)、生活史も未だに未解明である。実際に、琉球において齢期の異なる若虫や成虫が同時期に得られることも多い (大島 2018；大島・瑤寺 2019；大島ら 2020)。

本研究により、若虫における正確な種同定や齢期判別が可能になることによ

って、若虫発生時期での個体数調査や生物相調査、生態学的研究が進展し、とくに、南西諸島におけるマエモンとチョウセンの環境嗜好性や月ごとの発育段階が明らかになることで、2種の棲み分けの実態や化性が解明されることが期待される。

### **Tenodera 属 3 種の若虫による種、齢期、性別の検索表**

1. 前脚腿節の中列刺は第 I 刺がもっとも長い……………2  
— 前脚腿節の中列刺は第 III 刺がもっとも長い……………4
2. 前脚腿節の縦は横の 6 倍……………マエモン 1 齢  
— 前脚腿節の縦は横の 5 倍……………3
3. 前胸背板の縦は横の 3 倍以上……………チョウセン 1 齢  
— 前脚腿節の縦は横の 3 倍未満……………オオ 1 齢
4. 体長は 13 mm 未満……………5  
— 体長は 13 mm 以上……………6
5. 腹部第 IX 腹板の後縁が前方に深く抉れ、小さな切れ込みがある……………チョウセン 2 齢雌  
— 腹部第 IX 腹板の後縁はほぼ平坦である……………チョウセン 2 齢雄
6. 前脚基節窩間の発色は体色と同色……………7  
— 前脚基節窩間の発色は体色と異なる……………22
7. 前胸背板の縦は横の 4 倍未満；前脚腿節の縦は横の 6 倍未満……………8  
— 前脚背板の縦は横の 4 倍以上；前脚腿節の縦は横の 6 倍以上……………9
8. 腹部第 IX 腹板の後縁が前方に深く抉れ、小さな切れ込みがある……………オオ 2 齢雌  
— 腹部第 IX 腹板の後縁はほぼ平坦である……………オオ 2 齢雄
9. 体長は 15 mm 未満……………10  
— 体長は 18 mm 以上……………11
10. 腹部第 IX 腹板の後縁が前方に深く抉れ、小さな切れ込みがある……………マエモン 2 齢雌  
— 腹部第 IX 腹板の後縁はほぼ平坦である……………マエモン 2 齢雄
11. 体長は 22 mm 未満……………12  
— 体長は 25 mm 以上……………13
12. 腹部第 VII 腹板の後縁は弱く湾曲し、後方に弱く伸長する…マエモン 3 齢雌  
— 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン 3 齢雄
13. 体長は 32 mm 未満……………14  
— 体長は 34 mm 以上……………15
14. 腹部第 VII 腹板の後縁は湾曲し、後方に伸長する……………マエモン 4 齢雌

- 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン 4 齡雄
- 15. 体長は 41 mm 未満；尾角長は体長の 0.07 倍で節数は最低 10 節……………16
- 体長は 41 mm 以上；尾角長は体長の 0.08 倍で節数は最低 12 節……………17
- 16. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………マエモン 5 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン 5 齡雄
- 17. 後翅芽の末端は腹部第 I 背板の後縁に達しない……………18
- 後翅芽の末端は腹部第 I 背板の後縁に達する……………19
- 18. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………マエモン前亜終齡 (6 齡, 7 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン前亜終齡 (6 齡) 雄
- 19. 後翅芽の末端は腹部第 I 背板の後縁に達する……………20
- 後翅芽の末端は腹部第 I 背板の後縁を大きく超える……………21
- 20. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………マエモン亜終齡 (7 齡, 8 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン亜終齡 (6 齡, 7 齡) 雄
- 21. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………マエモン終齡 (8 齡, 9 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………マエモン終齡 (7 齡, 8 齡) 雄
- 22. 前脚基節窩間は白色……………23
- 前脚基節窩間は橙色または黄色……………28
- 23. 体長は 16 mm 未満……………24
- 体長は 16 mm 以上……………25
- 24. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に弱く伸長する……………チョウセン 3 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………チョウセン 3 齡雄
- 25. 体長は 21 mm 未満……………26
- 体長は 21 mm 以上……………27
- 26. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に弱く伸長する……………オオ 3 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………オオ 3 齡雄
- 27. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に弱く伸長する……………オオ 4 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………オオ 4 齡雄
- 28. 体長は 25 mm 未満……………29
- 体長は 26 mm 以上……………30
- 29. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する……………チョウセン 4 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………チョウセン 4 齡雄
- 30. 前脚基節窩間は橙色……………31



— 前脚基節窩間は黄色	40
31. 翅脈を欠く；尾角の節数は最低 8 節	32
— 翅脈を有する；尾角の節数は最低 10 節	33
32. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・チョウセン 5 齢雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・チョウセン 5 齢雄
33. 後翅芽の末端は腹部第 I 背板の後縁に達しない	・・・・・34
— 後翅芽の末端は腹部第 I 背板の後縁に達する	・・・・・37
34. 体長は 44 mm 未満	・・・・・35
— 体長は 44 mm 以上	・・・・・36
35. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・チョウセン 6 齢雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・チョウセン 6 齢雄
36. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・チョウセン前亜終齡 (7 齢) 雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・チョウセン前亜終齡 (7 齢) 雄
37. 後翅芽の末端は腹部第 I 背板の後縁に達する	・・・・・38
— 後翅芽の末端は腹部第 I 背板の後縁を大きく超える	・・・・・39
38. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する	・・・・・チョウセン亜終齡 (7 齢, 8 齢) 雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・チョウセン亜終齡 (7 齢, 8 齢) 雄
39. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する	・・・・・チョウセン終齡 (8 齢, 9 齢) 雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・チョウセン終齡 (8 齢, 9 齢) 雄
40. 翅脈を欠く；尾角の節数は最低 8 節	・・・・・41
— 翅脈を有する；尾角の節数は最低 10 節	・・・・・42
41. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・オオ 5 齢雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・オオ 5 齢雄
42. 後翅芽の末端は腹部第 I 背板の後縁に達しない	・・・・・43
— 後翅芽の末端は腹部第 I 背板の後縁に達する	・・・・・46
43. 尾角の節数は最低 10 節	・・・・・44
— 尾角の節数は最低 12 節	・・・・・45
44. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・オオ 6 齢雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・オオ 6 齢雄
45. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に伸長する	・・・・・オオ前亜終齡 (7 齢) 雌
— 腹部第 VII 腹板の後縁はほぼ平坦である	・・・・・オオ前亜終齡 (7 齢) 雄
46. 後翅芽の末端は腹部第 I 背板の後縁に達する	・・・・・47

- 後翅芽の末端は腹部第 I 背板の後縁を大きく超える……………48
- 47. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………オオ亜終齡 (7 齡, 8 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………オオ亜終齡 (7 齡, 8 齡) 雄
- 48. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………オオ終齡 (8 齡, 9 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………オオ終齡 (8 齡, 9 齡) 雄

2-1-4 図および表

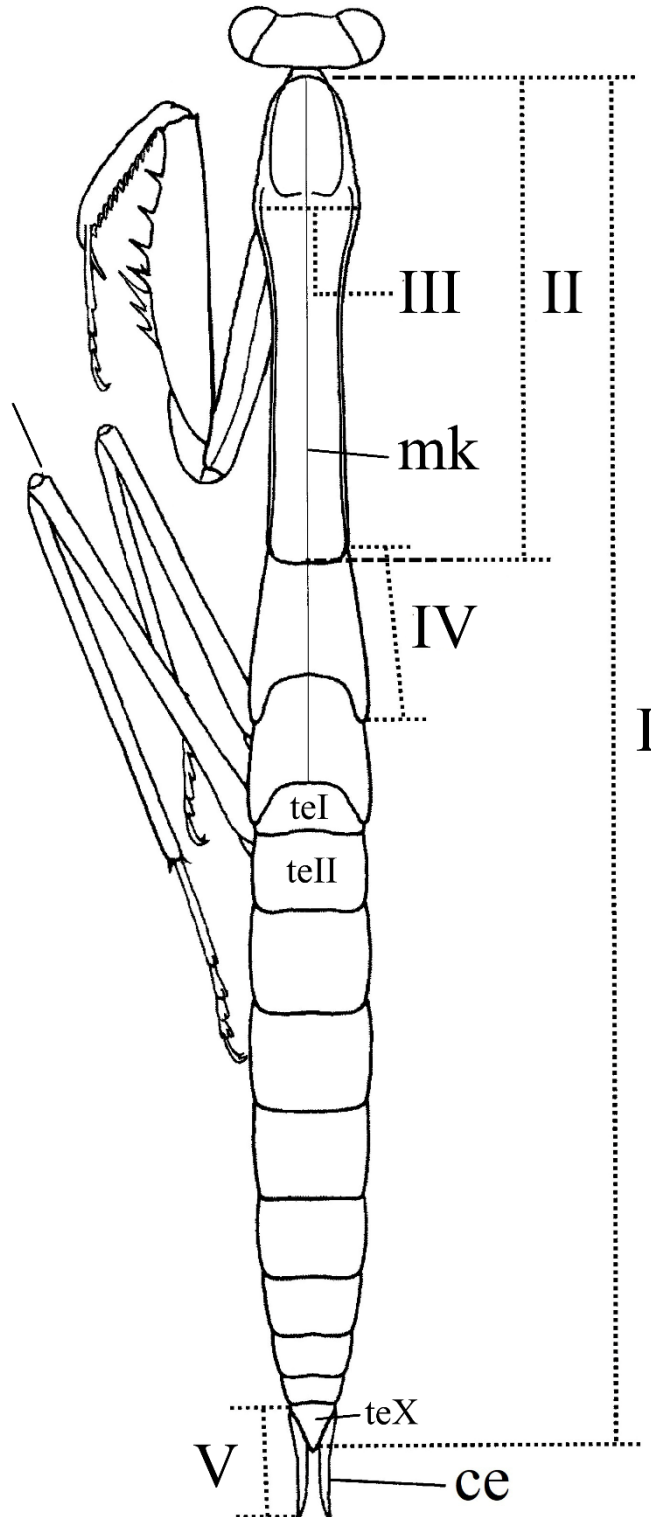


Fig. 1. General structure of nymphs of the genus *Tenodera*, dorsal view. I: body length. II: pronotum length. III: pronotum width. IV: fore wing pad length. V: cercus length. mk = medial keel; teI = tergite I; teII = tergite II; teX = tergite X.

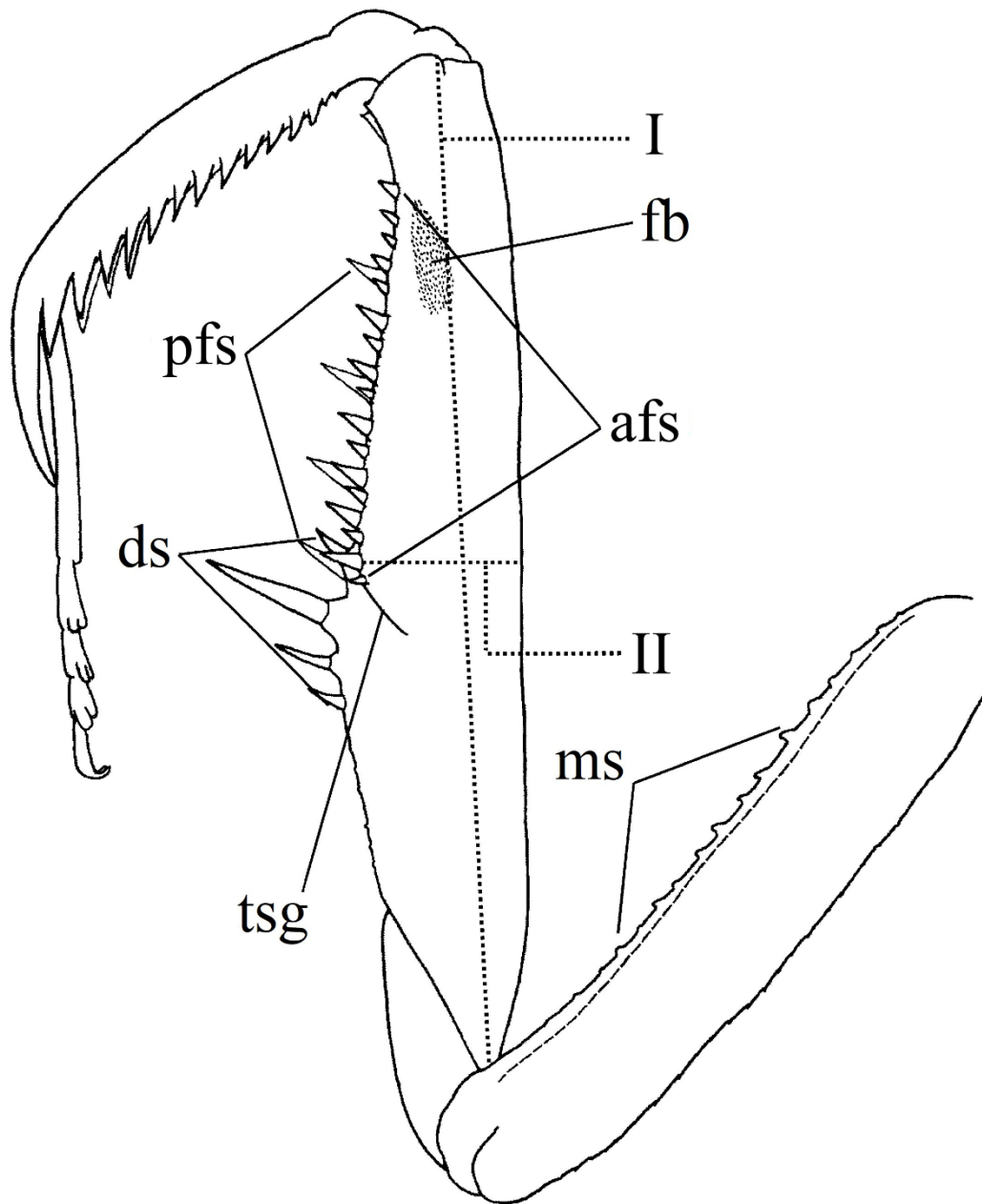


Fig. 2. General structure of foreleg of the genus *Tenodera*, lateral view. I: profemur length. II: profemur width. afs = anteroventral-femoral spines; ds = discoidal spines; fb = ; ms = marginal spines; pfs = posteroventral-femoral spines; tsg = .

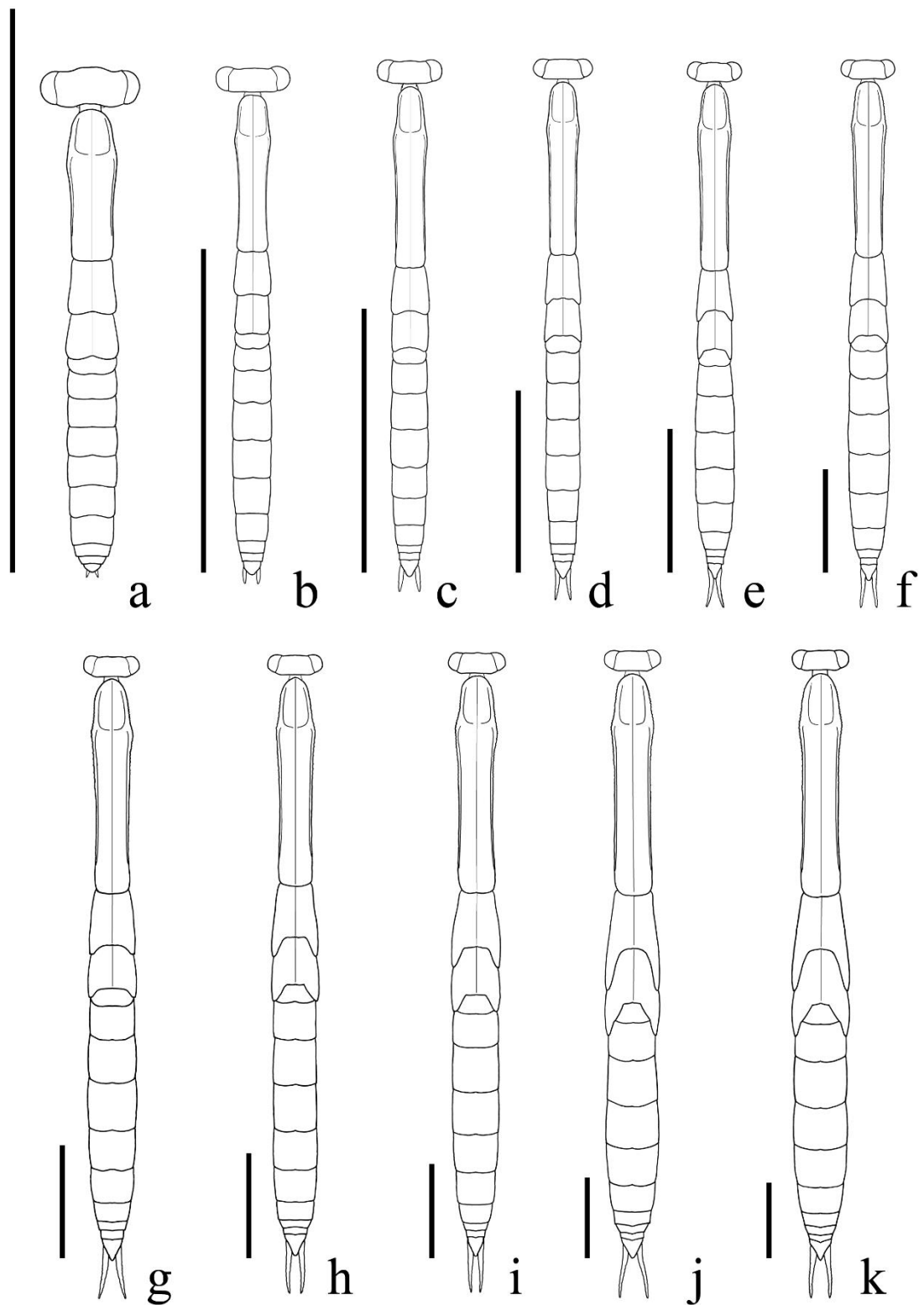


Fig. 3. General aspect in nymphal stages of *T. fasciata*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 10 mm.

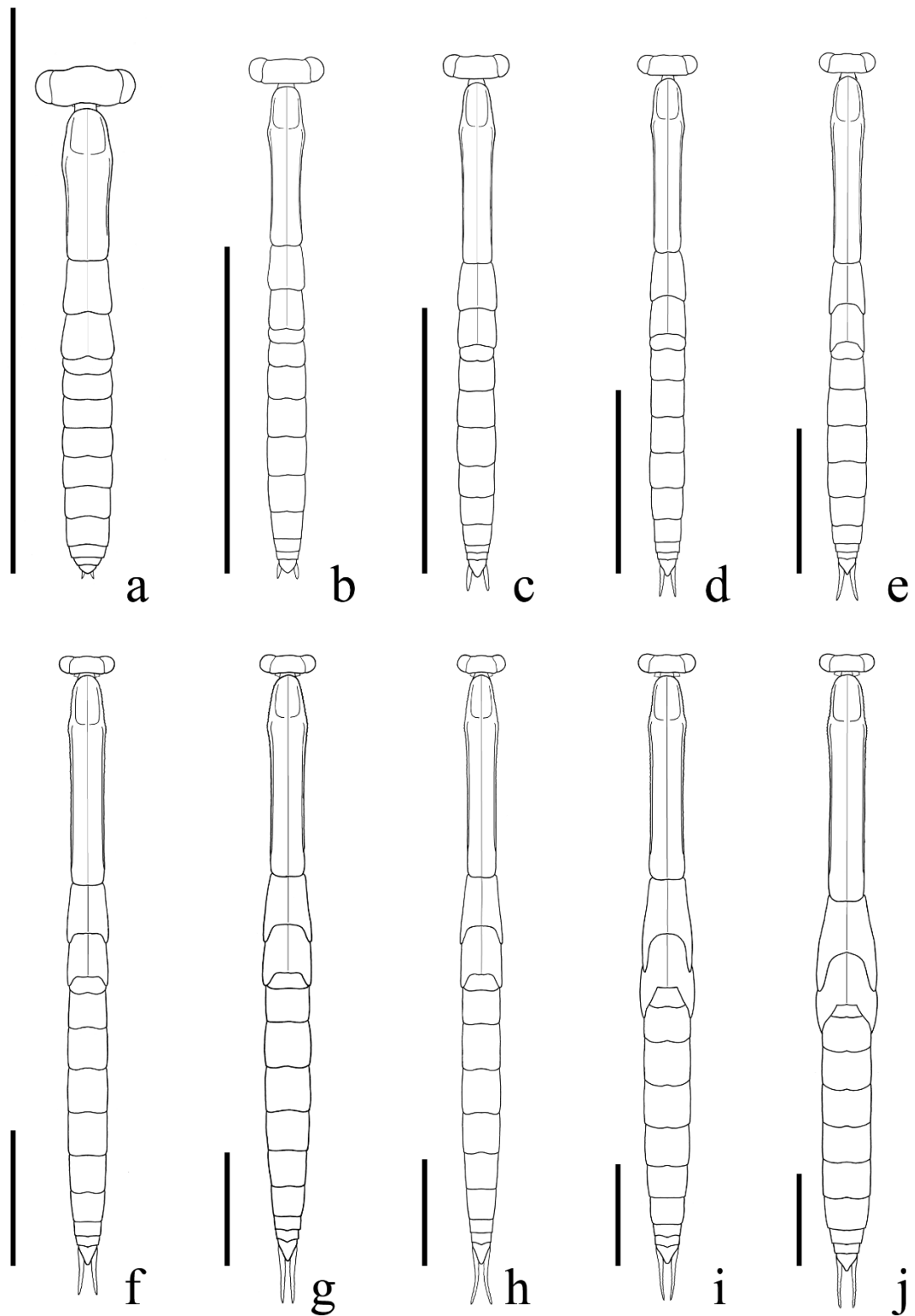


Fig. 4. General aspect in nymphal stages of *T. fasciata*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 10 mm.

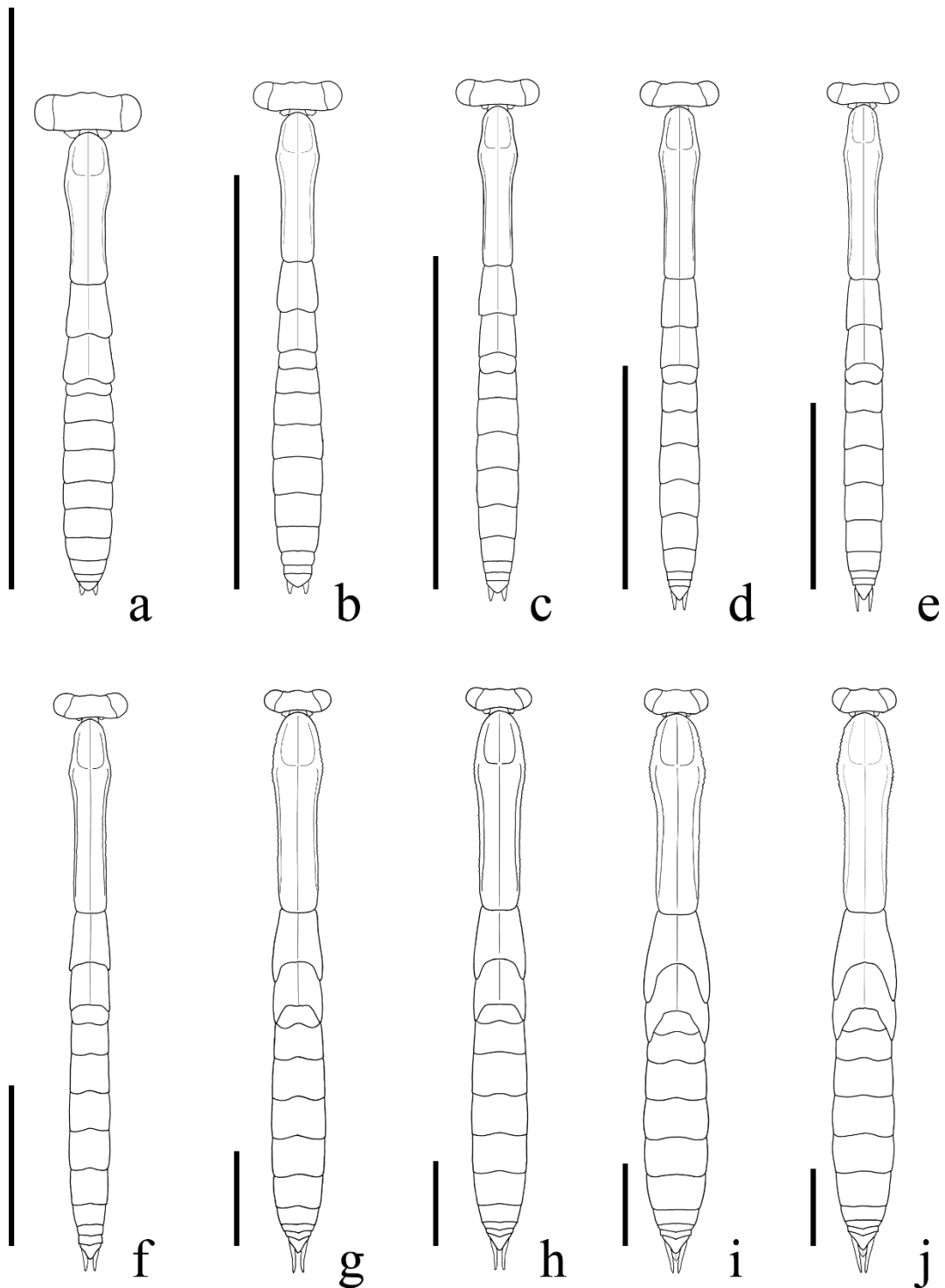


Fig. 5. General aspect in nymphal stages of *T. angustipennis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (penultimate) instar; h, 8th (penultimate) instar; i, 8th (last) instar; j, 9th instar. Scale bars: 10 mm.

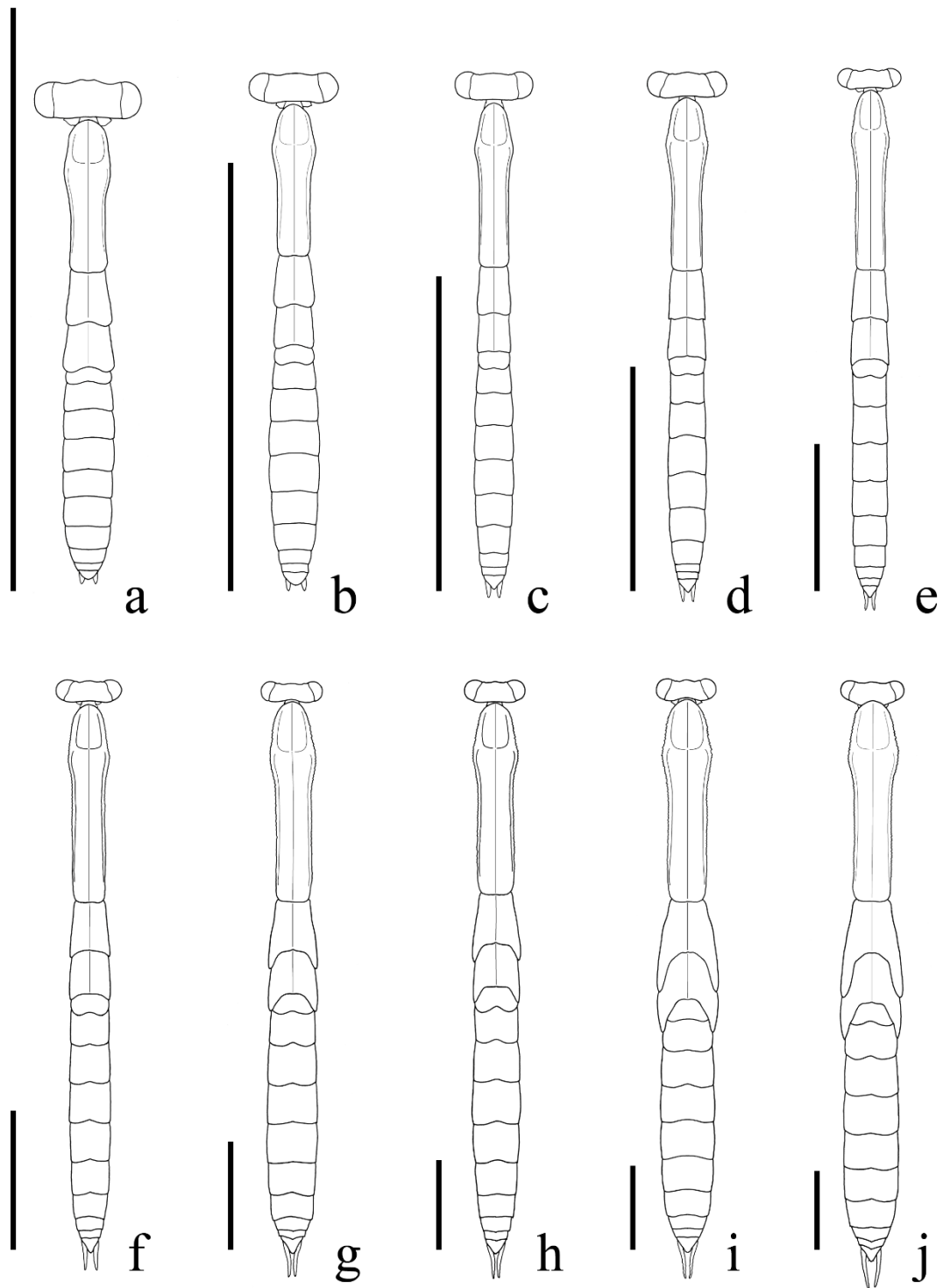


Fig. 6. General aspect in nymphal stages of *T. angustipennis*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th insyiar; f, 6th instar; g, 7th (penultimate) instar; h, 8th (penultimate) instar; i, 8th (last) instar; j, 9th instar. Scale bars: 10 mm.



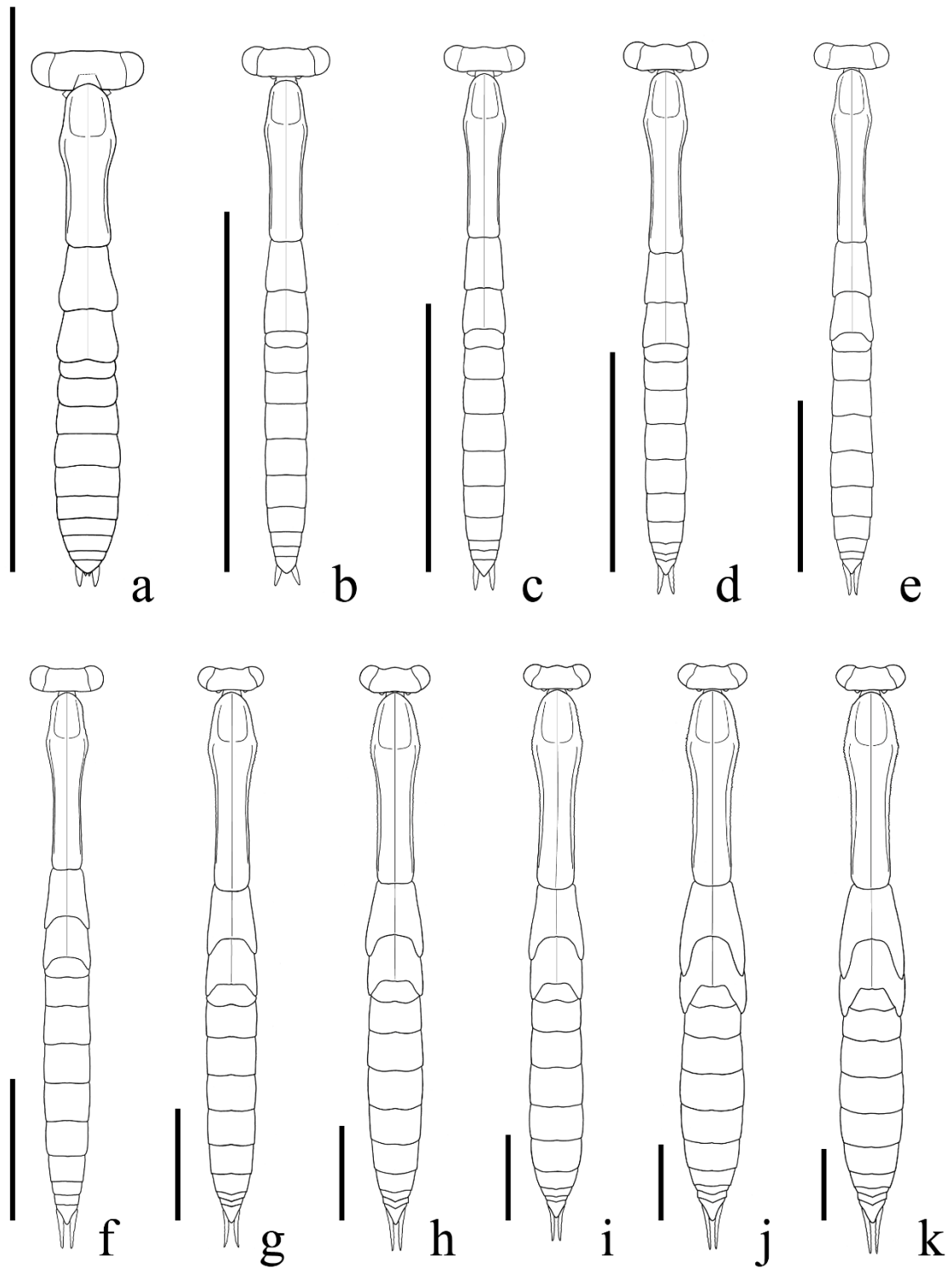


Fig. 7. General aspect in nymphal stages of *T. sinensis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 10 mm.

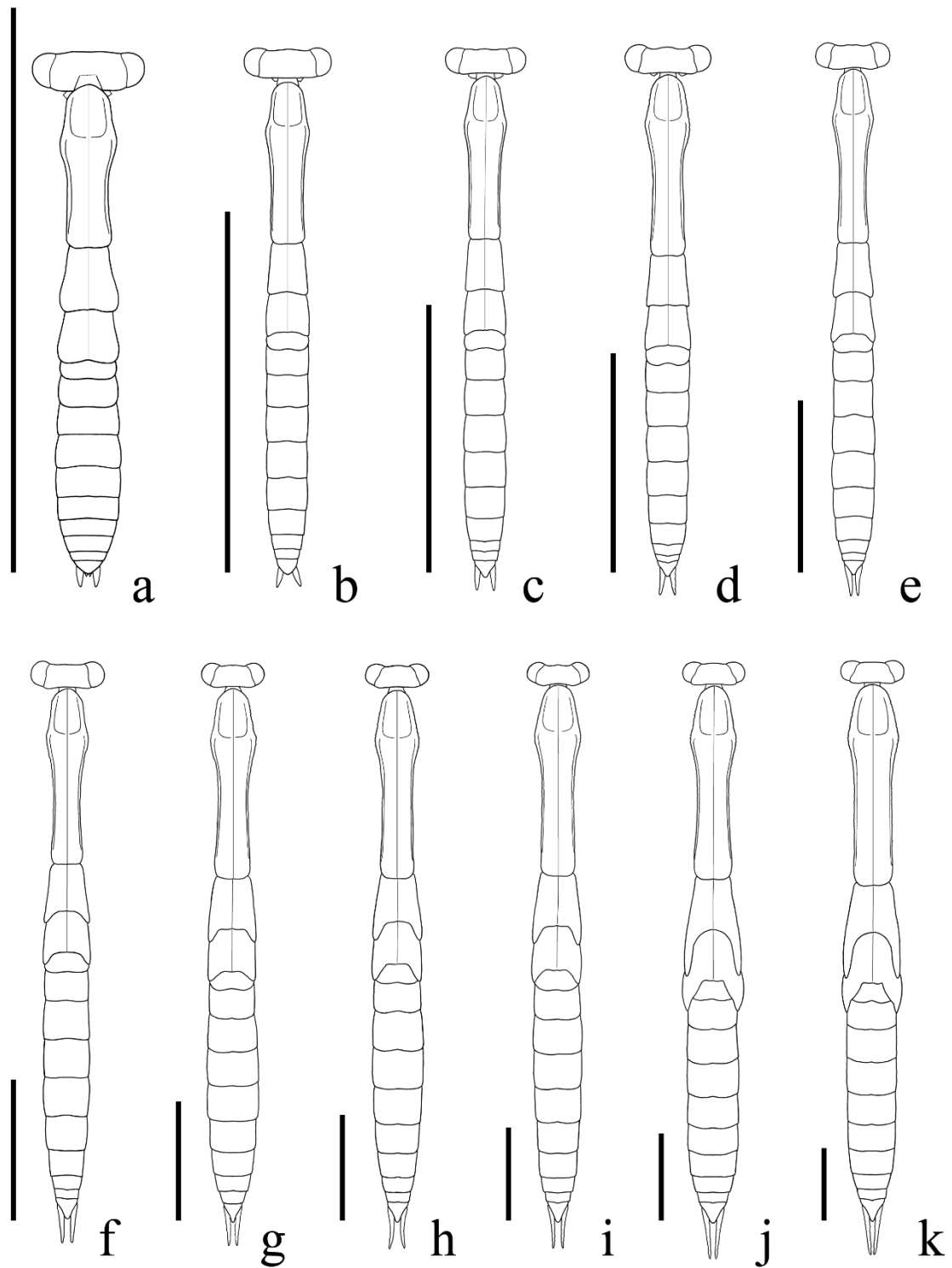


Fig. 8. General aspect in nymphal stages of *T. sinensis*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 10 mm

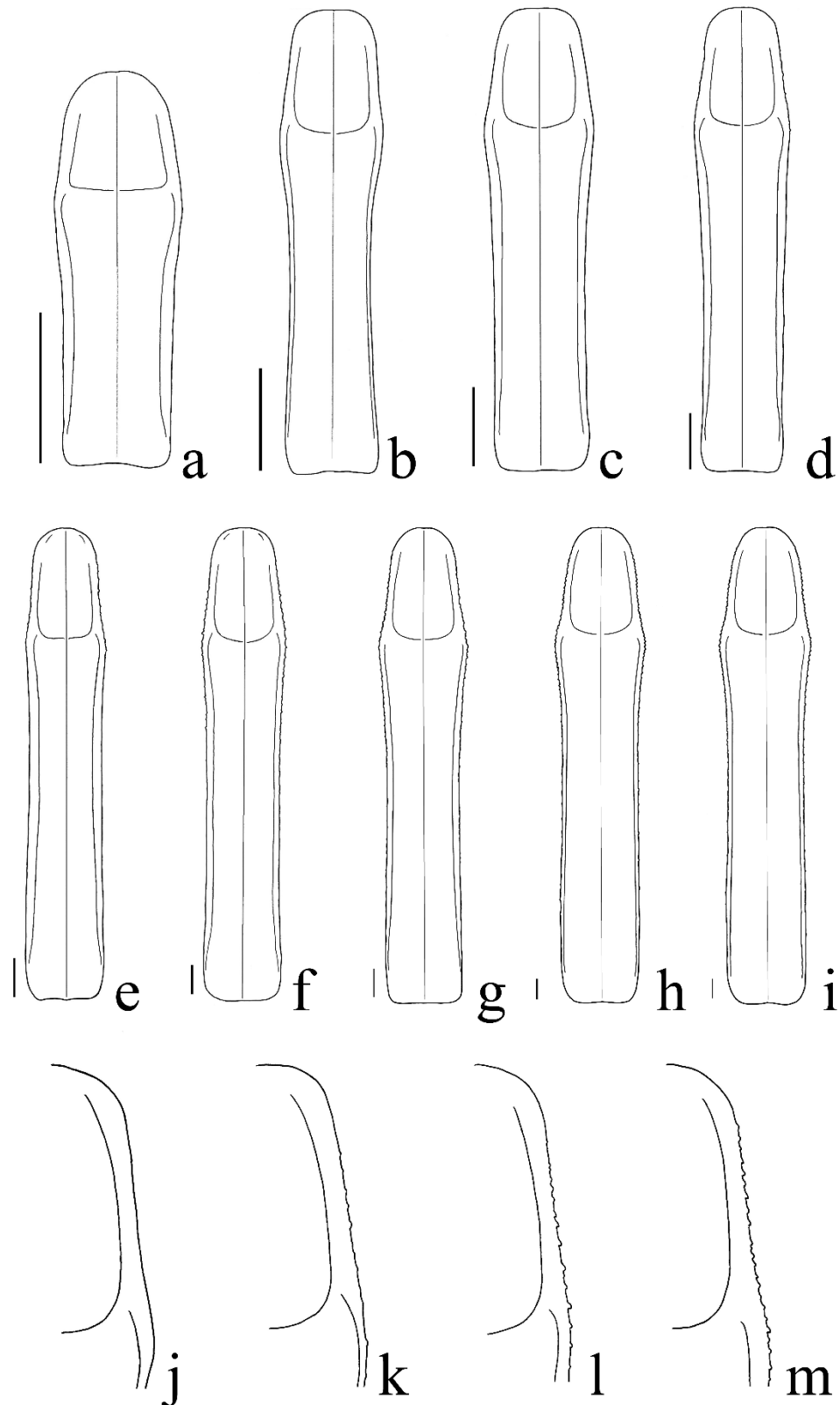


Fig. 9. Pronotum in nymphal stages of *T. fasciata*, female, dorsal view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

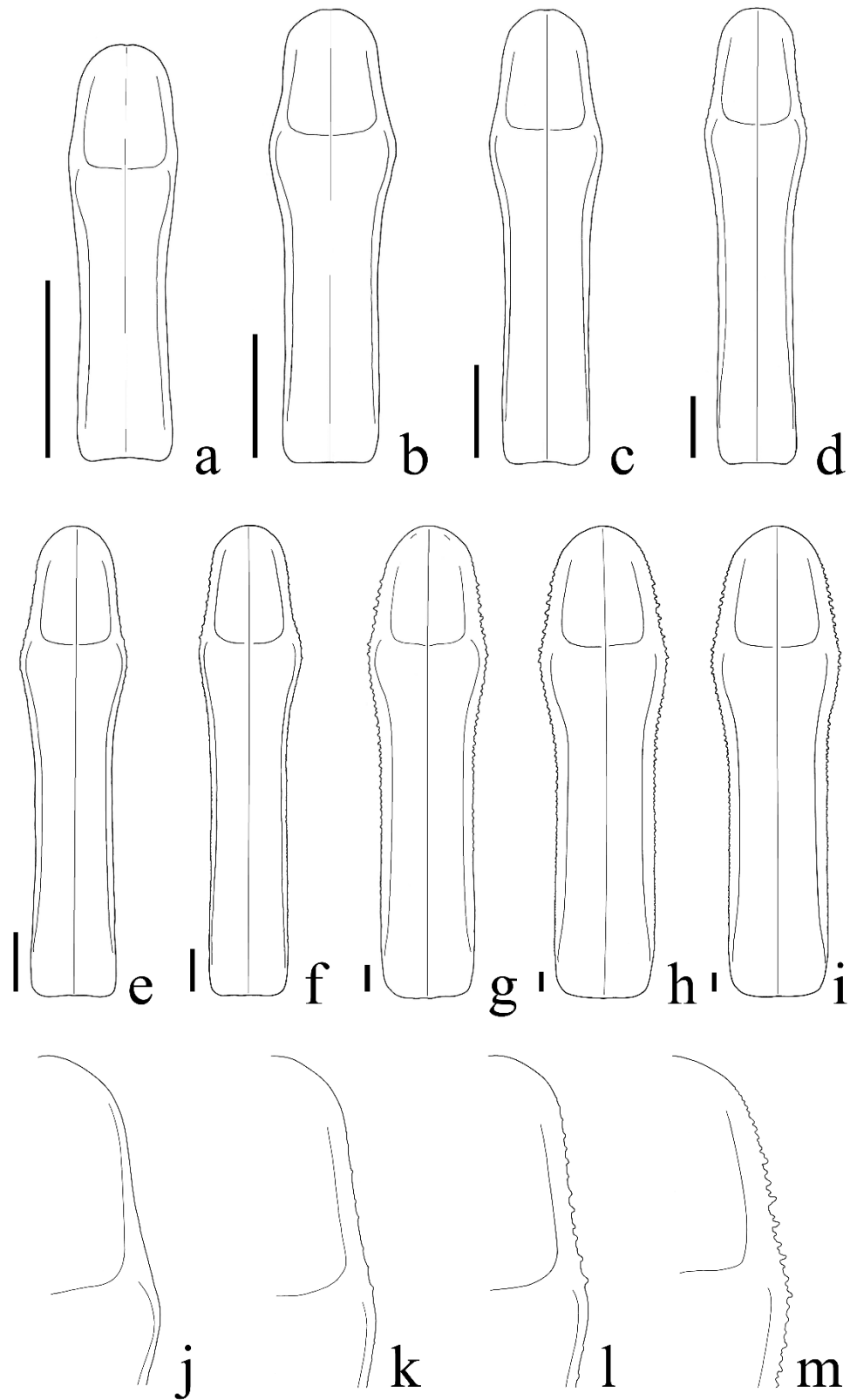


Fig. 10. Pronotum in nymphal stages of *T. angustipennis*, female, dorsal view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (punultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

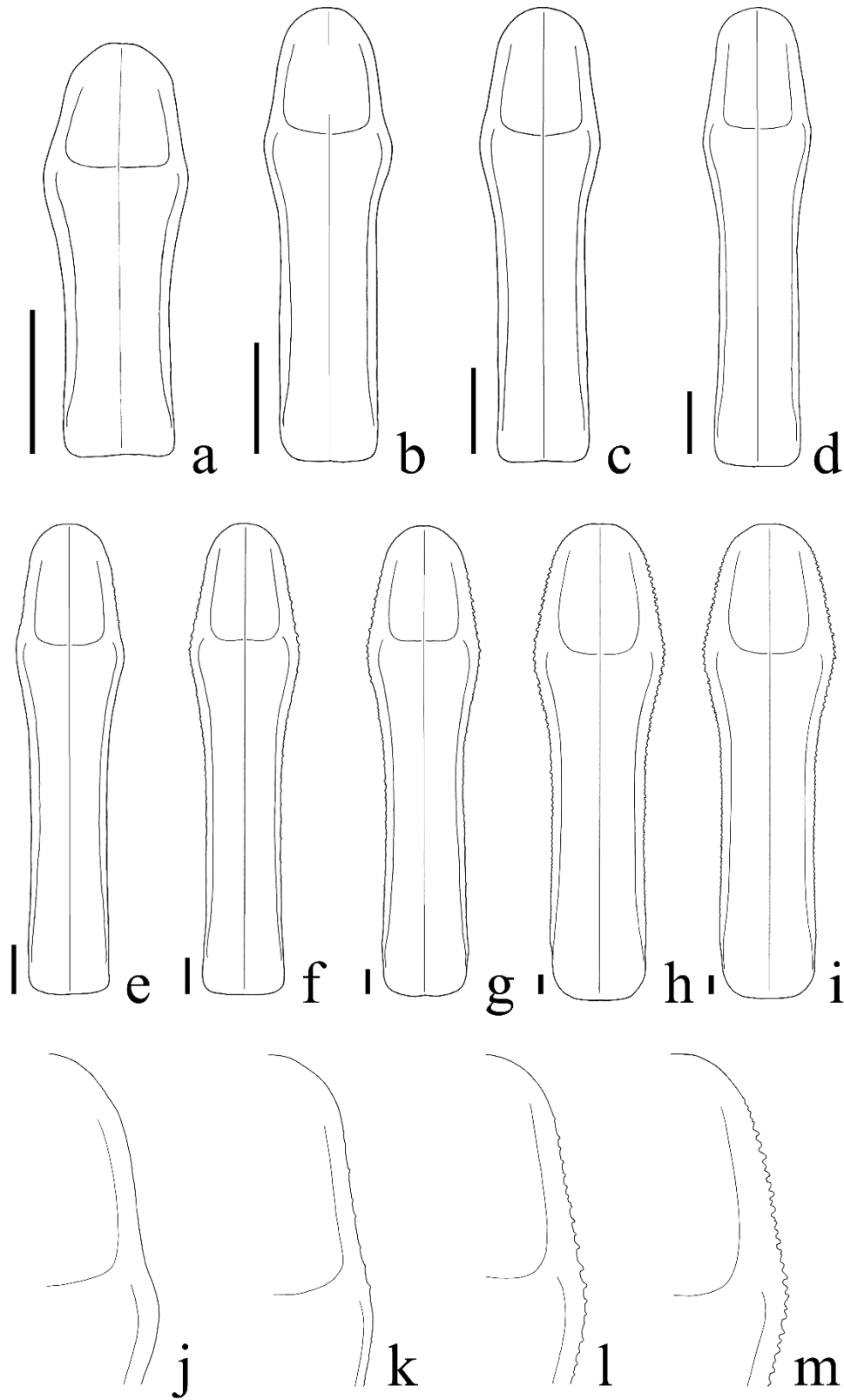


Fig. 11. Pronotum in nymphal stages of *T. sinensis*, female, dorsal view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

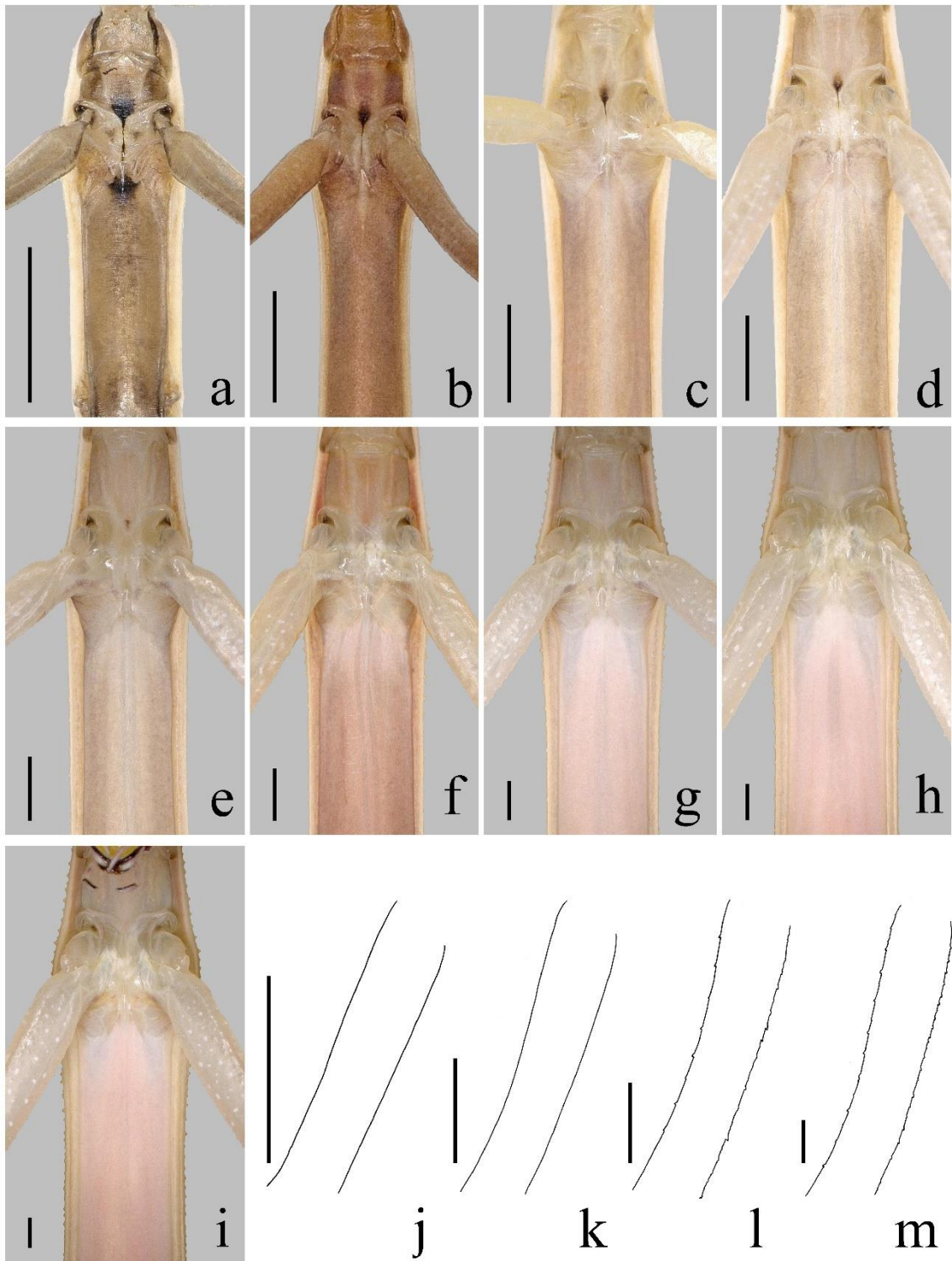


Fig. 12. Prothorax and procoxae in nymphal stages of *T. fasciata*, female, ventral view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

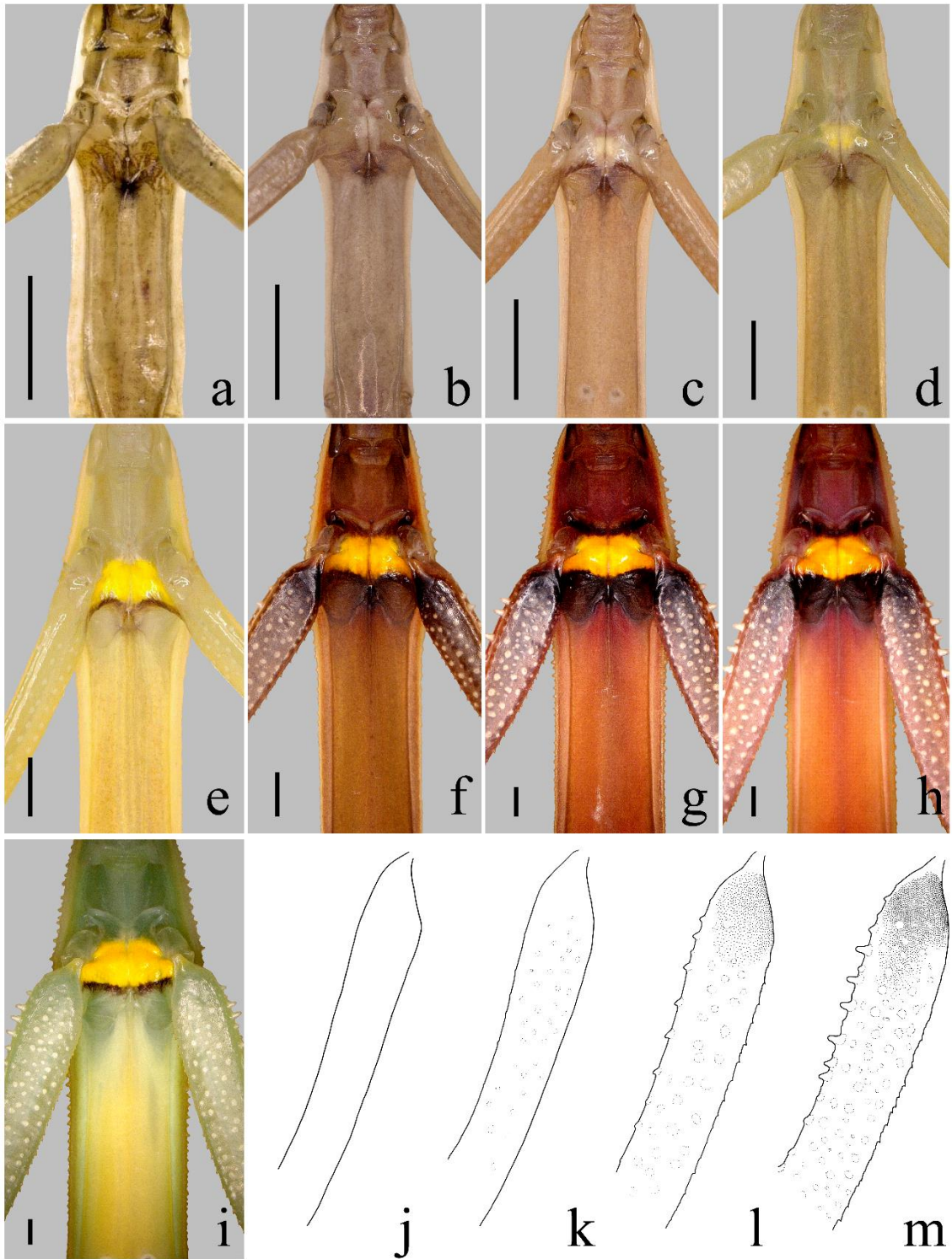


Fig. 13. Prothorax and procoxae in nymphal stages of *T. angustipennis*, female, ventral view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

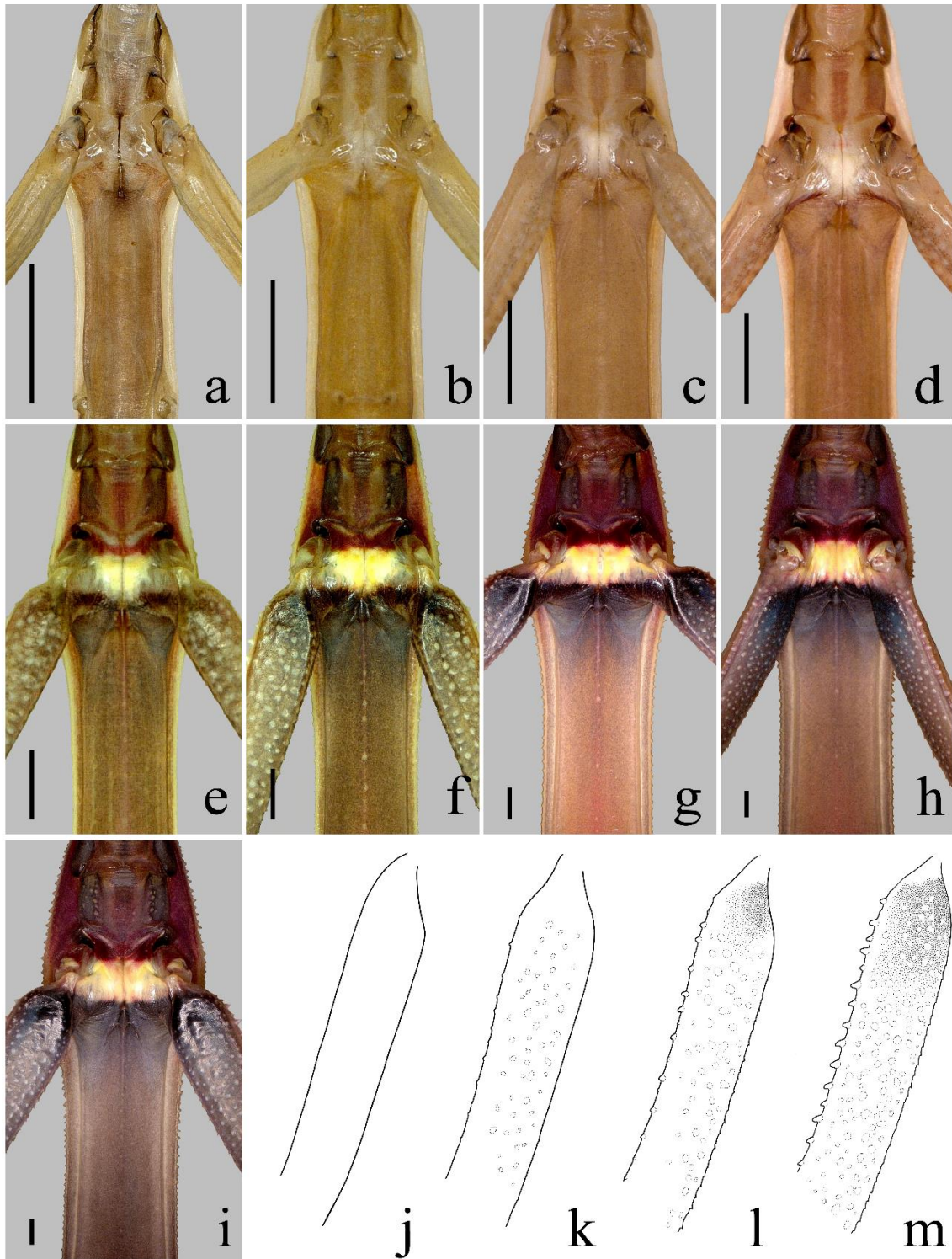


Fig. 14. Prothorax and procoxae in nymphal stages of *T. sinensis*, female, ventral view. a, 1st instar; b & j, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm



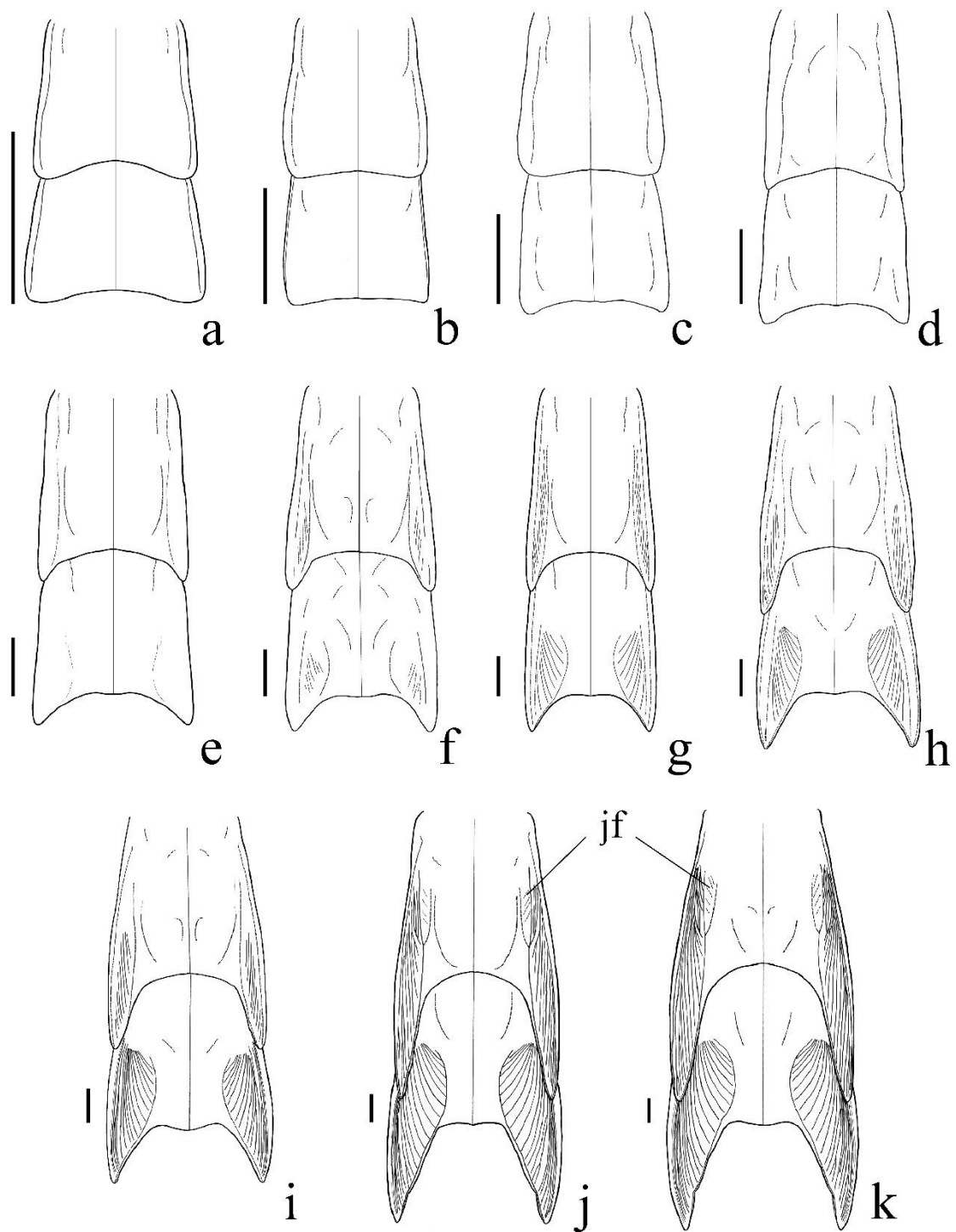


Fig. 15. Pterothorax and wing pads in nymphal stages of *T. fasciata*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. jf = jugal field. Scale bars: 1 mm.

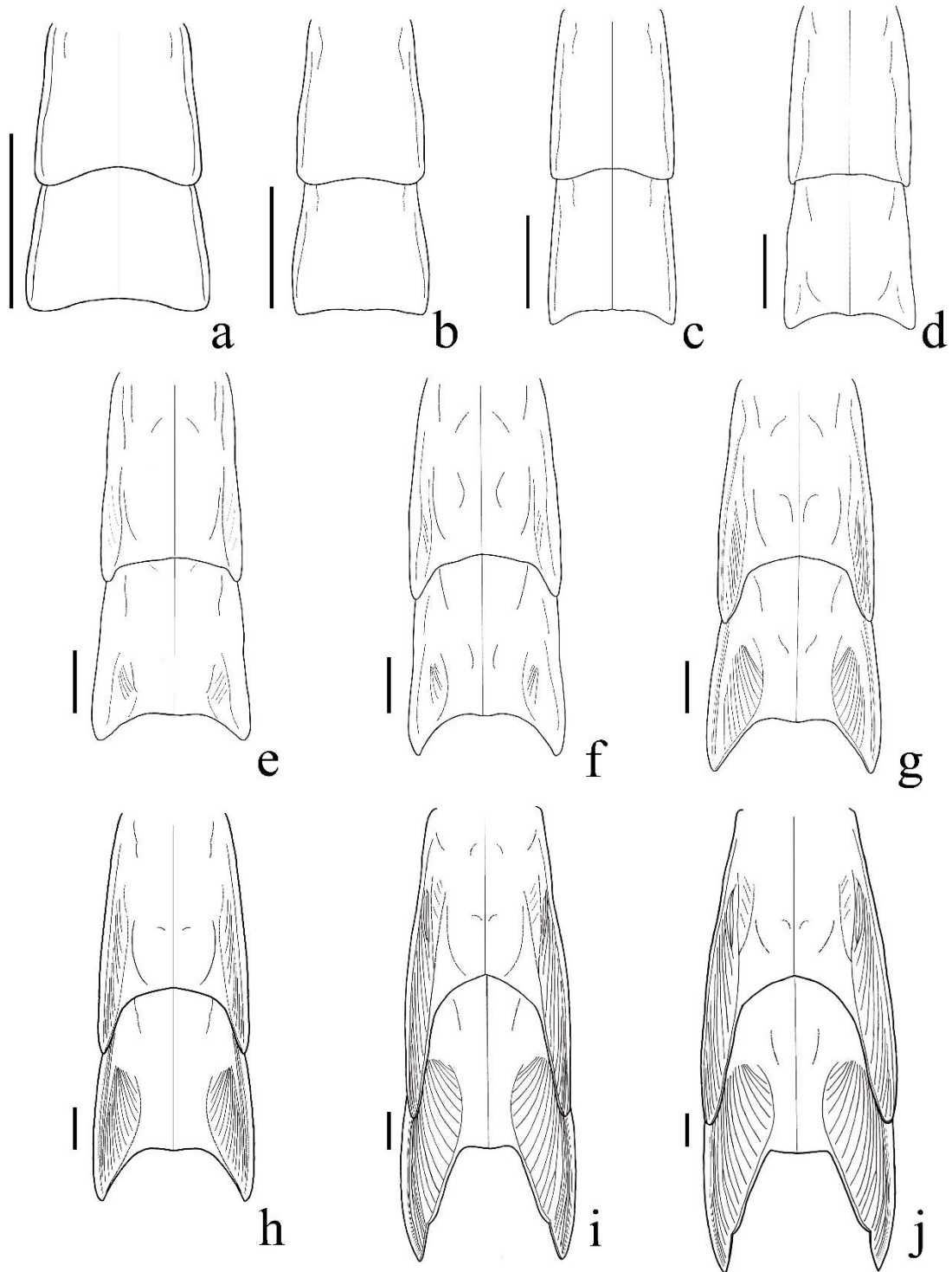


Fig. 16. Pterothorax and wing pads in nymphal stages of *T. fasciata*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

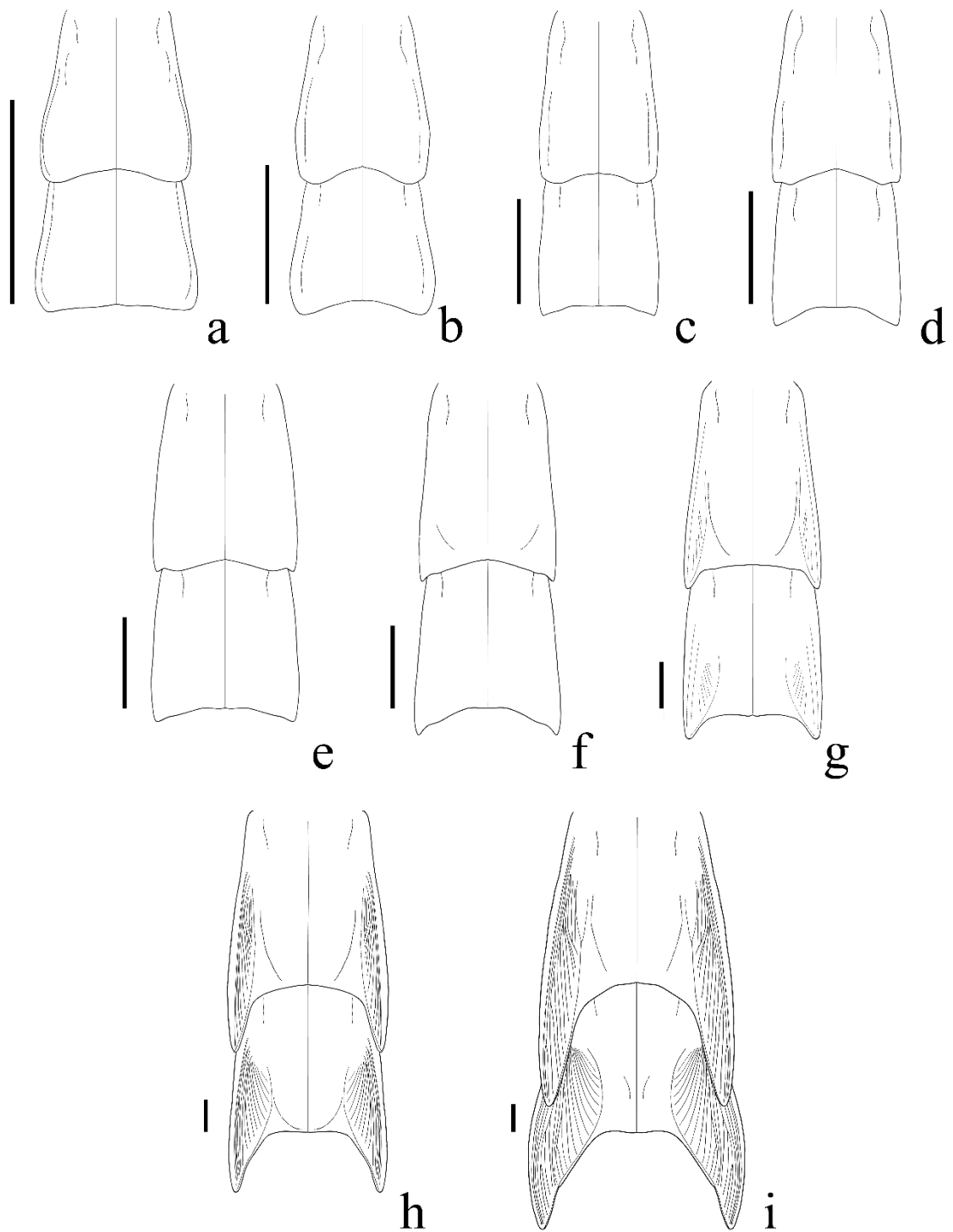


Fig. 17. Pterothorax and wing pads in nymphal stages of *T. angustipennis*, female, dorsal view. a, 1st instar; b, 2nd instar; c & d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (last) instar. Scale bars: 1 mm.

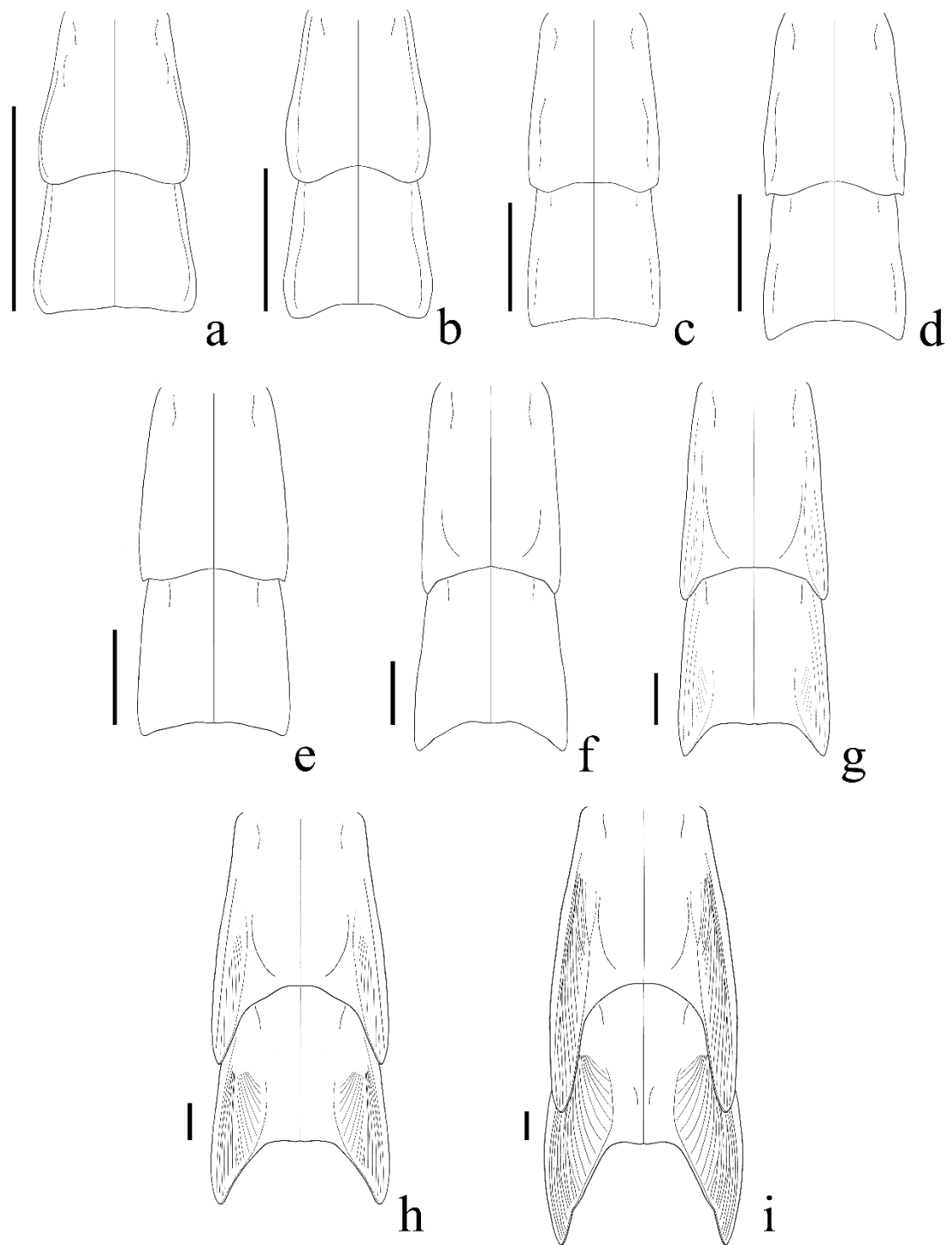


Fig. 18. Pterothorax and wing pads in nymphal stages of *T. angustipennis*, male, dorsal view. a, 1st instar; b, 2nd instar; c & d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (last) instar. Scale bars: 1 mm.

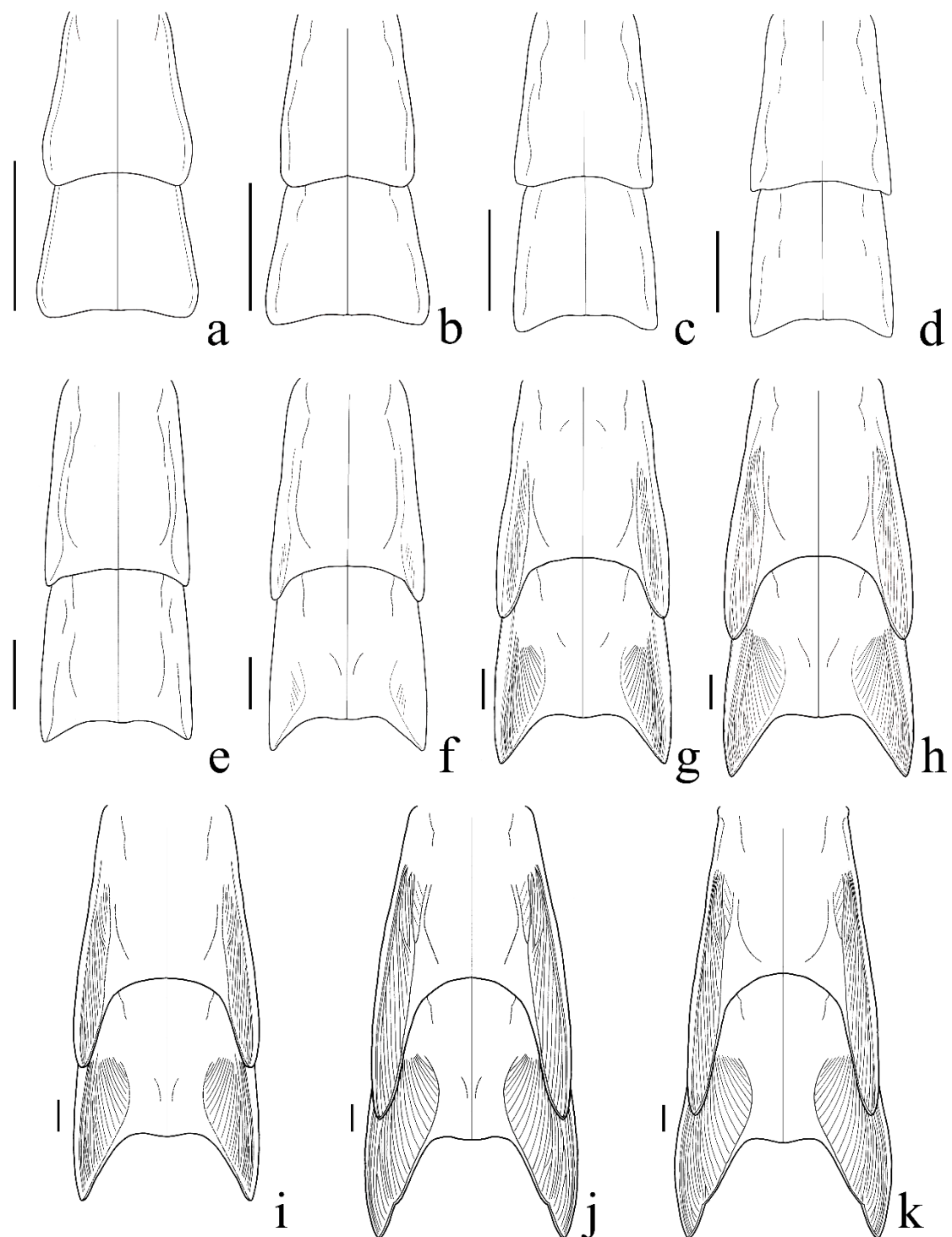


Fig. 19. Pterothorax and wing pads in nymphal stages of *T. sinensis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 1 mm.

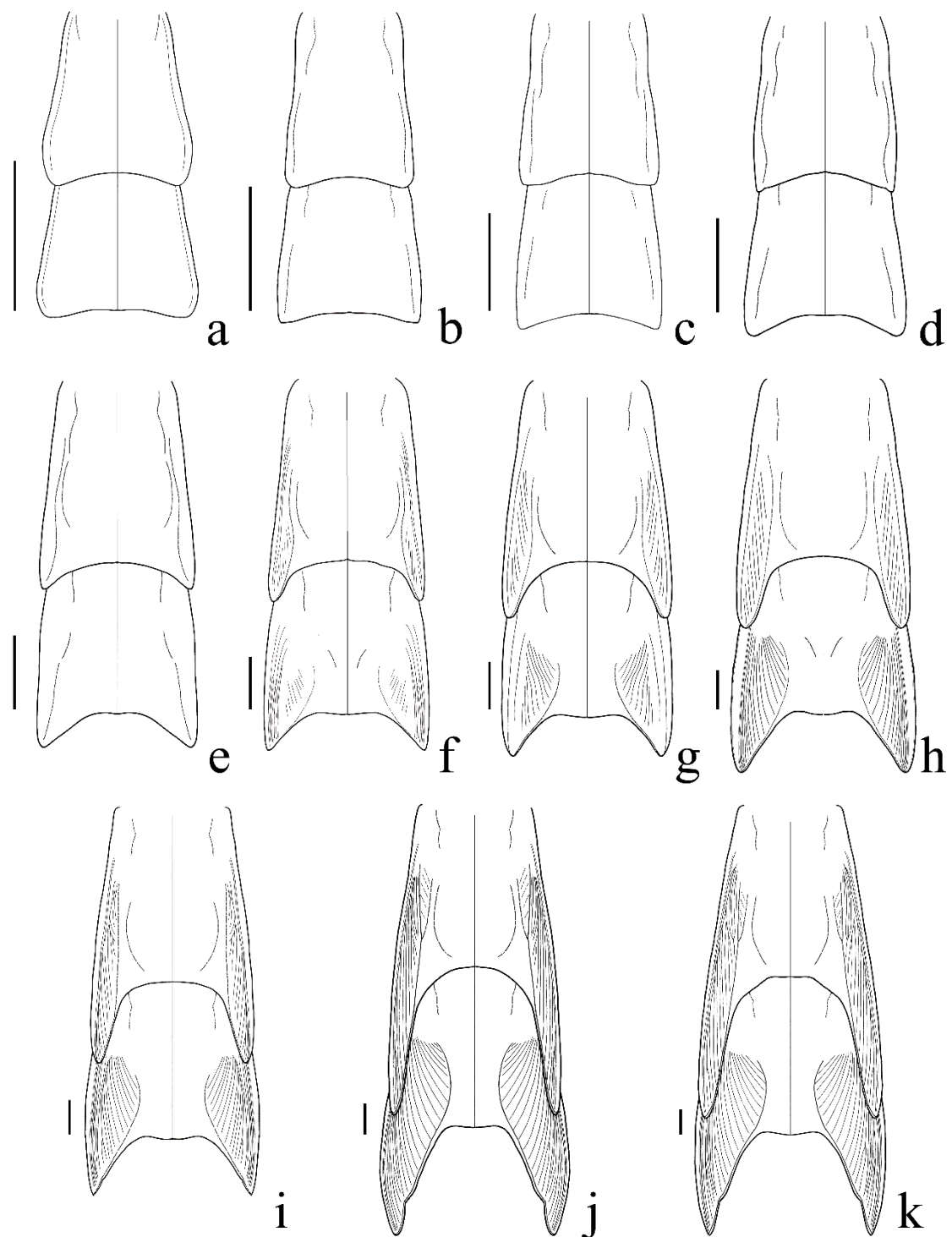


Fig. 20. Pterothorax and wing pads in nymphal stages of *T. sinensis*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 1 mm.

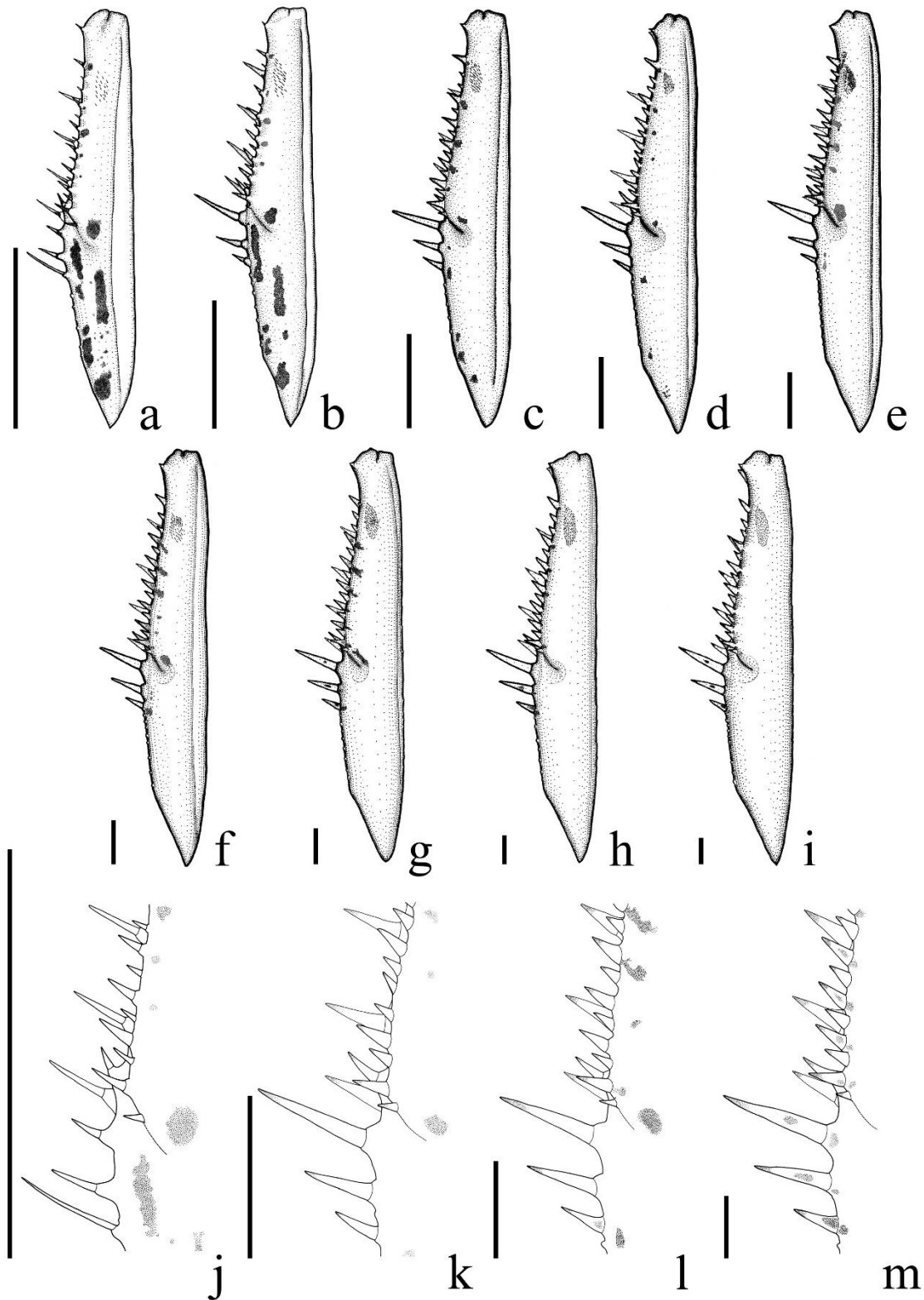


Fig. 21. Profemur in nymphal stages of *T. fasciata*, female, lateral view. a & j, 1st instar; b, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

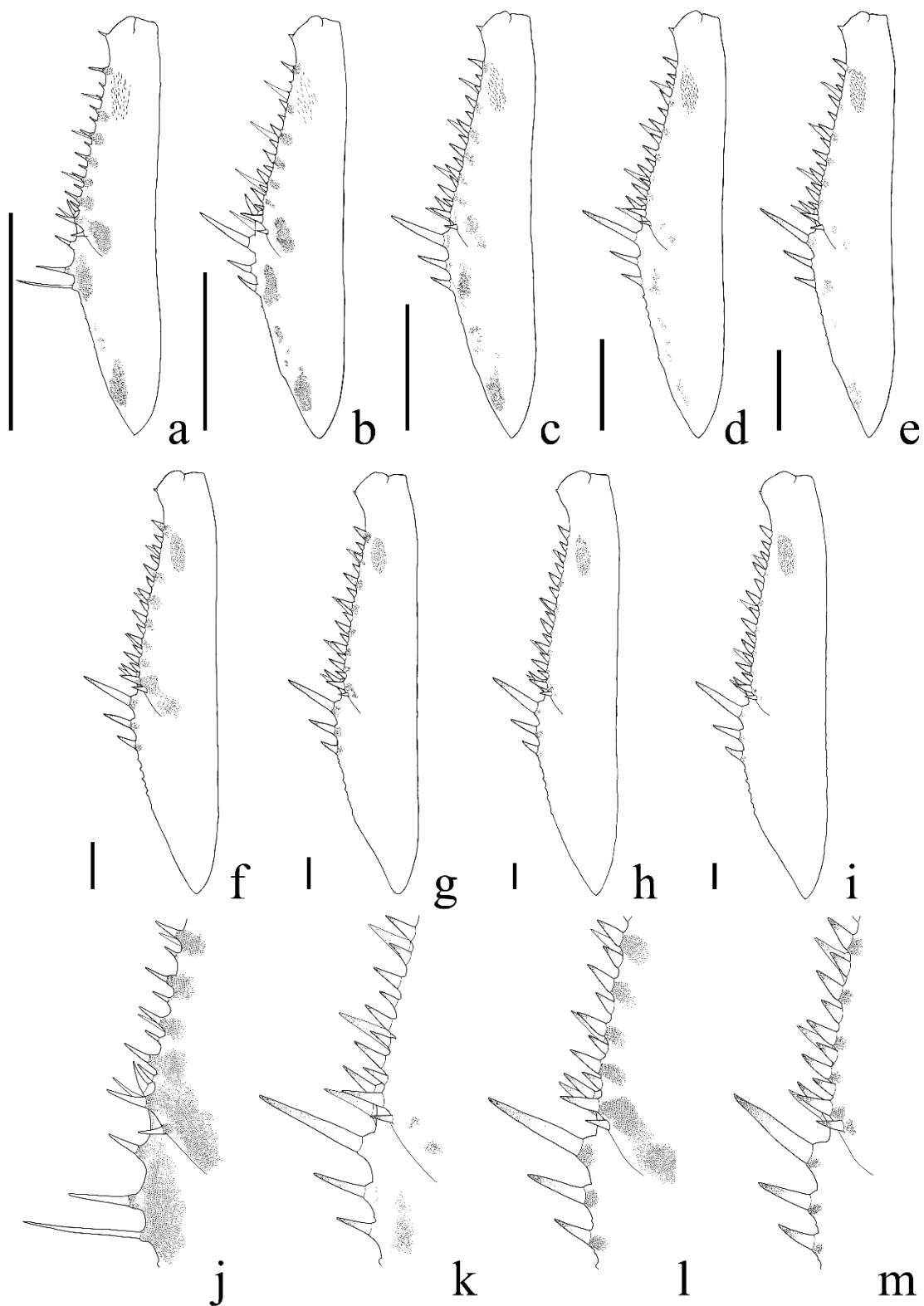


Fig. 22. Profemur in nymphal stages of *T. angustipennis*, female, lateral view. a & j, 1st instar; b, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.



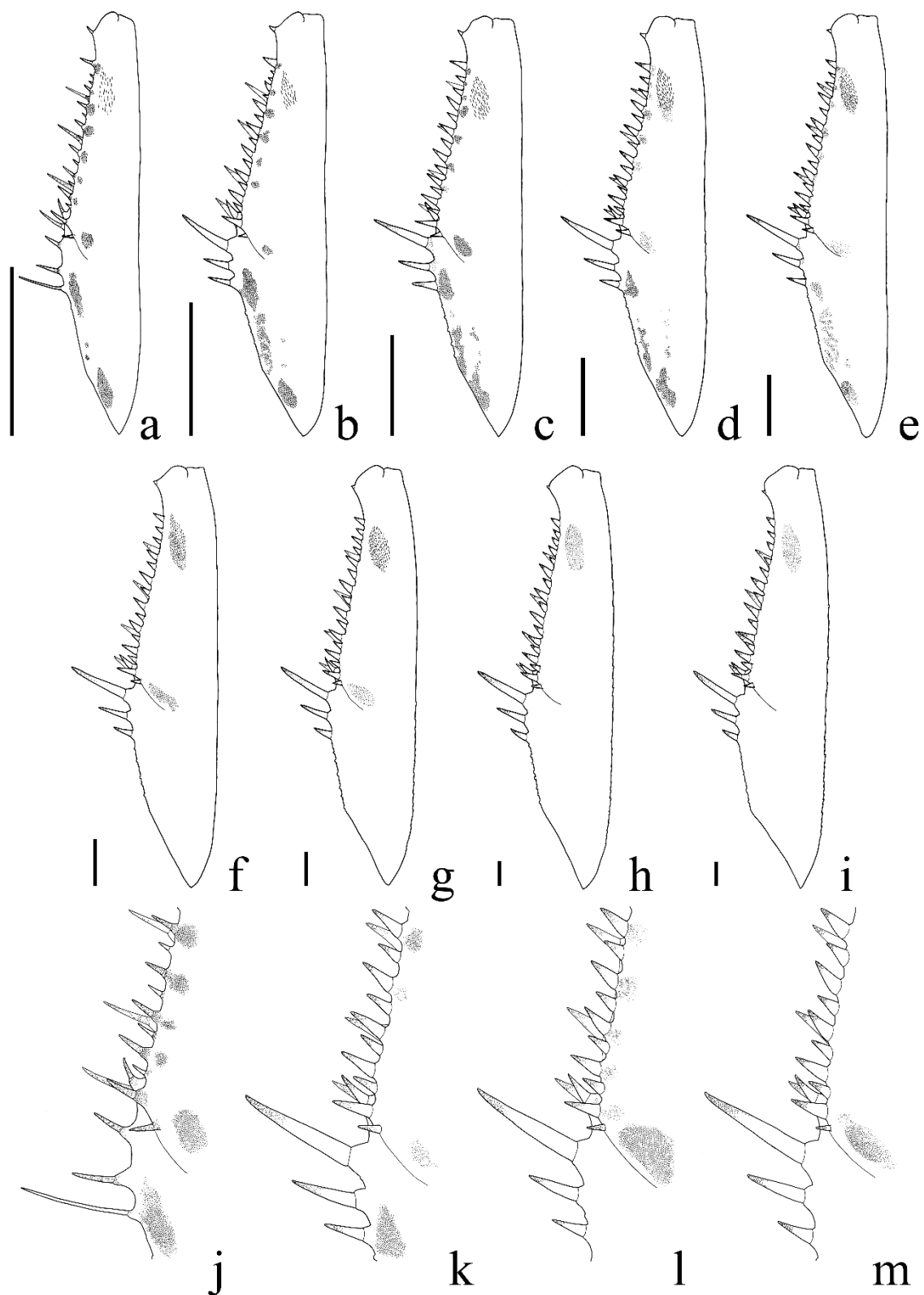


Fig. 23. Profemur in nymphal stages of *T. sinensis*, female, lateral view. a & j, 1st instar; b, 2nd instar; c, 3rd instar; d & k, 4th instar; e, 5th instar; f & l, 6th instar; g, 7th (penultimate) instar; h & m, 8th (last) instar; i, 9th instar. Scale bars: 1 mm.

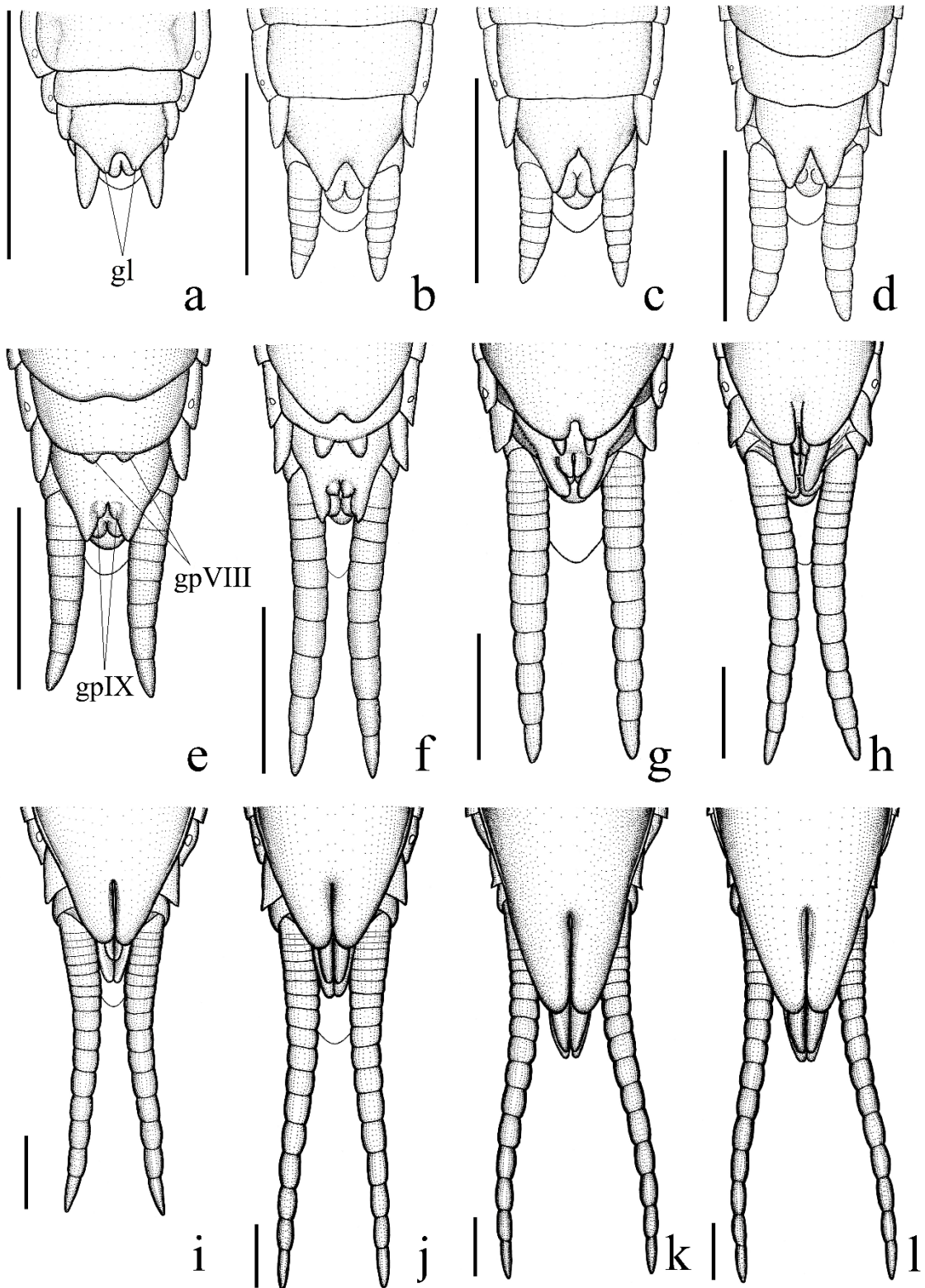


Fig. 24. Abdominal sternites VII to IX and cerci in nymphal stages of *T. fasciata*, female, ventral view. a, 1st instar; b & c, 2nd instar; d & e, 3rd instar; f, 4th instar; g, 5th instar; h, 6th instar; i, 7th (penultimate) instar; j, 8th (penultimate) instar; k, 8th (last) instar; l, 9th instar. gl= gonoplacs; gpVIII = gonapophyses VIII; gpIX = gonapophyses IX. Scale bars: 1 mm.

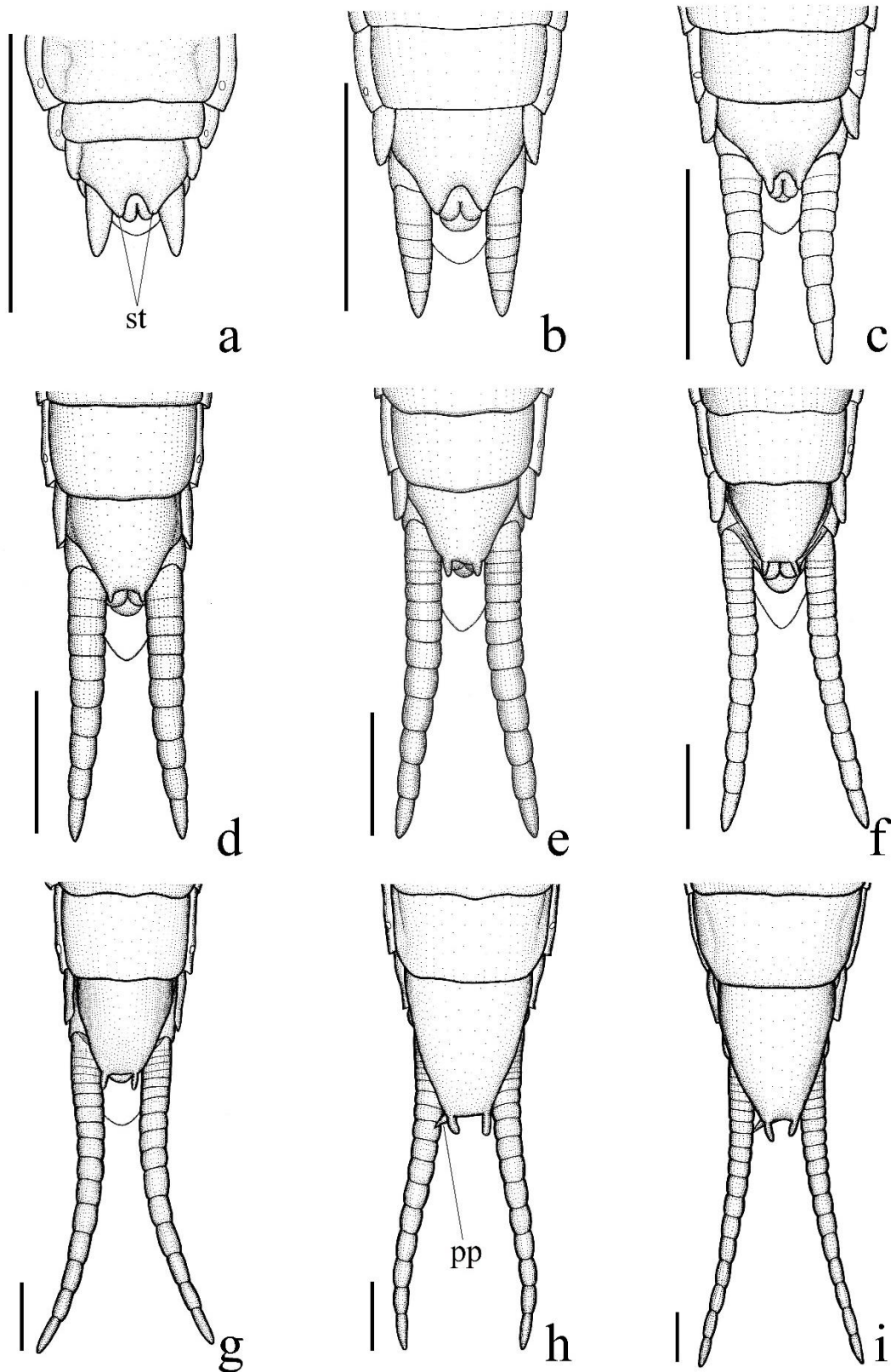


Fig. 25. Abdominal sternites VII to IX and cerci in nymphal stages of *T. fasciata*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (penultimate) instar; h, 7th (last) instar; i, 8th instar. pp = posterior process; st = styles. Scale bars: 1 mm.

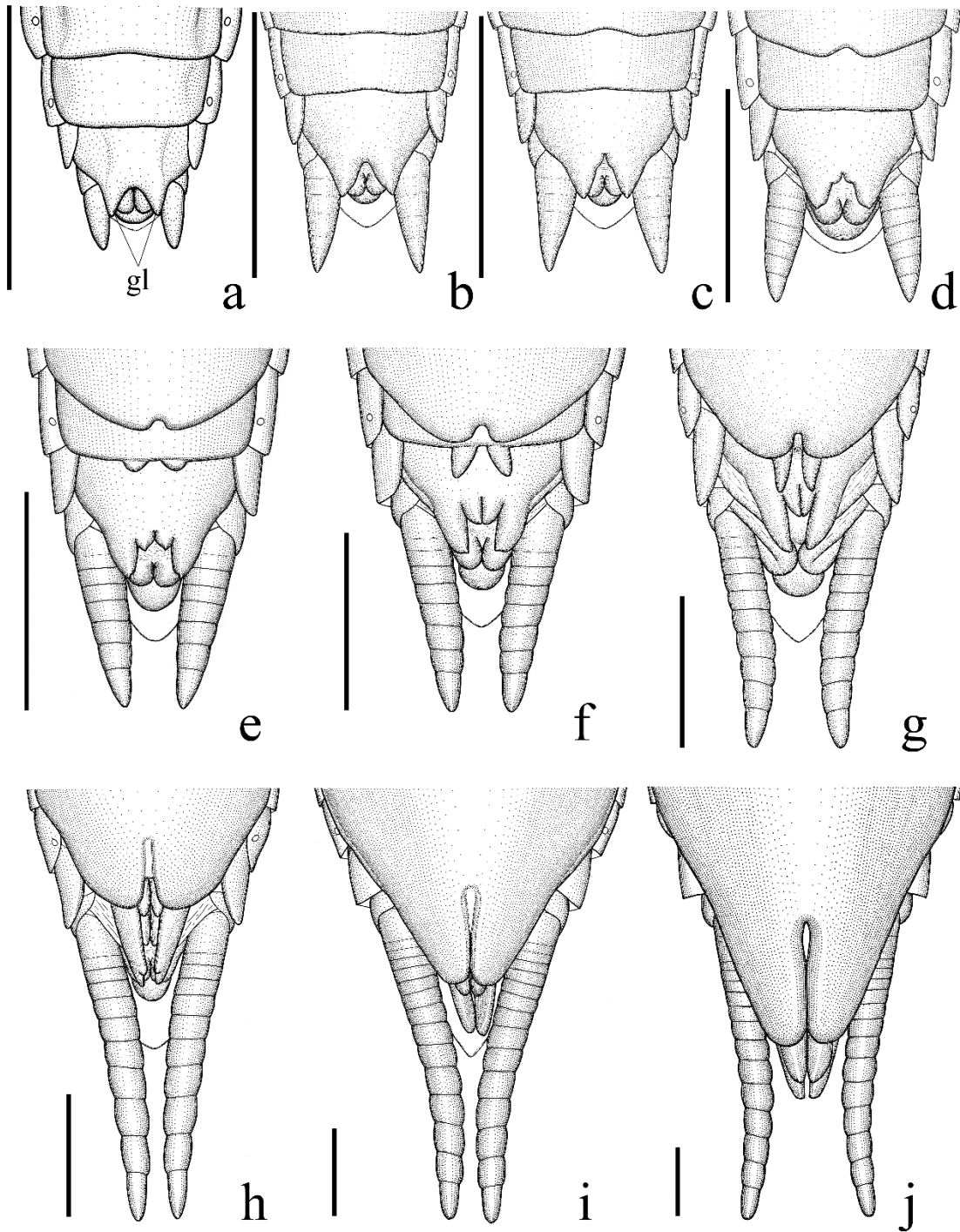


Fig. 26. Abdominal sternites VII to IX and cerci in nymphal stages of *T. angustipennis*, female, ventral view. a, 1st instar; b & c, 2nd instar; d & e, 3rd instar; f, 4th instar; g, 5th instar; h, 6th instar; i, 7th (penultimate) instar; j, 8th (last) instar. gl = gonoplacs. Scale bars: 1 mm.

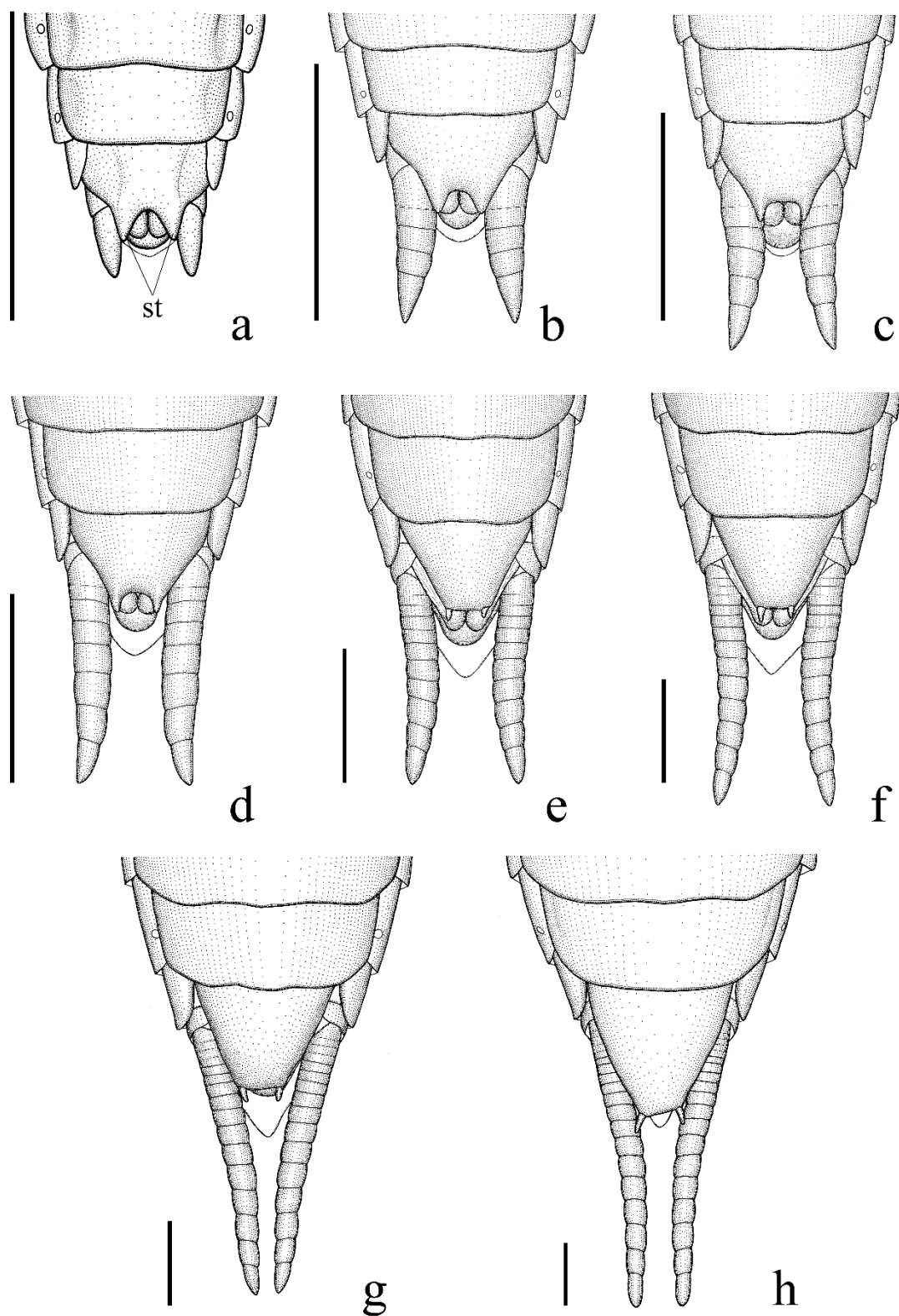


Fig. 27. Abdominal sternites VII to IX and cerci in nymphal stages of *T. angustipennis*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (penultimate) instar; h, 8th (last) instar. st = styles. Scale bars: 1 mm.

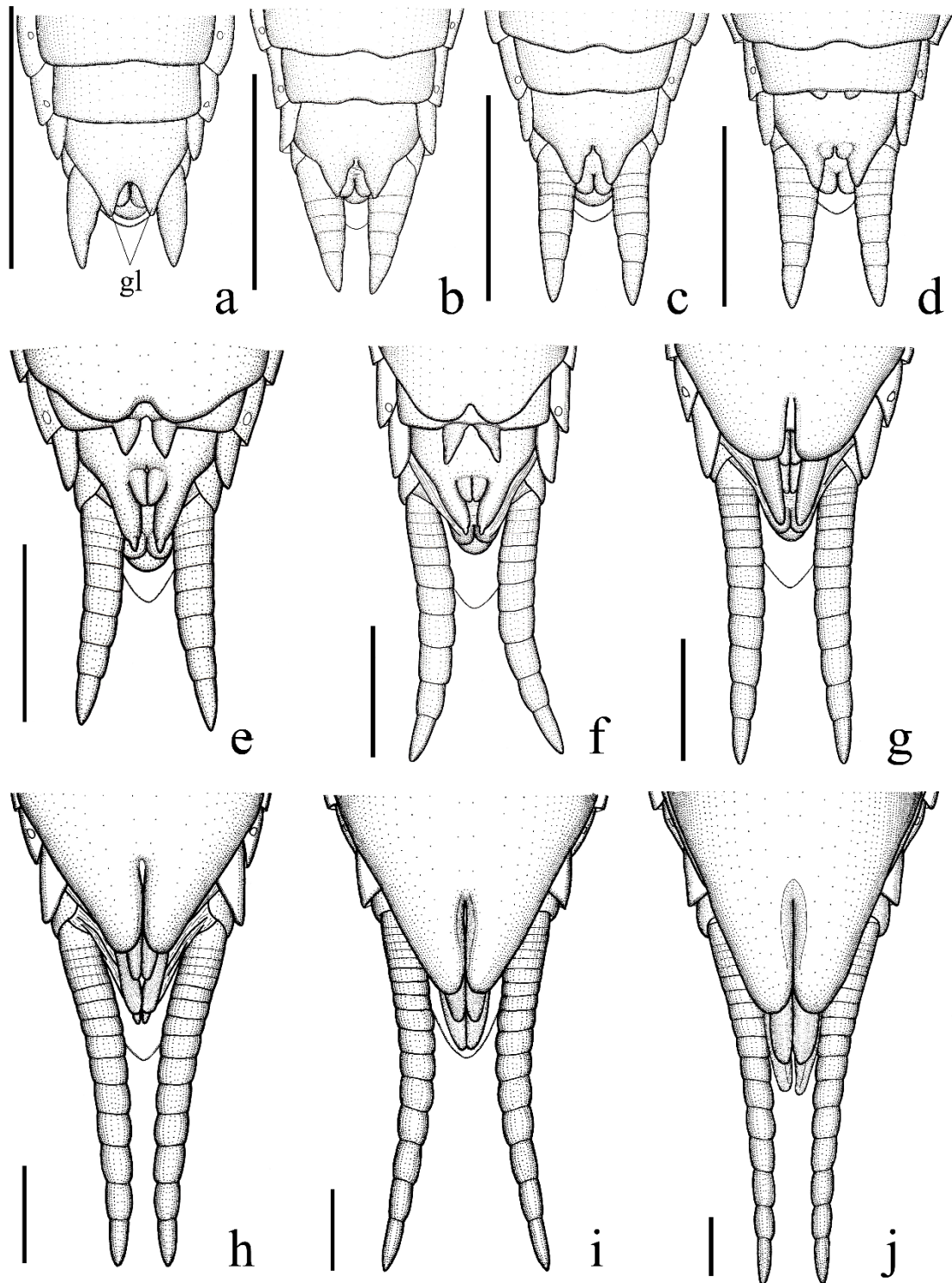


Fig. 28. Abdominal sternites VII to IX and cerci in nymphal stages of *T. sinensis*, female, ventral view. a, 1st instar; b, 2nd instar; c & d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th instar; h, 7th (antepenultimate) instar; i, 7th (penultimate) instar; j, 8th (last) instar. gl = gonoplares Scale bars: 1 mm.

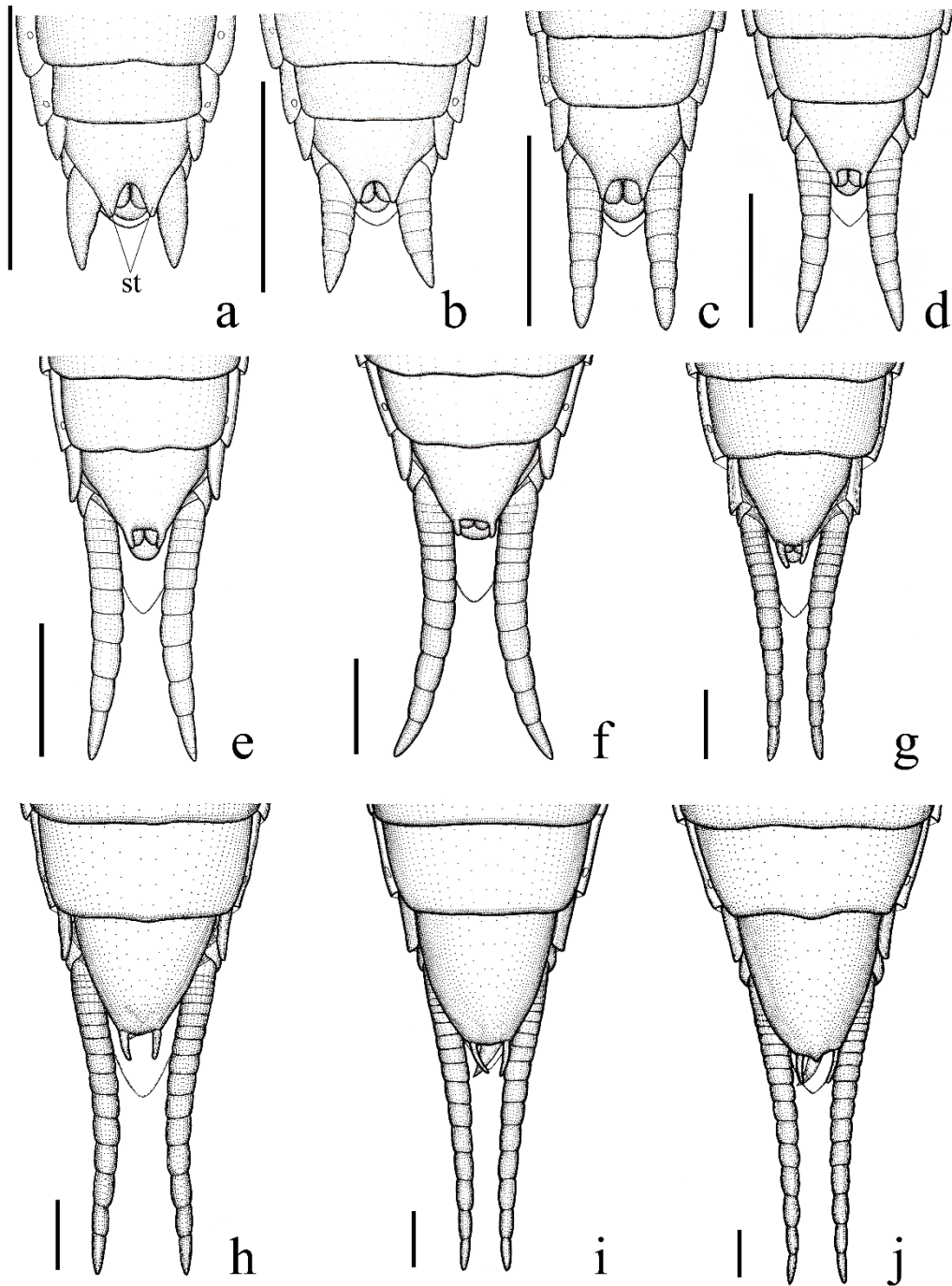


Fig. 29. Abdominal sternites VII to IX and cerci in nymphal stages of *T. sinensis*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th instar (penultimate) nymph; h, 8th (penultimate) instar; i, 8th (last) instar; j, 9th instar. st = styles Scale bars: 1 mm.

Table 1. Measurements (mm) of body parts in each nymphal stage of *Tenodera fasciata*.

Nymphal stages	Sex	Number	Body length	Length of pronotum	Width of pronotum	Length of forewing pad	Length of profemur	Width of profemur	Length of cercus
1st	–	10	8.0-9.0	2.56-2.58	0.83-0.84	–	2.27-2.29	0.36-0.37	0.26-0.27
2nd	male	6	13.0-14.6	4.50-4.52	0.09-1.00	–	3.04-3.22	0.52-0.54	0.57-0.60
	female	6	13.3-14.9	4.50-4.52	0.09-1.00	–	3.04-3.22	0.52-0.54	0.57-0.60
3rd	male	6	18.5-20.7	5.87-6.35	1.37-1.43	–	4.48-5.02	0.74-0.82	1.01-1.18
	female	6	18.6-20.3	5.87-6.34	1.37-1.43	–	4.51-5.02	0.74-0.82	1.03-1.18
4th	male	6	26.0-31.5	7.60-8.46	1.69-1.76	2.48-2.52	5.72-6.15	0.88-0.95	1.80-1.97
	female	6	26.5-30.4	7.60-8.34	1.55-1.72	2.48-2.51	5.72-6.10	0.88-0.93	1.79-1.92
5th	male	6	34.7-40.9	11.95-13.51	2.02-2.31	3.28-3.35	7.80-9.34	1.16-1.34	2.51-2.86
	female	6	35.4-40.8	11.95-13.50	2.03-2.31	3.28-3.35	7.83-9.34	1.17-1.34	2.51-2.86
6th	male	6	44.0-50.4	15.56-16.18	2.69-2.83	4.10-4.75	9.49-10.04	1.38-1.43	3.55-4.24
	female	6	42.0-51.6	15.50-16.16	2.65-2.83	4.05-4.96	9.39-10.20	1.35-1.49	3.50-4.22
6th	male	6	44.2-55.6	15.56-17.74	2.69-3.15	5.00-6.30	9.50-11.25	1.38-1.53	3.55-4.65
(penultimate)	female	–	–	–	–	–	–	–	–
7th	male	–	–	–	–	–	–	–	–
	female	5	51.1-59.2	15.95-22.90	2.73-4.18	4.97-5.82	9.95-13.95	1.40-1.95	4.64-5.64
7th	male	6	51.8-60.0	16.52-23.57	3.04-4.38	6.05-7.04	11.14-13.52	1.50-1.88	4.79-5.77
(penultimate)	female	6	52.3-60.0	16.95-23.83	3.07-4.45	6.05-7.03	11.56-14.03	1.67-2.02	4.90-5.74
7th	male	5	56.0-65.2	18.72-24.71	3.44-4.57	8.64-10.12	11.30-13.75	1.56-1.90	5.06-6.20
(last)	female	–	–	–	–	–	–	–	–
8th	male	–	–	–	–	–	–	–	–
(penultimate)	female	5	59.0-66.5	21.56-25.25	4.20-4.91	6.97-7.73	13.98-14.79	2.00-2.18	5.86-6.38
8th	male	6	60.6-70.8	23.40-26.88	4.24-4.85	9.97-11.62	13.53-14.65	1.84-2.03	6.46-7.13
(last)	female	5	61.4-73.5	23.95-28.87	4.67-5.52	10.10-11.98	14.24-15.80	2.05-2.26	6.08-6.87
9th	male	–	–	–	–	–	–	–	–
(last)	female	5	69.2-78.4	26.89-29.45	5.10-5.60	11.10-12.66	15.06-16.53	2.15-2.41	6.82-7.66

Table 2. Measurements (mm) of body parts in each nymphal stage of *Tenodera angustipennis*.

Nymphal stages	Sex	Number	Body length	Length of pronotum	Width of pronotum	Length of forewing pad	Length of profemur	Width of profemur	Length of cercus
1st	–	8	7.5-8.0	2.3-2.3	0.7	–	2	0.4	0.3
2nd	male	5	11.0-11.5	3.6	1	–	2.6	0.5	0.5
	female	6	11.0-11.5	3.6	1	–	2.6	0.5	0.5
3rd	male	7	14.0-15.0	3.9-4.0	1.2	1.5	3.3	0.6	0.7-0.8
	female	8	14.0-15.0	3.9-4.0	1.2	1.5	3.3	0.6	0.7-0.8
4th	male	8	20.0-24.0	6.5-7.6	1.5-1.8	1.7-2.2	4.5-5.2	0.8-0.9	0.8-1.2
	female	8	20.0-24.0	6.5-7.6	1.5-1.8	1.7-2.2	4.5-5.2	0.8-0.9	0.8-1.2
5th	male	8	26.0-34.5	8.0-10.5	1.8-2.2	2.4-3.3	5.3-7.5	0.9-1.3	1.2-1.8
	female	8	26.0-34.5	8.0-10.5	1.8-2.2	2.4-3.3	5.3-7.5	0.9-1.3	1.2-1.8
6th	male	8	34.0-40.0	10.5-14.5	2.2-3.0	3.4-4.5	7.4-10.0	1.3-1.7	1.8-2.2
	female	8	34.0-40.0	10.5-14.5	2.2-3.0	3.4-4.5	7.4-10.0	1.3-1.7	1.8-2.2
7th	male	8	47.5-50.5	16.0-17.0	3.7-4.2	5.0-5.4	10.5-11.0	1.8-1.9	2.6
	female	8	47.0-50.0	16.0-17.0	3.7-4.2	5.0-5.4	10.5-11.0	1.8-1.9	2.6
7th	male	8	50.5-61.0	17.5-22.0	4.2-5.2	7.0-8.0	11.0-14.5	1.9-2.5	2.8-3.0
(penultimate)	female	8	51.5-61.5	17.5-22.0	4.3-5.4	7.0-8.0	11.0-14.5	1.9-2.5	2.8-3.0
8th	male	8	60.0-65.0	21.5-23.5	5.1-5.8	7.8-8.2	14.5-16.5	2.5-2.8	3
(penultimate)	female	8	60.5-66.0	21.5-24.0	5.3-5.8	7.8-8.3	14.5-16.7	2.5-2.8	3
8th	male	8	62.0-66.0	22.0-24.0	5.2-6.0	10.0-11.5	14.8-16.5	2.5-2.8	3.6-4.0
(last)	female	8	63.0-68.0	23.5-25.0	5.4-6.5	10.5-11.5	15.0-16.5	2.5-2.8	3.6-4.0
9th	male	8	63.0-70.5	22.5-26.0	5.4-6.5	10.7-12.0	15.1-17.6	2.5-3.0	3.8-4.6
(last)	female	8	65.5-74.0	24.0-27.3	6.2-7.1	11.0-12.5	15.5-18.5	2.5-3.1	4.0-4.8



Table 3. Measurements (mm) of body parts in each nymphal stage of *Tenodera sinensis*.

Nymphal stages	Sex	Number	Body length	Length of pronotum	Width of pronotum	Length of forewing pad	Length of profemur	Width of profemur	Length of cercus
1st	–	8	8.5-9.0	2.6-2.8	0.9-1	–	2.5-2.6	0.5	0.4
2nd	male	5	13.5-14.5	4.0-4.4	1.1-1.2	–	3.0-3.2	0.6	0.6
	female	6	13.5-14.5	4.0-4.4	1.1-1.2	–	3.0-3.2	0.6	0.6
3rd	male	7	16.5-20.0	5.3-6.2	1.4-1.6	–	4.0-4.5	0.7-0.8	0.8-0.9
	female	8	16.5-20.0	5.3-6.2	1.4-1.6	–	4.0-4.5	0.7-0.8	0.8-0.9
4th	male	8	22.0-26.5	6.6-8.0	1.6-1.8	2.2-2.5	5.4-5.6	1.0-1.1	1.2-1.4
	female	8	22.0-26.5	6.6-8.0	1.6-1.8	2.2-2.5	5.4-5.6	1.0-1.1	1.2-1.4
5th	male	8	29.0-34.5	8.8-10.0	1.9-2.2	2.9-3.3	6.4-7.3	1.2-1.4	2.0-2.1
	female	8	29.0-34.5	8.8-10.0	1.9-2.2	2.9-3.3	6.4-7.3	1.2-1.4	2.0-2.1
6th	male	8	36.0-42.0	12.7-15.0	2.8-3.3	4.0-4.2	8.0-10.5	1.5-1.8	2.5-3.0
	female	8	36.0-42.0	12.8-15.0	3.0-3.5	4.0-4.2	8.0-10.5	1.5-1.8	2.5-3.0
7th	male	8	42.0-50.0	14.3-17.5	3.3-4.1	5.0-5.8	10.5-12.1	1.8-2.1	3.6-4.2
	female	8	42.0-50.0	14.5-17.5	3.6-4.3	5.0-5.8	10.3-12.1	1.8-2.2	3.6-4.1
7th	male	8	45.0-60.0	16.5-23.0	3.9-5.4	5.5-7.5	11.0-13.5	1.9-2.3	3.7-4.8
(penultimate)	female	8	45.0-61.5	16.5-23.5	4.1-5.9	5.5-7.5	11.0-14.0	1.9-2.4	3.7-4.8
8th	male	8	54.5-62.0	20.0-23.5	4.7-5.5	6.5-7.5	12.5-14.0	2.1-2.4	4.5-5.5
(penultimate)	female	8	53.0-63.0	20.0-24.0	5.0-6.1	6.5-7.6	12.0-14.5	2.1-2.5	4.5-5.5
8th	male	8	60.0-70.5	23.0-25.0	5.4-6.2	10.0-12.0	14.0-17.5	2.4-3.0	5.7-6.2
(last)	female	8	62.5-74.5	23.5-27.5	6.1-7.2	10.5-12.5	14.7-18.5	2.5-3.2	5.8-6.6
9th	male	8	65.5-75.0	24.5-28.0	5.8-6.8	10.8-12.8	16.3-19.2	2.8-3.3	5.9-6.7
(last)	female	8	66.0-76.0	24.5-28.6	6.3-7.5	11.0-12.9	16.4-19.5	2.8-3.4	6.0-6.7

## 2-2 *Hierodula* 属 2 種の若虫

### 2-2-1 緒言

*Hierodula* 属には、日本からはハラビロカマキリ *H. patellifera* (Audinet-Serville, 1839) (以下, ハラビロ) とムネアカハラビロカマキリ *H. sp.* (以下, ムネアカ) の 2 種が知られる (岡田 2001; 中峰 2016, 2020). ハラビロが本州から沖縄にかけて広く分布する在来種であるのに対し, ムネアカは中国から輸入された竹箒に付着して国内に侵入したとされる外来種で (櫻井ら 2018; 松本 2018a; 苅部 2019), 本種の学名にはこれまでに *H. membranacea* (Burmeister, 1838), *H. formosana* Giglio-Tos, 1912, *H. venosa* (Olivier, 1792) が提唱されてきた (市川 2014) ものの, これらのいずれにも相当しないとされており, 現在でも種名は未決定のままである (中峰 2016, 2020).

ムネアカは, 藤野ら (2010) によって国内で初めて報告されて以降, その分布域を拡大しつつあり, 2020 年末には 24 都府県で記録されている (山崎ら 2012; 大串ら 2015; 中峰 2016; 田中 2016; 田留ら 2017; 古川 2017; 田村 2017; 奥島・高橋 2018; 苅部・加賀 2019; 酒井・北原 2019; 金杉ら 2019; 長田 2020; 増渕 2020). また, 在来種のハラビロを駆逐し, その個体数を減少させることが報告されており (間野・宇野 2014, 2015; 吉鶴 2014b; 松本ら 2016; 渡邊ら 2017; 苅部・加賀 2018; 松本 2018b), 今後も, ムネアカの分布調査や個体数調査, ハラビロへの影響などの調査が求められる.

ハラビロとムネアカの成虫は, 体長, 前胸背板の縦横比, 叉甲腹板の発色と斑紋の有無, 前脚背縁突起の数と形状, 雄外部生殖器の形状によって容易に判別可能であり (吉鶴 2013; 間野・宇野 2014; 市川 2014; 中峰 2016), とくに叉甲腹板と前脚背縁突起の特徴が種の同定をするうえで頻繁に用いられている (吉鶴 2013, 2014a; 間野・宇野 2015; 田留ら 2017; 苅部 2019; 酒井・北原 2019). 両種における成虫以外の発育段階での形態的特徴は, 卵鞘で明らかになっており, 種の同定も可能である (市川 2014; 渡邊ら 2017). しかし, 若虫では両種ともにほとんど調べられておらず, 岡田 (2001) によって, ハラビロの 1 齢若虫の特徴がごく僅かに報告されている程度である. そのため, 成虫における同定形質が若虫にも有効であるかは不明であり, 若虫におけるハラビロとムネアカの同定方法は確立されていない. 実際に, ムネアカの採集記録や分布調査, 生態調査は, 成虫または卵が得られる晩夏から冬に集中しており, 若虫発生時期における調査報告は皆無である. 若虫発生時期での分布調査や個体数調査などを可能にするためにも, 両種の若虫における正確な同定方法の確立が必要である. また, 若虫の齢期や雌雄の判別方法も不明であり, 若虫の生態学的研究に向けた基礎情

報の蓄積という観点から、これらの判別方法も必要だと思われる。

そこで、ハラビロとムネアカの全齢期における若虫の形態を記載し両種間で比較した結果、全齢期において、若虫期に種を同定するための有用な形態的特徴を見いだした。また、両種において外部形態による齢期ごとの特徴および 2 齢以降の雌雄の特徴を見だし、種、齢期、雌雄を判別可能な検索表を作成した。

## 2-2-2 材料および方法

### 1) 若虫の採集と飼育方法

観察した若虫は、すべて人工管理下で孵化させたものを用いた。ハラビロは、2020 年 3 月 5 日に兵庫県神戸市押部谷町において採集した卵鞘を気温 30°C、湿度 60–80%の条件下で管理し孵化させた。ムネアカは、2020 年 3 月 25 日に神奈川県秦野市東田原において採集した卵鞘を気温 30°C、湿度 60–80%の条件下で管理し孵化させた。

得られた卵鞘は、プラスチック製ケース（縦 181 mm、横 124 mm、深さ 112 mm）に入れ管理した。孵化した若虫はすべて、気温 30°C、湿度 60–80%、日長 15L:9D の条件下で飼育した。1 齢から 6 齢若虫の飼育には、プラスチック製プリンカップ（口径 102 mm、深さ 80 mm）、7 齢と 8 齢若虫には同製プリンカップ（口径 129 mm、深さ 97 mm）を用いた。カップの蓋には容器内の蒸れを防ぐために複数の小さな穴をあけた。8 齢と 9 齢若虫には、プラスチック製ケース（縦 181 mm、横 124 mm、深さ 112 mm）を用いた。飼育に用いた各容器には、若虫の足場として園芸用の鉢底ネットをアーチ状にして配置し、底には乾燥防止用に水を含ませたティッシュペーパーを置いた。

餌は以下の要領で与えた。1 齢と 2 齢若虫にはキイロショウジョウバエ *Drosophila melanogaster* Meigen, 1830（ショウジョウバエ科）をそれぞれ 3 頭と 5 頭与えた。3 齢以降の若虫には、体長に適したサイズのレッドローチ *Shelfordella lateralis* (Walker, 1868)（ゴキブリ科）をそれぞれ 1 頭与えた。給餌は週 5 回行なったが、脱皮直前または直後の場合や、捕食を拒否した場合は給餌を見送った。また、脱皮前の数日間は消化能力が低下するため、餌の量を減らすか、または見送った。

### 2) 若虫の観察方法

ハラビロおよびムネアカともに、2 齢以降の各齢において-5°C の低温に 20–120 秒晒し、麻酔をかけた状態で観察した。1 齢若虫は軽度の麻酔でも死亡してしまうため、死後数時間以内の新鮮な標本を観察に用いた。両種各齢における検視個体数は Table 1, 2 にまとめた。

観察部位は、成虫において種の差異が認められていた体長、前胸背板、又甲腹板、前脚基節に加えて、これまで着目されていなかった有翅胸節（翅芽）、前脚腿節、内縁刺、外縁刺、中列刺、中脚腿節、中脚脛節、後脚腿節、後脚脛節、腹部第 VII-IX 腹板、尾角を対象とした。両種各齢の若虫において、各部位を実態顕微鏡 (SZ60; Olympus, 東京) とデジタルマイクロスコープ (VHX-1000; Keyence, 大阪) を用いて観察した。撮影には同デジタルマイクロスコープとデジタルカメラ (WG-4; Ricoh, 東京) を使用し、トレス法で作図した。また、各部位の計測には定規を用いた。両種各齢の若虫における各部位の形態的特徴を記載し、種、齢、雌雄の判別方法を検証した。

各部位名称は、Roberto *et al.* (2010) と Brannoch *et al.* (2017) に従ったが、雌生殖器官の一部では Matsuda (1976) に従った。日本語名称については、おもに中峰 (2016) に従ったが、前脚腿節の刺については岡田 (2001) に従った。また、日本語名称のない部位は和訳した。なお、本論文では、各種の記載については英文で行なった。各部位名称の和英対応および計測箇所は以下のとおりである (Figs. 1, 2) : 体長 body length ; 前胸背板 pronotum ; 又甲腹板 furcasternite ; 有翅胸節 (翅芽) pterothrax (wing pad) ; 前脚基節 procoxa ; 基節背縁突起 marginal spine ; 前脚腿節 profemur ; 内縁刺 anteroventral-femoral spine ; 外縁刺 posteroventral-femoral spine ; 中列刺 discoidal spine ; 中脚腿節 mesofemur ; 中脚脛節 mesotibia ; 後脚腿節 metafemur ; 後脚脛節 metatibia ; 腹部腹板 sternite ; 腹部背板 tergite ; 陰具片 gonapophysis ; 生殖片 gonoplac ; 尾突起 stylus ; 下陰基板突起 posterior process ; 尾角 cercus :

- (1) 体長 Body length: 前胸背板の前縁から腹部第 X 背板の後縁までの最大長 ;
- (2) 前胸背板長 Pronotum length: 前胸背板の前縁から後縁までの最大長 ;
- (3) 前胸背板幅 Pronotum width: 前胸背板の横幅の最も広い部分の長さ ;
- (4) 前翅芽長 Fore wing pad length: 肩部から前翅芽の先端までの最大長 ;
- (5) 前脚腿節長 Profemur length: 前脚腿節の前縁から後縁までの最大長 ;
- (6) 前脚腿節幅 Profemur width: 前脚腿節の背縁から第 II 内縁刺の基部までの最大長 ;
- (7) 中脚腿節長 Mesofemur length: 中脚腿節の基部から先端までの最大長 ;
- (8) 中脚脛節長 Mesotibia length: 中脚脛節の基部から先端までの最大長 ;
- (9) 後脚腿節長 Metafemur length: 後脚腿節の基部から先端までの最大長 ;
- (10) 後脚脛節長 Metatibial length: 後脚脛節の基部から先端までの最大長 ;
- (11) 尾角長 Cercus length: 尾角の基部から先端までの最大長.

## 2-2-3 結果および考察

### ハラビロカマキリ

#### *Hierodula patellifera* (Audinet-Serville, 1839)

各齢期における各部位の測定値を Table 1 にまとめた。成虫になるまでの齢数は、雄で 8 齢，雌で 8 齢または 9 齢である。羽化までの脱皮回数が少ない個体（雌：8 齢）と多い個体（雌：9 齢）は、同じ飼育条件下において出現した。以下に記載した形態的特徴を用いて、本種の若虫期における齢，性別，種の判別が可能である。

#### 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 7.0–7.5 mm in long (Figs. 3a, 4a), generally wholly brownish or greenish, with dark brown markings dorsally. Pronotum (Fig. 7a, i) approximately 2.4 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 9a) same in color as rest of body. Posterolateral angles of pterothoracic segments (Figs. 11a, 12a) rounded, lacking wing pads. Procoxa lacking marginal spines (Fig. 9a, i). Profemur (Fig. 16a, i) approximately 4.8 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interlaterally and along anteroventral (internal) -femoral spines. Anteroventral-femoral spines, posteroventral (external) -femoral spines and discoidal spines blackish wholly except apical spine of discoidal spines. Among four discoidal spines basal spine longest; proportional length of basal to apical spines 3.7: 2: 1.3: 1. Mesofemur approximately 0.4 times as long as body length, weakly darkened medially and apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur (Fig. 18a) approximately 0.5 times as long as body length, darkened medially and apically. Metatibia (Fig. 18a) approximately 0.5 times as long as body length, darkened basally, medially and apically. Posterior margin of abdominal sternite VII and VIII (Figs. 20a, 21a) straight in medial region. Sternite IX with a pair of immature styles (in prospective adult male) or immature gonoplacs (in prospective adult female); immature styles and gonoplacs conical, same in shape and size between sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Male: body 9.5–10.0 mm in long (Fig. 3b), generally wholly greenish, with dark brown markings dorsally. Pronotum (Fig. 7b) approximately 2.7 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 9b) same in color as rest of body. Posterolateral angles of pterothoraces (Fig. 12b) rounded, lacking wing pads. Procoxa (Fig. 9b) lacking

marginal spines. Profemur (Fig. 16b) approximately 4.6 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines, posteroventral-femoral spines and discoidal spines brownish wholly. Among four discoidal spines subapical spine longest; proportional length of basal to apical spines 1: 1.1: 2.7: 1.1. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur (Fig. 18b, c) approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia (Fig. 18b, c) approximately 0.5 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Posterior margin of abdominal sternite VII and VIII (Fig. 20b) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles conical. Cerci at least 4-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 9.5–10.0 mm (Fig. 4b). Posterior margin of sternite IX (Fig. 21b, c) rounded between immature gonoplags. Immature gonoplags conical. Margin between immature gonoplags with or without short groove.

**3rd instar.** Male: body 11.5–13.0 mm in long (Fig. 3c), generally wholly greenish, with light or dark brown markings dorsally. Pronotum (Fig. 7c, j) approximately 2.7 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 9c) same in color as rest of body. Posterolateral angles of pterothoraces (Fig. 12c) rounded, lacking wing pads. Procoxa (Fig. 9c) with a few slightly developed marginal spines, and 2 or 3 yellow beaded processes. Profemur (Fig. 16c, j) approximately 3.8 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines weakly darkened apically; longer spines of them partly darkened throughout their length except apical spine. Posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine basally blackish and longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur (Fig. 18d) approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia (Fig. 18d) approximately 0.4 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Posterior margin of abdominal sternite VII and VIII (Fig. 20c) straight in medial region. Posterior margin of sternite IX straight between immature styles.

Immature styles narrowed apically. Cerci at least 5-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 12.0–13.0 mm (Fig. 4c). Abdominal sternite VII (Fig. 21d) weakly extended posteriorly, with posterior margin rounded evenly and straight or slightly concave at middle part. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplacs. Immature gonoplacs conical, abruptly narrowed at apical part.

**4th instar.** Male: body 16.5–17.5 mm in long (Fig. 3d), generally wholly brownish or greenish, with light or dark brown markings dorsally. Pronotum (Fig. 7d) approximately 2.8 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 9d) same in color as rest of body, with or without faintly brown marking in middle. Posterolateral angles of pterothoraces (Fig. 12d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins and 0.1 times as long as body length. Procoxa (Fig. 9d) with a few slightly developed marginal spines and 2 to 4 yellow beaded processes. Profemur (Fig. 16d) approximately 3.8 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines and discoidal spines. Anteroventral-femoral spines darkened apically; longer spines of them partly or mostly darkened throughout their length except apical spine. Posteroventral-femoral spines darkened apically. Discoidal spines darkened apically, with subapical spine blackish in basal half and longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur (Fig. 18e) approximately 0.4 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia (Fig. 18e) approximately 0.4 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Posterior margin of abdominal sternite VII and VIII (Fig. 20d) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 7-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 16.5–17.5 mm (Fig. 4d). Abdominal sternite VII (Fig. 21e) extended posteriorly, with posterior margin shallowly notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part.

**5th instar.** Male: body 18.0–20.5 mm in long (Fig. 3e), generally wholly

brownish or greenish, with or without light or dark brown markings dorsally. Pronotum (Fig. 7e, k) 2.7–2.8 times as long as its maximum width, with lateral margins weakly brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 9e) same in color as rest of body, with faintly brown marking in middle. Posterolateral angles of pterothoraces (Fig. 12e) angulated, weakly extended posteriorly, regarded as wing pads lacking veins and 0.13 times as long as body length. Procoxa (Fig. 9e) with a few slightly developed marginal spines and 2 to 4 yellow beaded processes. Profemur (Fig. 16e, k) approximately 3.8 times as long as its width, mottled with small, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines and discoidal spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length except apical spine, and basal spine wholly blackish. Posteroventral-femoral spines darkened apically. Basal and apical spines of discoidal spines darkened on apical part only, and subbasal and subapical spines wholly blackish; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur (Fig. 18f) approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia (Fig. 18f) approximately 0.4 times as long as body length, darkened or same in color of body basally, medially and apically. Posterior margin of abdominal sternite VII and VIII (Fig. 20e) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 8-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 18.0–20.5 mm (Fig. 4e). Abdominal sternite VII (Fig. 21f) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplares elongated, abruptly narrowed at apical part.

**6th instar.** Male: body 22.0–24.0 mm in long (Fig. 3f), generally wholly brownish or greenish. Pronotum (Fig. 7f) 2.6–2.8 times as long as its maximum width, brownish or same in color as rest of body along medial line, with lateral margins weakly brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 9f) same in color as rest of body, with rounded, brown marking in middle. Wing pads (Fig. 12f) provided with very slightly developed veins, 0.13 times as long as body length. Procoxa (Fig. 9f) with a few slightly developed marginal spines, and 2 to 4 yellow beaded processes. Profemur (Fig. 16f) approximately 3.8 times as long as its width, mottled with small, irregular, black spots along anteroventral-femoral spines and



discoïdal spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length except apical spine, and basal spine wholly blackish. Posteroventral-femoral spines darkened apically. Basal spine of discoïdal spines wholly blackish or darkened on apical part only, subbasal and subapical spines wholly blackish, and apical spine darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur (Fig. 18g) approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia (Fig. 18g) approximately 0.4 times as long as body length, same in color of body mostly. Posterior margin of abdominal sternite VII and VIII (Fig. 20f) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 9-segmented, 0.05 times as long as body length.

Female: similar to male. Body length 22.0–24.0 mm (Fig. 4f). Abdominal sternite VII (Fig. 21g) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, abruptly narrowed at apical part.

**7th instar.** Penultimate instar male: body 28.5–31.0 mm in long (Fig. 3g), generally wholly brownish or greenish. Pronotum (Fig. 7g, l) 2.6–2.8 times as long as its maximum width, brownish or same in color as rest of body along medial line, with lateral margins brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 9g) same in color as rest of body, with rounded, darkly brown marking in middle. Wing pads (Fig. 12g) provided with slightly developed veins, 0.15 times as long as body length. Procoxa (Fig. 9g) with a few slightly developed marginal spines and 2 to 4 yellow beaded processes. Profemur (Fig. 16g, l) approximately 3.8 times as long as its width, mottled with small, irregular, black spots along anteroventral-femoral spines and discoïdal spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly blackish darkened throughout their length except apical spine, and basal spine wholly blackish. Posteroventral-femoral spines darkened apically. Basal and subapical spines of discoïdal spines wholly blackish, and apical spine darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened extensively. Mesotibia 0.2–0.3 times as long as body length, same in color of body apically. Metafemur (Fig. 18h) approximately 0.4 times as long as body length, darkened or same in color of body extensively. Metatibia (Fig. 18h) approximately 0.4 times as long as body length, same in color of body extensively. Posterior margin of abdominal sternite VII and VIII (Fig.

20g) straight in medial region. Sternite IX extended posteriorly, covering supra-anal lobe; posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Immature posterior process extended behind sternite IX. Cerci at least 9-segmented, 0.07 times as long as body length.

Female antepenultimate instar: similar to penultimate instar male. Body length 26.0–27.0 mm (Fig. 4g). Wing pads (Fig. 13g) provided with very slightly developed veins. Abdominal sternite VII (Fig. 22a) extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci 0.06 times as long as body length.

Penultimate instar female: similar to antepenultimate instar female. Body length 29.5–31.5 mm (Fig. 4h). Wing pads (Fig. 13h) provided with slightly developed veins. Abdominal sternite VII (Fig. 22b) extended posteriorly, covering most of sternite VIII and supra-anal lobe, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt.

**8th instar.** Last instar male: body 37.5–40.0 mm in long (Fig. 3h), generally wholly brownish or greenish. Pronotum (Fig. 7h) 2.4–2.5 times as long as its maximum width, with lateral margins brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 9h) same in color as rest of body, with rounded, darkly brown marking in middle. Wing pads (Fig. 12h) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Procoxa (Fig. 9h) with a few slightly developed marginal spines, and 2 to 4 yellow beaded processes. Profemur (Fig. 16h) approximately 3.8 times as long as its width, mottled with small, irregular, black spots along anteroventral-femoral spines and discoidal spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length except apical spine, and basal spine wholly blackish. Posteroventral-femoral spines darkened apically. Basal to subapical spines of discoidal spines wholly blackish and apical spine darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened extensively. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur (Fig. 18i) approximately 0.3 times as long as body length, darkened or same in color of body extensively. Metatibia (Fig. 18i) approximately 0.3 times as long as body length, same in color of body extensively. Posterior margin of abdominal sternite VII and VIII (Fig. 20h) straight in medial region. Sternite IX extended to level of posterior margin of tergite X, with posterior margin

straight between immature styles. Immature styles narrowed apically. Immature posterior process extended behind sternite IX. Cerci at least 11-segmented, 0.09 times as long as body length.

Penultimate instar female: similar to last instar male. Body length 32.5–35.0 mm (Fig. 4i). Wing pads (Fig. 13i) provided with slightly developed veins, 0.17 times as long as body length. Abdominal sternite VII (Fig. 22c) extended posteriorly, covering most of sternite VIII and supra-anal lobe, with posterior margin incised at middle and reaching posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 9-segmented, 0.08 times as long as body length.

Last instar female: similar to penultimate instar female. Body length 38.0–41.5 mm (Fig. 4j). Wing pads (Fig. 13j) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 22d) extended to level of posterior margin of tergite X. Cerci at least 10-segmented, 0.09 times as long as body length.

**9th instar.** Last instar female: body 37.5–41.5 mm in long (Fig. 4k), generally wholly brownish or greenish. Pronotum 2.4–2.5 times as long as its maximum width, with lateral margins minutely but distinctly serrate throughout their length. Furcasternite same in color as rest of body, mottled with rounded, darkly brown marking in middle. Wing pads (Fig. 13k) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Procoxa with a few slightly developed marginal spines, and 2 to 4 yellow beaded processes. Profemur approximately 3.8 times as long as its width, mottled with small, irregular, black spots along anteroventral-femoral spines and discoidal spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length except apical spine, and basal spine wholly blackish. Posteroventral-femoral spines darkened apically. Basal to subapical spines of discoidal spines wholly blackish and apical spine darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened extensively. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.3 times as long as body length, darkened or same in color of body extensively. Metatibia approximately 0.3 times as long as body length, same in color of body extensively. Abdominal sternite VII (Fig. 22e) extended to level of posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature

gonoplacs elongated, with apex blunt. Cerci at least 10-segmented, 0.1 times as long as body length.

### 若虫の齡期判別

1 齡若虫は、体長 9 mm 未満であること (Figs. 3, 4) や中列刺のうち第 I 刺がもっとも長いこと (Fig. 16a, i) から、ほかの齡と判別できる。2 齡から 4 齡の判別には、体長や基節背縁突起の有無、翅芽の有無が有用である (Figs. 3, 4, 9, 12, 13) : 2 齡は体長 10 mm 内外, 基節背縁突起と翅芽を欠く ; 3 齡は体長 12 mm 内外, 基節背縁突起を有し, 翅芽を欠く ; 4 齡は体長 17 mm 内外, 基節背縁突起と翅芽を有する。5 齡と 6 齡の判別には、体長や翅脈の有無が有用である (Figs. 3, 4, 12, 13) : 5 齡は体長 20 mm 内外, 翅脈を欠く ; 6 齡は体長 23 mm 内外, 翅脈を有する。雄における 6 齡と 7 齡 (亜終齡) の判別には、体長と下陰基板突起の発達度合いが有用である (Figs. 3, 4, 20) : 6 齡は体長 22.0–24.0 mm, 下陰基板突起は第 IX 腹板から露出しない ; 7 齡 (亜終齡) は体長 28.5–31.0 mm, 下陰基板突起は第 IX 腹板から露出する。前亜終齡 (雌 : 7 齡), 亜終齡 (雌 : 7 齡, 8 齡 ; 雄 : 7 齡), 終齡 (雌 : 8 齡, 9 齡 ; 雄 : 8 齡) の判別には、体長と後翅芽の伸長度合いが有用である (Figs. 3, 4) : 前亜終齡は体長 26.0–27.0 mm, 後翅芽の末端が腹部第 I 背板の後縁に達しない ; 亜終齡は体長 28.5–35.0 mm, 後翅芽の末端が腹部第 I 背板の後縁に達しない ; 終齡は体長 37.5–41.5 mm, 後翅芽の末端が第 I 背板の後縁を超える。また、亜終齡と終齡は、雌は腹部第 VII 腹板, 雄では第 IX 腹板の発達度合いでも判別できる : 亜終齡の雌は、第 VII 腹板の後縁が第 I 背板の後縁に達しない (Fig. 21b, c) が、終齡の雌では第 VII 腹板の後縁が第 I 背板の後縁を超える (Fig. 21d, e) ; 亜終齡の雄は、第 IX 腹板の後縁が第 I 背板の後縁に達しない (Fig. 20g) が、終齡の雄では第 IX 腹板の後縁が第 I 背板の後縁を超える (Fig. 20h)。

以上の特徴から、ハラビロカマキリは外部形態による齡期判別が可能である。

### 若虫の雌雄判別

1 齡若虫では、外部形態における雌雄差は確認できなかった。2 齡では、雌は腹部第 IX 腹板の後縁 (生殖片の間) に小さな切れ込みが生じる (Fig. 21c) のに対し、雄の腹部第 IX 腹板の後縁 (尾突起の間) はほぼ平坦である (Fig. 20b) ことから雌雄が判別できる。ただし、一部の雌個体は雄に似た特徴を表すことがある (Fig. 21b)。3 齡から終齡では、3 つの形質から判別できる (Figs 20–22) : (1) 雌は第 VII 腹板の後縁が湾曲しながら後方に拡張し、加齢に伴い亜生殖板を形成するのに対し、雄の第 VII 腹板の後縁はほぼ平坦であり、加齢に伴う形状の変化はほとんどない ; (2) 雌は 3 齡の一部の個体を除き、第 VIII 腹板の後縁に一對の

陰具片を有するのに対し、雄の第 VIII 腹板の後縁はほぼ平坦であり、加齢に伴う形状の変化はほとんどない；(3) 雌は第 IX 腹板に一对の陰具片と生殖片を有し、それらの形状が加齢に伴い変化するのに対し、雄の第 IX 腹板の尾突起には加齢に伴う形状の変化はほとんどない。また、終齢の雄は下陰基板突起が腹部第 IX 腹板から露出する。

以上の特徴から、ハラビロカマキリは 2 齢以降に外部形態による雌雄判別が可能である。

### ムネアカハラビロカマキリ

#### *Hierodula* sp.

各齢期における各部位の測定値を Table 2 にまとめた。成虫になるまでの齢数は、雌雄ともに 7 齢または 8 齢である。羽化までの脱皮回数が少ない個体（7 齢）と多い個体（8 齢）は、同じ飼育条件下において出現した。以下に記載した形態的特徴を用いて、本種の若虫期における齢、性別、種の判別が可能である。

#### 若虫の記載 **Descriptions of nymphal stages.**

**1st instar.** Body 7.5–8.0 mm in long (Figs. 5a, 6a), generally wholly brownish or greenish. Pronotum (Fig. 8a, j) approximately 2.5 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 10a) same in color as rest of body. Posterolateral angles of pterothoracic segments (Figs. 14a, 15a) rounded, lacking wing pads. Procoxa (Fig. 10a, i) lacking marginal spines. Profemur (Fig. 17a, j) approximately 5 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines, posteroventral-femoral spines and discoidal spines brownish wholly. Among four discoidal spines basal spine longest; proportional length of basal to apical spines 3.8: 1.8: 1.4: 1. Mesofemur approximately 0.4 times as long as body length, same in color of body wholly. Mesotibia approximately 0.3 times as long as body length, same in color of body wholly. Metafemur (Fig. 19a) approximately 0.5 times as long as body length, same in color of body wholly. Metatibia (Fig. 19a) approximately 0.5 times as long as body length, darkened apically. Posterior margin of abdominal sternite VII and VIII (Figs. 23a, 24a) straight in medial region. Sternite IX with a pair of immature styles (in prospective adult male) or immature gonoplacs (in prospective adult female); immature styles and gonoplacs conical, same in shape and size between sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Male: body 11.0–11.5 mm in long (Fig. 5b), generally wholly greenish. Pronotum (Fig. 8b) approximately 2.8 times as long as its maximum width, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 10b) same in color as rest of body. Posterolateral angles of pterothoraces (Fig. 14b) rounded, lacking wing pads. Procoxa (Fig. 8b) lacking marginal spines. Profemur (Fig. 17b) approximately 5 times as long as its width, mottled with small to large, irregular, black spots in basal half interlaterally and along anteroventral-femoral spines. Anteroventral-femoral spines, posteroventral-femoral spines and discoidal spines brownish wholly. Among four discoidal spines subapical spine longest; proportional length of basal to apical spines 1: 1.1: 2.6: 1.1. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.3 times as long as body length, same in color of body wholly. Metafemur (Fig. 19b) approximately 0.4 times as long as body length, same in color of body wholly, darkened apically. Metatibia (Fig. 19b) approximately 0.4 times as long as body length, weakly darkened or same in color of body apically. Posterior margin of abdominal sternite VII and VIII (Fig. 23b) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles conical. Cerci at least 4-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 11.0–11.5 mm (Fig. 6b). Posterior margin of sternite IX (Fig. 24b, c) rounded between immature gonoplacs. Immature gonoplacs conical. Margin between immature gonoplacs with or without short groove.

**3rd instar.** Male: body 16.5–17.0 mm in long (Fig. 5c), generally wholly greenish. Pronotum (Fig. 8c, k) 3.2–3.3 times as long as its maximum width, brownish in basal half dorsally and along medial line, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 10c) same in color as rest of body. Posterolateral angles of pterothoraces (Fig. 14c) rounded, lacking wing pads. Procoxa (Fig. 10c) with a few slightly developed marginal spines. Profemur (Fig. 17c, k) approximately 5 times as long as its width, mottled with small to large, irregular, black spots in basal half interlaterally and along anteroventral-femoral spines. Anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically, brownish wholly. Discoidal spines weakly darkened apically; subapical spine brownish or blackish in basal half and longest. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur (Fig. 19c) approximately 0.4 times as long as body length, same in color of body wholly. Metatibia (Fig. 19c) approximately 0.3 times as long as body length, same in color of body wholly. Posterior

margin of abdominal sternite VII and VIII (Fig. 23c) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 5-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 16.5–17.0 mm (Fig. 6c). Abdominal sternite VII (Fig. 24d) weakly extended posteriorly, with posterior margin rounded evenly and straight or slightly concave at middle part. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplags. Immature gonoplags conical, abruptly narrowed at apical part.

**4th instar.** Male: body 21.5–23.0 mm in long (Fig. 5d), generally wholly greenish. Pronotum (Fig. 8d) 3.2–3.3 times as long as its maximum width, brownish in basal half dorsally and along medial line, with lateral margins minutely serrate throughout their length. Furcasternite (Fig. 10d, e) same in color as rest of body or weakly to strongly red. Posterolateral angles of pterothoraces (Fig. 14d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins and 0.1 times as long as body length. Procoxa (Fig. 10d, e) with a few slightly developed marginal spines. Profemur (Fig. 17d) approximately 5 times as long as its width, mottled with small to large, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines weakly darkened apically; longer spines of them partly or mostly darkened throughout their length. Posteroventral-femoral spines weakly darkened apically. Basal and subapical spines of discoidal spines wholly blackish, and subbasal spine and apical spines darkened on apical part only; subapical spine longest. Mesofemur approximately 0.2 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur (Fig. 19d) 0.3–0.4 times as long as body length, darkened or same in color of body medially. Metatibia (Fig. 19d) approximately 0.3 times as long as body length, same in color of body wholly. Posterior margin of abdominal sternite VII and VIII (Fig. 23d) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 7-segmented, 0.04 times as long as body length.

Female: similar to male. Body length 21.5–23.0 mm (Fig. 6d). Furcasternite (Fig. 11a) same in color as rest of body or weakly red. Abdominal sternite VII (Fig. 24e) extended posteriorly, with posterior margin shallowly notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplags elongated, abruptly narrowed at apical part.

**5th instar.** Male: body 24.5–28.0 mm in long (Fig. 5e), generally wholly greenish. Pronotum (Fig. 8e, l) 3.2–3.3 times as long as its maximum width, brownish or same in color as rest of body in basal half dorsally and brownish along medial line, with lateral margins weakly brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 10f, k) weakly to strongly red. Posterolateral angles of pterothoraces (Fig. 14e, f) angulated, weakly extended posteriorly, regarded as wing pads lacking veins and 0.12 times as long as body length. Procoxa (Fig. 10f, k) with a few slightly developed marginal spines. Profemur (Fig. 17e, l) approximately 5 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines darkened apically; longer spines of them partly or mostly darkened throughout their length. Posteroventral-femoral spines darkened apically. Basal and subapical spines of discoidal spines wholly blackish, and subbasal spine and apical spines darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur (Fig. 19e) approximately 0.4 times as long as body length, wholly dark brownish. Metatibia (Fig. 19e) approximately 0.3 times as long as body length, same in color of body wholly. Posterior margin of abdominal sternite VII and VIII (Fig. 23e) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 8-segmented, 0.05 times as long as body length.

Female: similar to male. Body length 24.5–28.0 mm (Fig. 6e). Furcasternite (Fig. 11b, c) same in color as rest of body or weakly red. Abdominal sternite VII (Fig. 24f) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplags elongated, abruptly narrowed at apical part.

**6th instar.** Male antepenultimate instar: body 28.5–29.0 mm in long (Fig. 6f), generally wholly greenish. Pronotum approximately 3.4 times as long as its maximum width, weakly brownish along medial line, with lateral margins clearly brownish and minutely but distinctly serrate throughout their length. Furcasternite strongly red. Wing pads (Fig. 14g) provided with or without very slightly developed veins, 0.14 times as long as body length. Procoxa with a few slightly developed marginal spines. Profemur 4.8–5 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines darkened apically; longer spines of them partly or mostly darkened throughout their length. Posteroventral-femoral spines darkened apically. Basal and subapical



spines of discoidal spines wholly blackish, and subbasal and apical spines darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur approximately 0.4 times as long as body length, wholly dark brownish. Metatibia approximately 0.3 times as long as body length, same in color of body wholly. Posterior margin of abdominal sternite VII and VIII (Fig. 23f) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Cerci at least 9-segmented, 0.05 times as long as body length.

Penultimate instar male: similar to antepenultimate instar male. Body length 32.0–33.0 mm (Fig. 5g). Wing pads (Fig. 14h) provided with slightly developed veins, 0.16 times as long as body length. Abdominal sternite IX (Fig. 23g) extended posteriorly, covering supra-anal lobe. Immature posterior process extended behind sternite IX or not. Cerci 0.06 times as long as body length.

Female antepenultimate instar: similar to antepenultimate instar male. Body length 28.0–29.0 mm (Fig. 6f). Furcasternite (Fig. 11e) same in color as rest of body or weakly red. Abdominal sternite VII (Fig. 24g) extended posteriorly, covering most of sternite VIII and supra-anal lobe, with posterior margin incised at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, abruptly narrowed at apical part.

Penultimate instar female: similar to antepenultimate instar female. Body length 32.0–33.0 mm (Fig. 6g). Wing pads (Fig. 15g) provided with slightly developed veins, 0.16 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Immature gonapophyses VIII (Fig. 24h) elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci 0.06 times as long as body length.

**7th instar.** Penultimate instar male: body 35.5–36.0 mm in long (Fig. 5h), generally wholly greenish. Pronotum (Fig. 8g) approximately 3.4 times as long as its maximum width, weakly brownish along medial line, with lateral margins clearly brownish and minutely but distinctly serrate throughout their length. Furcasternite strongly red. Wing pads (Fig. 14i) provided with slightly developed veins, 0.15 times as long as body length. Procoxa with a few slightly developed marginal spines. Profemur (Fig. 17g) 4.8–5 times as long as its width, mottled with small to medium, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length. Posteroventral-femoral spines darkened apically. Basal and

subapical spines of discoidal spines wholly blackish, and subbasal and apical spines darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur (Fig. 19g) approximately 0.4 times as long as body length, wholly brownish. Metatibia (Fig. 19g) approximately 0.3 times as long as body length, same in color of body wholly. Posterior margin of abdominal sternite VII and VIII (Fig. 23h) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Immature posterior process extended behind sternite IX or not. Cerci at least 11-segmented, 0.07 times as long as body length.

Last instar male: similar to penultimate instar male. Body length 42.0–44.5 mm (Fig. 5i). Pronotum (Fig. 8h, m) along medial line same in color as rest of body. Wing pads (Fig. 14j) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Immature posterior process (Fig. 23i) extended behind sternite IX. Cerci at least 12-segmented, 0.08 times as long as body length.

Penultimate instar female: similar to penultimate instar male. Body length 36.0–37.5 mm (Fig. 6h). Furcasternite (Fig. 11f) same in color as rest of body or weakly red. Abdominal sternite VII (Fig. 24i) extended posteriorly, covering most of sternite VIII and supra-anal lobe, with posterior margin incised at middle and reaching posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt.

Last instar female: similar to penultimate instar female. Body length 42.0–44.5 mm (Fig. 6i). Wing pads (Fig. 15i) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 24j) extended to level of posterior margin of tergite X. Cerci at least 12-segmented, 0.08 times as long as body length.

**8th instar.** Last instar male: body 44.0–45.0 mm in long (Fig. 5j), generally wholly greenish. Pronotum (Fig. 8i) approximately 3.2 times as long as its maximum width, with lateral margins clearly brownish and minutely but distinctly serrate throughout their length. Furcasternite (Fig. 10h) strongly red. Wing pads (Fig. 14k) provided with clearly developed veins, 0.2 times as long as body length; apex of hind wing pads extended to posterior margin of abdominal tergite I. Procoxa (Fig. 10h) with a few slightly developed marginal spines. Profemur (Fig. 17i) 4.8–5 times as long as its width, mottled with small to medium, irregular, black spots in basal half

interolaterally and along anteroventral-femoral spines. Anteroventral-femoral spines darkened apically; longer spines of them mostly darkened throughout their length. Posteroventral-femoral spines darkened apically. Basal and subapical spines of discoidal spines wholly blackish, and subbasal and apical spines darkened on apical part only; subapical spine longest. Mesofemur approximately 0.3 times as long as body length, same in color of body wholly. Mesotibia approximately 0.2 times as long as body length, same in color of body wholly. Metafemur (Fig. 19i) approximately 0.4 times as long as body length, wholly dark brownish. Metatibia (Fig. 19i) approximately 0.3 times as long as body length, same in color of body wholly. Posterior margin of abdominal sternite VII and VIII (Fig. 23j) straight in medial region. Posterior margin of sternite IX straight between immature styles. Immature styles narrowed apically. Immature posterior process extended behind sternite IX. Cerci at least 12-segmented, 0.09 times as long as body length.

Last instar female: similar to last instar male. Body length 44.5–48.0 mm (Fig. 6j). Furcasternite (Fig. 11h) same in color as rest of body or weakly red. Abdominal sternite VII (Fig. 24k) extended to level of posterior margin of tergite X. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt.

### 若虫の齡期判別

1 齡若虫は、体長 9 mm 未満であること (Figs. 5, 6) や中列刺のうち第 I 刺がもっとも長いこと (Fig. 17a, j) から、ほかの齡と判別できる。2 齡から 4 齡の判別には、体長や基節背縁突起の有無、翅芽の有無が有用である (Figs. 5, 6, 10, 14, 15) : 2 齡は体長 11 mm 内外、基節背縁突起と翅芽を欠く ; 3 齡は体長 17 mm 内外、基節背縁突起を有し、翅芽を欠く ; 4 齡は体長 22 mm 内外、基節背縁突起と翅芽を有する。5 齡は、体長 24 mm 以上で翅脈を欠くことから、ほかの齡と判別できる (Figs. 5, 6, 14, 15)。6 齡と 7 齡の判別には、体長が有用である (Figs. 5, 6) : 6 齡は体長 28.0–33.0 mm ; 7 齡は体長 42.0–44.5 mm。前亜終齡 (6 齡), 亜終齡 (6 齡, 7 齡), 終齡 (7 齡, 8 齡) の判別には、とくに後翅芽の伸長度合いが有用である : 前亜終齡は後翅芽の末端が腹部第 I 背板の後縁に達しない (Figs. 5f, 6f) ; 亜終齡は後翅芽の末端が第 I 背板の後縁に達しない (Figs. 5g, h, 6g, h) ; 終齡は後翅芽の末端が第 I 背板の後縁を大きく超える (Figs. 5i, j, 6i, j)。また、亜終齡と終齡は、雌は腹部第 VII 腹板、雄では第 IX 腹板と下陰基板突起の発達度合いでも判別できる : 亜終齡の雌は、第 VII 腹板の後縁が第 I 背板の後縁に達しない (Fig. 24h, i) が、終齡の雌では第 VII 腹板の後縁が第 I 背板の後縁を超える (Fig. 24j, k) ; 亜終齡の雄は、第 IX 腹板の後縁が第 I 背板の後縁に達せず、下陰基板突

起は第 IX 腹板から露出しない (Fig. 23g, h) が、終齢の雄では、第 IX 腹板の後縁が第 I 背板の後縁を超え、下陰基板突起は第 IX 腹板から露出する (Fig. 23i, j).

以上の特徴から、ムネアカハラビロカマキリは外部形態による齢期判別が可能である.

### 若虫の雌雄判別

1 齢若虫では、外部形態における雌雄差は確認できなかった. 2 齢では、雌は腹部第 IX 腹板の後縁 (生殖片の間) に小さな切れ込みが生じる (Fig. 24c) のに対し、雄の腹部第 IX 腹板の後縁 (尾突起の間) はほぼ平坦である (Fig. 23b) ことから雌雄が判別できる. ただし、一部の雌個体は雄に似た特徴を表すことがある (Fig. 24b). 3 齢から終齢では、3 つの形質から判別できる (Figs. 23, 24) : (1) 雌は第 VII 腹板の後縁が湾曲しながら後方に拡張し、加齢に伴い垂生殖板を形成するのに対し、雄の第 VII 腹板の後縁はほぼ平坦であり、加齢に伴う形状の変化はほとんどない ; (2) 雌は 3 齢の一部の個体を除き、第 VIII 腹板の後縁に一对の陰具片を有するのに対し、雄の第 VIII 腹板の後縁はほぼ平坦であり、加齢に伴う形状の変化はほとんどない ; (3) 雌は第 IX 腹板に一对の陰具片と生殖片を有し、それらの形状が加齢に伴い変化するのに対し、雄の第 IX 腹板の尾突起には加齢に伴う形状の変化はほとんどない. また、雄の叉甲腹板は 4 齢以降において明瞭に赤色を呈する (Fig. 10e-h) が、雌では 5 齢以降において、基本的に薄い赤色を呈し (Fig. 11e), 明瞭に赤色化することはまれである (Fig. 11c) うえ、個体によっては終齢まで赤色化しないこともある (Fig. 11g).

以上の特徴から、ムネアカハラビロカマキリは 2 齢以降に外部形態による雌雄判別が可能である.

### 若虫期における種同定

ハラビロとムネアカの若虫期において、種の同定形質として有用な形態は、体長 (Figs. 3-6), 胴体背面の紋の有無 (Figs. 3-6), 前胸背板の縦横比と側縁の突起の発達度合い (Figs. 7, 8), 叉甲腹板の斑紋の有無 (Figs. 9-11), 基節背縁突起の形状 (Figs. 9-11), 前脚腿節の縦横比 (Figs. 16, 17), 中・後脚腿節と中・後脚脛節の発色 (Figs. 18, 19) であった. 1 齢から終齢までの各齢における 2 種間の形態差は多く、全齢期において種の同定は容易である.

ハラビロとムネアカは以下の特徴で同定できる : (1) 体長は 2 齢から終齢の各齢において、ムネアカ > ハラビロである ; (2) ハラビロの胴体は、1 齢から 5 齢において背面に濃褐色の紋を有するが、ムネアカは 3 齢から 5 齢の前胸背板を除いて紋を欠く ; (3) 前胸背板の縦横比は 3 齢以降の各齢においてハラビロ > ムネアカであり、前胸背板側縁の突起の発達は 5 齢以降においてハラビロ > ムネアカ

である；(4) 又甲腹板は、ハラビロは 4 齢以降において後半部中央付近に褐色または濃褐色の斑紋を有するが、ムネアカは全齢において同箇所を欠く；(5) 基節背縁突起は、ハラビロは 3 齢以降において、無数の細かい突起と 2 から 4 個の黄色のいぼ状突起からなるが、ムネアカは 3 齢以降において無数の鋸歯状となる；(6) 前脚腿節の縦横比は 3 齢以降においてハラビロ>ムネアカである；(7) 中・後脚腿節は、ハラビロは 1 齢から 6 齢において中腹部と末端部が、7 齢以降ではより広範囲が基本的に褐色を呈するが、ムネアカは 1 齢から 4 齢において全体的に体色と同色で、5 齢以降では全体的に濃褐色を呈する；(8) 中・後脚脛節は、ハラビロは 1 齢から 6 齢において基部、中腹部、末端部が基本的に褐色を呈し、7 齢以降では体色と同色であるが、ムネアカは 1 齢と 2 齢において末端部のみが褐色を呈し、3 齢以降では全体的に体色と同色である。

成虫に有用な同定形質である体長は、2 齢以降の各齢において若虫でも有用であり、雌雄ともにハラビロに対してムネアカが、2 齢で約 1.2 倍、3 齢から終齢においては約 1.3–1.4 倍大きい。同じく成虫の同定に有用な前胸背板の縦横比と基節背縁突起は、3 齢以降において若虫でも有用であった。とくに基節背縁突起は、2 種間で形状が著しく異なり個体変異も小さいことから、成虫と同様に 2 種における最も有用な同定形質と考えられる。一方で、同じく成虫における種同定によく用いられ、ムネアカの和名の由来にもなった又甲腹板の発色は、4 齢以降に両種間に形態差が生じたものの、安定して明瞭に赤色化したのはムネアカの雄のみであった。ムネアカの雌は、5 齢以降において基本的に薄く赤色化、あるいは全齢期において体色と同色であり、明瞭に赤色化するのはいずれであるなど、発色具合に性差が確認されたため、若虫における又甲腹板の発色は 2 種の同定形質としては不安定である。しかし、ハラビロの特徴である又甲腹板の濃褐色の斑紋は、5 齢以降において安定して生じるため、若虫にも有用な同定形質である。

今回、新たに着目した部位のうち、胴体背面の紋の有無は 1 齢から 5 齢において、前脚腿節の縦横比は 3 齢以降において、中・後脚腿節と中・後脚脛節の発色は全齢期において種同定に有用であったが、胴体背面の紋の有無と中・後脚腿節、中・後脚脛節の発色は、ハラビロの野外個体では今回の特徴に完全には当てはまらない可能性があるため、より詳細な調査が必要である。翅芽と腹部腹板には種の同定に有用な差異は確認できなかった。

## 今後の展望

ムネアカが定着した地域におけるハラビロの減少要因のひとつとして、ムネアカの体長が、ハラビロの体長に対して雄で約 1.3 倍、雌で約 1.2 倍大きいこと（間野・宇野 2015；間野 2018）と、これに起因したムネアカによるハラビロに対する捕食圧が挙げられている（間野・宇野 2014；松本ら 2016）。間野・宇野

(2014) によるハラビロとムネアカを用いた捕食実験では、両種ともに優位性は認められなかったが、当実験に用いた個体は、羽化時期や摂食状況が不明な野外採集個体であり、反復数も少ないため、明瞭な結果は得られていない(間野・宇野 2014; 松本ら 2016)。加えて、これらは成虫同士による実験のみであり、若虫同士では検証されていない。本研究によって、ハラビロとムネアカの若虫期における体長差は、齢期によっては成虫同士の体長差を上回ることが確認されたため、若虫期における両種の優位性の検証が求められる。また、ムネアカの孵化時期は、ハラビロより約1ヶ月早いことが知られており(山崎ら 2016; 渡邊ら 2017)、孵化したハラビロが、先に成長を始め体長差がより大きくなったムネアカによって捕食されている可能性は高いと思われる。したがって、ムネアカによるハラビロに対する捕食圧の有無を検証するためには、野外における両種の齢期の差を調査し、その差を踏まえた捕食実験が必要だと考える。

ムネアカの生態は未解明な点が多く(間野 2018; 苅部・加賀 2019)、とくに若虫に関する知見は極めて少ない。本研究によって、ハラビロとムネアカの若虫における種同定が可能になったことで、若虫発生時期での分布調査や個体数調査、両種の競合の実態把握などの進展が期待される。

#### ***Hierodula* 属 2 種の若虫による種、齢期、性別の検索表**

1. 前脚腿節の中列刺は第 I 刺がもっとも長い……………2
  - 前脚腿節の中列刺は第 III 刺がもっとも長い……………3
2. 胴体の背面に濃褐色の紋を有する；中・後脚腿節は中腹部と末端部が褐色を呈する；中・後脚脛節は基部，中腹部，末端部が褐色を呈する……………ハラビロ 1 齢
  - 胴体の背面は濃褐色の紋を欠く；中・後脚腿節は体色と同色；中・後脚脛節は末端部が褐色を呈する……………ムネアカ 1 齢
3. 基節背縁突起を欠く……………4
  - 基節背縁突起を有する……………7
4. 体長は 11 mm 未満……………5
  - 体長は 11 mm 以上……………6
5. 腹部第 IX 腹板の後縁が前方に深く抉れ，小さな切れ込みがある……………ハラビロ 2 齢雌
  - 腹部第 IX 腹板の後縁はほぼ平坦である……………ハラビロ 2 齢雄
6. 腹部第 IX 腹板の後縁が前方に深く抉れ，小さな切れ込みがある……………ムネアカ 2 齢雌
  - 腹部第 IX 腹板の後縁はほぼ平坦である……………ムネアカ 2 齢雄

7. 基節背縁突起は無数の細かい突起と 2 から 4 個の黄色のいぼ状突起からなる……………8  
 — 基節背縁突起は無数の細かい鋸歯状の突起からなる……………20
8. 体長は 14 mm 未満；翅芽を欠く……………9  
 — 体長は 15 mm 以上；翅芽を有する……………10
9. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に弱く伸長する…ハラビロ 3 齢雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ 3 齢雄
10. 体長は 18 mm 未満……………11  
 — 体長は 18 mm 以上……………12
11. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ハラビロ 4 齢雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ 4 齢雄
12. 体長は 21 mm 未満；翅脈を欠く……………13  
 — 体長は 21 mm 以上；翅脈を有する……………14
13. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ハラビロ 5 齢雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ 5 齢雄
14. 体長は 25 mm 未満……………15  
 — 体長は 25 mm 以上……………16
15. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ハラビロ 6 齢雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ 6 齢雄
16. 後翅芽の末端は腹部第 I 背板の後縁に達しない……………17  
 — 後翅芽の末端は腹部第 I 背板の後縁に達する……………19
17. 体長は 28 mm 未満……………ハラビロ前亜終齡（7 齢）雌  
 — 体長は 28 mm 以上……………18
18. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ハラビロ亜終齡（7 齢，8 齢）雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ亜終齡（7 齢）雄
19. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ハラビロ終齡（8 齢，9 齢）雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ハラビロ終齡（7 齢）雄
20. 体長は 19 mm 未満；翅芽を欠く……………21  
 — 体長は 20 mm 以上；翅芽を有する……………22
21. 腹部第 VII 腹板の後縁は弱く湾曲し，後方に弱く伸長する…ムネアカ 3 齢雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ 3 齢雄
22. 体長は 24 mm 未満……………23  
 — 体長は 24 mm 以上……………24

23. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ 4 齡雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ 4 齡雄
24. 翅脈を欠く……………25  
 — 翅脈を欠く……………26
25. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ 5 齡雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ 5 齡雄
26. 体長は 34 mm 未満……………27  
 — 体長は 34 mm 以上……………30
27. 体長は前翅芽長の約 7.5 倍である……………28  
 — 体長は前翅芽長の約 6.5 倍である……………29
28. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ前亜終齡 (6 齡) 雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ前亜終齡 (6 齡) 雄
29. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ亜終齡 (6 齡) 雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ亜終齡 (6 齡) 雄
30. 後翅芽の末端は腹部第 I 背板の後縁に達しない……………31  
 — 後翅芽の末端は腹部第 I 背板の後縁を大きく超える……………32
31. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ亜終齡 (7 齡) 雌  
 — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ亜終齡 (7 齡) 雄
32. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………ムネアカ終齡 (7 齡, 8 齡) 雌
33. — 腹部第 VII 腹板の後縁はほぼ平坦である……………ムネアカ終齡 (7 齡, 8 齡) 雄



2-2-4 図および表

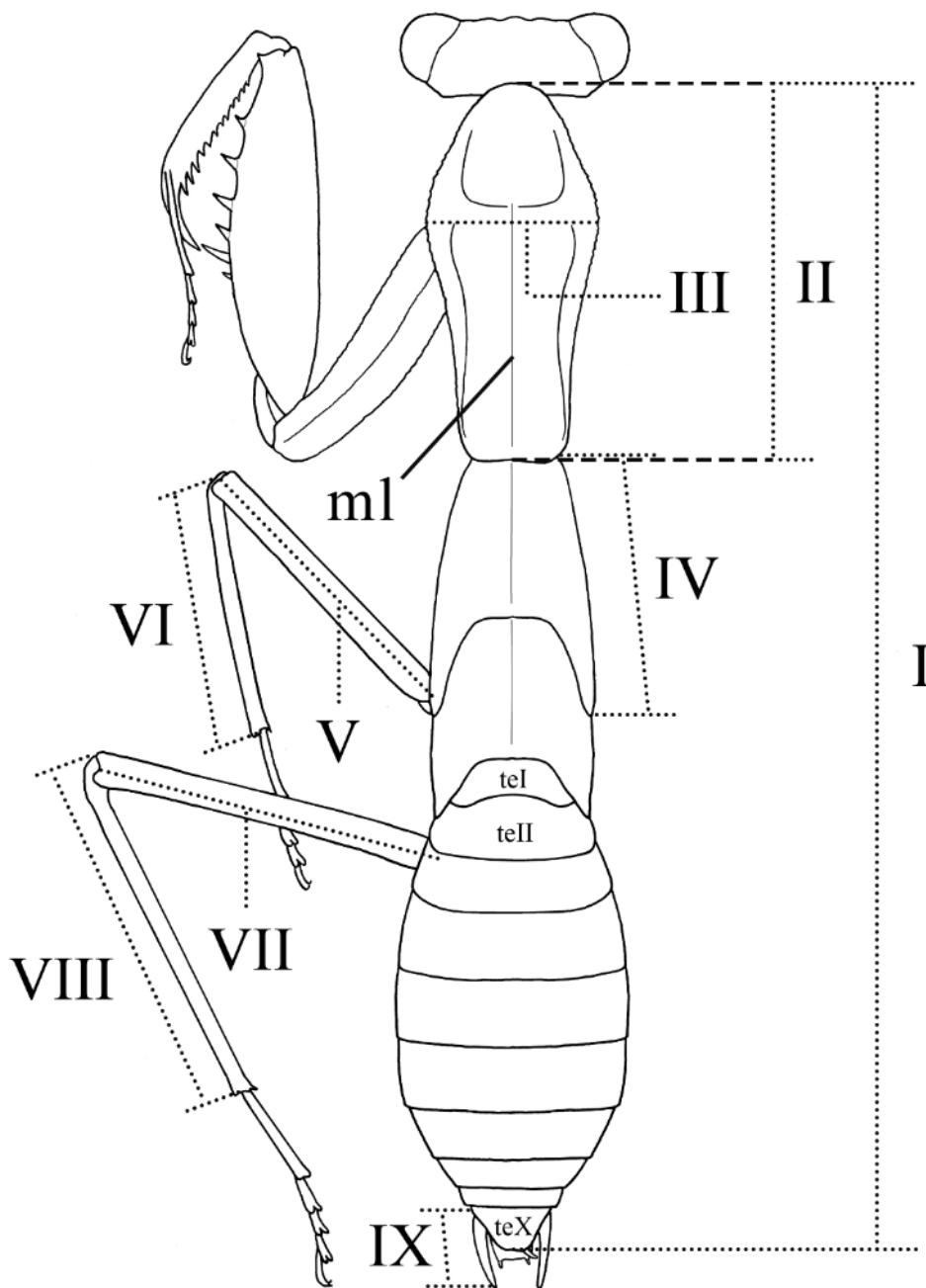


Fig. 1. General structure of nymphs of the genus *Hierodula*, dorsal view. I: body length. II: pronotum length. III: pronotum width. IV: fore wing pad length. V: mesofemur length. VI: mesotibia length. VII: metafemur length. VIII: metatibial length. IX: cercus length. ml = medial line; tel = tergite I; teII = tergite II; teX = tergite X.

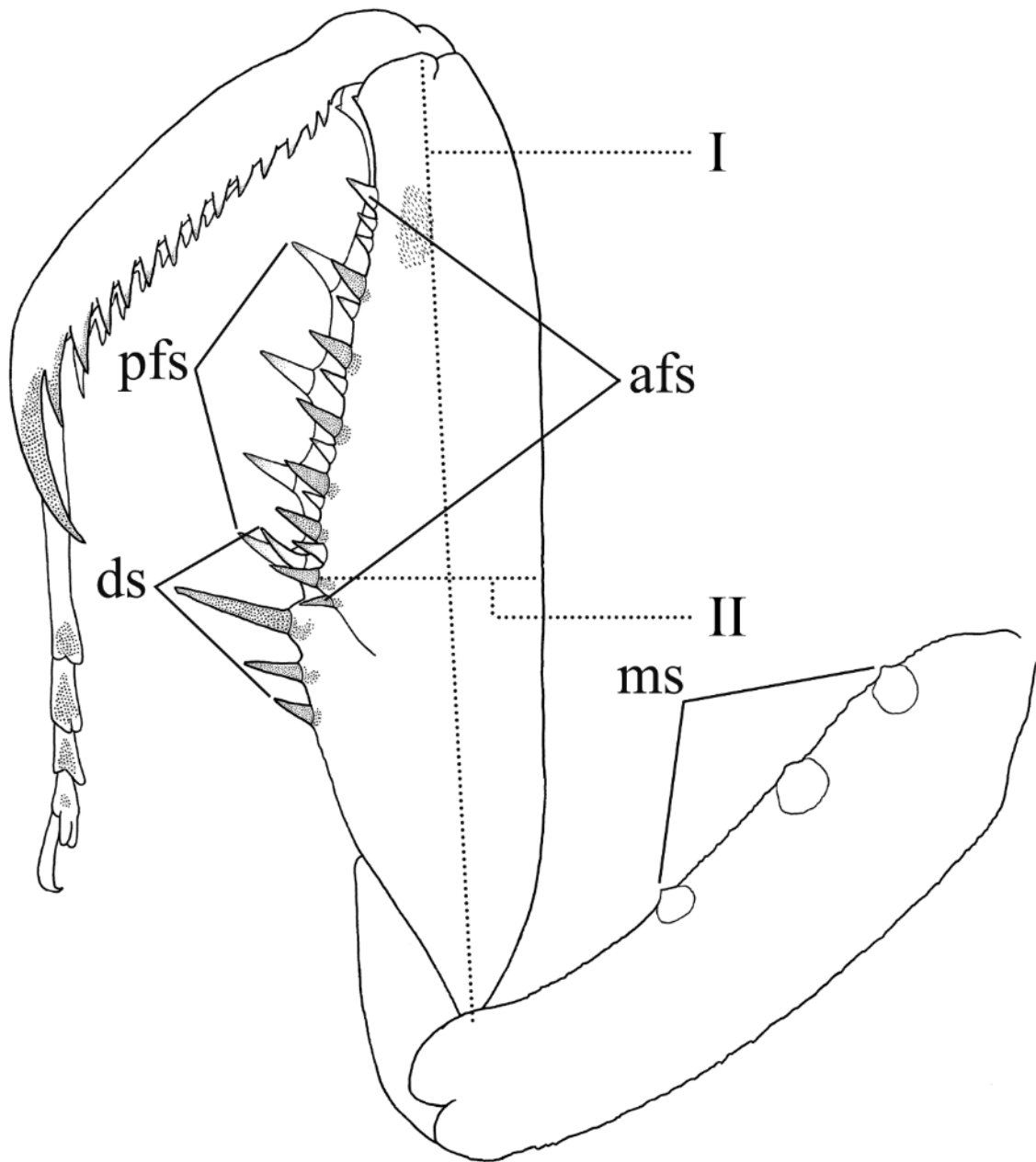


Fig. 2. General structure of foreleg of the genus *Hierodula*, lateral view. I: profemur length. II: profemur width. afs = anteroventral-femoral spines; ds = discoidal spines; ms = marginal spines; pfs = posteroventral-femoral spines.

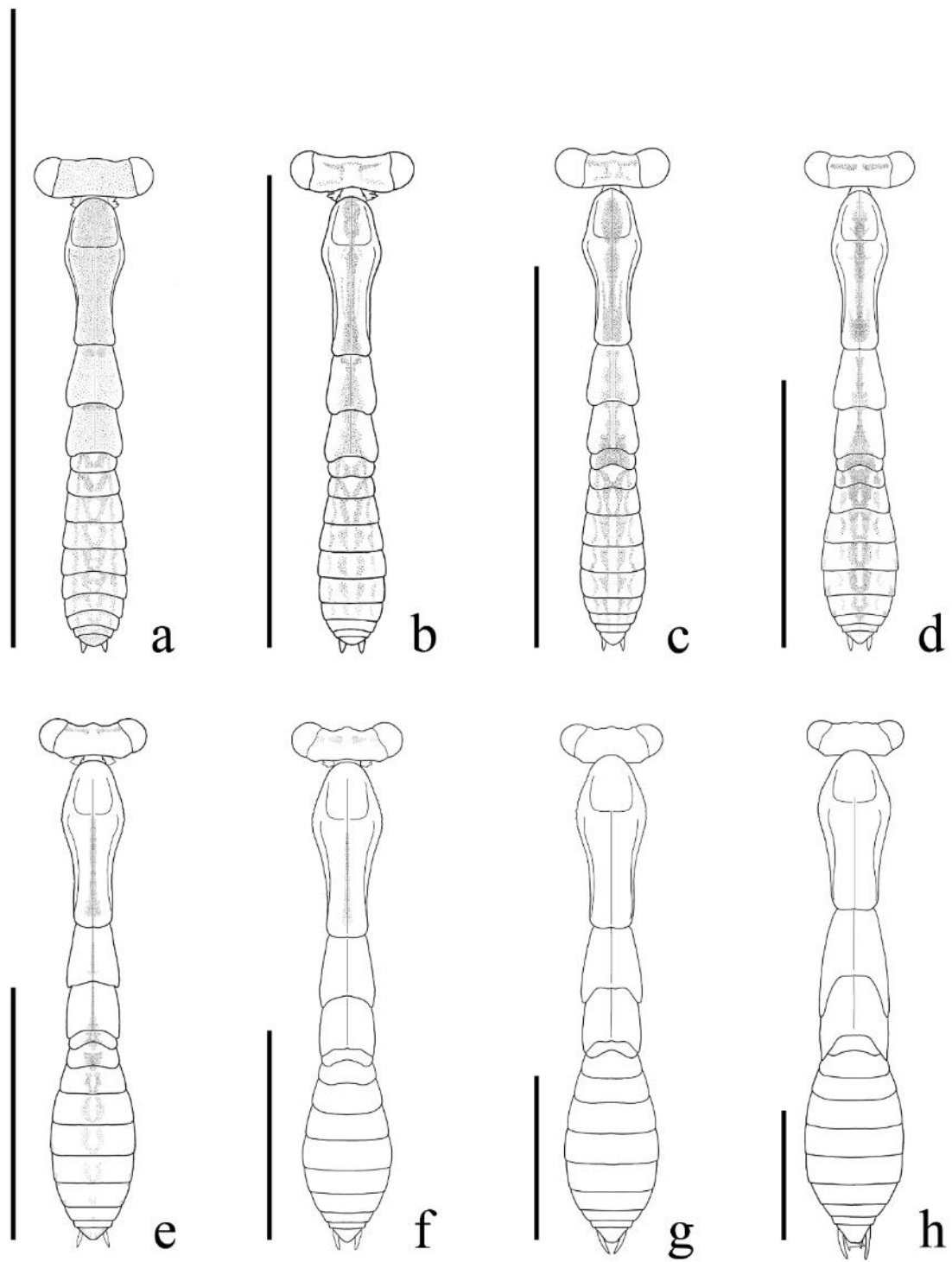


Fig. 3. General aspect in nymphal stages of *H. patellifera*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th instar; h, 8th instar. Scale bars: 10 mm.

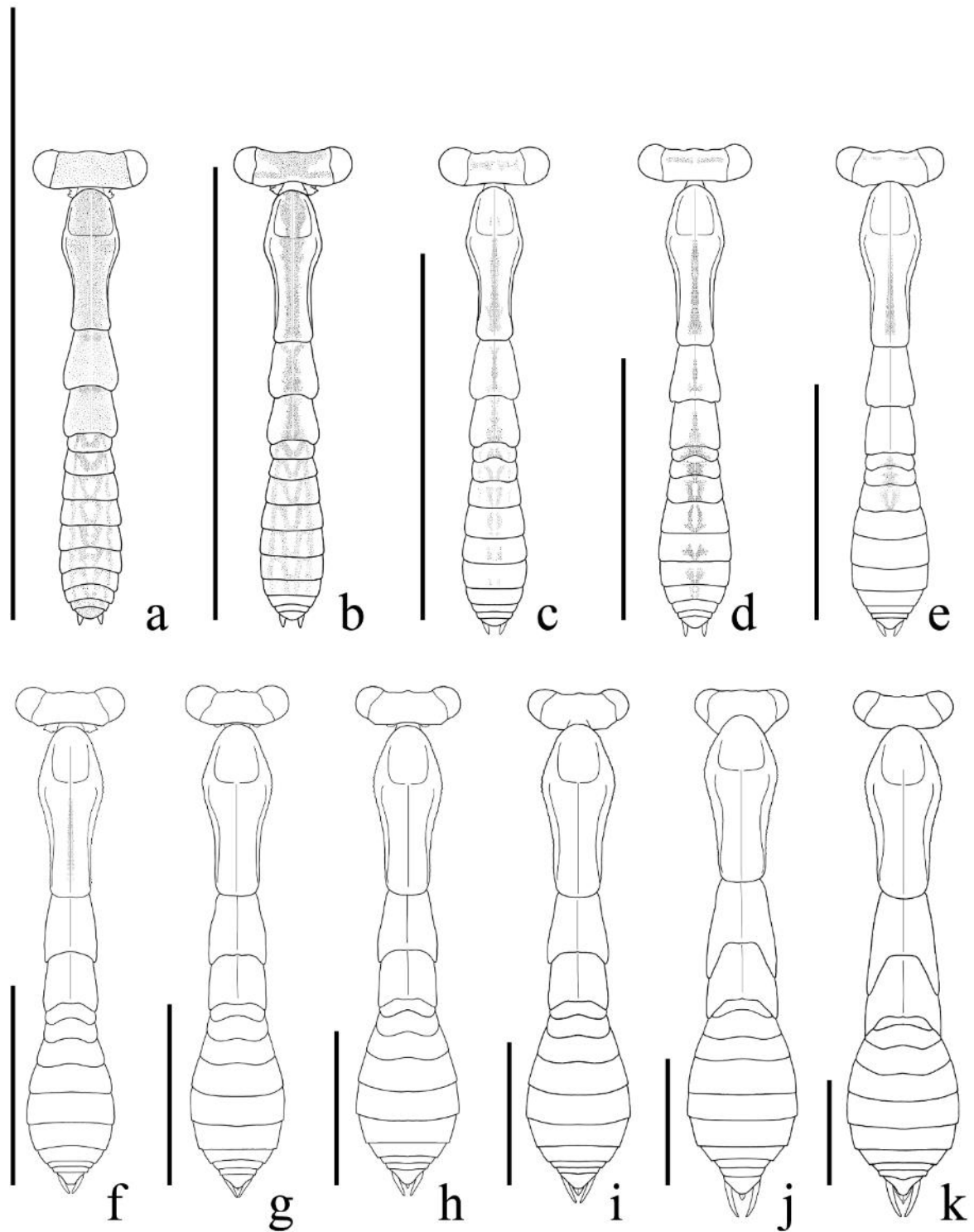


Fig. 4. General aspect in nymphal stages of *H. patellifera*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 10 mm.

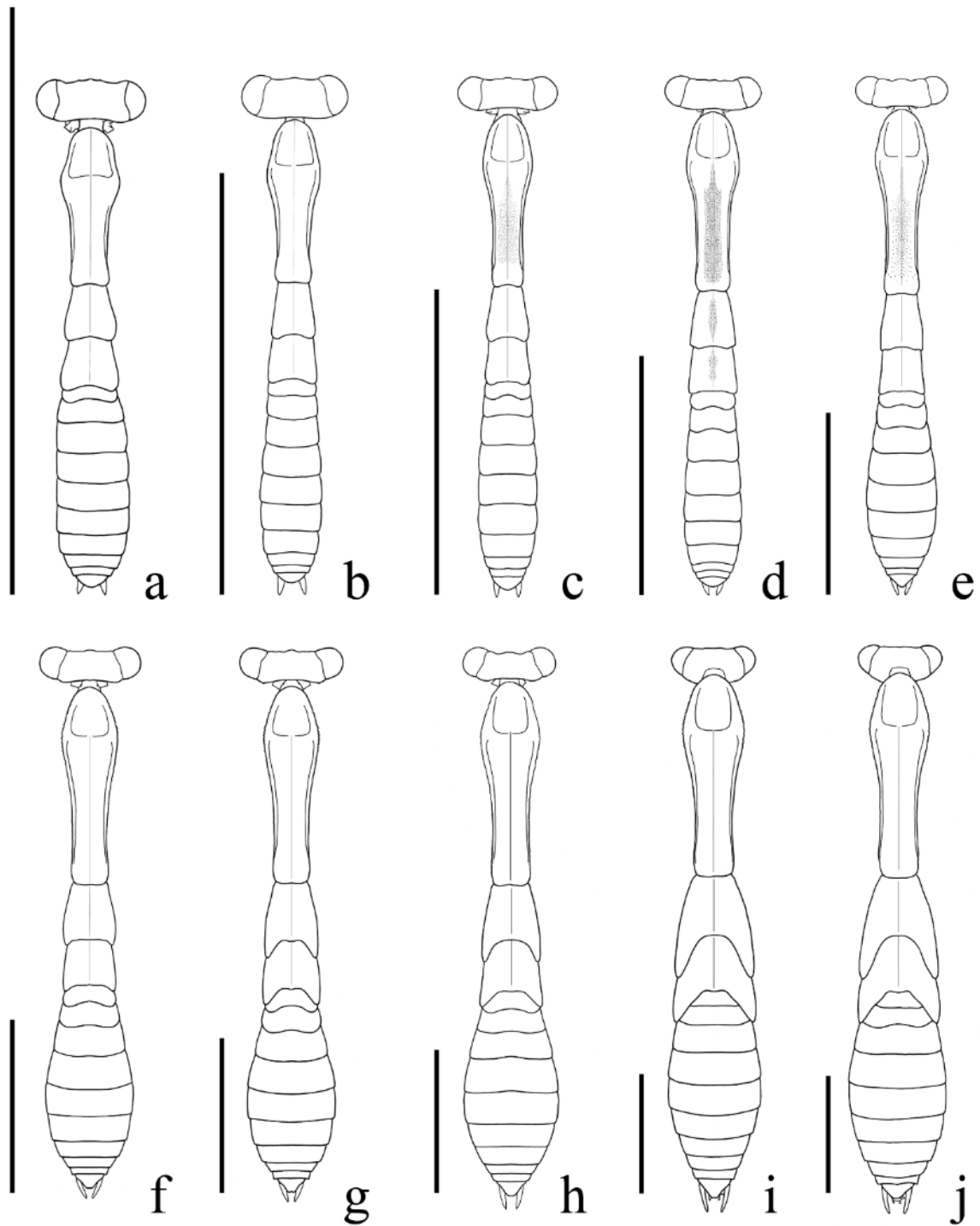


Fig. 5. General aspect in nymphal stages of *H. sp.*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 10 mm.

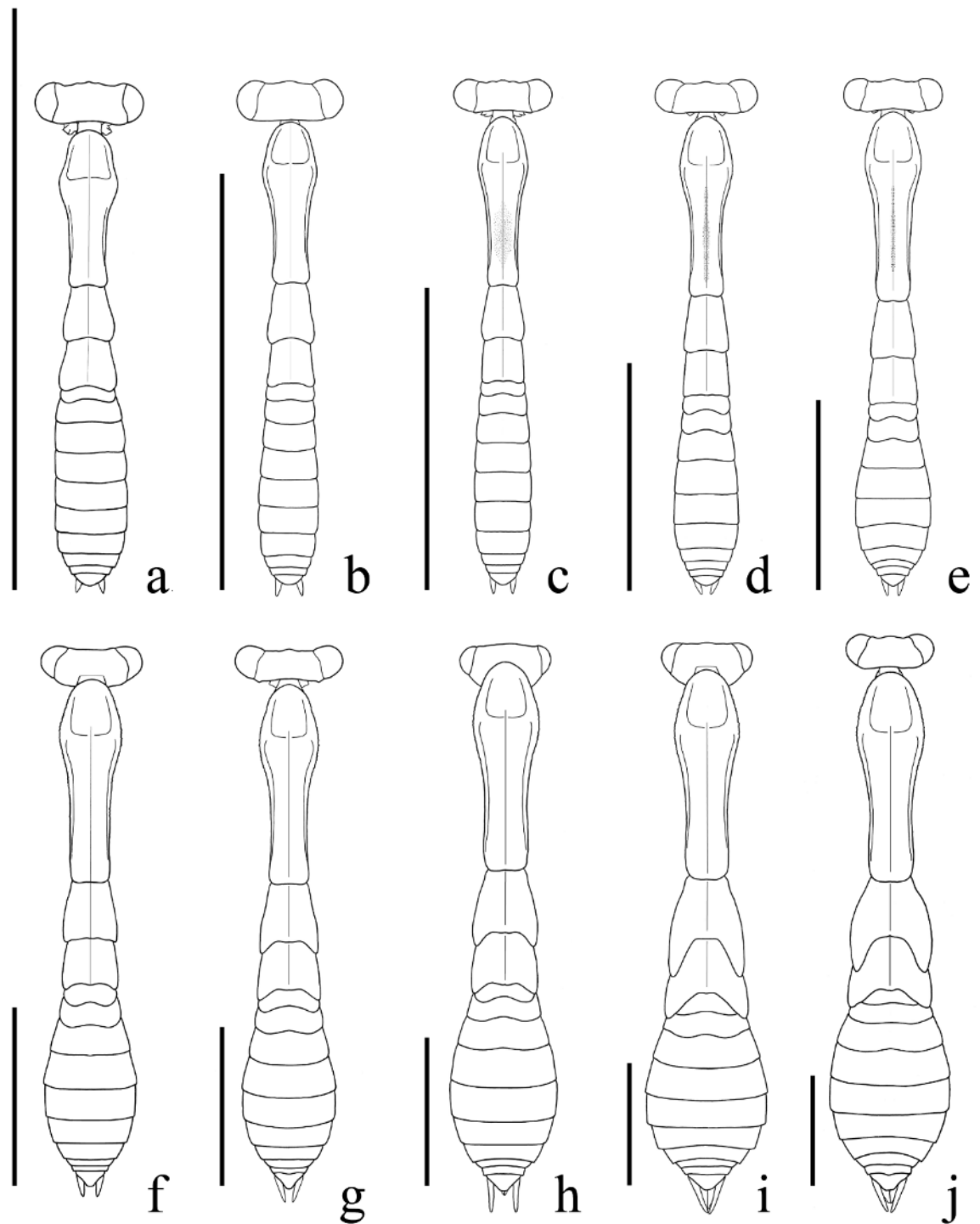


Fig. 6. General aspect in nymphal stages of *H. sp.*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 10 mm.

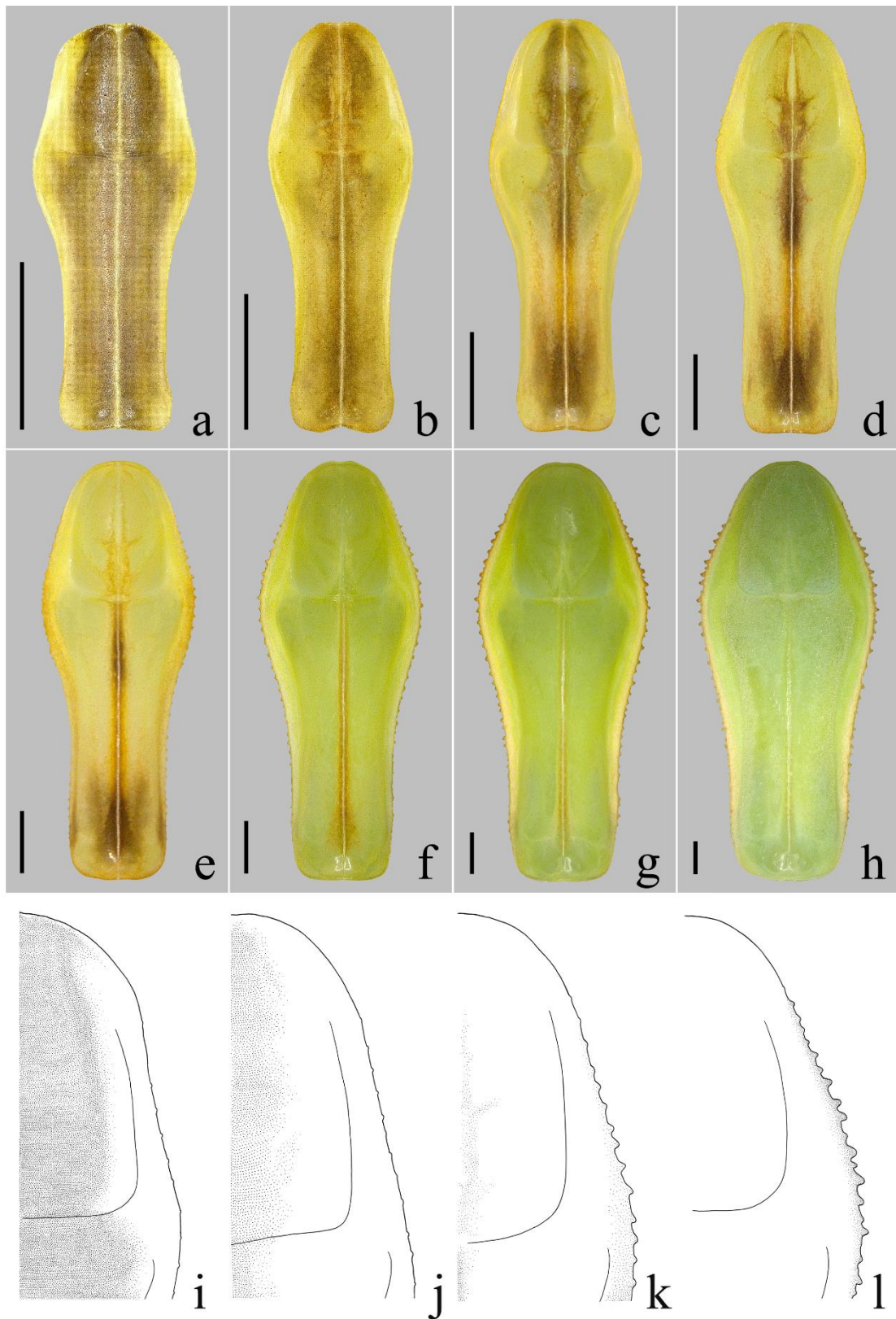


Fig. 7. Pronotum in nymphal stages of *H. patellifera*, male, dorsal view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th instar; g & l, 7th instar; h, 8th instar. Scale bars: 1 mm.

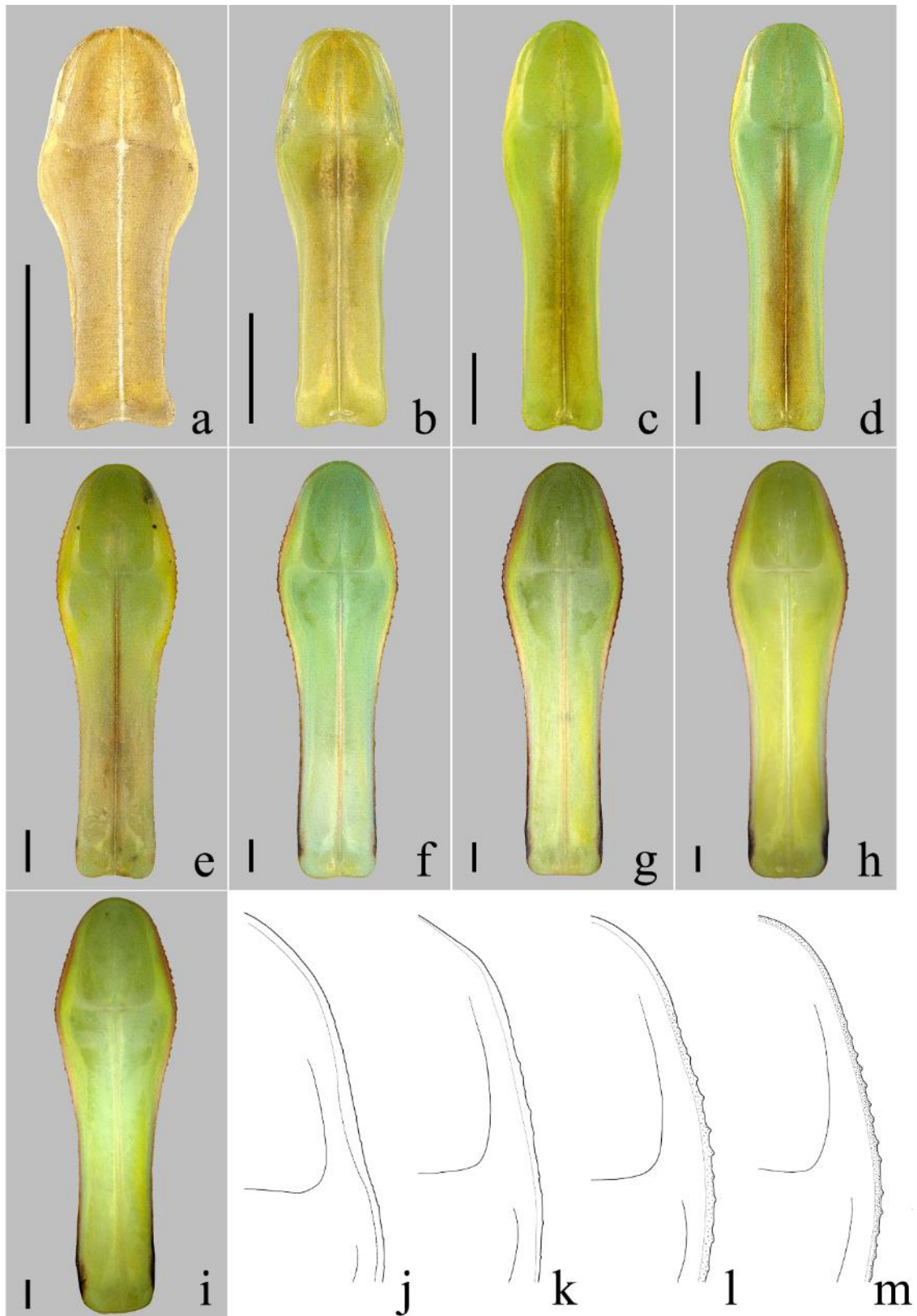


Fig. 8. Pronotum in nymphal stages of *H. sp.*, male, dorsal view. a & j, 1st instar; b, 2nd instar; c & k, 3rd instar; d, 4th instar; e & l, 5th instar; f, 6th (penultimate) instar; g, 7th (penultimate) instar; h & m, 7th (last) instar; i, 8th instar. Scale bars: 1 mm.



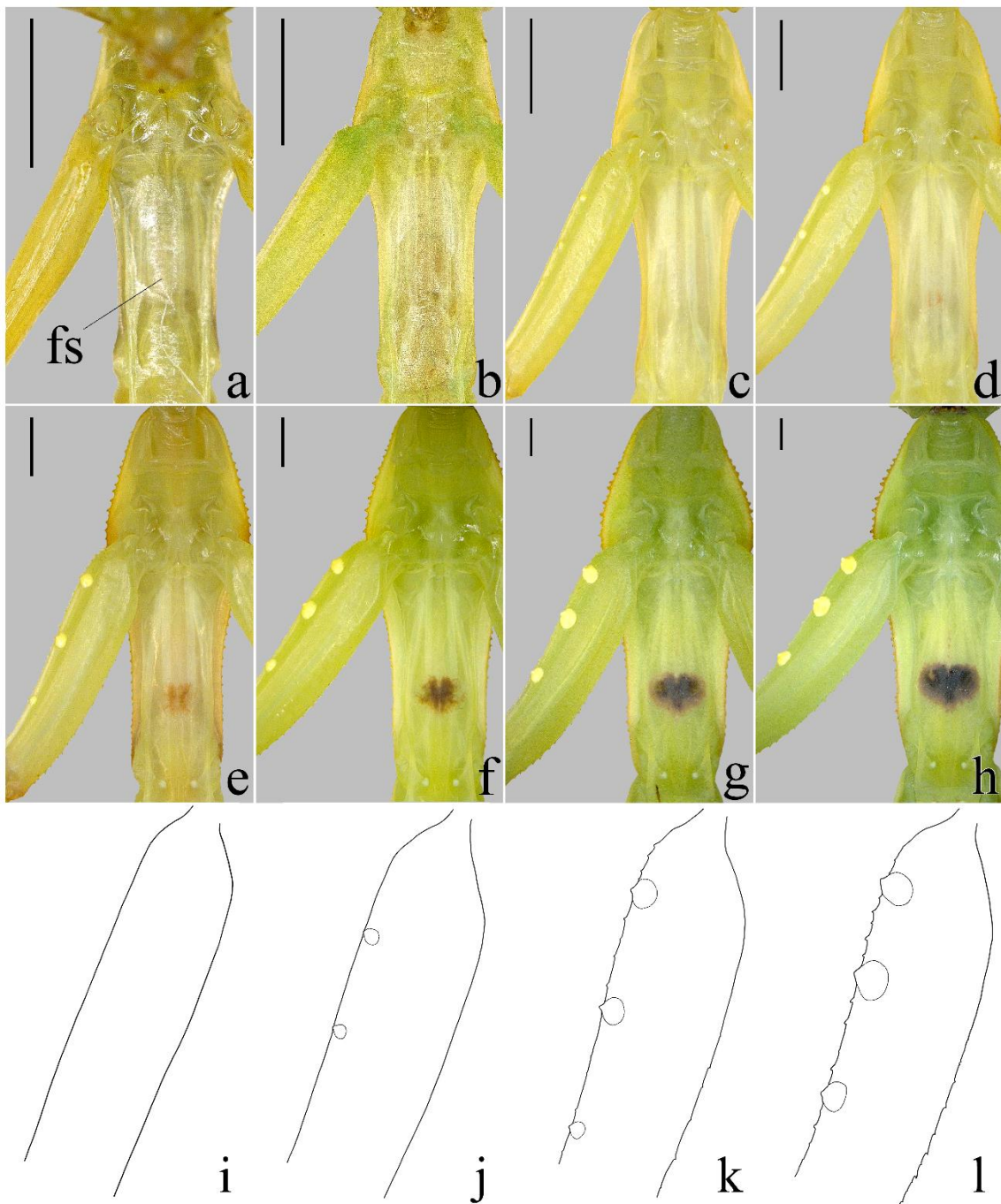


Fig. 9. Prothorax and procoxae in nymphal stages of *H. patellifera*, male, ventral view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th instar; g & l, 7th instar; h, 8th instar. fs = furcasternite. Scale bars: 1 mm.

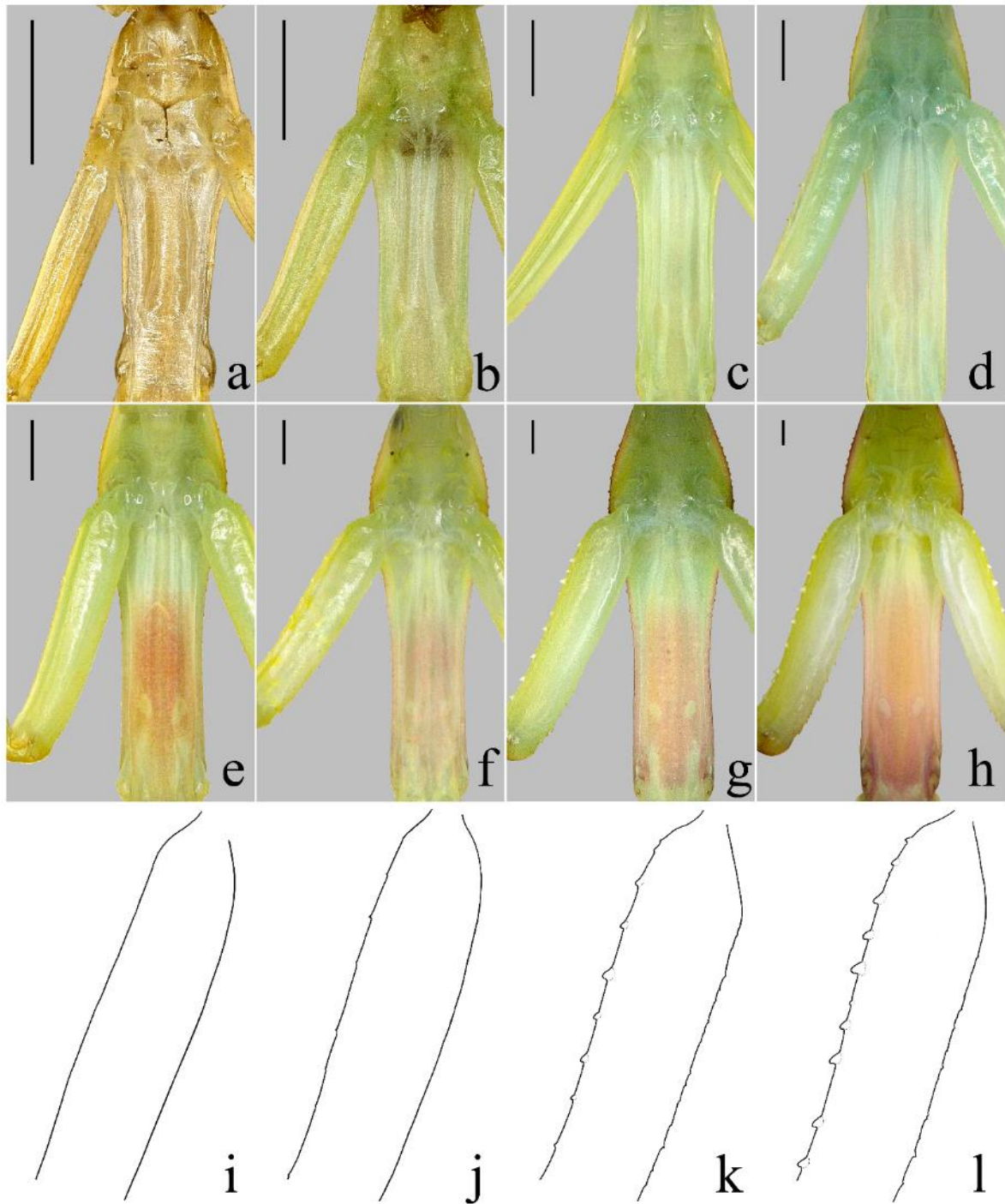


Fig. 10. Prothorax and procoxae in nymphal stages of *H. sp.*, male, ventral view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d & e, 4th instar; f & k, 5th instar; g, 6th (penultimate) instar; h & l, 7th (last) instar. Scale bars: 1 mm.

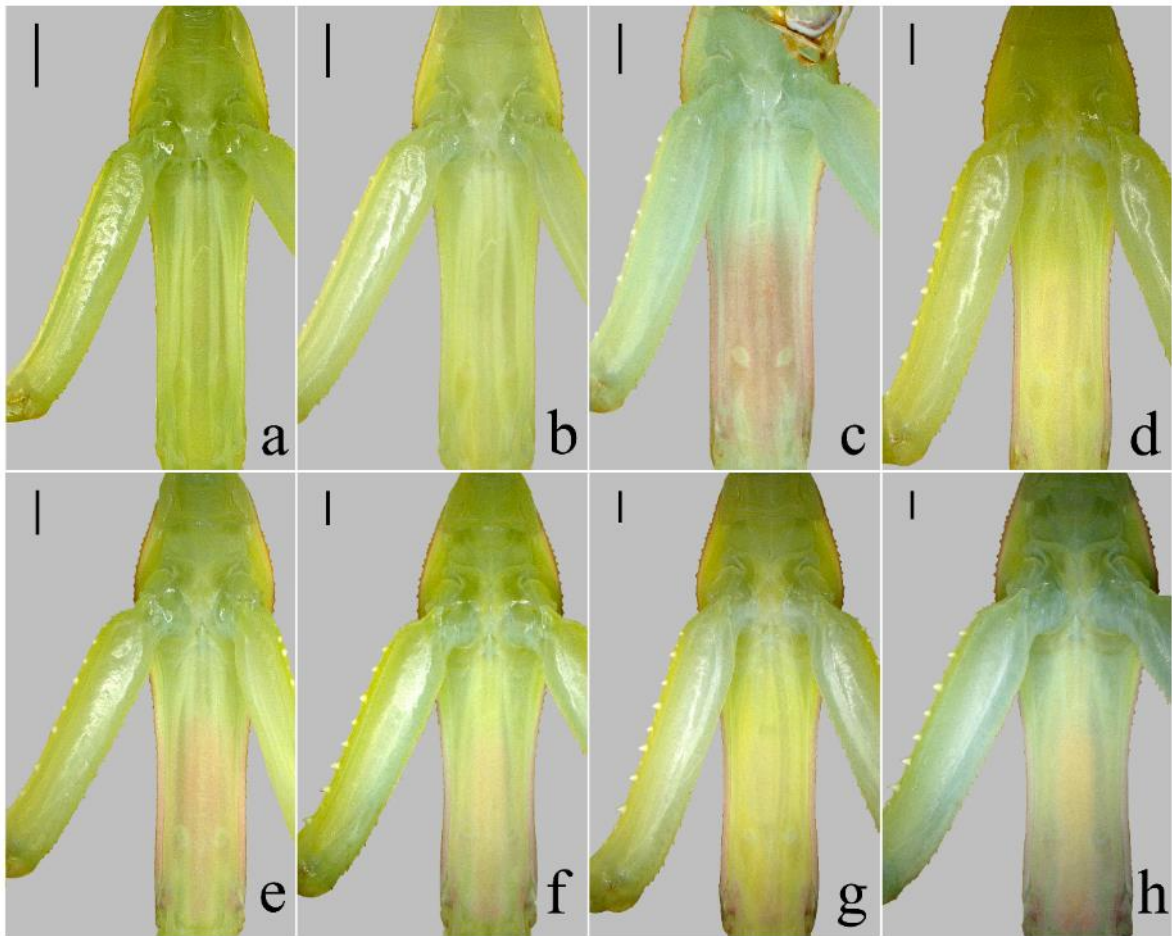


Fig. 11. Prosternum and procoxae in nymphal stages of *H. sp.*, female, ventral view. a, 4th instar; b & c, 5th instar; d & e, 6th instar; f, 7th (penultimate) instar; g, 7th (last) instar; h, 8th instar. Scale bars: 1 mm.

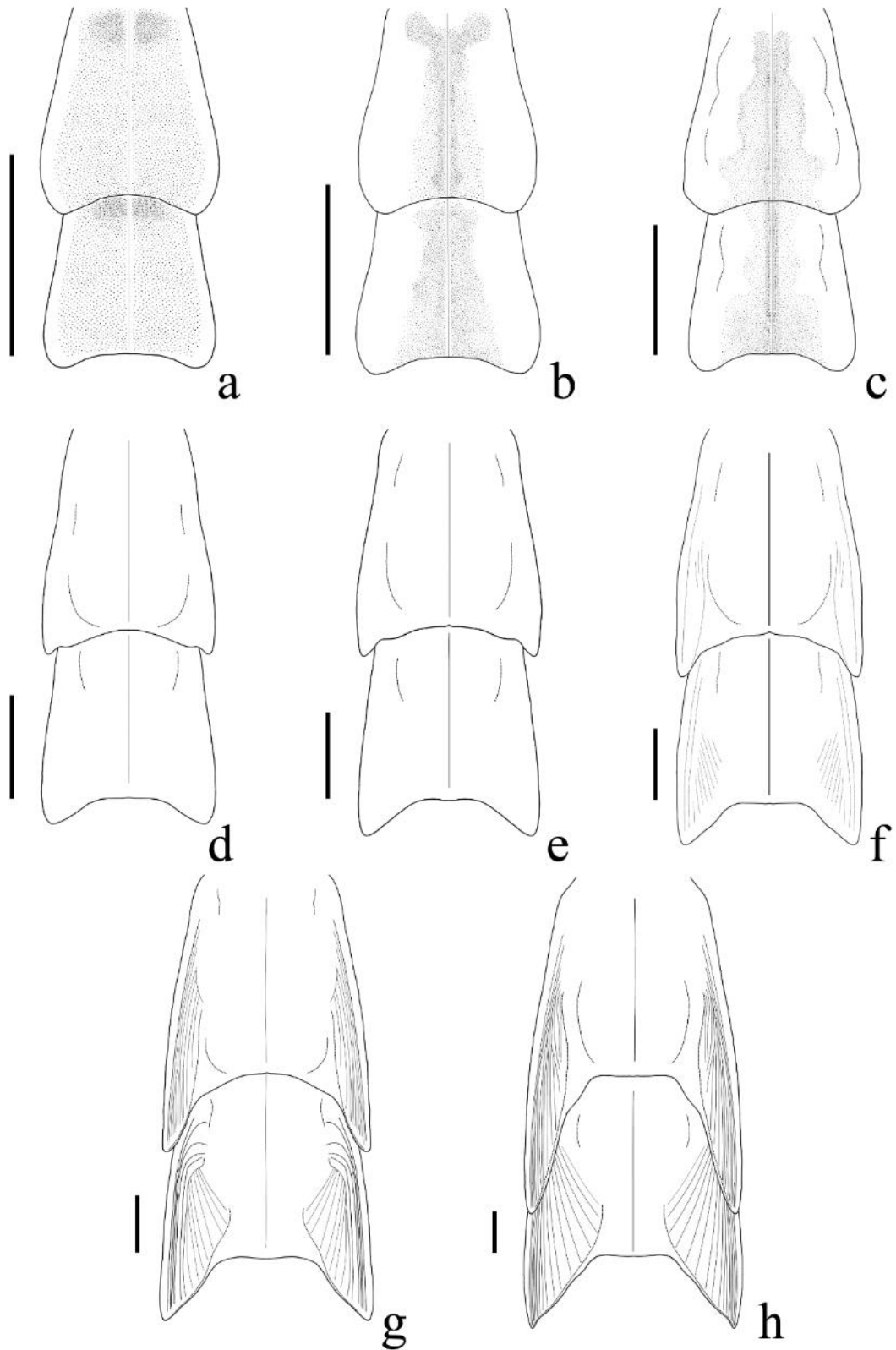


Fig. 12. Pterothorax and wing pads in nymphal stages of *H. patellifera*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th instar; h, 8th instar. Scale bars: 1 mm.

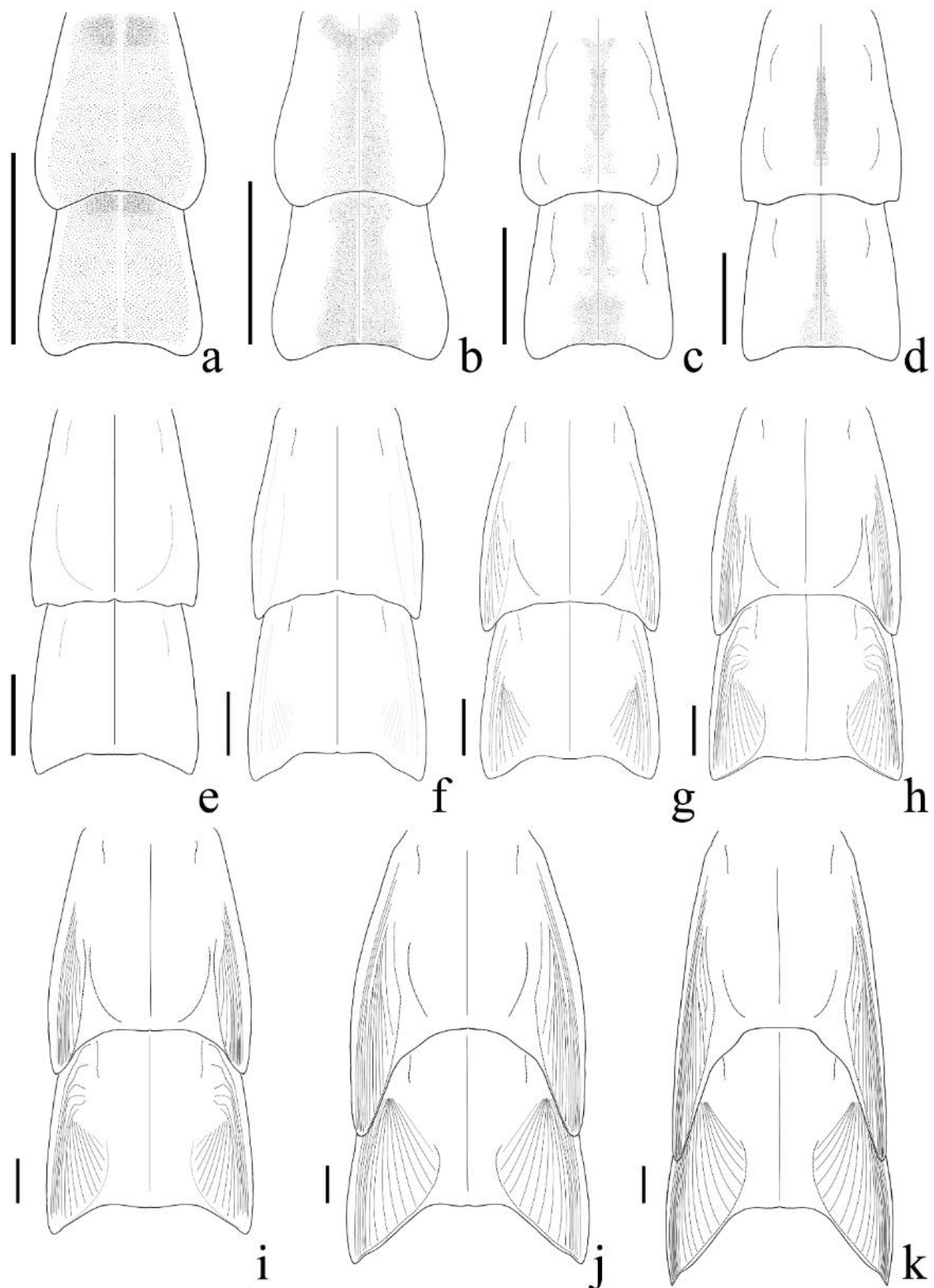


Fig. 13. Pterothorax and wing pads in nymphal stages of *H. patellifera*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (antepenultimate) instar; h, 7th (penultimate) instar; i, 8th (penultimate) instar; j, 8th (last) instar; k, 9th instar. Scale bars: 1 mm.

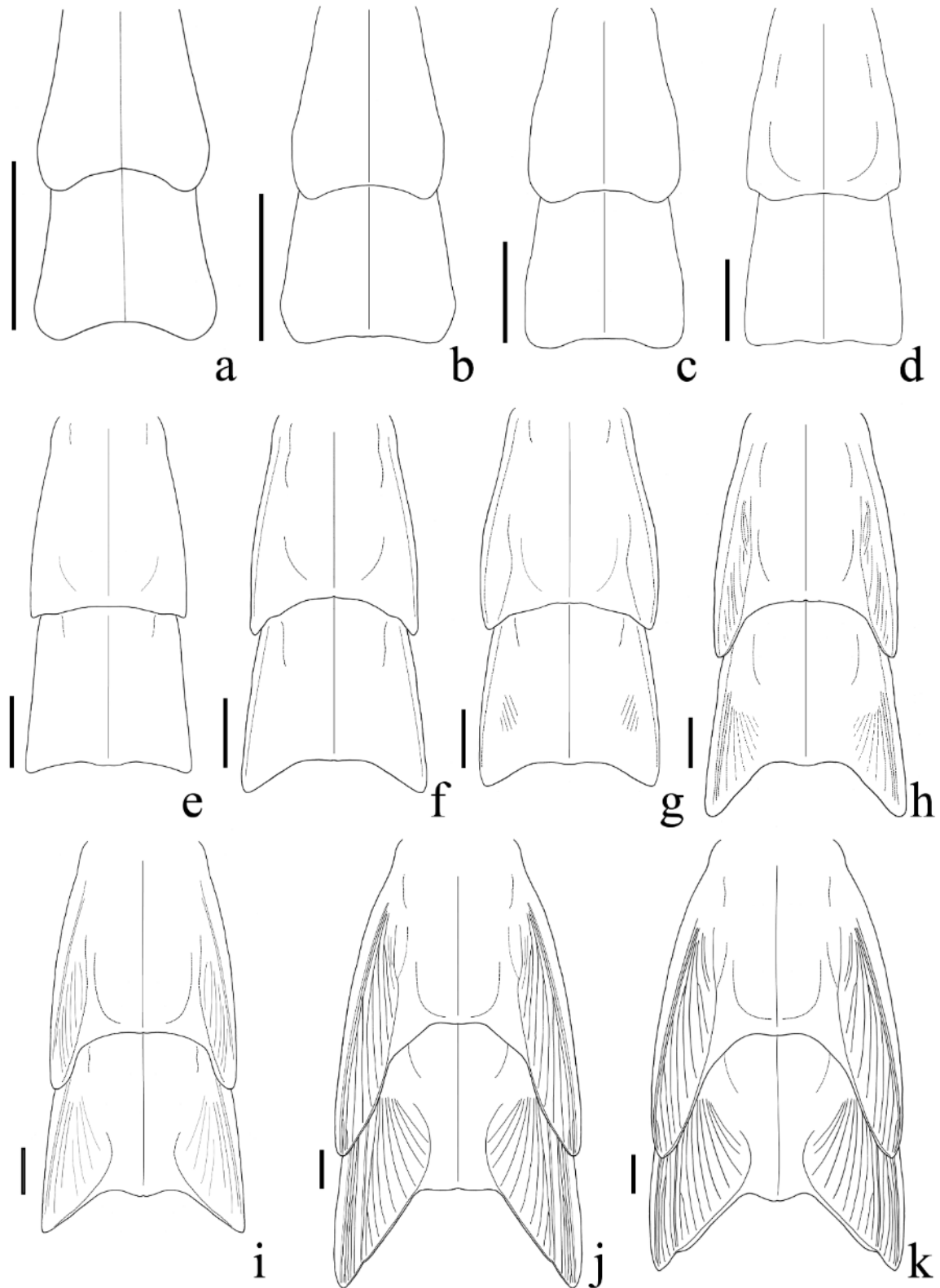


Fig. 14. Pterothorax and wing pads in nymphal stages of *H. sp.*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e & f, 5th instar; g, 6th (antepenultimate) instar; h, 6th (penultimate) instar; i, 7th (penultimate) instar; j, 7th (last) instar; k, 8th instar. Scale bars: 1 mm.

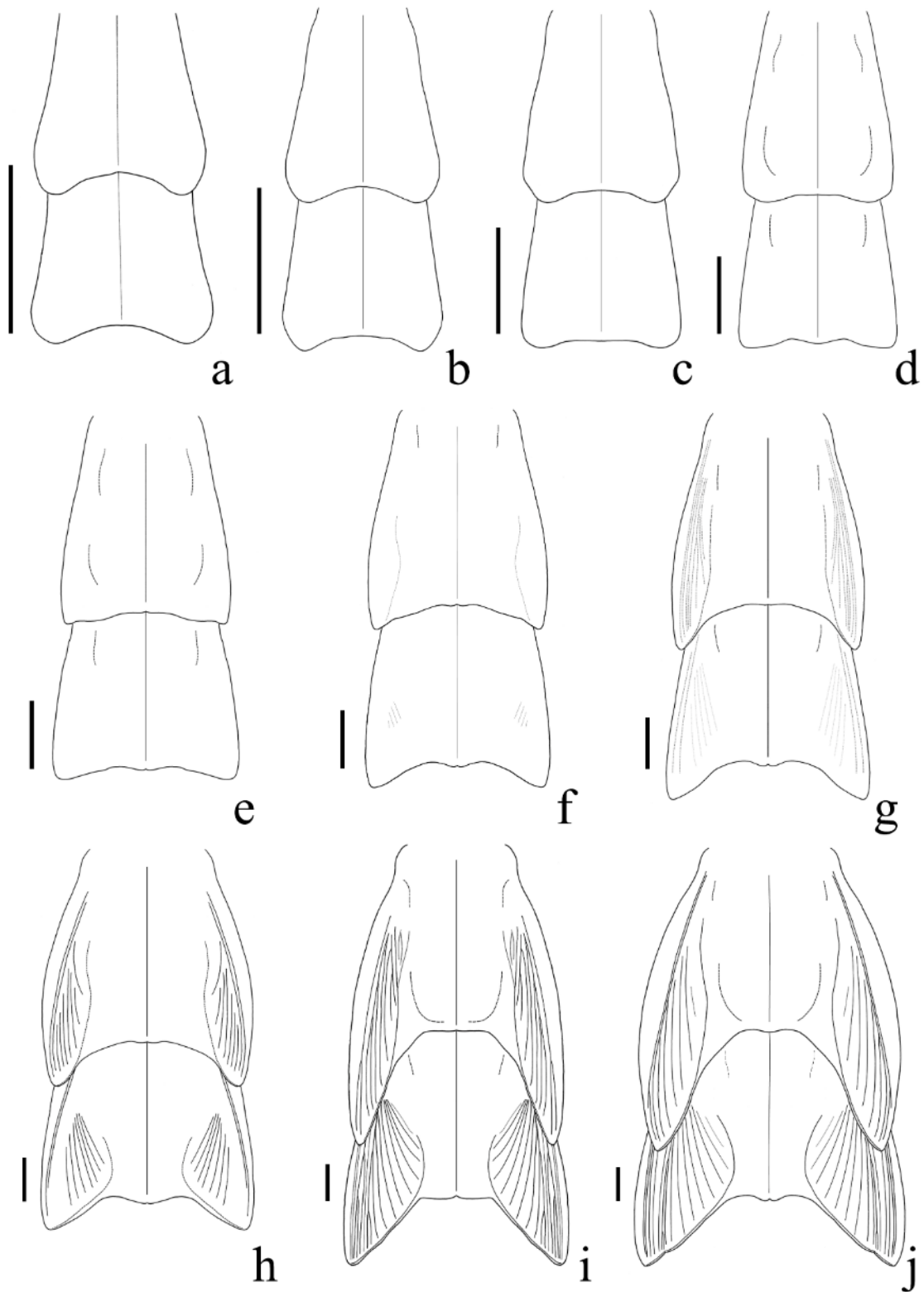


Fig. 15. Pterothorax and wing pads in nymphal stages of *H. sp.*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

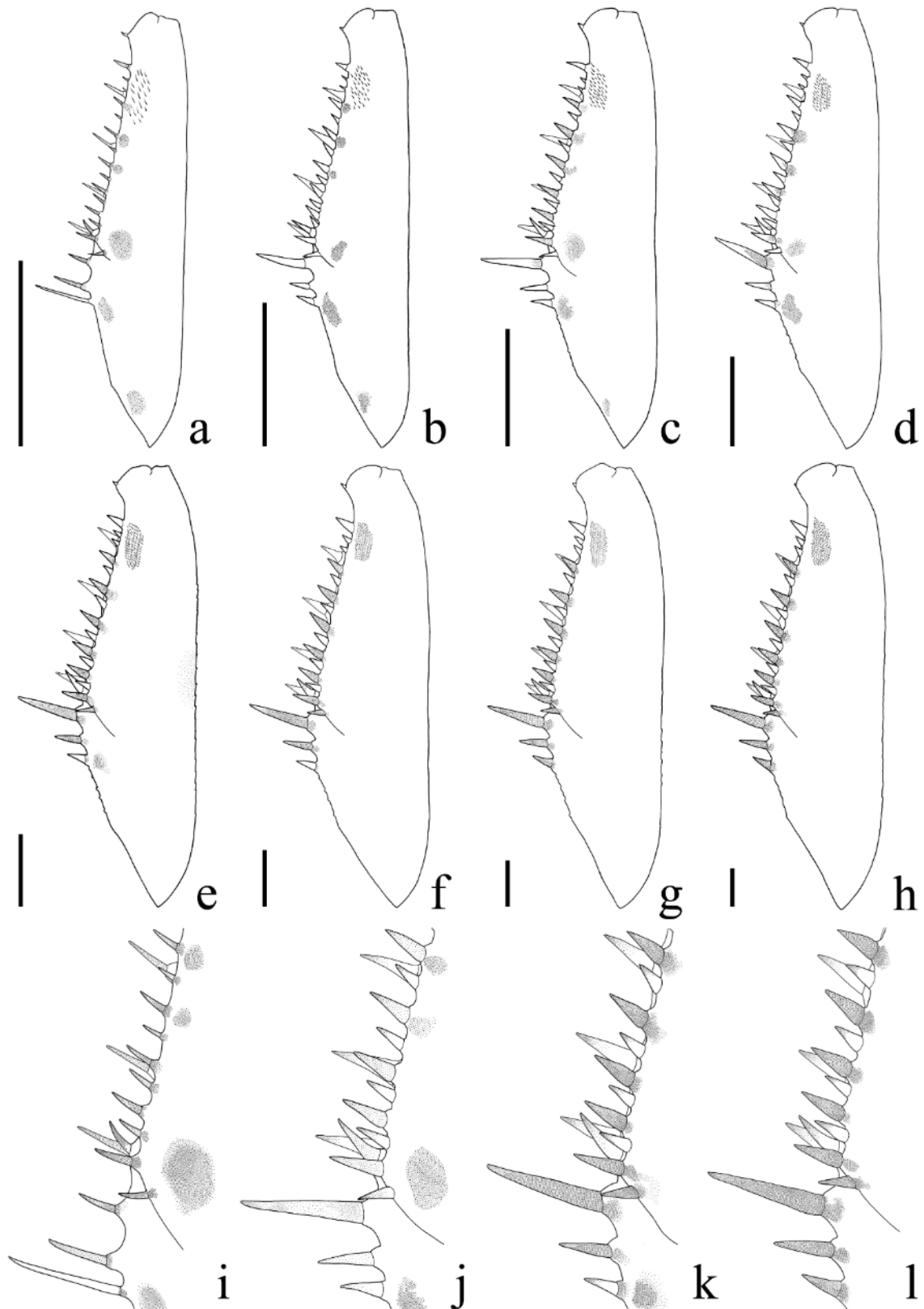


Fig. 16. Profemur in nymphal stages of *H. patellifera*, male, lateral view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th instar; g & l, 7th instar; h, 8th instar. Scale bars: 1 mm.



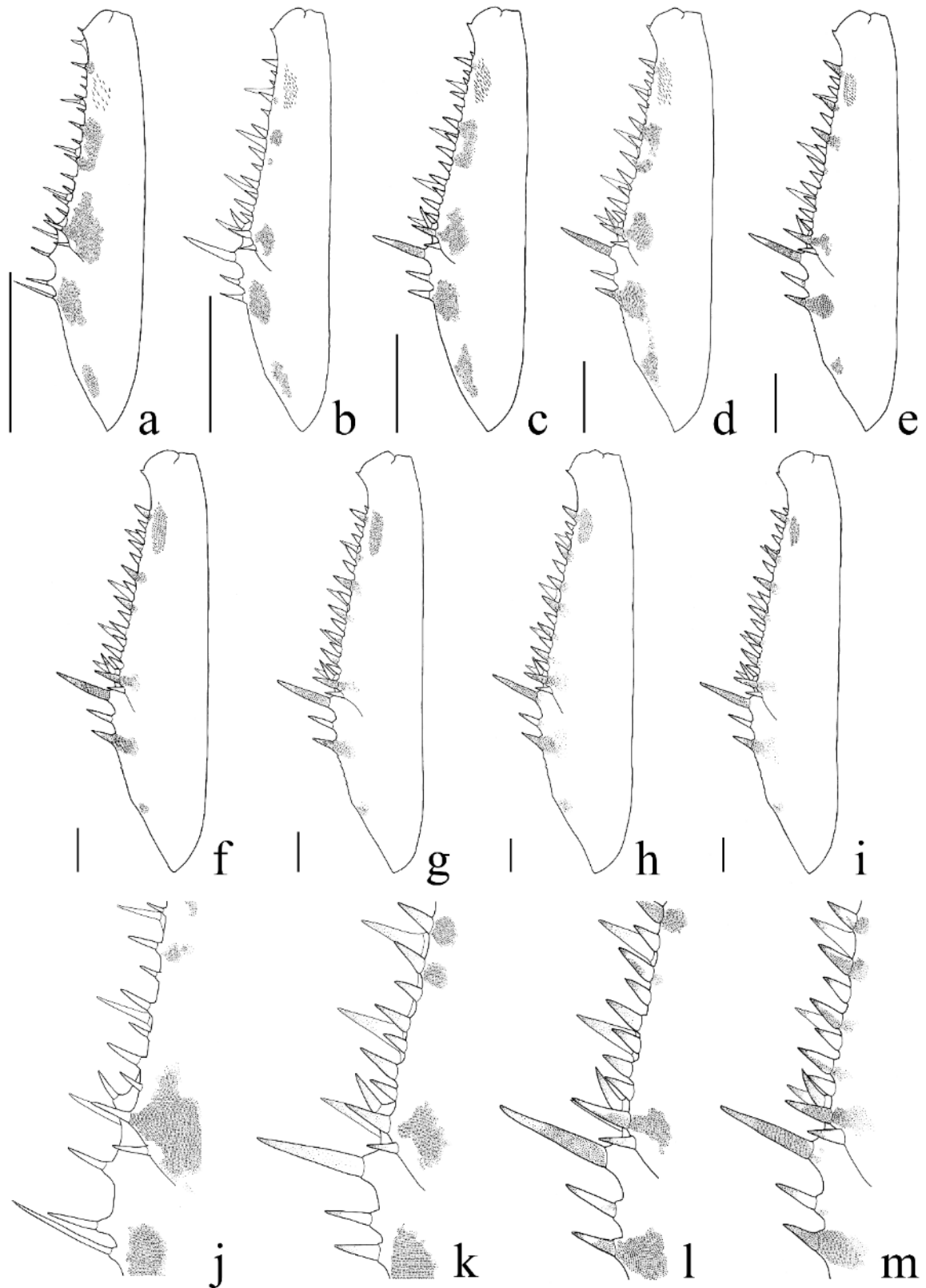


Fig. 17. Profemur in nymphal stages of *H. sp.*, male, lateral view. a & j, 1st instar; b, 2nd instar; c & k, 3rd instar; d, 4th instar; e & l, 5th instar; f, 6th (penultimate) instar; g, 7th (penultimate) instar; h & m, 7th (last) instar; i, 8th instar. Scale bars: 1 mm.

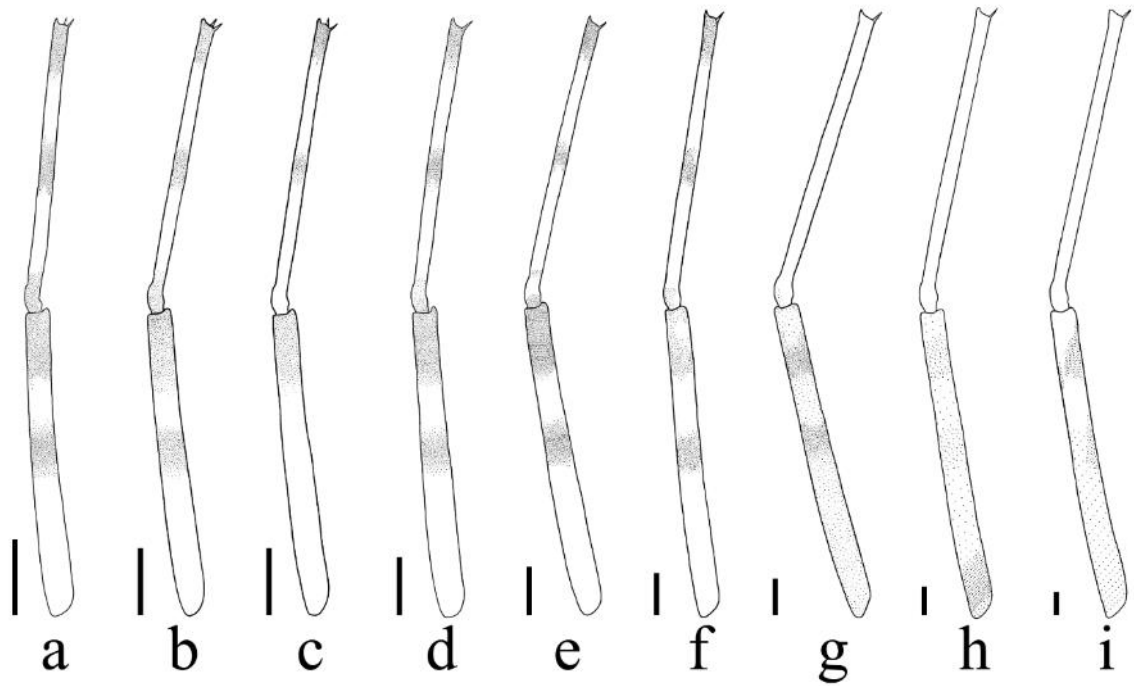


Fig. 18. Metafemur and metatibia in nymphal stages of *H. patellifera*, male, lateral view. a, 1st instar; b & c, 2nd instar; d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th instar; h, 7th instar; i, 8th instar. Scale bars: 1 mm.

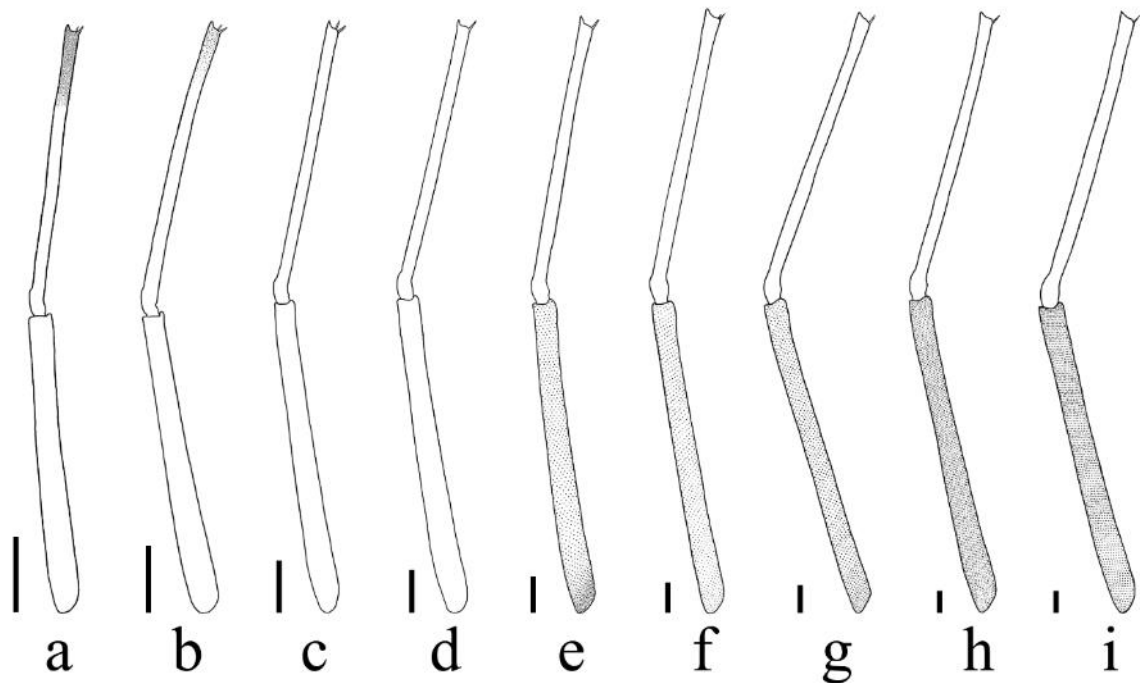


Fig. 19. Metafemur and metatibia in nymphal stages of *H. sp.*, male, lateral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (penultimate) instar; h, 7th (last) instar; i, 8th instar. Scale bars: 1 mm.

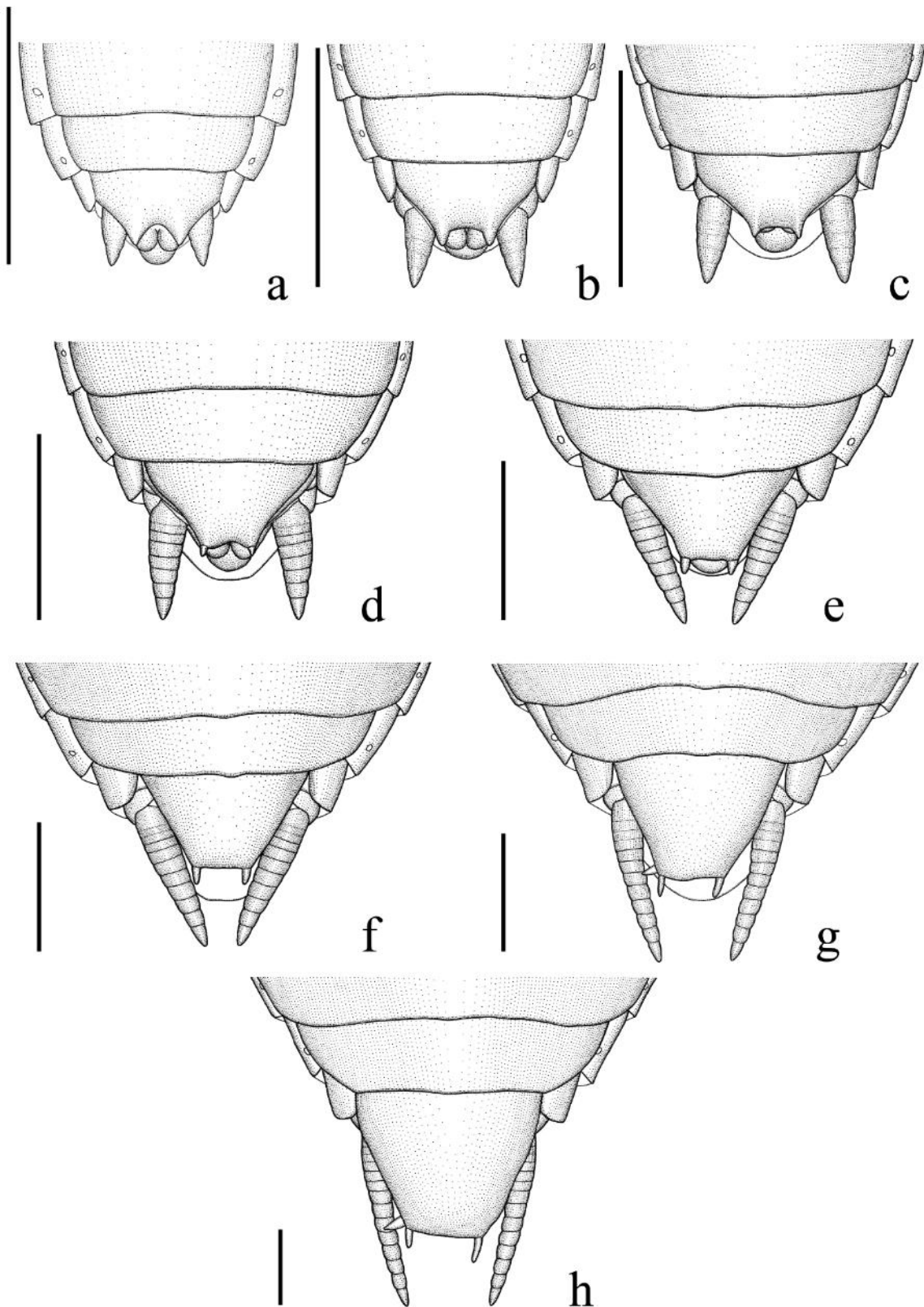


Fig. 20. Abdominal sternites VII to IX and cerci in nymphal stages of *H. patellifera*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th instar; h, 8th instar. Scale bars: 1 mm.

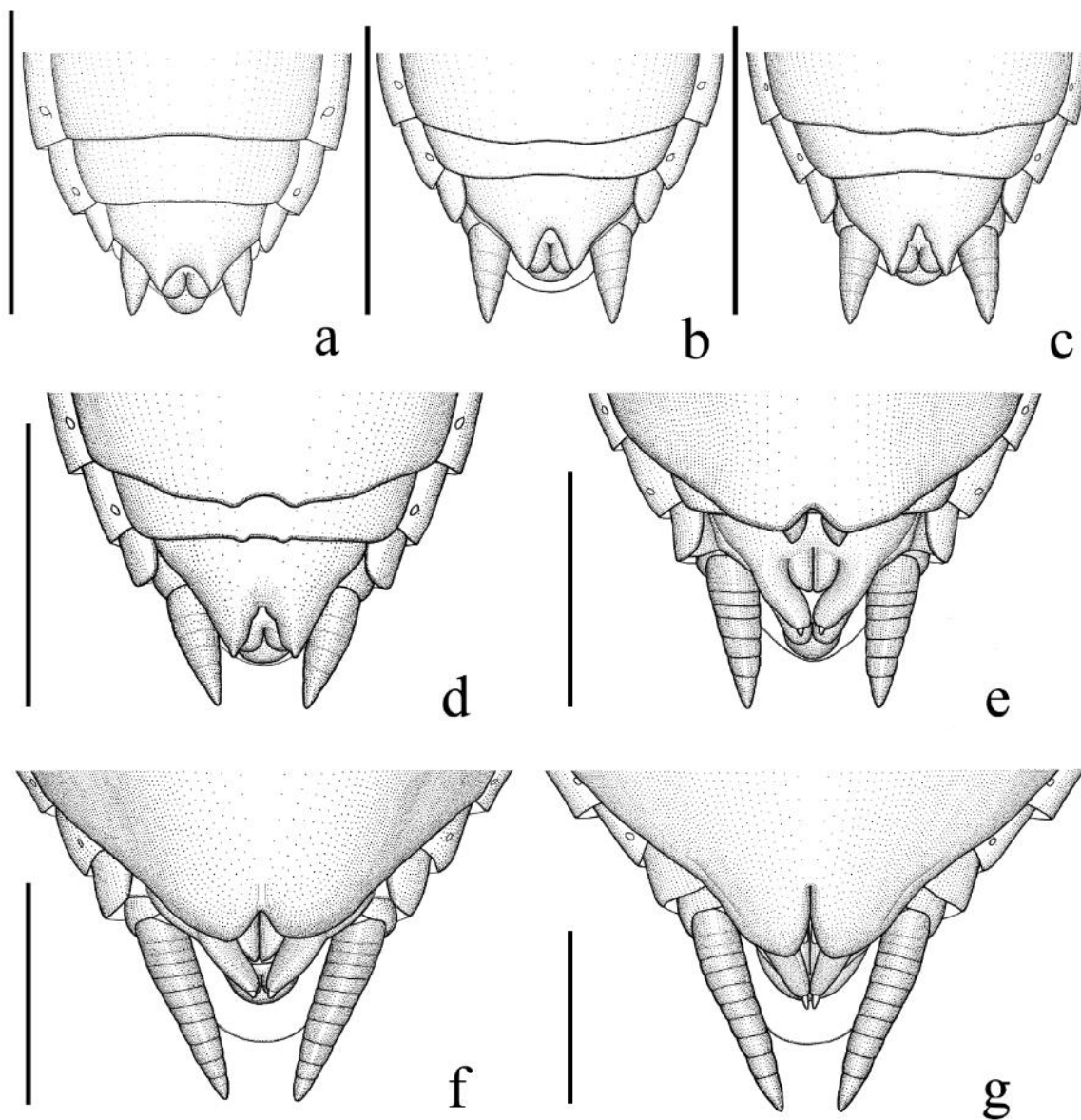


Fig. 21. Abdominal sternites VII to IX and cerci in first to six instar nymphs of *H. patellifera*, female, ventral view. a, 1st instar; b & c, 2nd instar; d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th instar. Scale bars: 1 mm.

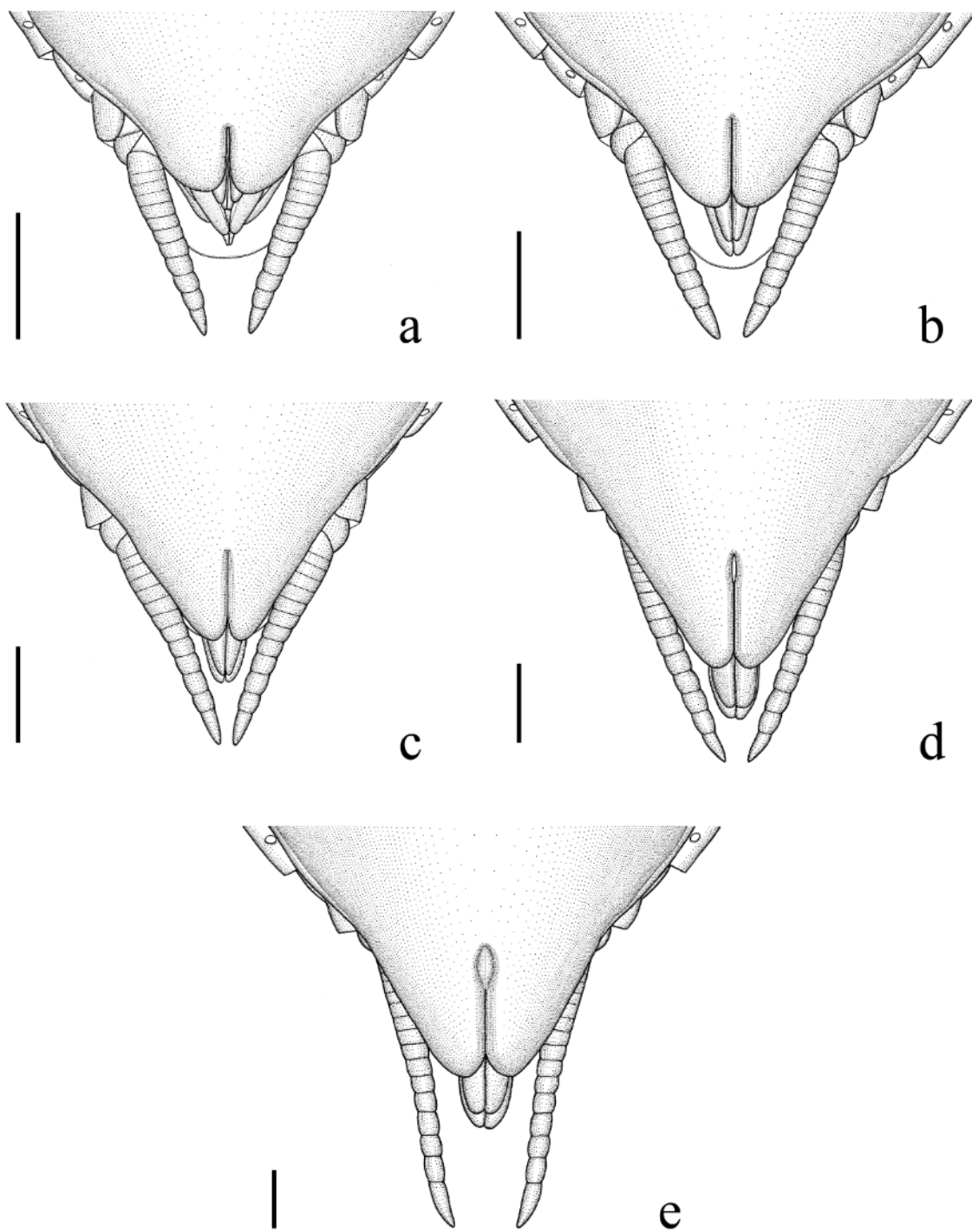


Fig. 22. Abdominal sternites VII to IX and cerci in seventh to ninth instar nymphs of *H. patellifera*, female, ventral view. a, 7th (antepenultimate) instar; b, 7th (penultimate) instar; c, 8th (penultimate) instar; d, 8th (last) instar; e, 9th instar. Scale bars: 1 mm.

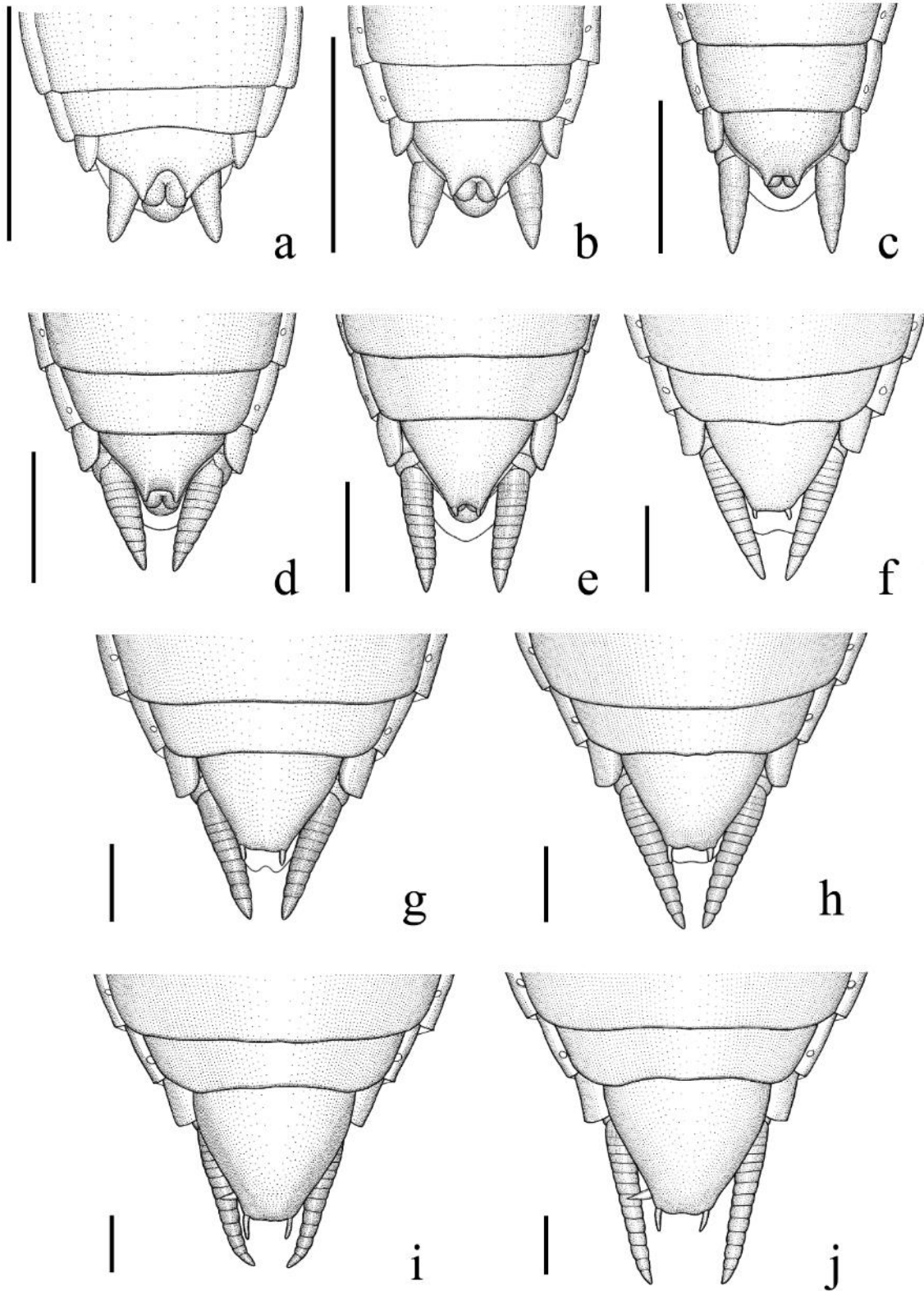


Fig. 23. Abdominal sternites VII to IX and cerci in nymphal stages of *H. sp.*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

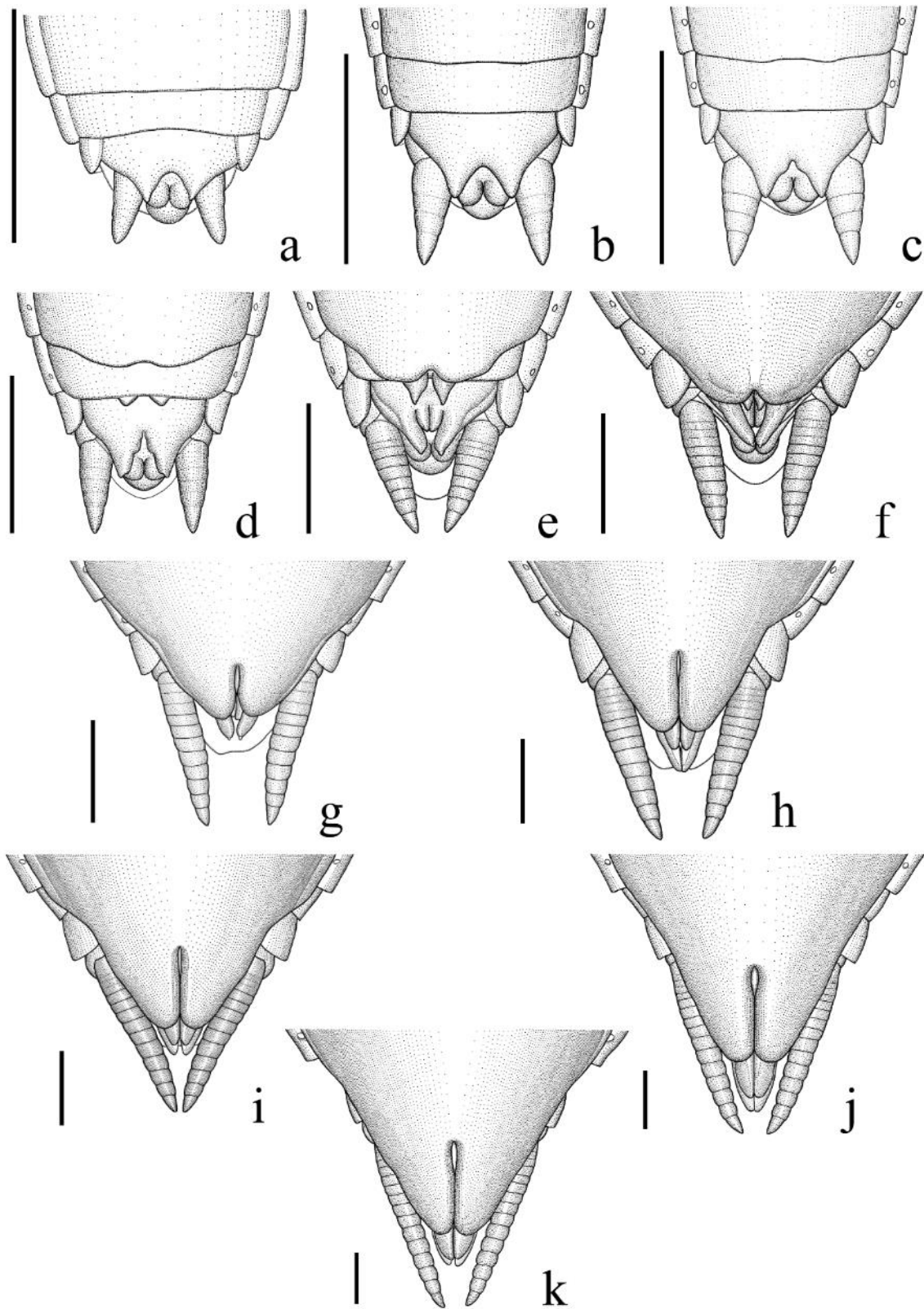


Fig. 24. Abdominal sternites VII to IX and cerci in nymphal stages of *H. sp.*, female, ventral view. a, 1st instar; b & c, 2nd instar; d, 3rd instar; e, 4th instar; f, 5th instar; g, 6th (antepenultimate) instar; h, 6th (penultimate) instar; i, 7th (penultimate) instar; j, 7th (last) instar; k, 8th instar. Scale bars: 1 mm.

Table 1. Measurements (mm) of body parts in each nymphal stage of *Hierodula patellifera*.

Nymphal stage	Sex	Individuals examined	Body length	Pronotum length	Pronotum width	Fore wing pad length	Profemur length	Profemur width	Mesofemur length	Mesofemur width	Mesotibia length	Metafemur length	Metatibia length	Cercus length
1st	-	20	7.0-7.5	2.4	1	-	2.4	0.5	3	2.5	4	4	4	0.3
2nd	Male	10	9.5-10.0	3	1.1	-	2.8	0.6	3.3	2.8	4.5	4.5	4.5	0.4
	Female	10	9.5-10.0	3	1.1	-	2.8	0.6	3.3	2.8	4.5	4.5	4.5	0.4
3rd	Male	10	11.5-13.0	4.3	1.6	-	3.5	0.9	4.5	3.5	5.5	5.5	5.5	0.4-0.5
	Female	10	11.5-13.0	4.3	1.6	-	3.5	0.9	4.5	3.5	5.5	5.5	5.5	0.4-0.5
4th	Male	10	16.5-17.5	5.5	2	2	5	1.3	5	4	6.5	6	6	0.7
	Female	10	16.5-17.5	5.5	2	2	5	1.3	5	4	6.5	6	6	0.7
5th	Male	8	18.0-20.5	6.5-7.0	2.4-2.5	2.5-2.7	6.5-6.8	1.7-1.8	5.5-6.5	4.8-5.5	7.7-7.8	7.0-7.2	7.0-7.2	0.8-0.9
	Female	9	18.0-20.5	6.5-7.0	2.4-2.5	2.5-2.7	6.5-6.8	1.7-1.8	5.5-6.5	4.8-5.5	7.7-7.8	7.0-7.2	7.0-7.2	0.8-0.9
6th	Male	8	22.0-24.0	8.5-9.0	3.0-3.4	3.5	7.5-9.0	2.0-2.4	7.0-7.5	6.0-6.5	8.5-9.0	8.0-8.5	8.0-8.5	1.2-1.3
	Female	8	22.0-24.0	8.5-9.0	3.0-3.4	3.5	7.5-9.0	2.0-2.4	7.0-7.5	6.0-6.5	8.5-9.0	8.0-8.5	8.0-8.5	1.2-1.3
7th	Penultimate instar male	8	28.5-31.0	10.0-10.5	4.0-4.2	4.5-5.0	9.5-10.0	2.5	8.0-9.5	7.0-8.5	10.5-12.0	9.5-11.0	9.5-11.0	1.9-2.0
	Antepenultimate instar female	5	26.0-27.0	9.5	3.8-4.0	4	9	2.0-2.5	8	7	9.0-9.5	8.5-9.0	8.5-9.0	1.5-1.6
8th	Penultimate instar female	8	37.5-40.0	12.5-13.5	5.2-5.3	8	12.0-13.0	3.2-3.5	11.0-12.0	8.5-9.5	12.5-13.0	12.5-13.0	12.5-13.0	3.5-3.8
	Last instar male	5	32.5-35.0	11.5-12.5	5.0-5.5	5.5-6.0	11.5-12.0	2.5-2.7	9.0-9.5	8.0-9.0	11.0-11.5	11.0-11.5	11.0-11.5	2.5-2.9
9th	Penultimate instar female	6	38.0-41.5	13.0-14.0	5.6-5.7	8.0-8.5	13.0-13.5	3.5	11.5-12.0	9.0-9.5	13.0-13.5	13.0-13.5	13.0-13.5	3.5-4.0
	Last instar female	5	37.5-41.5	14.0-16.0	6.0-7.0	9.0-11.5	13.5-15.5	3.5-4.0	12.0-14.0	10.0-11.5	14.0-16.0	14.0-16.0	14.0-16.0	4.0-5.0

Table 2. Measurements (mm) of body parts in each nymphal stage of *Hierodula* sp.

Nymphal stage	Sex	Individuals examined	Body length	Pronotum length	Pronotum width	Fore wing pad length	Profemur length	Profemur width	Mesofemur length	Mesofemur width	Mesotibia length	Metafemur length	Metatibia length	Cercus length
1st	-	26	7.5-8.0	2.5	1	-	2.5	0.5	3	2.5	4	4	4	0.3
2nd	Male	10	11.0-11.5	3.6	1.3	-	3	0.6	3.5	2.8	4.5	4.5	4.5	0.4
	Female	10	11.0-11.5	3.6	1.3	-	3	0.6	3.5	2.8	4.5	4.5	4.5	0.4
3rd	Male	10	16.5-17.0	5.5-6.0	1.7-1.8	-	4.5	0.9	4.8-5.0	3.5-3.7	6	6	5.5	0.7
	Female	10	16.5-17.0	5.5-6.0	1.7-1.8	-	4.5	0.9	4.8-5.0	3.5-3.7	6	6	5.5	0.7
4th	Male	10	21.5-23.0	7.8-8.0	2.4-2.5	2.0-2.1	6.0-6.5	1.2-1.3	6	4.5	8	7	7	0.9
	Female	10	21.5-23.0	7.8-8.0	2.4-2.5	2.0-2.1	6.0-6.5	1.2-1.3	6	4.5	8	7	7	0.9
5th	Male	10	24.5-28.0	9.5-10.5	2.9-3.1	3.0-3.5	7.0-8.5	1.5-1.8	7.0-8.0	5.5-6.0	9.5-10.0	8.0-9.0	8.0-9.0	1.2-1.4
	Female	10	24.5-28.0	9.5-10.5	2.9-3.1	3.0-3.5	7.0-8.5	1.5-1.8	7.0-8.0	5.5-6.0	9.5-10.0	8.0-9.0	8.0-9.0	1.2-1.4
6th	Antepenultimate male	2	28.5-29.0	11.0-11.5	3.4-3.5	4	9	2	8.0-8.5	6.5-7.0	10.0-10.5	9.5-10.0	9.5-10.0	1.6-1.8
	Penultimate instar male	6	32.0-33.0	13.0-13.5	3.6-4.0	5.5-6.0	10.0-10.5	2.0-2.2	9.0-9.5	7.5-8.0	11.5-12.0	10.5-11.0	10.5-11.0	2
7th	Antepenultimate female	7	28.0-29.0	11.0-11.5	3.4-3.5	3.8-4.0	9	2	8.0-8.5	6.5-7.0	10.5-11.0	9.5-10.0	9.5-10.0	1.6-1.8
	Penultimate instar female	10	32.0-33.0	13.0-13.5	3.6-4.0	5.5-6.0	10.0-11.5	2.0-2.4	9.0-9.5	8.0-8.5	12.0-12.5	10.5-11.5	10.5-11.5	2
8th	Penultimate instar male	2	35.5-36.0	14.0-14.5	4.2-4.3	5.5-6.0	12.0-12.5	2.5	10	8	12.5	11	11	2.5
	Last instar male	6	42.0-44.5	16.5-17.0	5	8.5-9.5	13.0-13.5	3	12.0-12.5	9.0-10.0	14.0-15.0	13.5-14.5	13.5-14.5	3.0-3.5
9th	Penultimate instar female	7	36.0-37.5	14.5-15.0	4.8-5.0	5.5-6.0	12.0-12.5	2.5	10.5-11.5	8.5-9.0	13.0-14.0	12.0-13.0	12.0-13.0	2.5
	Last instar female	6	42.0-44.5	16.5-17.0	5	8.0-8.5	13.0-14.0	3.5	12	10	14.5-15.5	14.0-15.0	14.0-15.0	3.0-3.5
10th	Last instar male	2	44.0-45.0	17.0-18.0	5	9.5	13.0-13.5	3	12.0-12.5	9.0-10.0	14.0-15.0	13.5-14.0	13.5-14.0	3.0-3.5
	Last instar female	6	44.5-48.0	18.0-19.0	5.0-6.0	9.0-9.5	15	3.7	12.5-14.0	10.0-11.0	15.5-17.0	15.0-15.5	15.0-15.5	3.0-4.0



## 2-3 *Statilia* 属 2 種の若虫期における形態

### 2-3-1 緒言

*Statilia* 属は、日本からはコカマキリ *S. maculata* (Thunberg, 1784) (以下, コカマ), スジイリコカマキリ *S. nemralis* (Saussure, 1870) (以下, スジイリ), ヤサガタコカマキリ *S. apicalis* (Saussure, 1871) (以下, ヤサガタ) の 3 種が知られる (岡田 2001; 中峰 2016, 2020). これら 3 種は国内において, コカマが本州~トカラ列島中之島にかけて分布 (中峰 2016; 守山・金井 2016; 山下 2018; 小浜 2019) するのに対し, スジイリとヤサガタは, それぞれ沖永良部島~与那国島 (中峰 2016; 大島・瑤寺 2019), 石垣島~与那国島 (岡田 2001; 中峰 2016) に分布する. 各種の分布域において, コカマとスジイリは住宅街でも採集される普通種であるが, ヤサガタは国内での採集例が極めて少ない希少種である. コカマとスジイリの分布域は重なっていないため, 現時点では両種は同所的に得られていない. しかし, スジイリは 1990 年代末に八重山から沖縄島まで分布域を拡大させた (杉本 2014) ことや, 2019 年には鹿児島県沖永良部島からも記録された (大島・瑤寺 2019) ことから, 今後, スジイリの分布域がさらに広がることによって, 将来的にコカマと同所分布する可能性がある. また, カマキリ類は, 生体や卵鞘が物資に付着して分布域を広げたとされる例が知られているため (櫻井ほか 2018; Battiston *et al.* 2018; Nisip *et al.* 2019), 将来, 物流によって両種の分布域が重なる可能性も考えられる. 八重山にのみ分布するヤサガタは, 採集記録の少なさからその生態はほとんど未知であり, スジイリとの棲み分けや競合などの調査が望まれている (杉本 2016).

3 種の形態はそれぞれ酷似しているが, 雄外部生殖器の形状と前脚腿節の黒紋によって種同定が可能である. しかし, それらは成虫の場合であり, 若虫の形態的特徴はほとんど明らかにされていない. 若虫における既知の同定形質に関する形態的特徴は, 唯一, スジイリの前脚腿節の黒紋について記述された (大島 2018) ものの, 近縁種同士の比較は行なわれておらず, 若虫同士の種の同定方法は不明である. 加えて, 同一種の齢期や雌雄の判別も同時に困難である. 今後, コカマとスジイリの分布域が重なった場合やヤサガタの生態調査を進める場合, すべての発育段階での正確な種の同定方法が必要である.

そこで, 本研究ではコカマとスジイリの全齢期における若虫の形態を記載し, 2 種間で比較した結果, 4 齢以降において, 若虫期に種を同定するための有用な形態的特徴を見いだした. また, 2 種の外部形態による齢期ごとの特徴および 2 齢以降の雌雄の特徴を見だし, 種, 齢期, 雌雄を判別可能な検索表を作成した.

## 2-3-2 材料および方法

### 1) 若虫の採集と飼育方法

観察した若虫は、すべて人工管理下で孵化させたものを用いた。コカマは、2017年2月20日に神奈川県厚木市船子において採集された卵鞘を気温 30°C、湿度 60-80%の条件下で管理し、孵化させた。スジイリは2016年9月16日に沖縄県石垣島において採集した雌成虫が産下した卵鞘を気温 30°C、湿度 60-80%の条件下で管理し、孵化させた。

得られた卵鞘は、プラスチック製ケース（縦 181 mm、横 124 mm、深さ 112 mm）に入れ管理した。孵化した若虫はすべて、気温 30°C、湿度 60-80%、日長 15L:9D の条件下で飼育した。1 齢から 6 齢若虫の飼育には、プラスチック製プリンカップ（口径 102 mm、深さ 80 mm）、7 齢と 8 齢若虫には同製プリンカップ（口径 129 mm、深さ 97 mm）を用いた。カップの蓋には容器内の蒸れを防ぐために複数の小さな穴をあけた。飼育に用いた各容器には、若虫の足場として園芸用の鉢底ネットをアーチ状にして配置し、底には乾燥防止用に水を含ませたティッシュペーパーを置いた。

餌は以下の要領で与えた。1 齢から 5 齢若虫には、キイロショウジョウバエ *Drosophila melanogaster* Meigen, 1830（ショウジョウバエ科）をそれぞれ 1 頭、2 頭、3 頭、5 頭与えた。6 齢以降の若虫には、体長に適したサイズのレッドローチ *Shelfordella lateralis* (Walker, 1868)（ゴキブリ科）をそれぞれ 1 頭与えた。給餌は週 5 回行なったが、脱皮直前または直後の場合や、捕食を拒否した場合は給餌を見送った。また、脱皮前の数日間は消化能力が低下するため、餌の量を減らすか、または見送った。

### 2) 若虫の観察方法

コカマとスジイリは、2 齢以降の各齢において 3-5°C の低温に 30 分以上晒し、麻酔をかけた状態で観察した。1 齢若虫は軽度の麻酔でも死亡してしまうため、死後数時間以内の新鮮な標本を観察に用いた。各種各齢における検視個体数は Table 1, 2 にまとめた。

各種各齢の若虫において、体長、前胸背板、前脚基節窩間、有翅胸節（翅芽）、前脚基節、基節背縁突起、前脚腿節、内縁刺、外縁刺、中列刺、腹部第 VII-IX 腹板、尾角を実態顕微鏡（SZ60; Olympus, 東京）とデジタルマイクروسコープ（VHX-1000; Keyence, 大阪）を用いて観察した。撮影には同デジタルマイクروسコープとデジタルカメラ（WG-4; Ricoh, 東京）を使用し、トレス法で作図した。また、各部位の計測には定規を用いた。各種各齢の若虫における各部位の形態的特徴を記載し、種、齢、雌雄の判別方法を検証した。

各部位名称は, Roberto *et al.* (2010) と Brannoch *et al.* (2017) に従ったが, 雌生殖器官の一部では Matsuda (1976) に従った. 日本語名称については, おもに中峰 (2016) に従ったが, 前脚腿節の刺については岡田 (2001) に従った. また, 日本語名称のない部位は和訳した. なお, 本論文では, 各種の記載については英文で行なった. 各部位名称の和英対応および計測箇所は以下のとおりである (Figs. 1, 2): 体長 body length; 前胸背板 pronotum; 叉甲腹板 furcasternite; 有翅胸節 (翅芽) pterothrax (wing pad); 前脚基節 procoxa; 基節背縁突起 marginal spine; 前脚腿節 profemur; 内縁刺 anteroventral-femoral spine; 外縁刺 posteroventral-femoral spine; 中列刺 discoidal spine; 中脚腿節 mesofemur; 中脚脛節 mesotibia; 後脚腿節 metafemur; 後脚脛節 metatibia; 腹部腹板 sternite; 腹部背板 tergite; 陰具片 gonapophysis; 生殖片 gonoplac; 尾突起 stylus; 下陰基板突起 posterior process; 尾角 cercus:

- (1) 体長 Body length: 前胸背板の前縁から腹部第 X 背板の後縁までの最大長;
- (2) 前胸背板長 Pronotum length: 前胸背板の前縁から後縁までの最大長;
- (3) 前胸背板幅 Pronotum width: 前胸背板の横幅の最も広い部分の長さ;
- (4) 前翅芽長 Fore wing pad length: 肩部から前翅芽の先端までの最大長;
- (5) 前脚腿節長 Profemur length: 前脚腿節の前縁から後縁までの最大長;
- (6) 前脚腿節幅 Profemur width: 前脚腿節の背縁から第 II 内縁刺の基部までの最大長;
- (7) 中脚腿節長 Mesofemur length: 中脚腿節の基部から先端までの最大長;
- (8) 中脚脛節長 Mesotibia length: 中脚脛節の基部から先端までの最大長;
- (9) 後脚腿節長 Metafemur length: 後脚腿節の基部から先端までの最大長;
- (10) 後脚脛節長 Metatibial length: 後脚脛節の基部から先端までの最大長;
- (11) 尾角長 Cercus length (cl): 尾角の基部から先端までの最大長.

### 2-3-3 結果および考察

#### コカマキリ

##### *Statilia maculata* (Thunberg, 1784)

各齢期における各部位の測定値を Table 1 にまとめた. 成虫になるまでの齢数は, 雌雄ともに 7 齢または 8 齢である. 羽化までの脱皮回数が少ない個体と多い個体は, 同じ飼育条件下において発生した. 以下に記載した形態的特徴を用いて, 本種の幼虫期における齢, 性別, 種の判別が可能である.

## 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 5.0–5.5 mm in long (Figs. 3a, 4a), generally wholly blackish. Pronotum (Fig. 7a) approximately 1.7 times as long as its maximum width, with lateral margins minutely serrate throughout its length (Fig. 7i). Posterolateral angles of pterothoracic segments (Figs. 9a, 10a) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 13a, i) approximately 5 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral (internal) -femoral spines; black spots along anteroventral-femoral spines disconnected each other. Four discoidal spines basal spine longest; proportional length of basal to apical spines 1: 2: 3.3: 5. Mesofemur approximately 0.4 times as long as body length, weakly darkened medially and apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened medially and apically. Metatibia approximately 0.5 times as long as body length, darkened basally, medially and apically. Posterior margin of abdominal sternite VII and VIII (Figs. 15a, 16a) straight in medial region. Sternite IX with a pair of immature gonoplags (in prospective adult female) or immature styles (in prospective adult male); immature gonoplags and styles conical and same in shape and size between the sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Female: body 7.0–7.5 mm in long (Fig. 3b), generally wholly brownish. Pronotum (Fig. 7b) approximately 2.5 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoraces (Fig. 9b) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 13b) approximately 5.2 times as long as its width, mottled with small to large, irregular black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other. Four discoidal spines, subapical spine longest; proportional length of basal to apical spines 1: 3.6: 1.7: 1. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically.

Metatibia approximately 0.5 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Posterior margin of abdominal sternite VII and VIII straight in medial region. Posterior margin of sternite IX rounded between immature gonoplags. Immature gonoplags conical. Margin between immature gonoplags with or without short groove (Fig. 15b). Cerci at least 4-segmented, length 0.04 times as long as body length.

Male: similar to female. Body length 7.0–7.5 mm (Fig. 4b). Immature styles (Fig. 16b) same shape and size as immature gonoplags.

**3rd instar.** Female: body 11.5–12.0 mm in long (Fig. 3d), generally wholly brownish. Pronotum (Fig. 7c) approximately 2.9 times as long as its maximum width, with lateral margins minutely serrate throughout its length (Fig. 7j). Posterolateral angles of pterothoraces (Fig. 10c) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 13c, j) approximately 6.2 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interlaterally, on tibial spur groove, and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral (external) -femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia approximately 0.5 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Abdominal sternite VII weakly extended posteriorly; posterior margin rounded evenly, straight or slightly concave at middle part. Sternite VIII with or without a pair of immature gonapophyses VIII (Fig. 15c) at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplags. Immature gonoplags conical. Cerci at least 5-segmented, 0.04 times as long as body length.

Male: similar to female. Body length 11.5–12.0 mm (Fig. 4c). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 16c). Posterior margin of sternite IX rounded between immature styles. Immature styles narrowed apically.

**4th instar.** Female: body 13.5–14.0 mm in long (Fig. 3c), generally wholly brownish. Pronotum (Fig. 7d) approximately 3.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoraces (Fig. 9d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.12 times as long as body length. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 13d) approximately 5.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia approximately 0.4 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Abdominal sternite VII (Fig. 15d) extended posteriorly, posterior margin shallowly notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci at least 6-segmented, 0.04 times as long as body length.

Male: similar to female. Body length 13.5–14.0 mm (Fig. 4d). Posterior margin of abdominal sternites VII and VIII straight in middle region (Fig. 16d). Posterior margin of sternite IX slightly rounded between immature styles. Immature styles short, papillate.

**5th instar.** Female: body 18.0–21.0 mm in long (Fig. 3e), generally wholly brownish. Pronotum (Fig. 7e) approximately 3.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Wing pads (Fig. 9e) 0.12 times as long as body length, with or without slightly developed veins. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 13e, k) approximately 6 times as long as its maximum width, mottled with small to medium-sized, irregular,

black spots in basal half interolaterally, on tibial spur groove and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, darkened or same in color of body basally, medially and apically. Abdominal sternite VII (Fig. 15e) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplares elongated, with apex blunt. Cerci at least 8-segmented, 0.07 times as long as body length.

Male: similar to female. Body length 18.0–21.0 mm (Fig. 4e). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 16e). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**6th instar.** Female antepenultimate instar: body 22.5–23.0 mm in long, generally wholly brownish. Pronotum (Fig. 7f) approximately 3.8 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length. Wing pads (Fig. 9f) provided with developed veins, 0.13 times as long as body length. Procoxa with slightly developed marginal spines. Profemur (Fig. 13f) approximately 7 times as long as its width, mottled with small, irregular, black spots in basal half interolaterally, on tibial spur groove and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at

middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 10-segmented, 0.07 times as long as body length.

Penultimate instar female: similar to female antepenultimate instar. Body length 24.0–25.0 mm (Fig. 3f). Wing pads (Fig. 9g) provided with clearly developed veins, 0.15 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 15f) extended posteriorly, covering most of sternite VIII, with posterior margin stoutly notched and tucked at middle. Cerci at least 11-segmented, 0.08 times as long as body length.

Male antepenultimate instar: similar to female antepenultimate instar. Body length 22.5–23.0 mm. Posterior margin of abdominal sternites VII and VIII straight in the middle.

Penultimate instar male: similar to antepenultimate instar male. Body length 24.0–25.0 mm (Fig. 4f). Wing pads (Fig. 10g) provided with clearly developed veins, 0.15 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite IX (Fig. 16f) extended posteriorly, past posterior margin of tergite X. Immature posterior process extended behind sternite IX. Cerci at least 11-segmented, 0.08 times as long as body length.

**7th instar.** Female penultimate instar: body 25.0–28.0 mm in long, generally wholly brownish. Pronotum (Fig. 7g) approximately 4 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length (Fig. 7l). Wing pads (Fig. 9h) provided with developed veins, 0.15 times as long as body length. Procoxa with slightly developed marginal spines. Profemur (Fig. 13g, l) approximately 7 times as long as its width, mottled with small, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia



approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 10-segmented, 0.08 times as long as body length.

Last instar female: similar to female penultimate instar. Body length 55.0–65.2 mm (Fig. 3g). Fore-wing pads (Fig. 9i) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Anteroventral-femoral spines and posteroventral-femoral spine. Abdominal sternite IX (Fig. 15g) extended posteriorly, post posterior margin of tergite X. Immature posterior process extended behind sternite IX. Cerci at least 11-segmented, 0.08 times as long as body length.

Penultimate instar male: similar to female penultimate instar. Body length 25.0–28.0 mm. Posterior margin of abdominal sternites VII and VIII straight in the middle. Sternite IX extended posteriorly, covering supra-anal lobe; posterior margin of sternite IX straight between immature styles.

Last instar male: similar to penultimate instar male. Body length 28.0–30.0 mm (Fig. 4g). Fore-wing pads (Fig. 10i) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Cerci at least 11-segmented, 0.08 times as long as body length.

**8th instar.** Last instar female: body 35.0–41.5 mm in long (Fig. 3h), generally wholly brownish. Pronotum (Fig. 7h) approximately 4.3 times as long as its maximum width, with lateral margin minutely and distinctly serrate throughout its length. Wing pads (Fig. 9j) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Procoxa with slightly developed marginal spines. Profemur (Fig. 13h) approximately 7.1 times as long as its width, mottled with small, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically.

Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII (Fig. 15j) extended posteriorly, covering sternite VIII for the most part, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, with blunt apices. Cerci at least 14-segmented, 0.09 times as long as body length.

Last instar male: similar to last instar female. Body length 35.0–41.0 mm (4h). Posterior margin of abdominal sternite VII and VIII straight in medial region (Fig. 16j). Sternite IX extended to level of posterior margin of tergite X; posterior margin of sternite IX straight between immature styles, which are short and papillate.

#### 若虫の齡期判別

1 齡若虫は、体長 6 mm 未満であること (Figs. 3a, 4a) や中列刺のうち第 I 刺がもっとも長い (Fig. 13a, i) ことから、ほかの齡と判別できる。2 齡から 5 齡の判別には、体長が有用である (Figs. 3, 4) : 2 齡は体長 7 mm 内外 ; 3 齡は体長 12 mm 内外 ; 4 齡は体長 14 mm 内外 ; 5 齡は 20 mm 内外。5 齡と 6 齡の判別には、体長や尾角の節数が有用である (Figs. 3, 4, 15, 16) : 5 齡は体長 22 mm 未満, 尾角は最低 8 節 ; 6 齡は体長 22 mm 以上, 尾角は最低 10 節。前亜終齡 (6 齡), 亜終齡 (6 齡, 7 齡), 終齡 (7 齡, 8 齡) の判別には、とくに後翅芽の伸長度合いが有用である : 前亜終齡は後翅芽の末端が腹部第 I 背板の後縁に達しない ; 亜終齡は後翅芽の末端が第 I 背板の後縁に達する (Figs. 3f, 4f) ; 終齡は後翅芽の末端が第 I 背板の後縁を大きく超える (Figs. 3g, h, 4g, h)。

以上の特徴から、コカマキリは外部形態による齡期判別が可能である。

#### 若虫の雌雄判別

1 齡若虫では、外部形態における雌雄差は確認できなかった。2 齡では、雌は腹部第 IX 腹板の後縁 (生殖片の間) に小さな切れ込みが生じる (Fig. 15b) のに対し、雄の腹部第 IX 腹板の後縁 (尾突起の間) はほぼ平坦である (Fig. 16b) ことから雌雄が判別できる。ただし、一部の雌個体は雄に似た特徴を表すことがある。3 齡から終齡では、3 つの形質から判別できる (Figs. 15, 16) : (1) 雌は第 VII 腹板の後縁が湾曲しながら後方に拡張し、加齡に伴い亜生殖板を形成するのに

対し，雄の第 VII 腹板の後縁はほぼ平坦であり，加齢に伴う形状の変化はほとんどない；(2) 雌は 3 齢の一部の個体を除き，第 VIII 腹板の後縁に一对の陰具片を有するのに対し，雄の第 VIII 腹板の後縁はほぼ平坦であり，加齢に伴う形状の変化はほとんどない；(3) 雌は第 IX 腹板に一对の陰具片と生殖片を有し，それらの形状が加齢に伴い変化するのに対し，雄の第 IX 腹板の尾突起は加齢に伴う形状の変化はほとんどない。

以上の特徴から，コカマキリは 2 齢以降に外部形態による雌雄判別が可能である。

### スジイリコカマキリ

#### *Statilia nemoralis* (Saussure, 1870)

各齢期における各部位の測定値を Table 2 にまとめた。成虫になるまでの齢数は，雌雄ともに 7 齢または 8 齢である。羽化までの脱皮回数が少ない個体と多い個体は，同じ飼育条件下において発生した。以下に記載した形態的特徴を用いて，本種の幼虫期における齢，性別，種の判別が可能である。

#### 若虫の記載 Descriptions of nymphal stages.

**1st instar.** Body 5.0–5.5 mm in long (Figs. 5a, 6a), generally wholly blackish. Pronotum (Fig. 8a) approximately 1.7 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoracic segments (Figs. 11a, 12a) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 14a, j) approximately 5 times as long as its maximum width, mottled with small to large, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral (internal) -femoral spines; black spots along anteroventral-femoral spines disconnected each other. Four discoidal spines basal spine longest; proportional length of basal to apical spines 1: 2: 3.3: 5. Mesofemur approximately 0.4 times as long as body length, weakly darkened medially and apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened medially and apically. Metatibia approximately 0.5 times as long as body length, darkened basally, medially and apically. Posterior margin of abdominal sternite VII and VIII (Figs. 17a, 18a) straight in medial region. Sternite IX with a pair of immature gonoplacs (in prospective adult female) or immature styles (in prospective adult male); immature

gonoplacs and styles conical and same in shape and size between the sexes. Cerci unsegmented, 0.04 times as long as body length.

**2nd instar.** Female: body 7.0–7.5 mm in long (Fig. 5b), generally wholly brownish. Pronotum (Fig. 8b) approximately 2.5 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoraces (Fig. 11b) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 14b) approximately 5.2 times as long as its width, mottled with small to large, irregular black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other. Four discoidal spines, subapical spine longest; proportional length of basal to apical spines 1: 3.6: 1.7: 1. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia approximately 0.5 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Posterior margin of abdominal sternite VII and VIII straight in medial region. Posterior margin of sternite IX rounded between immature gonoplacs. Immature gonoplacs conical. Margin between immature gonoplacs with or without short groove (Fig. 17b). Cerci at least 4-segmented, length 0.04 times as long as body length.

Male: similar to female. Body length 7.0–7.5 mm (Fig. 6b). Immature styles (Fig. 18b) same shape and size as immature gonoplacs.

**3rd instar.** Female: body 11.5–12.0 mm in long (Fig. 5c), generally wholly brownish. Pronotum (Fig. 8c) approximately 2.9 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoraces (Fig. 11c) rounded, lacking wing pads. Procoxa lacking marginal spines. Profemur (Fig. 14c, j) approximately 6.2 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, and along anteroventral-femoral spines; black spots along anteroventral-femoral spines disconnected each other; anteroventral-femoral spines and posteroventral (external) -femoral spines weakly darkened apically. Discoidal spines weakly darkened

apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.3 times as long as body length, weakly darkened apically. Metafemur approximately 0.5 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia approximately 0.5 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Abdominal sternite VII weakly extended posteriorly; posterior margin rounded evenly, straight or slightly concave at middle part. Sternite VIII with or without a pair of immature gonapophyses VIII (Fig. 17d) at middle of posterior margin. Immature gonapophyses IX present or absent between immature gonoplags. Immature gonoplags conical. Cerci at least 5-segmented, 0.04 times as long as body length.

Male: similar to female. Body length 11.5–12.0 mm (Fig. 6c). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 18c). Posterior margin of sternite IX rounded between immature styles. Immature styles narrowed apically.

**4th instar.** Female: body 13.5–14.0 mm in long (Fig. 5d), generally wholly brownish. Pronotum (Fig. 8d) approximately 3.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Posterolateral angles of pterothoraces (Fig. 11d) angulated, weakly extended posteriorly, regarded as wing pads lacking veins, 0.12 times as long as body length. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 14d) approximately 5.6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove, along anteroventral-femoral spines, and on femoral brushes; black spots along anteroventral-femoral spines connected each other; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially, darkened apically. Metatibia approximately 0.4 times as long as body length, darkened or same in color of body basally, darkened medially and apically. Abdominal sternite VII (Fig. 17d) extended posteriorly, posterior margin shallowly

notched at middle. Sternite VIII with a pair of immature gonapophyses VIII at middle of posterior margin. Immature gonapophyses IX rounded, projected acutely at apex. Immature gonoplacs elongated, abruptly narrowed at apical part. Cerci at least 6-segmented, 0.04 times as long as body length.

Male: similar to female. Body length 13.5–14.0 mm (Fig. 6d). Posterior margin of abdominal sternites VII and VIII straight in middle region (Fig. 18d). Posterior margin of sternite IX slightly rounded between immature styles. Immature styles short, papillate.

**5th instar.** Female: body 18.0–21.0 mm in long (Fig. 5e), generally wholly brownish. Pronotum (Fig. 5e) approximately 3.3 times as long as its maximum width, with lateral margins minutely serrate throughout its length. Wing pads (Fig. 11e) 0.12 times as long as body length, with or without slightly developed veins. Procoxa with or without a few, slightly developed marginal spines. Profemur (Fig. 14e, k) approximately 6 times as long as its maximum width, mottled with small to medium-sized, irregular, black spots in basal half interolaterally, on tibial spur groove and along anteroventral-femoral spines; black spots along anteroventral-femoral spines connected each other; anteroventral-femoral spines and posteroventral-femoral spines weakly darkened apically. Discoidal spines weakly darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened apically. Mesotibia approximately 0.2 times as long as body length, weakly darkened apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, darkened or same in color of body basally, medially and apically. Abdominal sternite VII (Fig. 17e) extended posteriorly, covering most of sternite VIII, with posterior margin moderately notched at middle. Immature gonapophyses VIII and IX elongated, with apices obtuse. Immature gonoplacs elongated, with apex blunt. Cerci at least 8-segmented, 0.07 times as long as body length.

Male: similar to female. Body length 18.0–21.0 mm (Fig. 6e). Posterior margin of abdominal sternite VII and VIII straight in middle region (Fig. 18e). Posterior margin of sternite IX straight between immature styles. Immature styles short and papillate.

**6th instar.** Female antepenultimate instar: body 22.5–23.0 mm in long,

generally wholly brownish. Pronotum (Fig. 8f) approximately 3.8 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length. Wing pads (Fig. 11f) provided with developed veins, 0.13 times as long as body length. Procoxa with slightly developed marginal spines. Profemur (Fig. 14f) approximately 7 times as long as its width, mottled with small, irregular, black spots in basal half interlaterally, on tibial spur groove and along anteroventral-femoral spines; black spots along anteroventral-femoral spines connected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 10-segmented, 0.07 times as long as body length.

Penultimate instar female: similar to female antepenultimate instar. Body length 24.0–24.5 mm (Fig. 5f). Wing pads (Fig. 11g) provided with clearly developed veins, 0.15 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite VII (Fig. 17f) extended posteriorly, covering most of sternite VIII, with posterior margin stoutly notched and tucked at middle. Cerci at least 11-segmented, 0.08 times as long as body length.

Male antepenultimate instar: similar to female antepenultimate instar. Body length 22.5–23.0 mm. Posterior margin of abdominal sternites VII and VIII straight in the middle.

Penultimate instar male: similar to antepenultimate instar male. Body length 24.0–25.0 mm (Fig. 6f). Wing pads (Fig. 12g) provided with clearly developed veins, 0.15 times as long as body length; apex of hind wing pads reaching posterior margin of abdominal tergite I. Abdominal sternite IX (Fig. 18f) extended posteriorly, post posterior margin of tergite X. Immature posterior process extended behind sternite IX.

Cerci at least 11-segmented, 0.08 times as long as body length.

**7th instar.** Female penultimate instar: body 25.0–28.5 mm in long, generally wholly brownish. Pronotum (Fig. 8f) approximately 4 times as long as its maximum width, with lateral margins minutely and distinctly serrate throughout its length. Wing pads (Fig. 11h) provided with developed veins, 0.15 times as long as body length. Procoxa with slightly developed marginal spines. Profemur (Fig. 14g, l) approximately 7 times as long as its width, mottled with small, irregular, black spots in basal half interolaterally and along anteroventral-femoral spines; black spots along anteroventral-femoral spines connected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically, with subapical spine longest. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII extended posteriorly, covering most of sternite VIII, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with apex obtuse. Immature gonapophyses IX covered with immature gonoplacs. Immature gonoplacs elongated, with apex blunt. Cerci at least 10-segmented, 0.08 times as long as body length.

Last instar female: similar to female penultimate instar. Body length 55.0–65.2 mm (Fig. 5h). Fore-wing pads (Fig. 11i) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Anteroventral-femoral spines and posteroventral-femoral spine. Abdominal sternite IX (Fig. 17g) extended posteriorly, post posterior margin of tergite X. Immature posterior process extended behind sternite IX. Cerci at least 11-segmented, 0.08 times as long as body length.

Penultimate instar male: similar to female penultimate instar. Body length 25.0–28.0 mm. Posterior margin of abdominal sternites VII and VIII straight in the middle. Sternite IX extended posteriorly, covering supra-anal lobe; posterior margin of sternite IX straight between immature styles.

Last instar male: similar to penultimate instar male. Body length 28.0–30.0 mm



(Fig. 6g). Fore-wing pads (Fig. 12i) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Cerci at least 11-segmented (Fig. 18g), 0.08 times as long as body length.

**8th instar.** Last instar female: body 34.5–41.5 mm in long (Fig. 5h), generally wholly brownish. Pronotum (Fig. 8h) approximately 4.3 times as long as its maximum width, with lateral margin minutely and distinctly serrate throughout its length. Wing pads (Fig. 11i) provided with clearly developed veins, 0.17 times as long as body length; apex of hind wing pads strongly extended to posterior margin of abdominal tergite I. Procoxa with slightly developed marginal spines. Profemur (Fig. 14h) approximately 7.1 times as long as its width, mottled with small, irregular, black spots black spots in basal half interlaterally and along anteroventral-femoral spines; black spots along anteroventral-femoral spines connected each other; anteroventral-femoral spines and posteroventral-femoral spines darkened apically; discoidal spines darkened apically. Mesofemur approximately 0.3 times as long as body length, weakly darkened mostly. Mesotibia approximately 0.2 times as long as body length, same in color of body apically. Metafemur approximately 0.4 times as long as body length, darkened or same in color of body medially and apically. Metatibia approximately 0.4 times as long as body length, same in color of body mostly. Abdominal sternite VII extended posteriorly, covering sternite VIII for the most part, with posterior margin incised at middle. Immature gonapophyses VIII elongated, with obtuse apices. Immature gonapophyses IX covered by immature gonoplacs. Immature gonoplacs elongated, with blunt apices. Cerci at least 14-segmented, 0.09 times as long as body length.

Last instar male: similar to last instar female. Body length 35.0–41.0 mm (Fig. 6h). Posterior margin of abdominal sternite VII and VIII straight in medial region. Sternite IX extended to level of posterior margin of tergite X; posterior margin of sternite IX straight between immature styles, which are short and papillate.

### 若虫の齡期判別

1 齡若虫は、体長 6 mm 未満であること (Figs. 5a, 6a) や中列刺のうち第 I 刺がもっとも長い (Fig. 14a, i) ことから、ほかの齡と判別できる。2 齡から 5 齡の判別には、体長が有用である (Figs. 5, 6) : 2 齡は体長 7 mm 内外 ; 3 齡は体長 12 mm

内外；4 齢は体長 14 mm 内外；5 齢は 20 mm 内外。5 齢と 6 齢の判別には、体長や尾角の節数が有用である (Figs. 5, 6, 17, 18)：5 齢は体長 22 mm 未満，尾角は最低 8 節；6 齢は体長 22 mm 以上，尾角は最低 10 節。前亜終齢 (6 齢)，亜終齢 (6 齢，7 齢)，終齢 (7 齢，8 齢) の判別には、とくに後翅芽の伸長度合いが有用である：前亜終齢は後翅芽の末端が腹部第 I 背板の後縁に達しない；亜終齢は後翅芽の末端が第 I 背板の後縁に達する (Figs. 5f, 6f)；終齢は後翅芽の末端が第 I 背板の後縁を大きく超える (Figs. 5g, h, 6g, h)。

以上の特徴から、スジイリコカマキリは外部形態による齢期判別が可能である。

### 若虫の雌雄判別

概ねコカマキリと同様であったため、以下に要点をまとめた。

- (1) 1 齢には、外部形態における雌雄差がない。
- (2) 2 齢は、雌は一部の個体を除き、腹部第 IX 腹板の後縁に小さな切れ込みがある (Fig. 17b) が、雄の腹部第 IX 腹板の後縁はほぼ平坦である (Fig. 18b)。
- (3) 3 齢以降、雌は第 VII 腹板の後縁が加齢に伴い後方に拡張し、亜生殖板を形成する (Fig. 17c-g) が、雄の第 VII 腹板は加齢に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 18c-g)。
- (4) 3 齢以降、雌は一部の個体を除き、第 VIII 腹板の後縁に一对の陰具片を有する (Fig. 17c-g) が、雄の第 VIII 腹板は加齢に伴う形状の変化がほとんどなく、その後縁もほぼ平坦である (Fig. 18c-g)。
- (5) 3 齢以降、雌は第 IX 腹板の陰具片と生殖片が加齢に伴い発達し、それらの形状が変化する (Fig. 17c-g) が、雄の第 IX 腹板の尾突起には加齢に伴う形状の変化はほとんどない (Fig. 18c-g)。

以上の特徴から、スジイリコカマキリは 2 齢以降に外部形態による雌雄判別が可能である。

### 若虫期における種同定

コカマとスジイリの若虫において、2 種を判別するうえで有用な形態は、前脚腿節の黒紋の形状であった (Figs. 13, 14)。しかし、1 齢から 3 齢では 2 種の種同定に有用な同定形質は見いだせなかった。2 種は、4 齢以降において、以下の特徴で判別できる：コカマは前脚腿節の内縁刺基部に沿って現れる黒紋が互いに繋がらないのに対し、スジイリは前脚腿節の内縁刺基部に沿って現れる黒紋が繋がって帯状になる。

従来、コカマとスジイリの種同定に有用な同定形質は、外部生殖器以外では前脚腿節の黒紋の形状のみであったことや、本研究において新たな同定形質は見

いだせなかったことから、2種の1齢から3齢の若虫においては、同定形質となりうる形態差が生じない可能性が考えられる。また、スジイリの緑色型は、前脚腿節の黒紋が繋がらないことが多い（中峰 2016）ため、緑色型の個体を用いた種同定は、4齢以降の若虫でも困難であることが考えられる。

## 今後の展望

今回の研究で扱わなかったヤサガタは、前脚腿節の黒紋の形状のほかに前胸の長さが同定形質とされている（杉本 2016）。分布域が重なっているスジイリとは、前胸の比率を比較することで2種の若虫における形態差が明らかになる可能性があるため、今後の調査が期待される。

## *Statilia* 属 2 種の若虫による種、齢期、性別の検索表

1. 前脚腿節の中列刺は第 I 刺がもっとも長い……………2
- 前脚腿節の中列刺は第 III 刺がもっとも長い……………3
2. ……………コカマ 1 齢/スジイリ 1 齢
3. 体長は 10 mm 未満……………4
- 体長は 10 mm 以上……………5
4. 腹部第 IX 腹板の後縁が前方に深く抉れ、小さな切れ込みがある……………コカマ 2 齢雌/スジイリ 2 齢雌
- 腹部第 IX 腹板の後縁はほぼ平坦である……………コカマ 2 齢雄/スジイリ 2 齢雄
5. 体長は 13 mm 未満……………6
- 体長は 13 mm 以上……………7
6. 腹部第 IX 腹板の後縁が前方に深く抉れ、小さな切れ込みがある……………コカマ 3 齢雌/スジイリ 3 齢雌
- 腹部第 IX 腹板の後縁はほぼ平坦である……………コカマ 3 齢雄/スジイリ 3 齢雄
7. 前脚腿節の内縁刺基部に沿って現れる黒紋は互いに繋がらない……………8
- 前脚腿節の内縁刺基部に沿って現れる黒紋は互いに繋がる……………19
8. 体長は 17 mm 未満……………9
- 体長は 17 mm 以上……………10
9. 腹部第 VII 腹板の後縁は湾曲し、後方に伸長する……………コカマ 4 齢雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ 4 齢雄
10. 体長は 22 mm 未満……………11
- 体長は 22 mm 以上……………12
11. 腹部第 VII 腹板の後縁は湾曲し、後方に伸長する……………コカマ 5 齢雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ 5 齢雄
12. 後翅芽の末端は腹部第 I 背板の後縁に達しない……………13

- 後翅芽の末端は腹部第 I 背板の後縁に達するかまたは超える……………14
- 13. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………コカマ前亜終齡 (6 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ前亜終齡 (6 齡) 雄
- 14. 後翅芽の末端は腹部第 I 背板の後縁に達する……………15
- 後翅芽の末端は腹部第 I 背板の後縁を超える……………16
- 15. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………コカマ亜終齡 (6 齡, 7 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ亜終齡 (6 齡, 7 齡) 雄
- 16. 体長は 33 mm 未満……………17
- 体長は 33 mm 以上……………18
- 17. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………コカマ終齡 (7 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ終齡 (7 齡) 雄
- 18. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………コカマ終齡 (8 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………コカマ終齡 (8 齡) 雄
- 19. 体長は 17 mm 未満……………20
- 体長は 17 mm 以上……………21
- 20. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ 4 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………スジイリ 4 齡雄
- 21. 体長は 22 mm 未満……………22
- 体長は 22 mm 以上……………23
- 22. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ 5 齡雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………スジイリ 5 齡雄
- 23. 後翅芽の末端は腹部第 I 背板の後縁に達しない……………24
- 後翅芽の末端は腹部第 I 背板の後縁に達するかまたは超える……………25
- 24. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ前亜終齡 (6 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………スジイリ前亜終齡 (6 齡) 雄
- 25. 後翅芽の末端は腹部第 I 背板の後縁に達する……………26
- 後翅芽の末端は腹部第 I 背板の後縁を超える……………27
- 26. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ亜終齡 (6 齡, 7 齡) 雌
- 腹部第 VII 腹板の後縁はほぼ平坦であ

- る……………スジイリ亜終齡（6 齡, 7 齡）雄
27. 体長は 33 mm 未満……………28
- 体長は 33 mm 以上……………29
28. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ終齡（7 齡）雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………スジイリ終齡（7 齡）雄
29. 腹部第 VII 腹板の後縁は湾曲し，後方に伸長する……………スジイリ終齡（8 齡）雌
- 腹部第 VII 腹板の後縁はほぼ平坦である……………スジイリ終齡（8 齡）雄

2-3-4 図および表

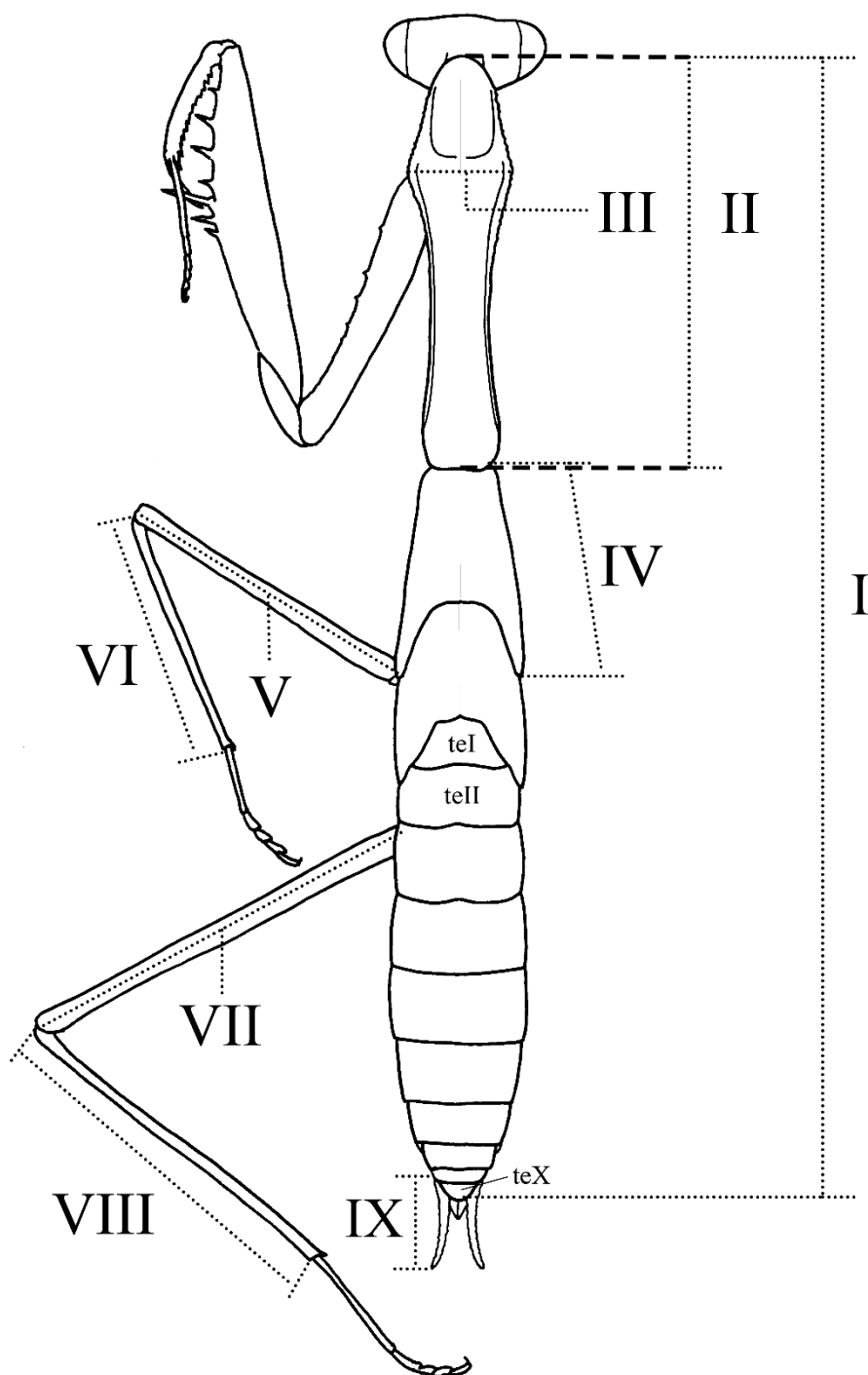


Fig. 1. General structure of nymphs of the genus *Statilia*, dorsal view. I: body length. II: pronotum length. III: pronotum width. IV: fore wing pad length. V: mesofemur length. VI: mesotibia length. VII: metafemur length. VIII: metatibial length. IX: cercus length. tel = tergite I; teII = tergite II; teX = tergite X.

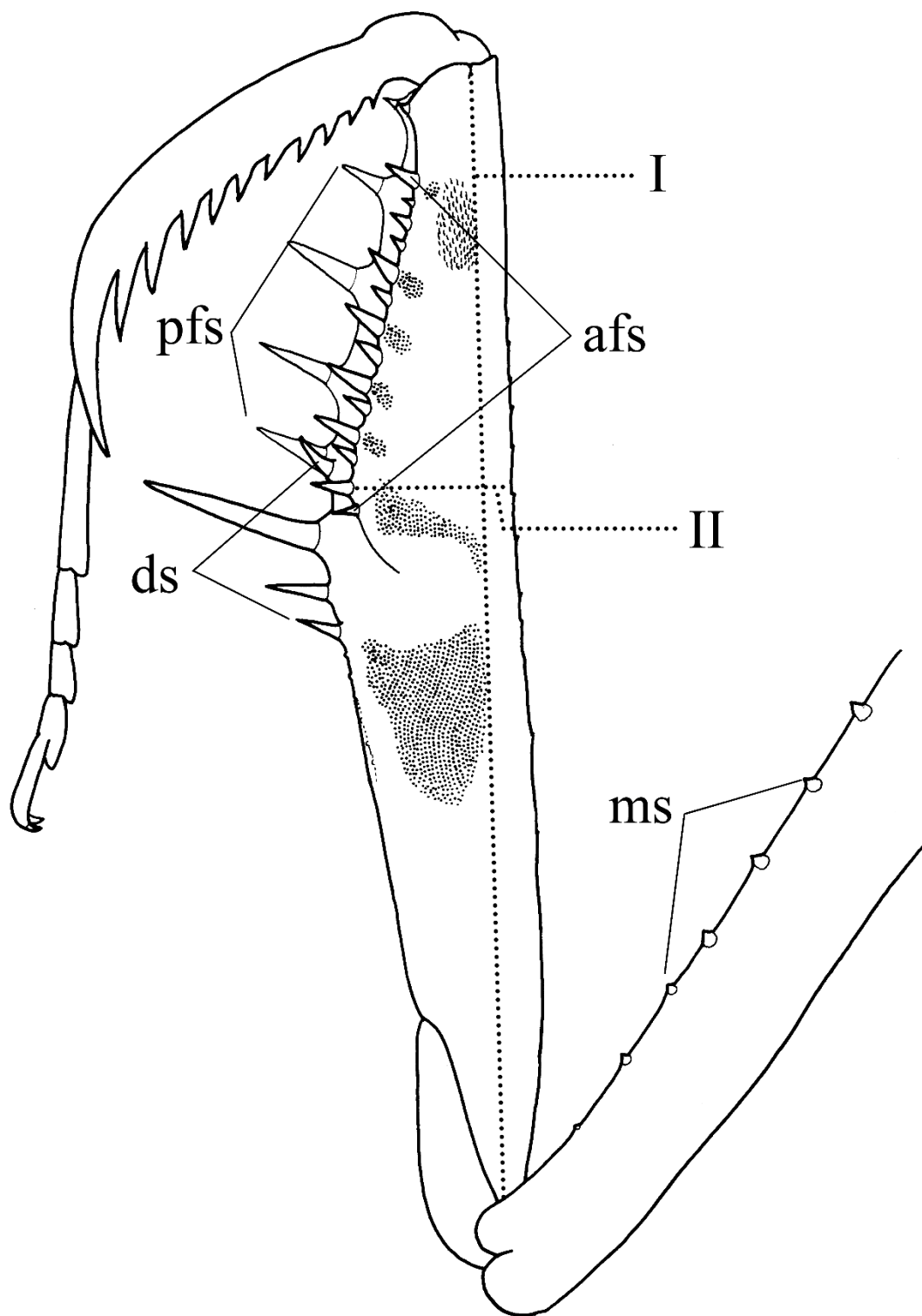


Fig. 2. General structure of foreleg of the genus *Statilia*, lateral view. I: profemur length. II: profemur width. afs = anteroventral-femoral spines; ds = discoidal spines; ms = marginal spines; pfs = posteroventral-femoral spines.

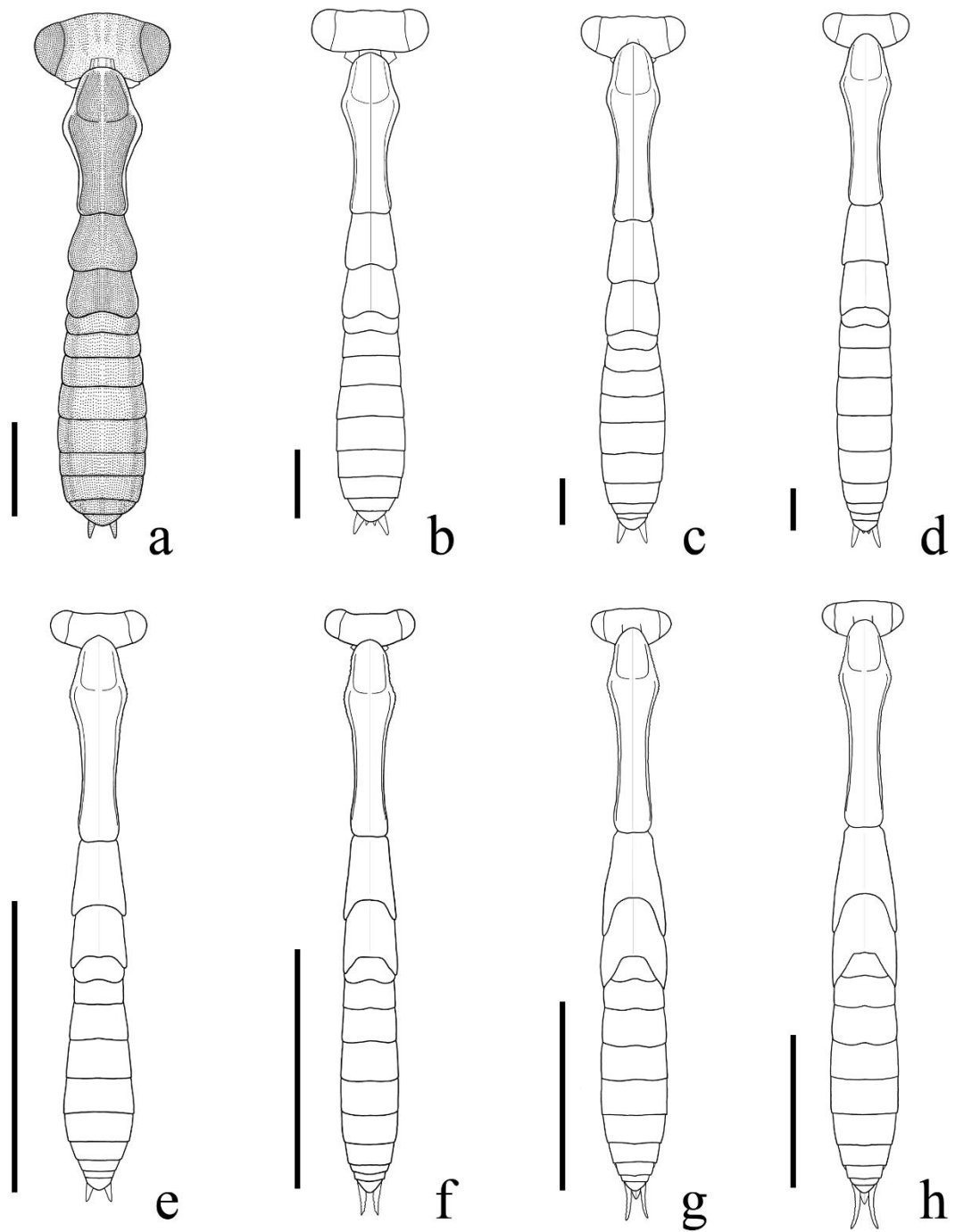


Fig. 3. General aspect in nymphal stages of *S. maculata*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; h, 8th instar. Scale bars: a–d, 1 mm; e–h, 10 mm.



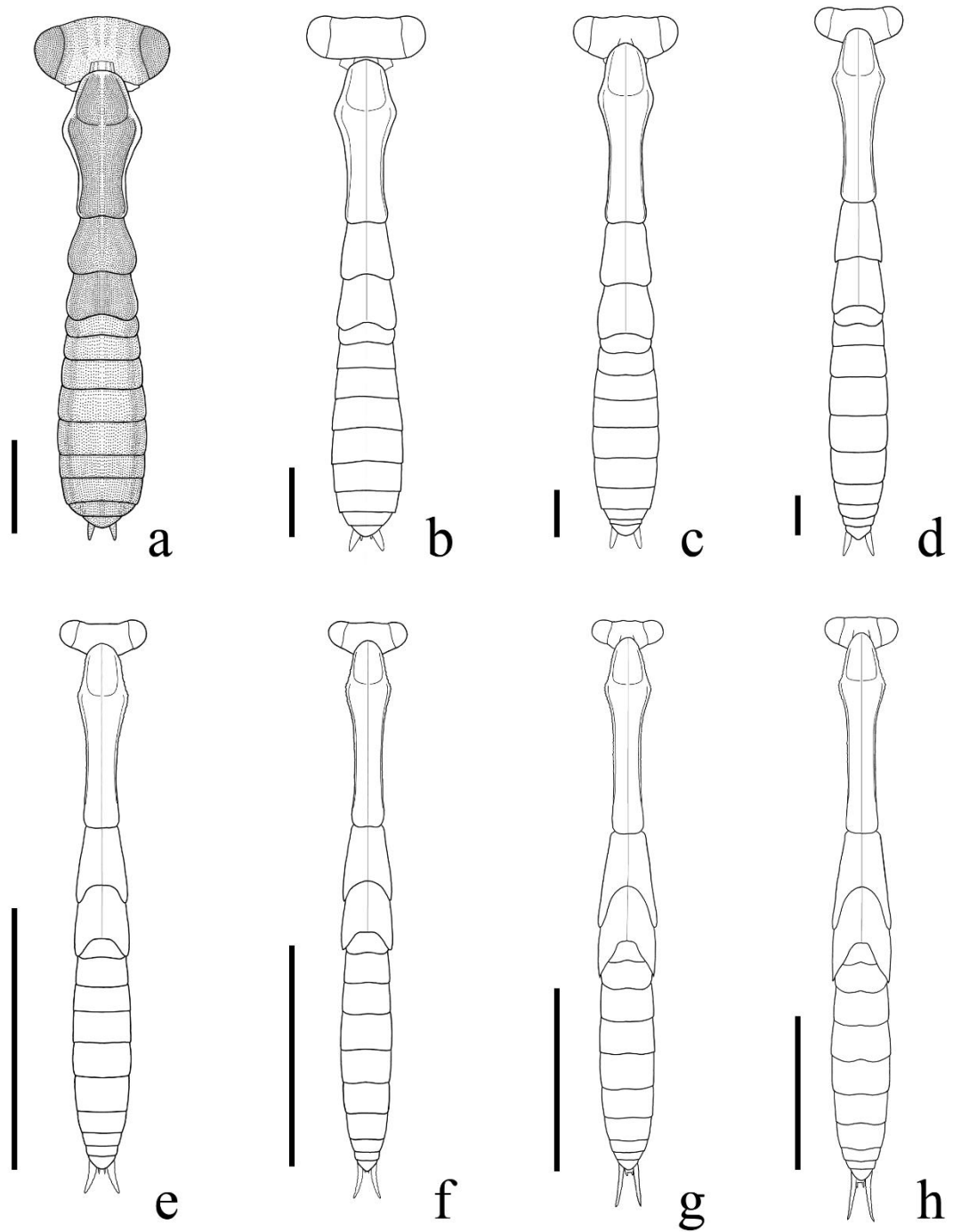


Fig. 4. General aspect in nymphal stages of *S. maculata*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; h, 8th instar. Scale bars: a–d, 1 mm; e–h, 10 mm.

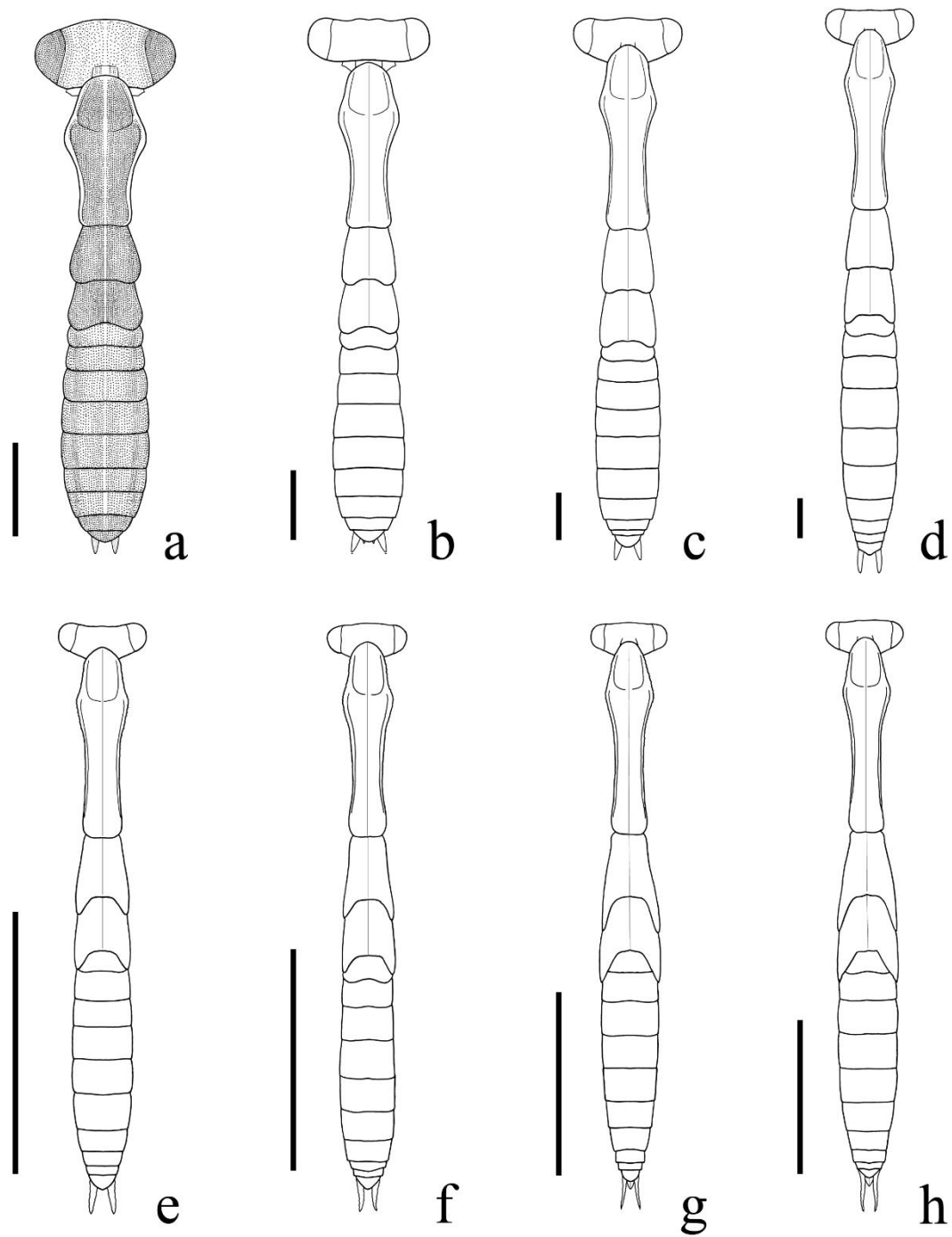


Fig. 5. General aspect in nymphal stages of *S. nemoralis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; h, 8th instar. Scale bars: a–d, 1 mm; e–h, 10 mm.

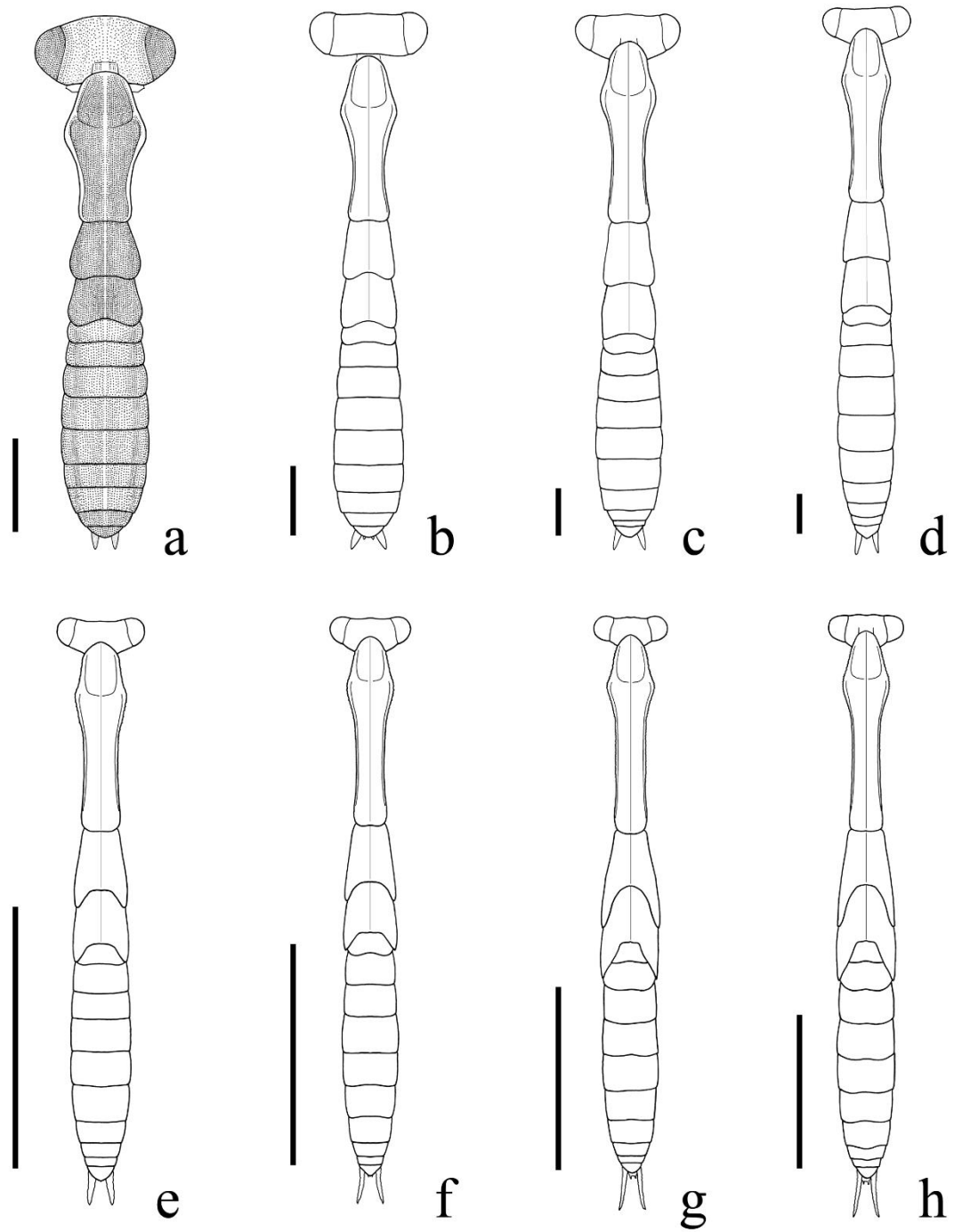


Fig. 6. General aspect in nymphal stages of *S. nemoralis*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; h, 8th instar. Scale bars: a–d, 1 mm; e–h, 10 mm.

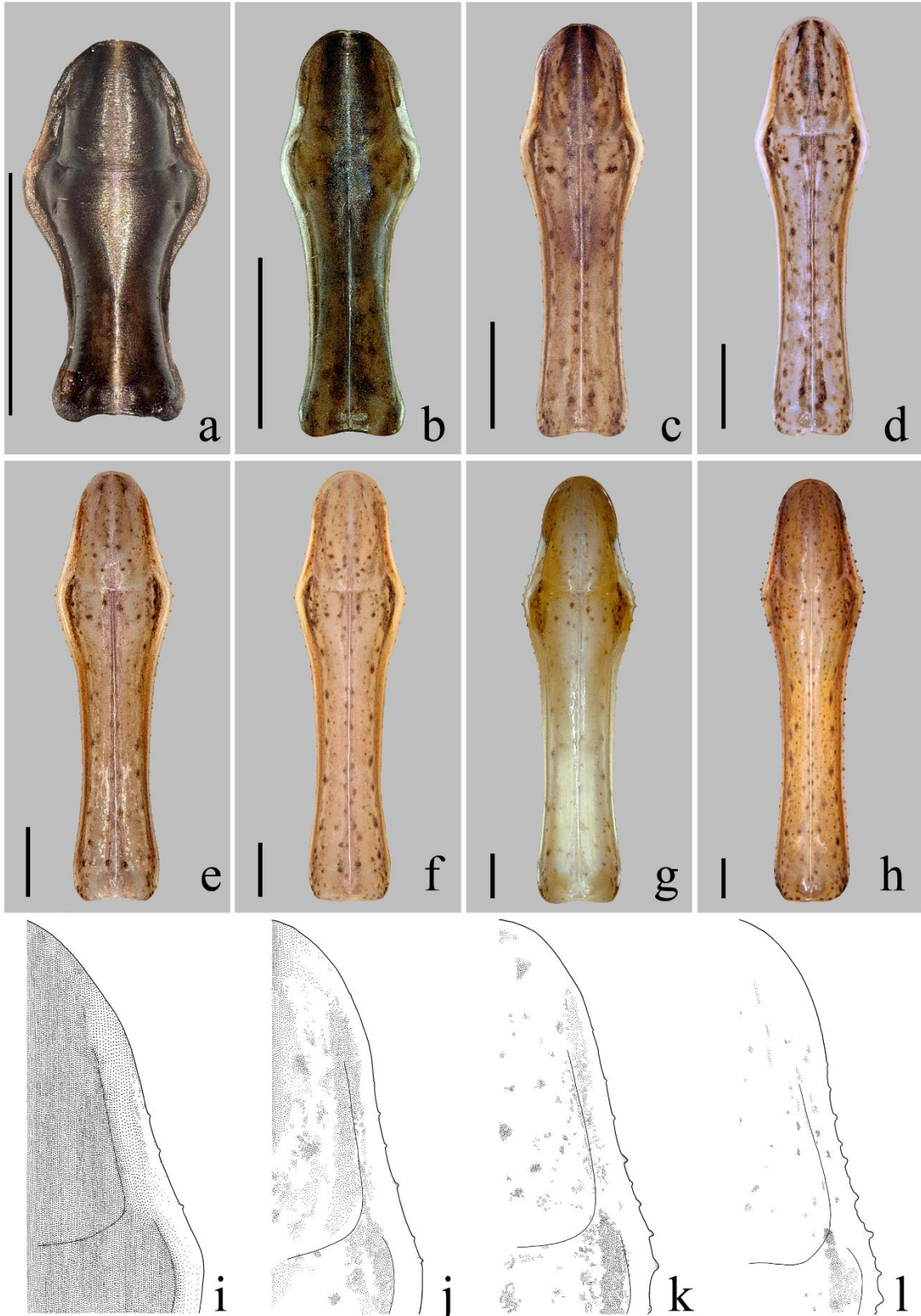


Fig. 7. Pronotum in nymphal stages of *S. maculata*, female, dorsal view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th (antepenultimate) instar; g & l, 7th (penultimate) instar; h, 8th instar. Scale bars: 1 mm.

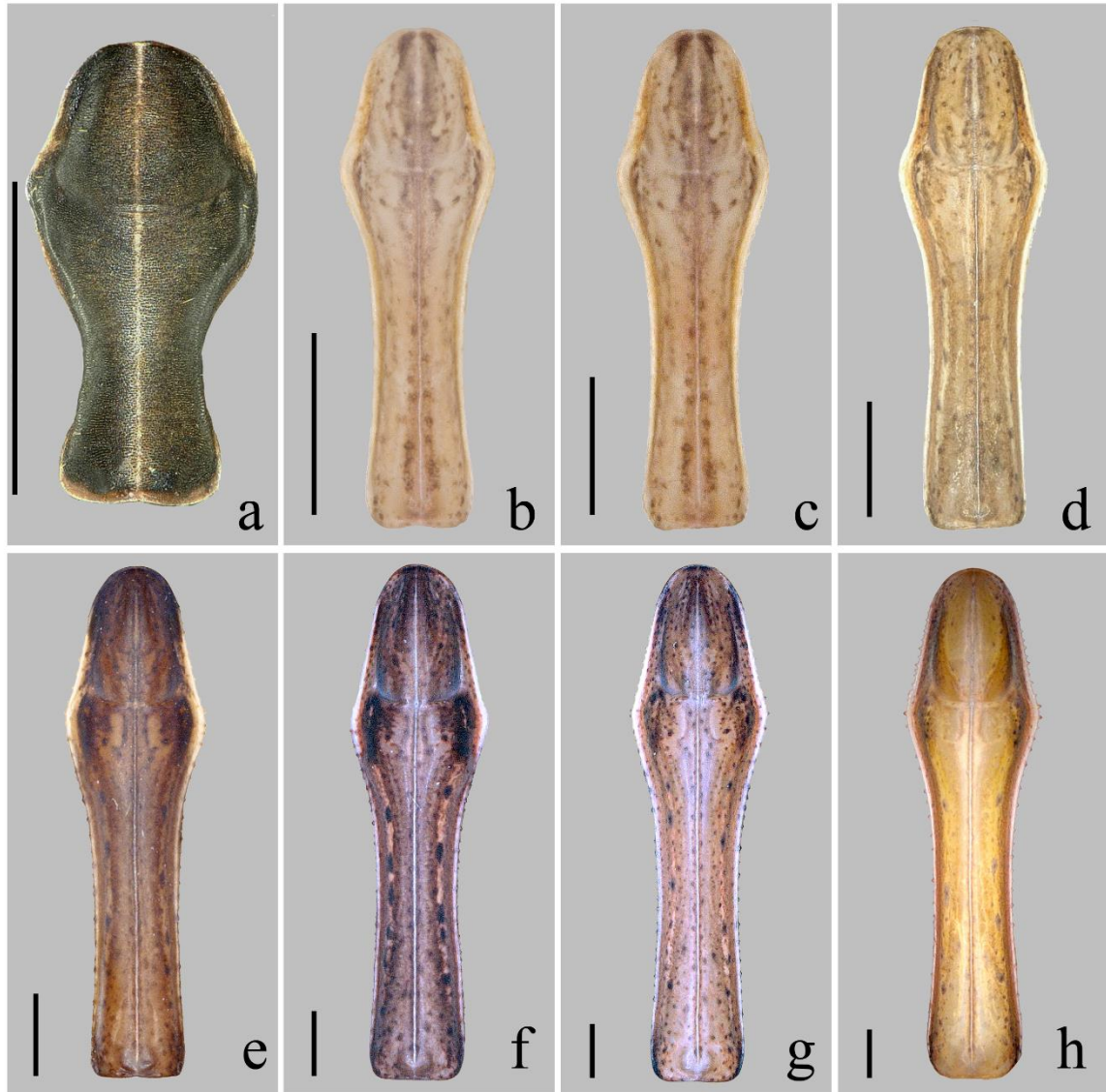


Fig. 8. Pronotum in nymphal stages of *S. nemoralis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 7th (penultimate) instar; h, 8th instar. Scale bars: 1 mm.

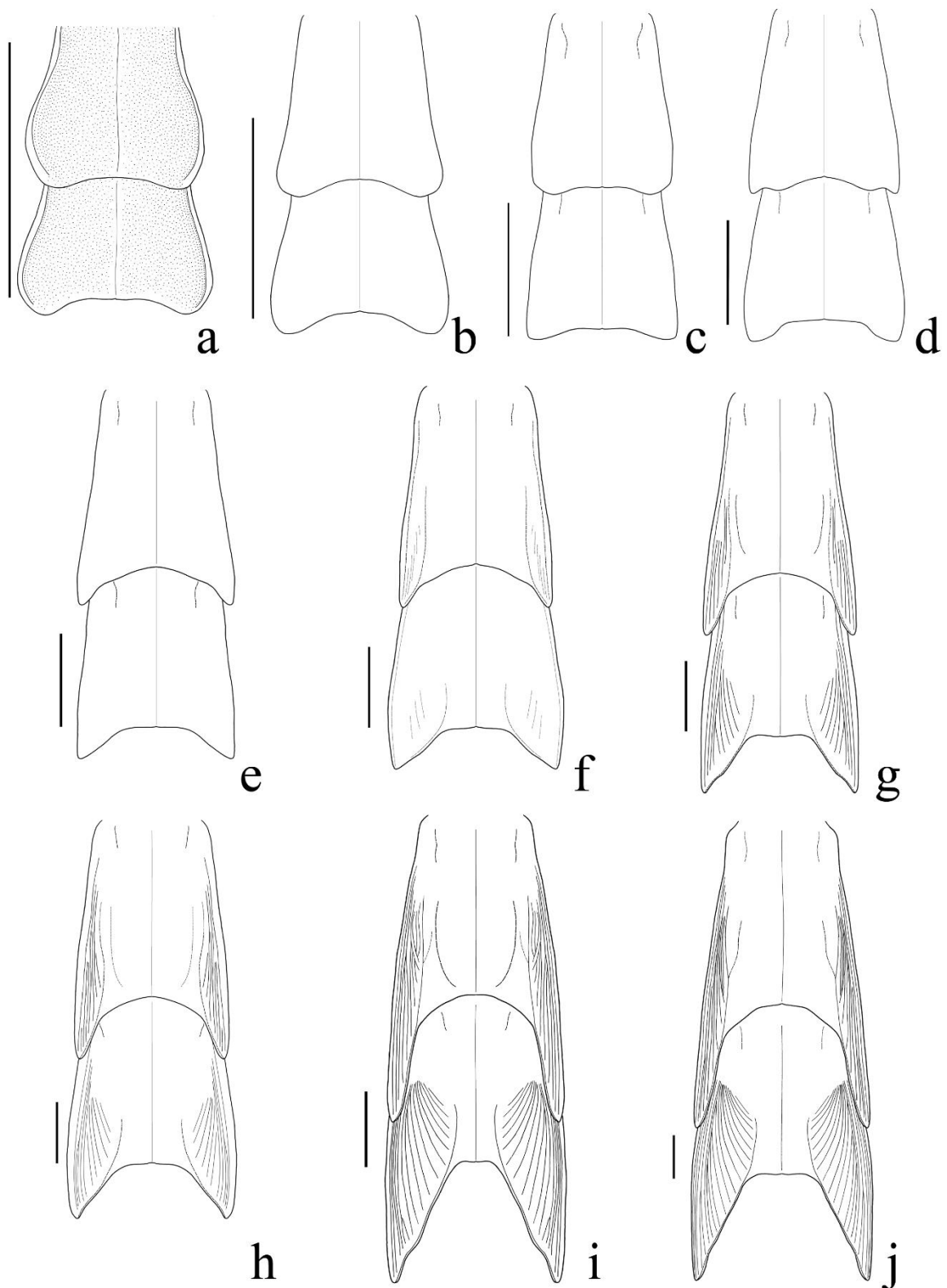


Fig. 9. Pterothorax and wing pads in nymphal stages of *S. maculata*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

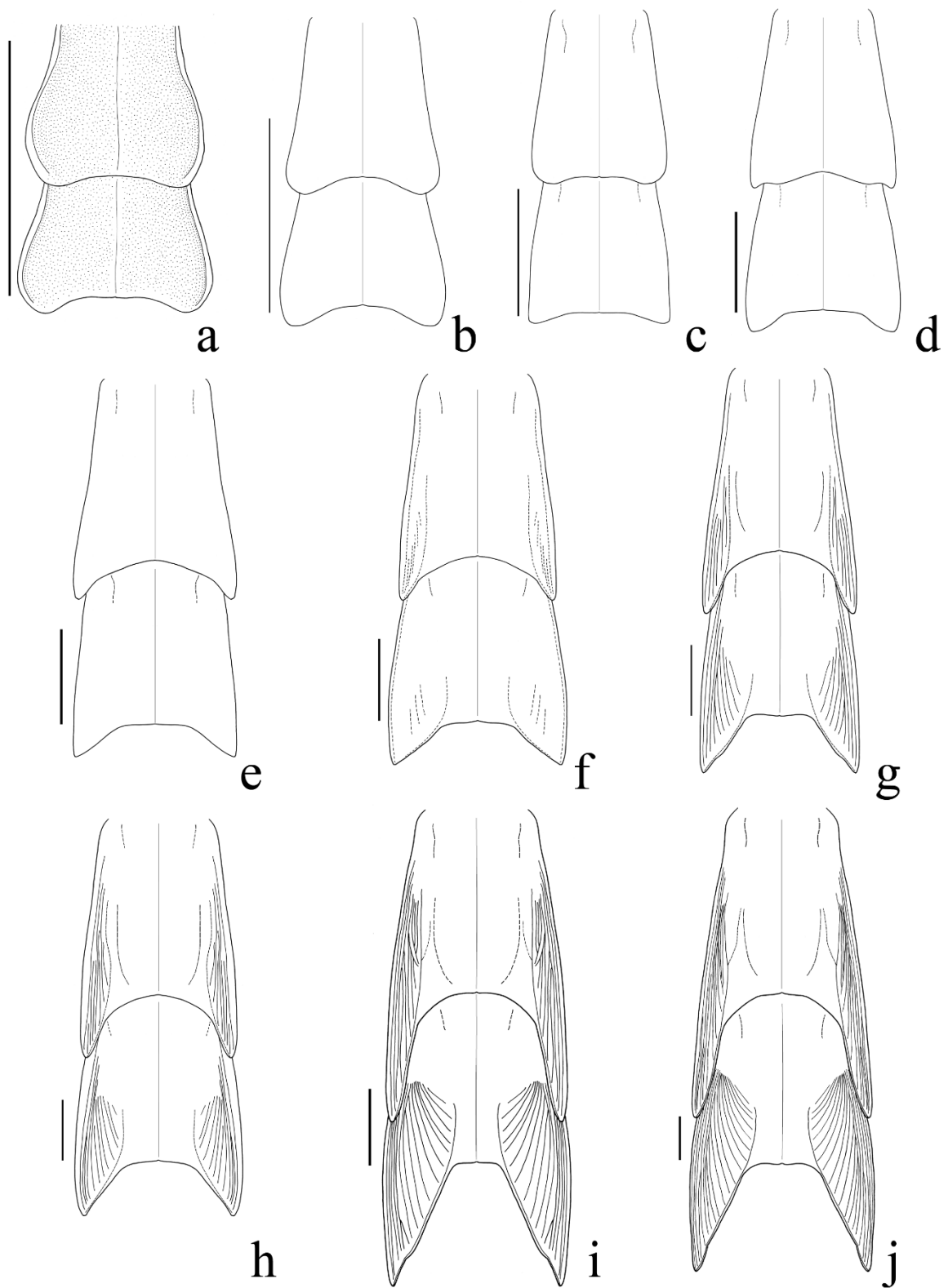


Fig. 10. Pterothorax and wing pads in nymphal stages of *S. maculata*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

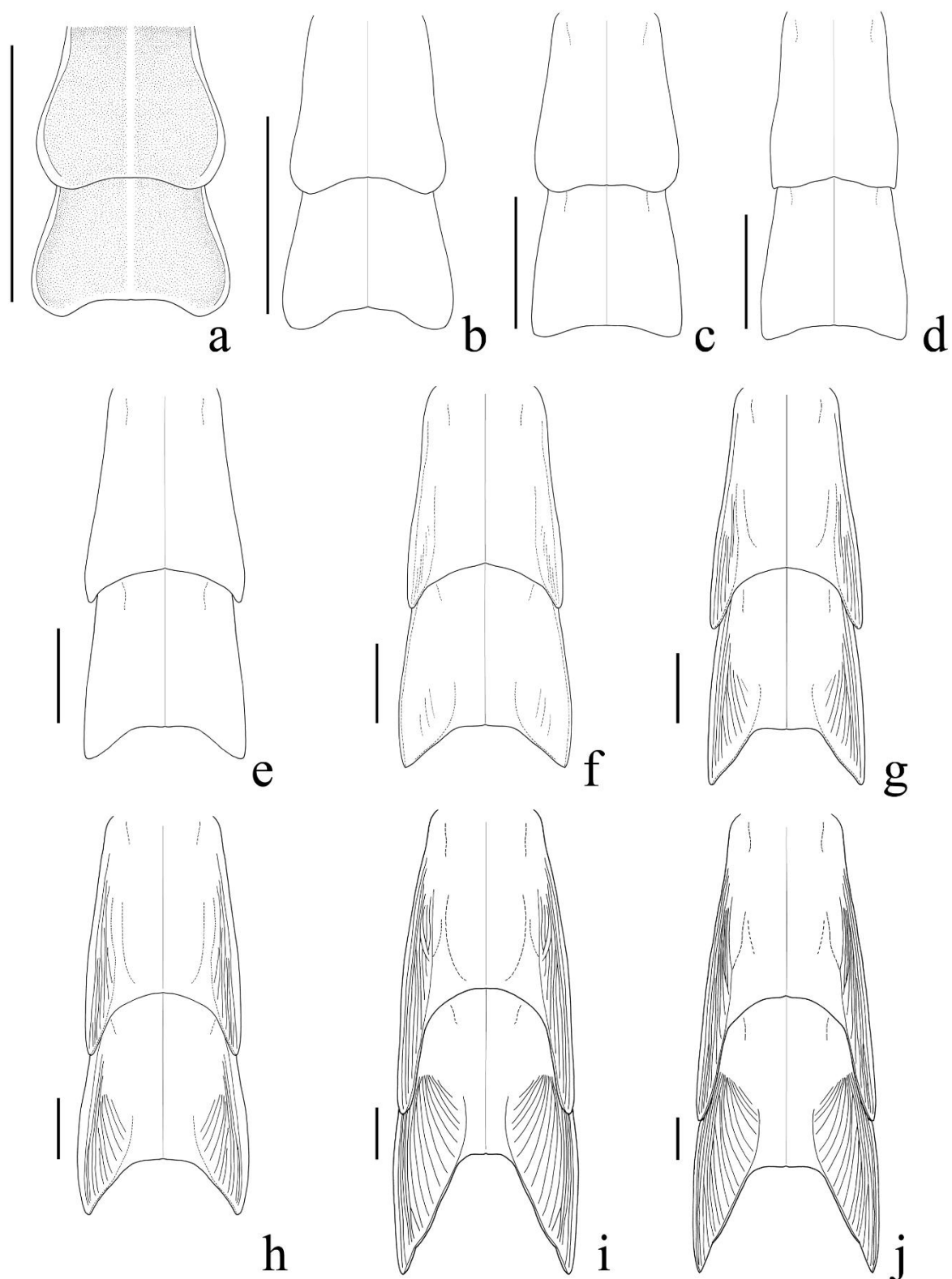


Fig. 11. Pterothorax and wing pads in nymphal stages of *S. nemoralis*, female, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.



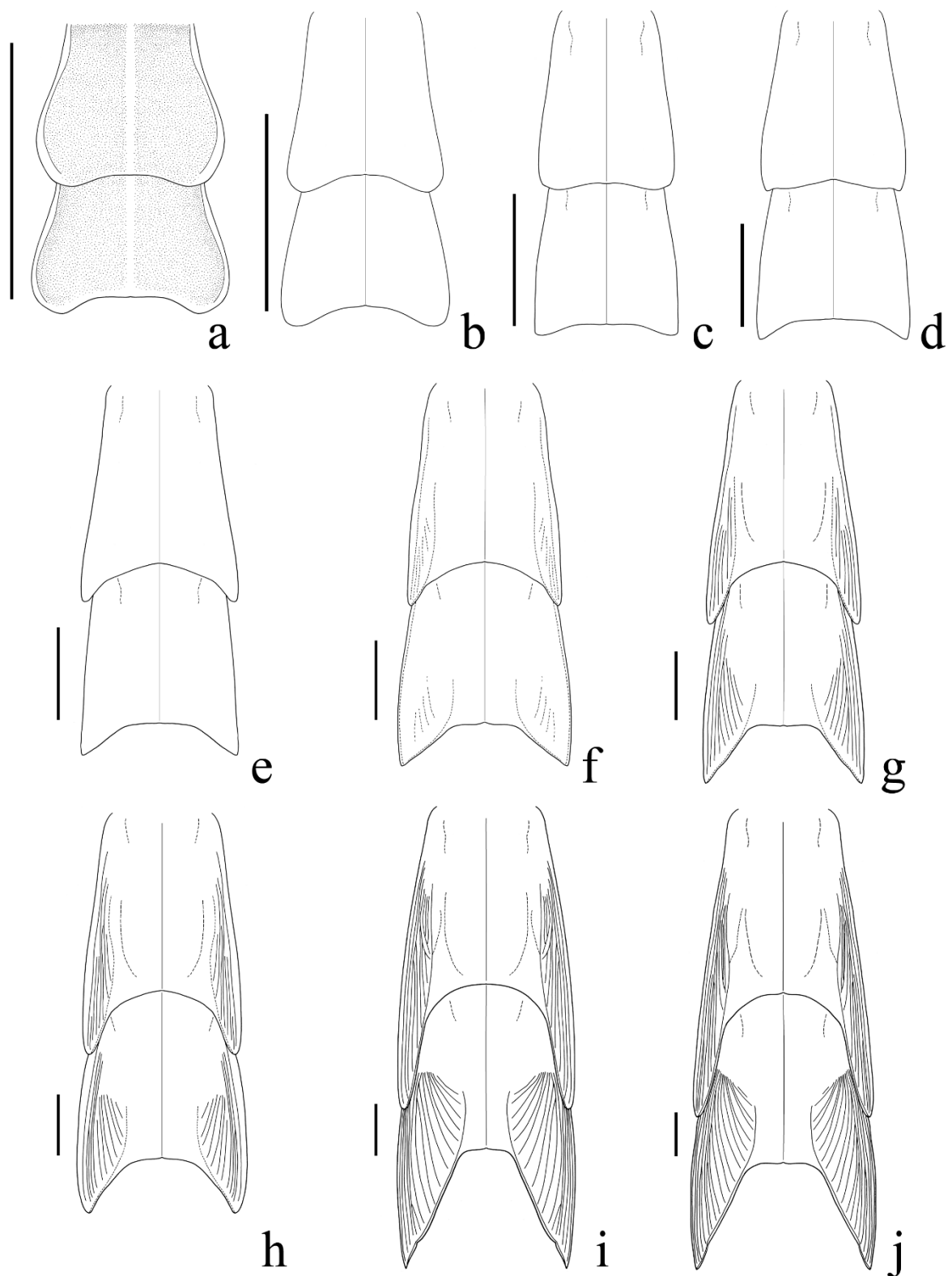


Fig. 12. Pterothorax and wing pads in nymphal stages of *S. nemoralis*, male, dorsal view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (antepenultimate) instar; g, 6th (penultimate) instar; h, 7th (penultimate) instar; i, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

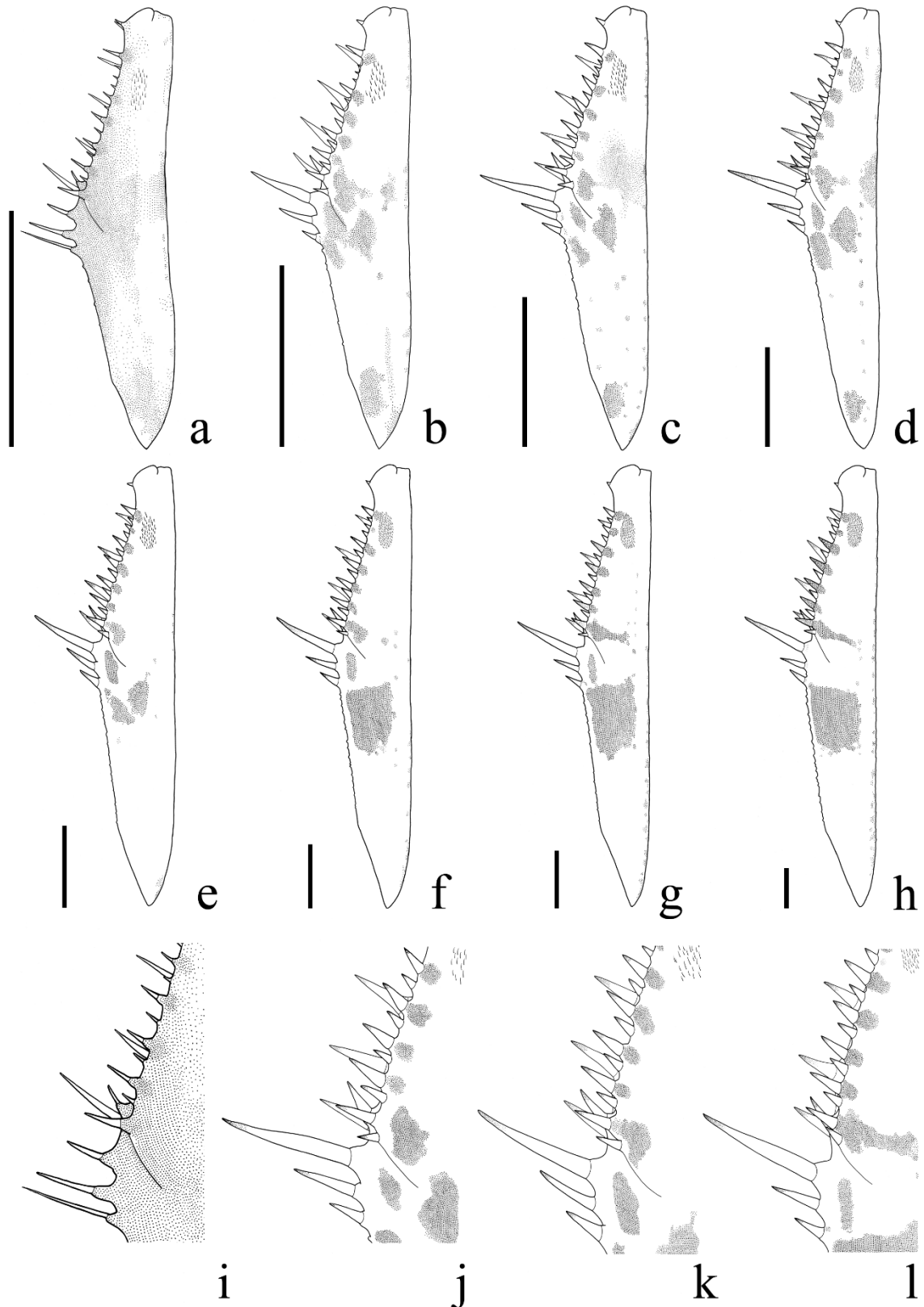


Fig. 13. Profemur in nymphal stages of *S. maculata*, female, lateral view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th (antepenultimate) instar; g & l, 7th (penultimate) instar; h, 8th instar. Scale bars: 1 mm.

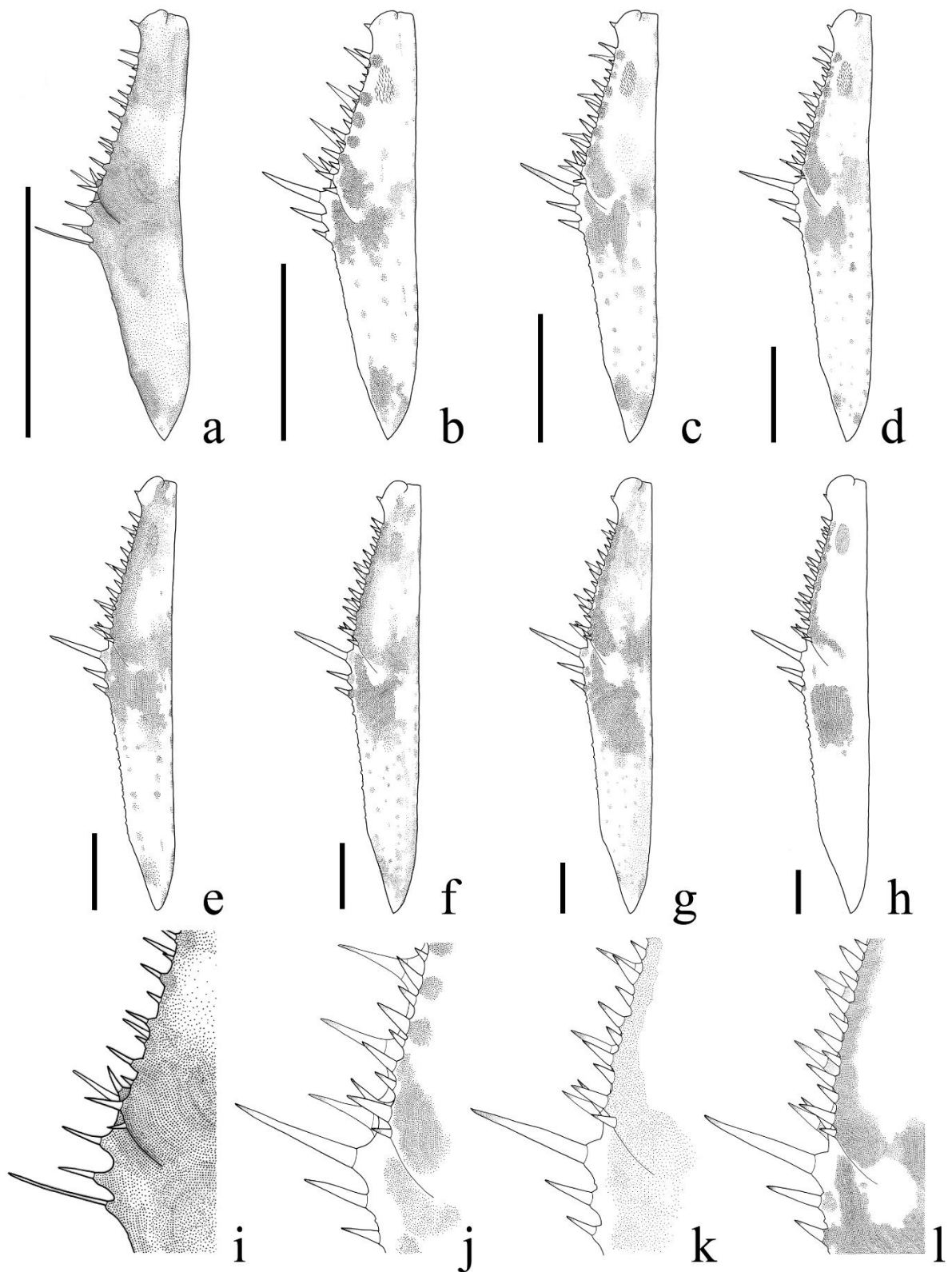


Fig. 14. Profemur in nymphal stages of *S. nemoralis*, female, lateral view. a & i, 1st instar; b, 2nd instar; c & j, 3rd instar; d, 4th instar; e & k, 5th instar; f, 6th (antepenultimate) instar; g & l, 7th (penultimate) instar; h, 8th instar. Scale bars: 1 mm.

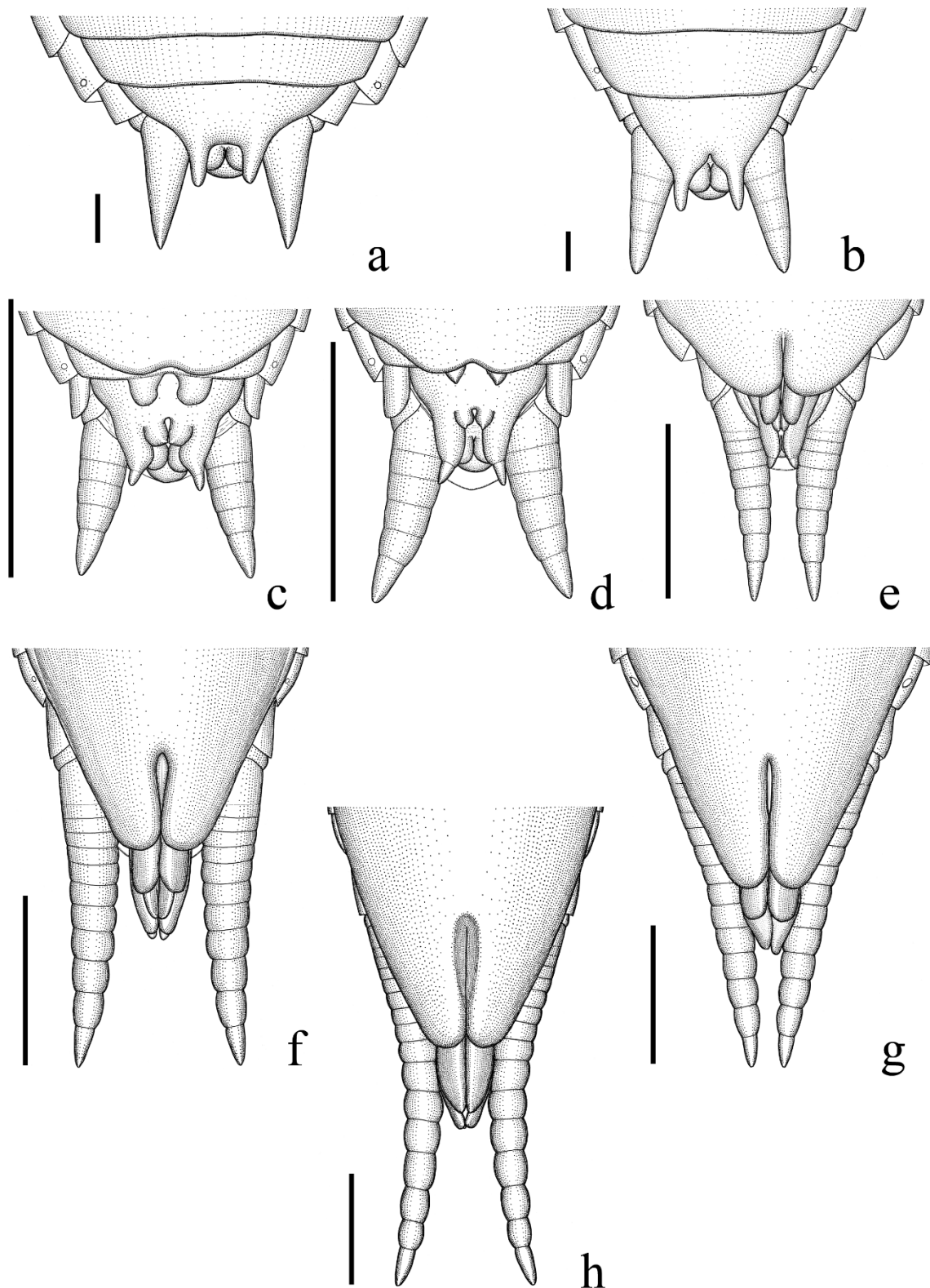


Fig. 15. Abdominal sternites VII to IX and cerci in nymphal stages of *S. maculata*, female, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

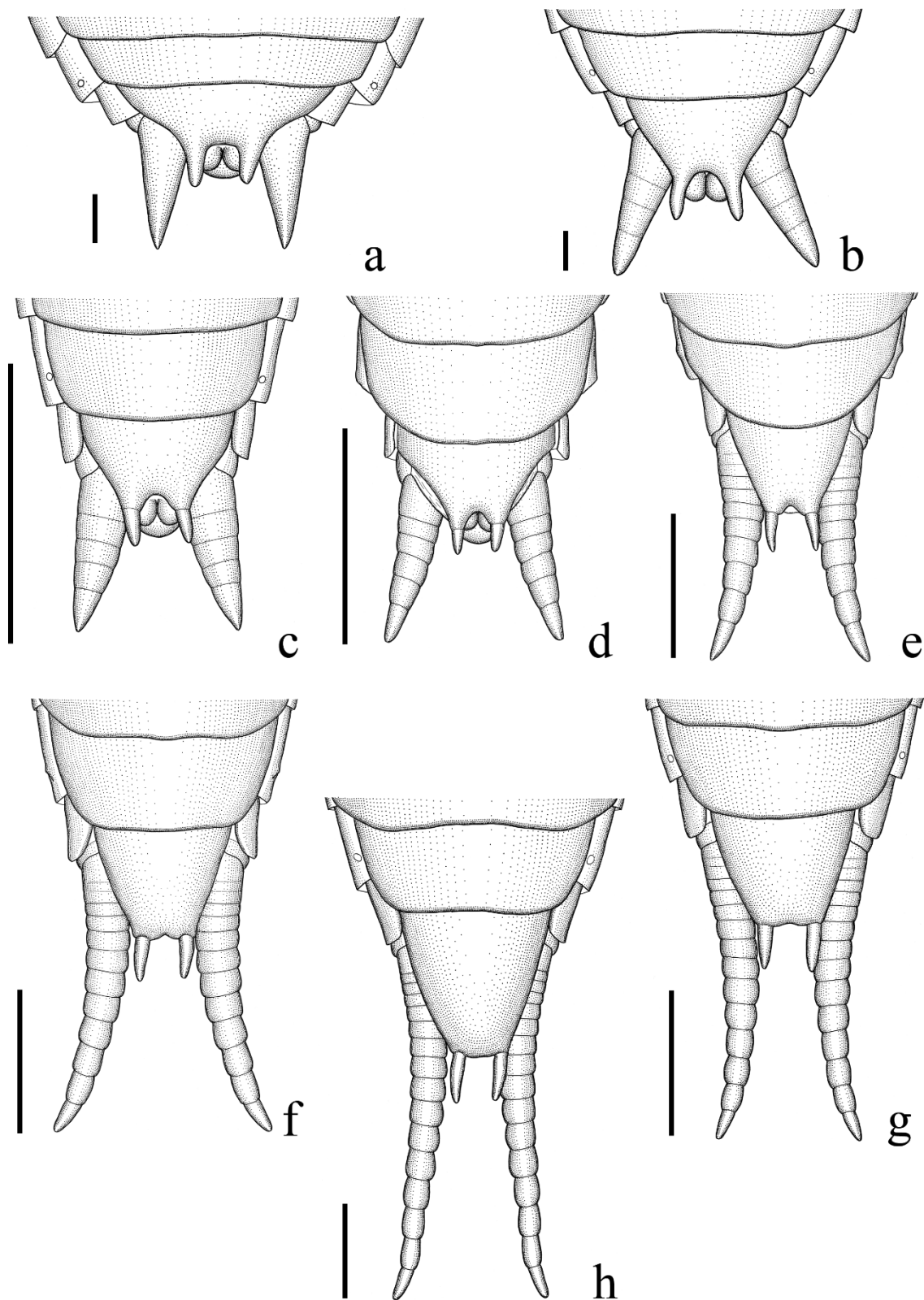


Fig. 16. Abdominal sternites VII to IX and cerci in nymphal stages of *S. maculata*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar; j, 8th instar. Scale bars: 1 mm.

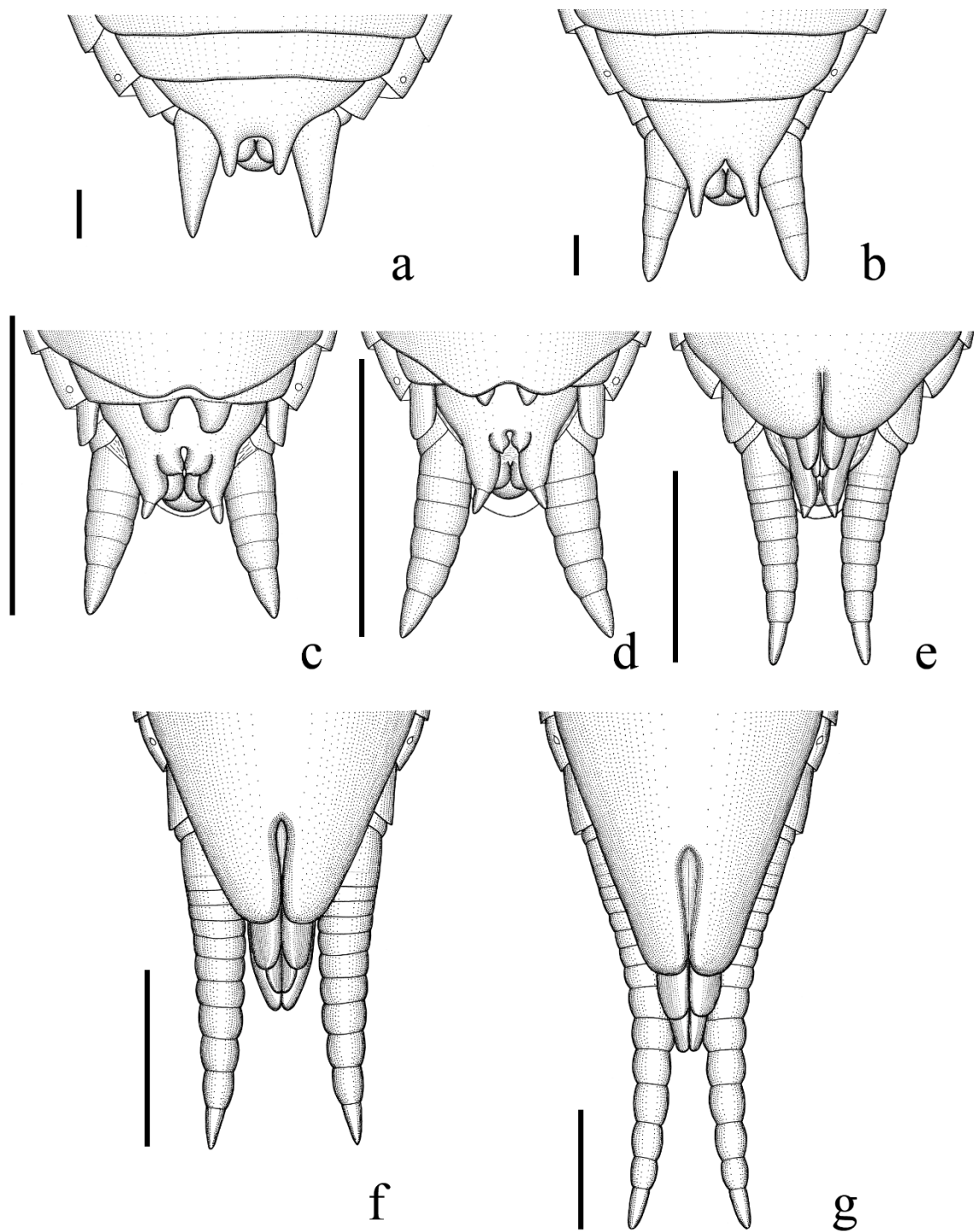


Fig. 17. Abdominal sternites VII to IX and cerci in nymphal stages of *S. nemoralis*, female, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar. Scale bars: a, b, 1 mm; c–g, 10 mm.

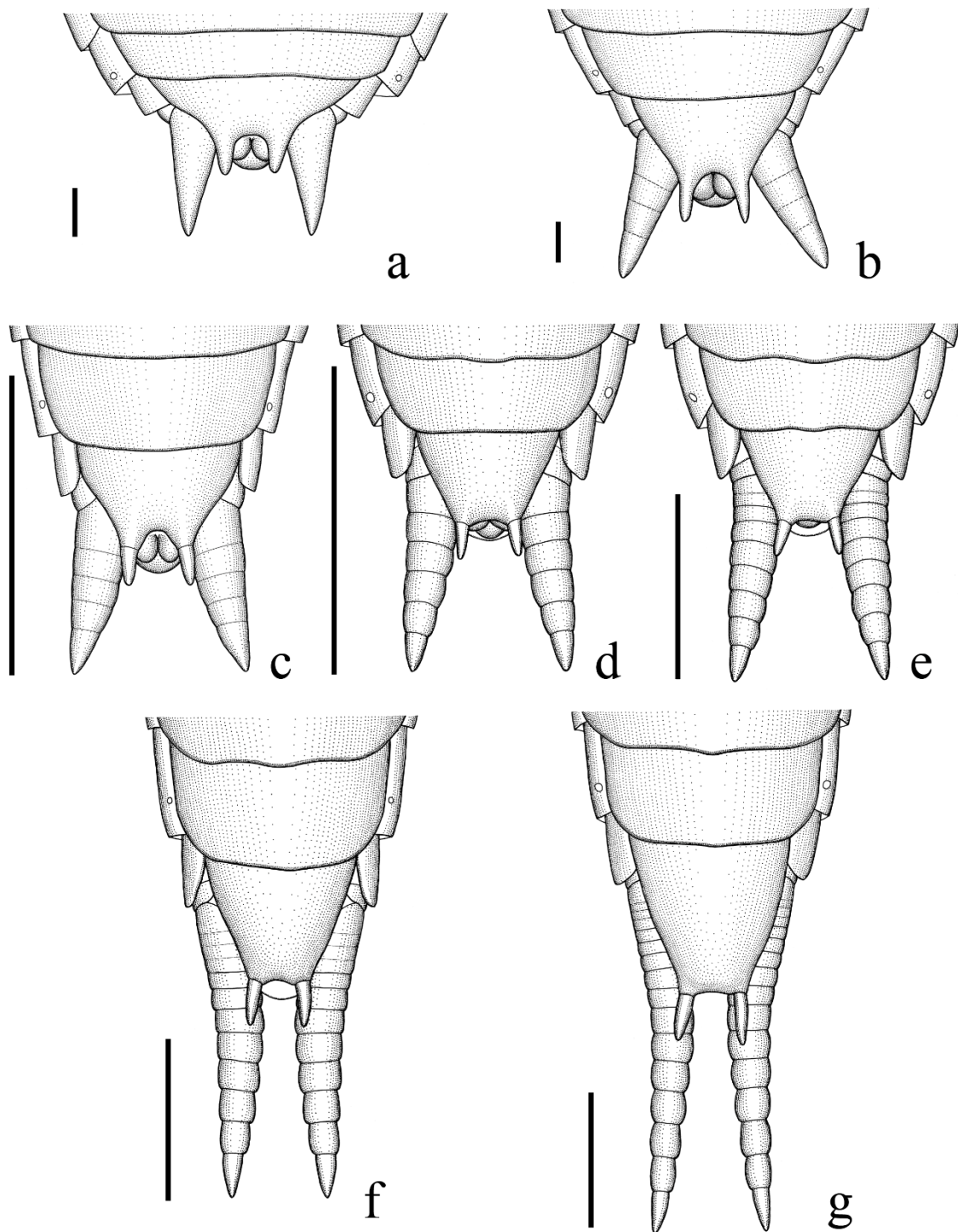


Fig. 18. Abdominal sternites VII to IX and cerci in nymphal stages of *S. nemoralis*, male, ventral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th (penultimate) instar; g, 7th (last) instar. Scale bars: a, b, 1 mm; c–g, 10 mm.

Table 1. Measurements (mm) of body parts in each nymphal stage of *Statilia maculata*.

Nymphal stage	Sex	Individuals examined	Body length	Pronotum length	Pronotum width	Fore wing pad length	Profemur length	Profemur width	Mesofemur length	Mesotibia length	Metafemur length	Metatibia length	Cercus length
1st	-	30	5.0-5.5	1.5	0.9	-	2	0.4	2	1.5	2.5	2.5	0.2
2nd	Male	15	7.0-7.5	2.5	1	-	2.6	0.5	2.2	2	3.2	3	0.3
	Female	15	7.0-7.5	2.5	1	-	2.6	0.5	2.2	2	3.2	3	0.3
3rd	Male	7	11.5-12.0	4	1.4	-	3.7	0.6	3.5	3	5	4.5	0.5
	Female	7	11.5-12.0	4	1.4	-	3.7	0.6	3.5	3	5	4.5	0.5
4th	Male	7	13.5-14.0	5	1.5	2	4.5	0.8	4	3.5	5.5	5	0.6
	Female	5	13.5-14.0	5	1.5	2	4.5	0.8	4	3.5	5.5	5	0.6
5th	Male	5	18.0-21.0	6.0-7.0	2.9-3.1	2.5-2.7	5.5-6.5	1	4.5	4	6.5	6	1
	Female	5	18.0-21.0	6.0-7.0	2.9-3.5	2.5-2.7	5.5-6.5	1	4.5	4	6.5	6	1
6th	Antepenultimate male	5	22.5-23.0	7.5	2	3	7	1	5.5	4.9	7.5	7	1.5
	Penultimate instar male	5	24.0-25.0	8	2.1	3.5	7.5	1.1	6	5	8.5	8	1.8
7th	Antepenultimate female	5	22.5-23.0	7.5	2	3	7	1	5.5	4.9	7.5	7	1.5
	Penultimate instar female	4	24.0-25.0	8	2.1	3.5	7.5	1.1	6	5	8.5	8	1.8
8th	Penultimate instar male	5	25.0-28.0	8.5-10.0	2.1-2.4	4.2-4.5	8.0-8.3	1.2	7.5-7.7	6.2	9.5	9.5	2
	Last instar male	5	28.0-30.0	10.0-11.5	2.4-2.5	5.2-5.5	8.3-8.6	1.2-1.3	7.8-7.9	6.5	9.7	9.7	2.2-2.6
8th	Penultimate instar female	5	25.0-28.0	8.5-10.0	4.8-5.0	4.2-4.5	8.0-8.3	1.2	7.5-7.7	6.2	9.5	9.5	2
	Last instar female	4	28.0-30.0	10.0-11.5	2.4-2.5	5.2-5.5	8.3-8.5	1.2-1.3	7.8-7.9	6.5	9.7	9.7	2.2-2.6
8th	Last instar male	4	35.0-41.5	13.0-16.5	3.1-3.8	6.5-7.5	11.5-12.5	1.6-1.8	8.5-10.0	7.5-9.0	12.5-13.5	12.5-13.5	3.0-3.5
	Last instar female	4	34.5-41.0	13.0-16.5	3.1-3.8	6.5-7.5	11.5-12.5	1.6-1.8	8.5-10.0	7.5-9.0	12.5-13.5	12.5-13.5	3.0-3.5

Table 2. Measurements (mm) of body parts in each nymphal stage of *Statilia nemoralis*.

Nymphal stage	Sex	Individuals examined	Body length	Pronotum length	Pronotum width	Fore wing pad length	Profemur length	Profemur width	Mesofemur length	Mesotibia length	Metafemur length	Metatibia length	Cercus length
1st	-	30	5.0-5.5	1.5	0.9	-	2	0.4	2	1.5	2.5	2.5	0.2
2nd	Male	15	7.0-7.5	2.5	1	-	2.6	0.5	2.2	2	3.2	3	0.3
	Female	15	7.0-7.5	2.5	1	-	2.6	0.5	2.2	2	3.2	3	0.3
3rd	Male	7	11.5-12.0	4	1.4	-	3.7	0.6	3.5	3	5	4.5	0.5
	Female	7	11.5-12.0	4	1.4	-	3.7	0.6	3.5	3	5	4.5	0.5
4th	Male	7	13.5-14.0	5	1.5	2	4.5	0.8	4	3.5	5.5	5	0.6
	Female	5	13.5-14.0	5	1.5	2	4.5	0.8	4	3.5	5.5	5	0.6
5th	Male	5	18.0-21.0	6.0-7.0	2.9-3.1	2.5-2.7	5.5-6.5	1	4.5	4	6.5	6	1
	Female	5	18.0-21.0	6.0-7.0	2.9-3.5	2.5-2.7	5.5-6.5	1	4.5	4	6.5	6	1
6th	Antepenultimate male	5	22.5-23.0	7.5	2	3	7	1	5.5	4.9	7.5	7	1.5
	Penultimate instar male	5	24.0-24.5	8	2.1	3.5	7.5	1.1	6	5	8.5	8	1.8
7th	Antepenultimate female	5	22.5-23.0	7.5	2	3	7	1	5.5	4.9	7.5	7	1.5
	Penultimate instar female	4	24.0-25.0	8	2.1	3.5	7.5	1.1	6	5	8.5	8	1.8
8th	Penultimate instar male	5	25.0-28.0	8.5-10.0	2.1-2.4	4.2-4.5	8.0-8.3	1.2	7.5-7.7	6.2	9.5	9.5	2
	Last instar male	5	28.0-30.0	10.0-11.5	2.4-2.5	5.2-5.5	8.3-8.6	1.2-1.3	7.8-7.9	6.5	9.7	9.7	2.2-2.6
8th	Penultimate instar female	5	25.0-28.5	8.5-10.0	4.8-5.0	4.2-4.5	8.0-8.3	1.2	7.5-7.7	6.2	9.5	9.5	2
	Last instar female	4	28.0-30.0	10.0-11.5	2.4-2.5	5.2-5.5	8.3-8.6	1.2-1.3	7.8-7.9	6.5	9.7	9.7	2.2-2.6
8th	Last instar male	4	35.0-41.5	13.0-16.5	3.1-3.8	6.5-7.5	11.5-12.5	1.6-1.8	8.5-10.0	7.5-9.0	12.5-13.5	12.5-13.5	3.0-3.5
	Last instar female	4	34.5-41.5	13.0-16.5	3.1-3.8	6.5-7.5	11.5-12.5	1.6-1.8	8.5-10.0	7.5-9.0	12.5-13.5	12.5-13.5	3.0-3.5



## 第3章

### 日本産カマキリ目の雌外部生殖器の形態および分類学的研究

#### 3-1 緒言

カマキリ目の種同定には頭部や前脚、翅などのほか、近年では外部生殖器が重視されている。Holwell *et al.* (2007) や Mukherjee & Ghate (2010) をはじめとする比較的最近の種の記載には、外部生殖器の形態も詳細に記述されており、日本産種でも外部生殖器は有用な同定形質として扱われている（岡田 2001；中峰 2016）。しかし、それらはおもに雄生殖器であり、雌生殖器を詳細に記述し、種の同定形質として用いた例はほとんどない。

雌生殖器の形態は Matsuda (1976) や Brannoch *et al.* (2017) などによって記述されており、雄生殖器と同様に部位名称が与えられている。雌外部生殖器の種ごとの形態的特徴の記載や近縁種間での比較は、Brannocha & Svenson (2016) や Rodrigues & Canello (2016), Rivera & Callohuari (2019) らにより一部の種において行なわれているが、同定形質に雌外部生殖器が用いられることが元来稀であり (Rodrigues & Canello 2016), 多くの種において、形態的特徴や同定形質としての有用性は不明である。これに起因して、雄のタイプ標本の損壊によって種同定が困難になることが実際に生じている (Tedrow *et al.* 2014) ほか、分類学的再検討が求められている種のタイプ標本が雌であることから、生殖器による種同定が行えないことも生じている。こういった事態を回避し、雌個体でも正確な種同定を可能にするため、雌外部生殖器の同定形質としての有用性を検討する必要がある。

今回、日本産カマキリ目 3 科 11 種の雌外部生殖器を観察し、各種の基本的な形態を把握するとともに、近縁種間で比較することで雌外部生殖器の同定形質としての有用性を検証した。

#### 3-2 材料および方法

研究に用いた材料は、日本産（移入種を含む）3 科 6 属 11 種である。各種検視標本の採集地および個体数を表 Table 1 に示した。これらのサンプルは実体顕微鏡 (SZ60; Olympus, 東京) 下で解剖した。多くは新鮮なものを用いたが、一部の乾燥標本や液浸標本は温水で軟化させてから解剖した。亜生殖板の内側に位置する生殖葉、乳頭状葉、生殖突起、前硬皮は、腹部の側面を肛門付近から解剖鉗で切開し、産卵管一式を背面側に持ち上げた状態でデジタルマイクロスコー

プ (VHX-1000; Keyence, 大阪) を用いて撮影し, 撮影した画像を基にトレス法を用いてスケッチを行なった. 産卵管一式は生殖葉などの撮影後に解剖鉗とピンセットで摘出し, 10%濃度の KOH 溶液に常温で 12 時間以上浸して付着物を溶かした後に 99%エタノールで固定し, 腹面と背面をデジタルマイクロスコープで撮影し観察した. 各種における生殖葉, 乳頭状葉, 生殖突起, 前硬皮, 産卵管の形態的特徴を記載し, カマキリ科のオオカマキリ属 3 種, ハラビロカマキリ属 2 種, コカマキリ属 2 種およびハナカマキリ科のヒメカマキリ属 2 種を同属内で比較した. ウスバカマキリおよびヒナカマキリは, 国内に同属の近縁種がないため, 詳細な形態の記載に努めた.

なお, 分類体系は Schwarz & Roy (2019) に準拠した. 形態用語に関しては Brannoch *et al.* (2017) に従い, 日本語の名称がない部位は和訳した. 各部位名称の和英対応は以下のとおりである (Fig. 1): 生殖葉 epigynal lobe; 乳頭状葉 papilla lobe; 生殖突起 process of genital fold; 前硬皮 vestibular sclerite; 生殖器基部 gonacoxa VIII; 基部前葉 antero-coxal lobe; 基部後葉 postero-coxal lobe; 尾部 caudogyne; 受精囊 spermathecal bulge; 付属腺支部 accessory-gland-supporting lobe; 陰具片 gonapophysis VIII; 前陰具片突起 antero-gonapophysal process; 生殖片基部 gonoplac-basal lobe. また, 基部前葉, 基部後葉, 前陰具片突起は, 今回新たな部位名称として提唱した.

### 3-3 結果および考察

#### 記載 Description

##### 1. カマキリ科 Mantidae Latreille, 1802

##### 1.1. オオカマキリ属 *Tenodera* Burmeister, 1838

##### 1.1.1. マエモンカマキリ *Tenodera fasciata* (Olivier, 1792)

(Fig. 2a-c)

Epigynal lobe and papilla lobe membranous, generally semitransparent. Process of genital fold short, projected obtusely at apex, with short bristles. Vestibular sclerite with many short bristles extensively. Gonacoxa VIII well sclerotized, with many shallow wrinkles on surface except for antero-coxal lobe; anterior-coxal lobe rounded and bulged ventrally, with many deep wrinkles on surface; postero-coxal lobe weakly extended posteriorly. Caudogyne wholly whitish. Spermathecal bulge generally wholly whitish, with a pair of large light brown markings. Accessory-gland-supporting lobe wholly whitish. Gonapophysis VIII strongly dented on ventral margin in basal half; antero-gonapophysal process extended posteriorly, with apex blunt. Gonoplac-basal lobe moderately bulged anteriorly.

### 1.1.2. チョウセンカマキリ *Tenodera angustipennis* Saussure, 1869

(Fig. 2d–f)

*Tenodera angustipennis* is similar to *T. fasciata*. Epigynal lobe with a large brown marking near apex. Gonacoxa VIII with many deep wrinkles wholly; anterior-coxal lobe rounded and bulged medially; postero-coxal lobe rounded, lacking acute angles. Caudogyne wholly whitish, with a large brown marking anteriorly. Spermathecal bulge and accessory-gland-supporting lobe generally wholly whitish. Gonapophysis VIII weakly dented on ventral margin in basal half; antero-gonapophysal process extended posteriorly, with apex acute. Gonoplac-basal lobe weakly bulged anteriorly.

### 1.1.3. オオカマキリ *Tenodera sinensis* Saussure, 1871

(Fig. 2g–i)

*Tenodera sinensis* is similar to *T. fasciata*. Gonacoxa VIII with many and deep wrinkles wholly; anterior-coxal lobe rounded and bulged medially; postero-coxal lobe angulated. Caudogyne wholly brownish. Spermathecal bulge generally wholly whitish, with a pair of large light brown markings. Gonapophysis VIII strongly dented on ventral margin in basal half; antero-gonapophysal process extended posteriorly, with apex blunt. Gonoplac-basal lobe strongly bulged anteriorly.

## 1.2. ハラビロカマキリ属 *Hierodula* Burmeister, 1838

### 1.2.1. ハラビロカマキリ *Hierodula patellifera* (Audinet-Serville, 1839)

(Figs. 3a–c, 4a–h)

Epigynal lobe and papilla lobe membranous, generally semitransparent and oblong in shape. Process of genital fold short, projected obtusely at apex, with short bristles. Vestibular sclerite with many short bristles extensively. Gonacoxa VIII well sclerotized, with or without wrinkles on surface; anterior-coxal lobe placoid, extended anteriorly, with lateral margins irregular serrate anteriorly, or crooked roundly; postero-coxal lobe extended posteriorly and obliquely. Caudogyne well sclerotized, wholly brownish, with bulged medially at both lateral ends. Spermathecal bulge generally wholly whitish. Area between caudogyne and spermathecal bulge well sclerotized, with a pair of brownish obtuse process. Accessory-gland-supporting lobe generally wholly whitish. Gonapophysis VIII weakly dented on ventral margin in basal half; antero-gonapophysal process lacking. Gonoplac-basal lobe moderately bulged anteriorly.

### 1.2.2. ムネアカハラビロカマキリ *Hierodula* sp.

(Fig. 3d–f)

*Hierodula* sp. is similar to *H. patellifera*. Vestibular sclerite with many short bristles partially. Gonacoxa VIII well sclerotized, lacking wrinkles on surface except for antero-coxal lobe; antero-coxal lobe rounded, weakly extended anteriorly, with deep wrinkles; postero-coxal lobe extended medially. Caudogyne well sclerotized, wholly brownish. Spermathecal bulge well sclerotized, anterior half and posterior margins darky brownish, and posterior half whitish. Gonapophysis VIII straight. Gonoplac-basal lobe strongly bulged anteriorly.

### 1.3. コカマキリ属 *Statilia* Stål, 1877

#### 1.3.1. コカマキリ *Statilia maculata* (Thunberg, 1784)

(Fig. 5a–c)

Epigynal lobe well sclerotized, wholly brownish, with sclerotized part triangle and covering most of papilla lobe. Papilla lobe membranous. Process of genital fold well sclerotized, wholly brownish, projected acutely at apex, with short bristles. Vestibular sclerite with many short bristles extensively. Gonacoxa VIII well sclerotized; antero-coxal lobe tapered, extended anteriorly; postero-coxal lobe rounded. Caudogyne weakly brownish. Spermathecal bulge generally weakly brownish. Accessory-gland-supporting lobe generally semitransparent. Gonapophysis VIII weakly dented on ventral margin in basal half; antero-gonapophysal process lacking. Gonoplac-basal lobe weakly bulged anteriorly.

#### 1.3.2. スジイリコカマキリ *Statilia nemoralis* (Saussure, 1870)

(Fig. 5d–f)

*Statilia nemoralis* is similar to *S. maculata*. Epigynal lobe well sclerotized, wholly brownish, sclerotized part upturned, T-shaped, covering most of papilla lobe, with apex acute. Process of genital fold projected obtusely at apex, with short bristles.

### 1.4. ウスバカマキリ属 *Mantis* Linnaeus, 1758

#### 1.4.1. ウスバカマキリ *Mantis religiosa* (Linnaeus, 1758)

(Fig. 6a–c)

Epigynal lobe well sclerotized, wholly brownish, sclerotized part trapezoid, covering most of papilla lobe. Papilla lobe membranous. Process of genital fold well sclerotized, weakly brownish, projected obtusely at apex, with short bristles. Vestibular sclerite with many short bristles extensively. Gonacoxa VIII well sclerotized, with many shallow

wrinkles wholly; antero-coxal lobe and postero-coxal lobe angulated. Caudogyne weakly brownish. Spermathecal bulge generally wholly whitish. Accessory-gland-supporting lobe generally semitransparent. Gonapophysis VIII weakly dented on ventral margin in basal half; antero-gonapophysal process lacking. Gonoplac-basal lobe lacking bulge.

## 2. ハナカマキリ科 *Hymenopodidae* Giglio-Tos, 1915

### 2.1. ヒメカマキリ属 *Acromantis* Saussure, 1870

#### 2.1.1 ヒメカマキリ *Acromantis japonica* Westwood, 1889

(Fig. 7a–c)

Epigynal lobe and papilla lobe membranous, generally semitransparent. Process of genital fold lacking. Vestibular sclerite with many short bristles extensively. Gonacoxa VIII well sclerotized, with shallow wrinkles wholly; antero-coxal lobe, extended anteriorly; postero-coxal lobe rounded. Caudogyne semitransparent or weakly brownish. Spermathecal bulge rounded generally wholly brownish. Accessory-gland-supporting lobe generally semitransparent. Gonapophysis VIII strongly dented on dorsal margin apically; antero-gonapophysal process lacking. Gonoplac-basal lobe weakly bulged anteriorly.

#### 2.1.2 サツマヒメカマキリ *Acromantis satsumensis* Matsumura, 1913

(Fig. 7d–f)

*Acromantis satsumensis* is similar to *A. japonica*. Gonapophysis VIII strongly dented on dorsal margin apically.

## 3. コブヒナカマキリ科 *Gonypetidae* Westwood, 1889

### 3.1. ヒナカマキリ属 *Amantis* Giglio-Tos, 1915

#### 3.1.1. ヒナカマキリ *Amantis nawai* (Shiraki, 1908)

(Fig. 8a–c)

Epigynal lobe and papilla lobe membranous, generally semitransparent. Process of genital fold lacking. Vestibular sclerite with many short bristles partially. Gonacoxa VIII well sclerotized, rounded generally, partially brownish; antero-coxal lobe and postero-coxal lobe rounded. Caudogyne semitransparent, with or without a small blown marking. Spermathecal bulge rounded generally, wholly brownish. Accessory-gland-supporting lobe generally semitransparent. Gonapophysis VIII lacking antero-gonapophysal process. Gonoplac-basal lobe weakly bulged anteriorly.

## 同定形質としての有用性

マエモンカマキリ, チョウセンカマキリ, オオカマキリの雌外部生殖器は, おもに産卵管の多くの部位において, それぞれ安定した形質を有しており, とくに, 尾部の発色と紋の有無で容易に種を同定できる (Fig. 2). ハラビロカマキリとムネアカハラビロカマキリは, 前硬皮と産卵管の形態が全体的に著しく異なっており, 容易に同定できる (Fig. 3). コカマキリとスジイリコカマキリは, 産卵管では種間における明瞭な形態差は確認できなかったものの, 角質化した生殖葉の形状が異なっていることから容易に同定できる (Fig. 5). また, 本研究では扱えなかったヤサガタコカマキリ *Statilia apicalis* (Saussure, 1871) も同部位に種差が生じる可能性が高く, 今後の観察が望まれる. ヒメカマキリとサツマヒメカマキリは, 雌外部生殖器の全体をとおして特徴的な形質は認められなかった (Fig. 7). 唯一, 陰具片の末端付近に僅かな形態差を確認したが, あくまで傾向に過ぎないため, ヒメカマキリ属 2 種の雌外部生殖器による同定は困難であると考えられる. また, ヒメカマキリとサツマヒメカマキリは, 雄外部生殖器の形態においても特徴的な形質が認められず, 同定が困難である (中峰 2016) ことから, ヒメカマキリ属においては, 外部生殖器そのものが同定形質として有効ではない可能性がある. 今回, 同属の種間で比較できなかったウスバカマキリ (Fig. 6) とヒナカマキリ (Fig. 8) は, 海外産の個体群や近縁種との比較が望まれる.

以上により, 日本産カマキリ目の雌外部生殖器は, オオカマキリ属, ハラビロカマキリ属, コカマキリ属において各種に特徴的な形質があり, とくに産卵管の形態が種の同定形質として有効であると考えられる.

## 雌外部生殖器の形態の解明によって進展が期待される研究

オオカマキリの有効名は, 現在 *Tenodera sinensis* Saussure, 1871 である (中峰 2016, 2020) が, *T. japonica* (Saussure, 1869) とシノニム (同物異名) の関係にあると示唆されている (中峰 2016, 2020). この問題を最善の手段で解決するためには, タイプ標本を基に分類学的に検討する必要がある. しかしながら, *T. japonica* のタイプ標本は雌個体であるため, 生殖器による種の詳細な比較を検討できない状況が続いている. 本研究によって, 日本産オオカマキリ属 3 種の雌外部生殖器の形態が分類・同定の形質として有効であることが明らかになったため, *T. sinensis* と *T. japonica* のホロタイプ間での検証が可能になるであろう.

昆虫類の雌生殖器は高次系統分類に多く用いられる (Sasakawa 1958; Tschinkel & Doyen 1980; Hirowatari 1986; Ohshima & Yata 2005). カマキリ目における高次系統分類は, Schwarz & Roy (2019) によって, おもに雄生殖器の形態に基づいてまとめられたが, 改善の余地を残している. オオカマキリ属, ハラビロカマキリ属, コカマキリ属の 3 属は, それぞれオオカマキリ亜科 Tenoderinae, ハラビロカマ

キリ亜科 Hierodulinae, カマキリ亜科 Mantinae に分類されており (Schwarz & Roy 2019), 亜科ごとに雌外部生殖器の形態が著しく異なっていることも明らかになった。また, ウスバカマキリ属はコカマキリ属と同じカマキリ族 Mantini に属しており, ウスバカマキリの生殖葉と生殖突起が角質化する形質 (Fig. 6a) がコカマキリ属の2種 (Fig. 5a, d) と類似していた。以上のように, 雌外部生殖器が亜科ごとに異なることや族内で類似していることから鑑みて, カマキリ目においても雌外部生殖器が亜科や族レベルの高次系統分類に活用できる可能性がある。

今後, 雄外部生殖器と同様に, より多くの種において雌外部生殖器の形態的特徴が解明されることによって, 雌個体のみでの正確な種同定が可能になるとともに, 種分類から高次分類体系までの分類学上の諸問題も解決するための一助となることが期待される。

3-4 図および表

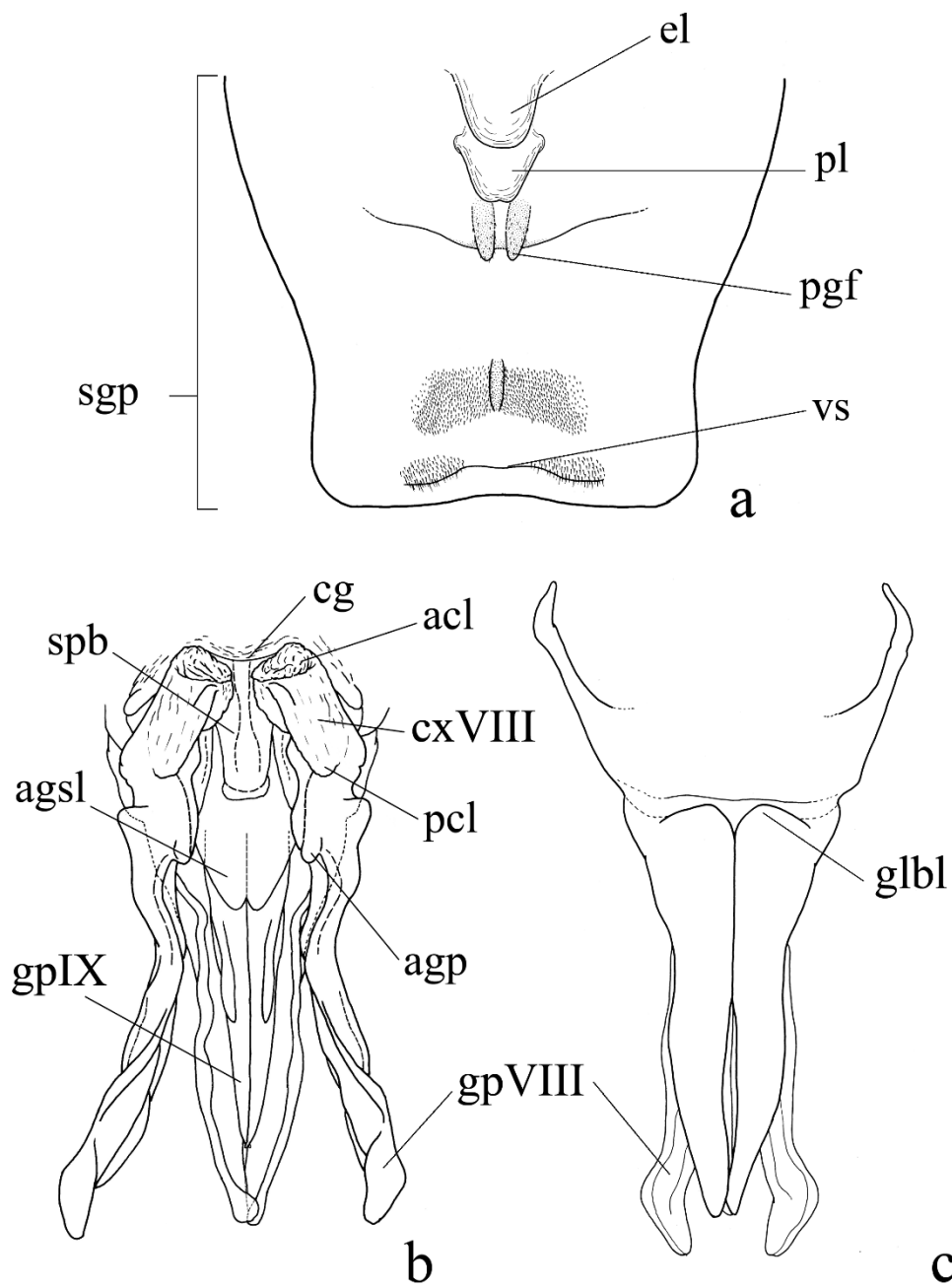


Fig. 1. General structure of genital complex of *Tenodera fasciata*, female. a, ventral segmental fold, dorsal view; b, ovipositor, ventral view; c, ovipositor, dorsal view. acl= antero-coxal lobe; agp= antero-gonapophysal process; agsl= accessory-gland-supporting lobe; cg= caudogyne; cxVII= gonacoxa VII; el= epigynal lobe; gplb= gonoplac basal lobe; gpVIII= gonapophysis VIII; gpIX= gonapophysis IX; pcl= postero-coxal lobe; pgf= process of genital fold; pl= papilla lobe; sgp= segmental plate; spb= spermathecal bulge; vs= vestibular sclerite.



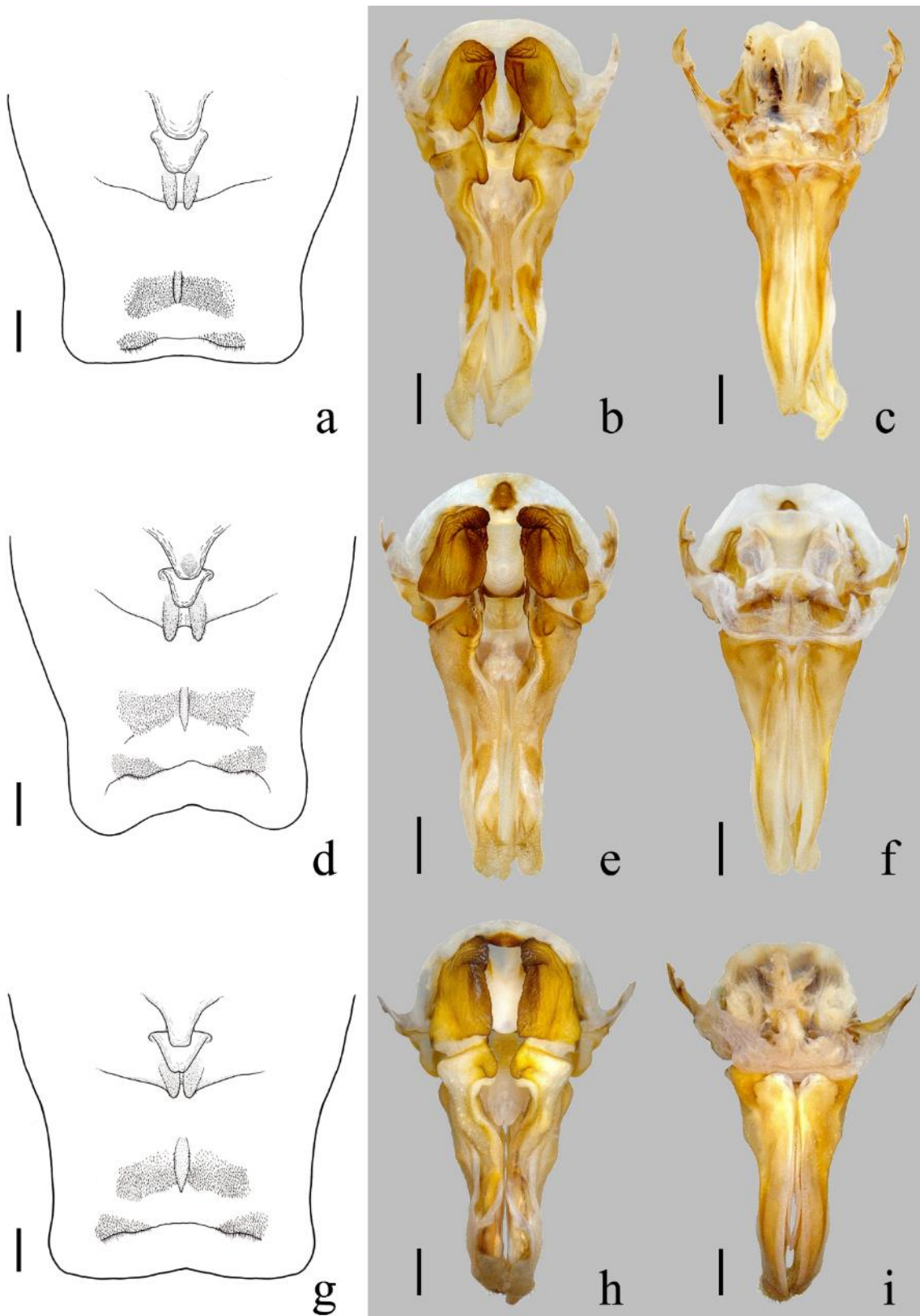


Fig. 2. Female genital complex of *Tenodera*. a–c, *T. fasciata*; d–f, *T. angustipennis*; g–i, *T. sinensis*. a, d, g, ventral segmental fold, dorsal view; b, e, h, ovipositor, ventral view; c, f, i, ovipositor, dorsal view. Scale bars: 1 mm.

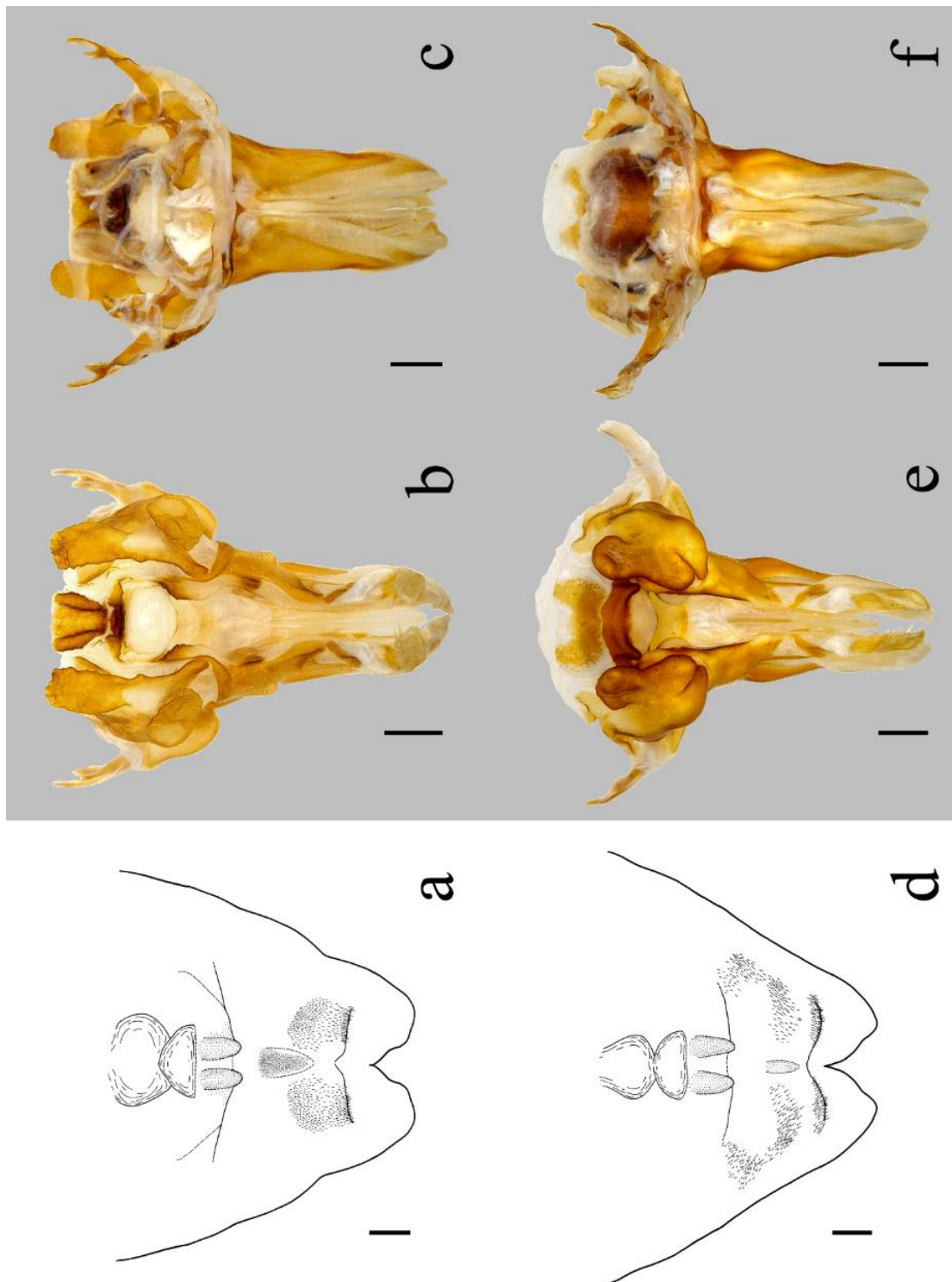


Fig. 3. Female genital complex of *Hierodula*. a–c, *H. patellifera*; d–f, *H. sp.* a, d, ventral segmental fold, dorsal view; b, e, ovipositor, ventral view; c, f, ovipositor, dorsal view. Scale bars: 1 mm.

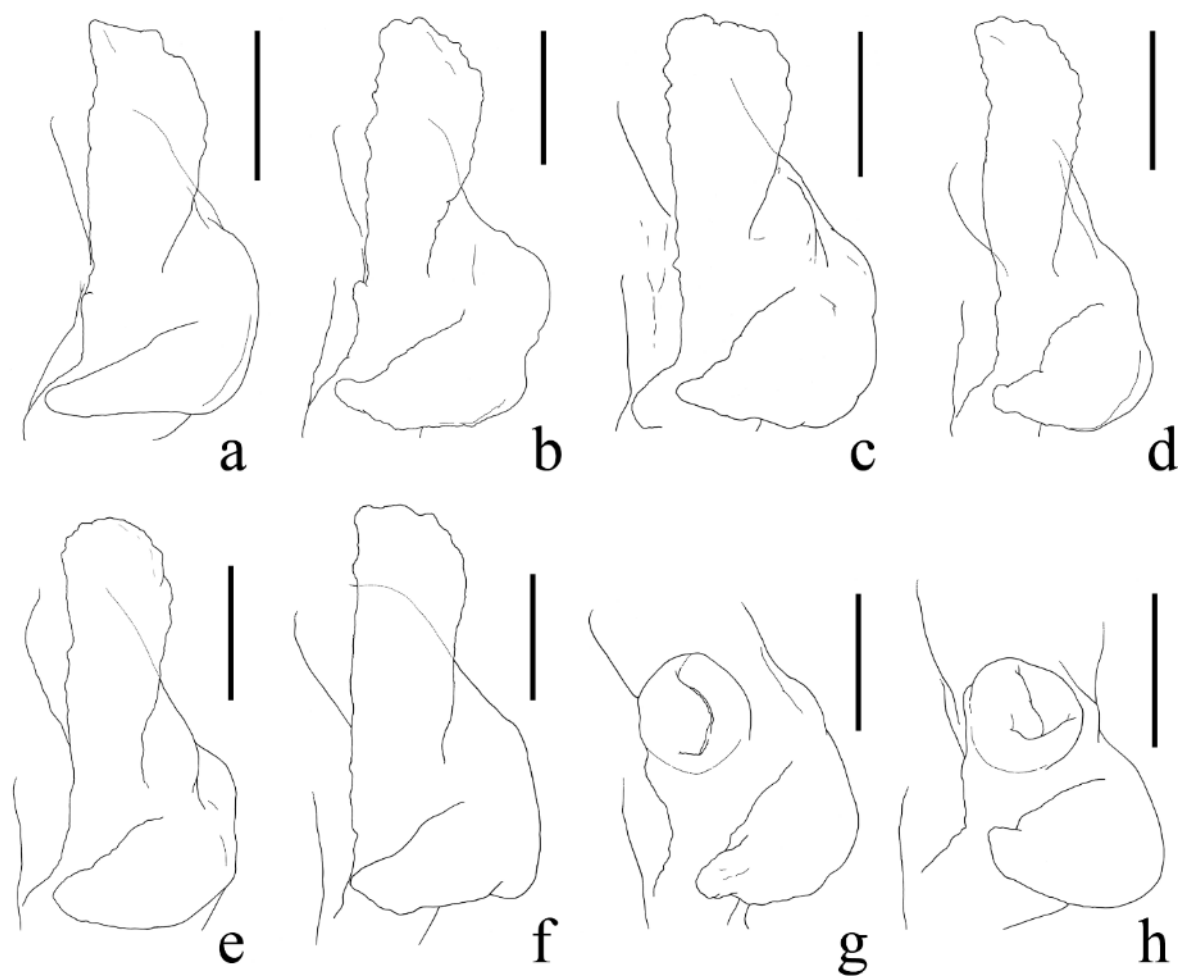


Fig. 4. Intraspecific variation in coxa 8 of *Hierodula patellifera*. a, Tokyo; b, Kanagawa; c, Hyogo; d, Kumamoto; e, Ie-jima Is.; f, Minami-daito-jima Is.; g, Noho-jima Is.; h, Saku-shima Is. Scale bars: 10 mm.

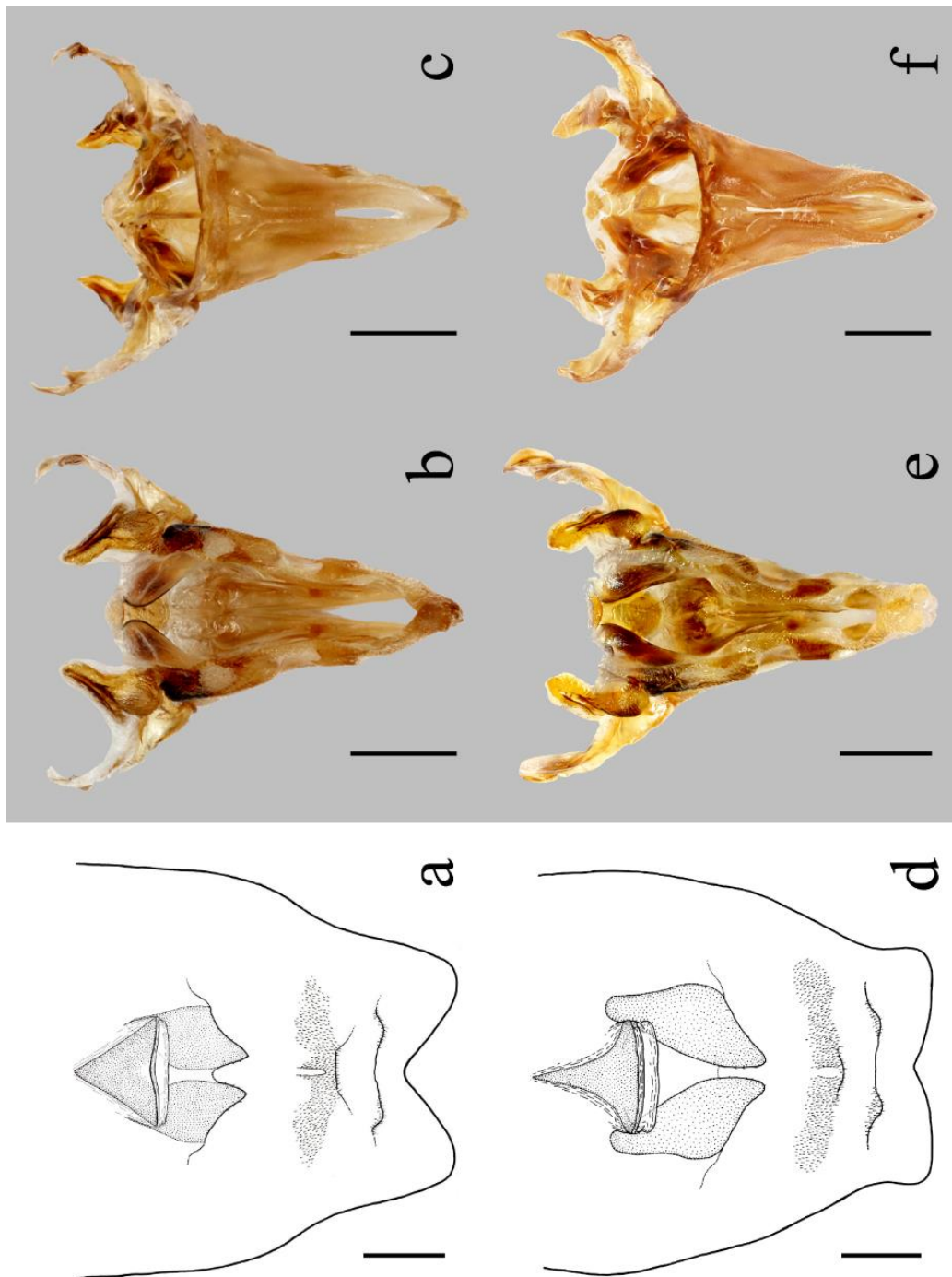


Fig. 5. Female genital complex of *Statilia*. a–c, *S. maculata*; d–f, *S. nemoralis*. a, d, ventral segmental fold, dorsal view; b, e, ovipositor, ventral view; c, f, ovipositor, dorsal view. Scale bars: 1 mm.

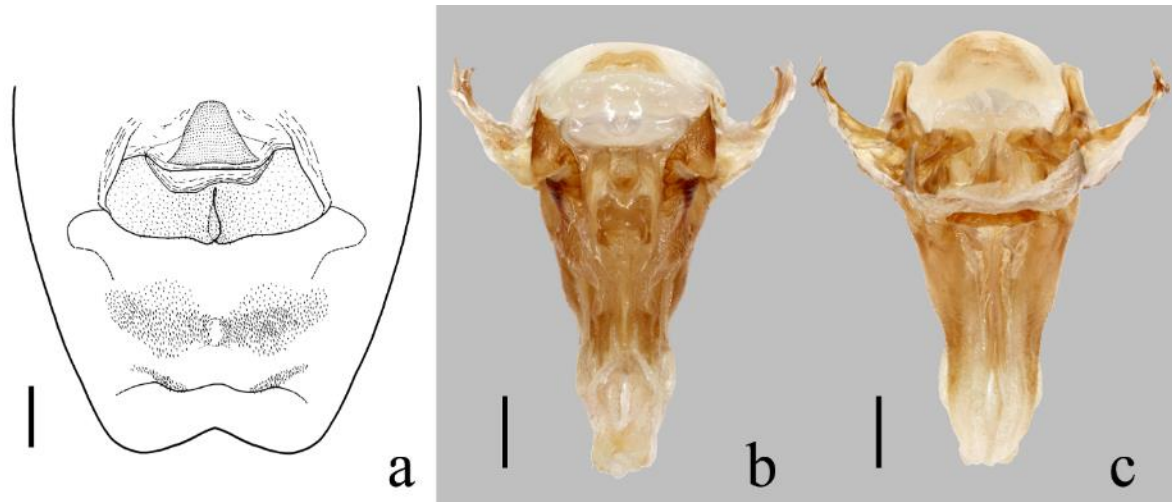


Fig. 6. Female genital complex of *Mantis religiosa*. a, ventral segmental fold, dorsal view; b, ovipositor, ventral view; c, ovipositor, dorsal view. Scale bars: 1 mm.

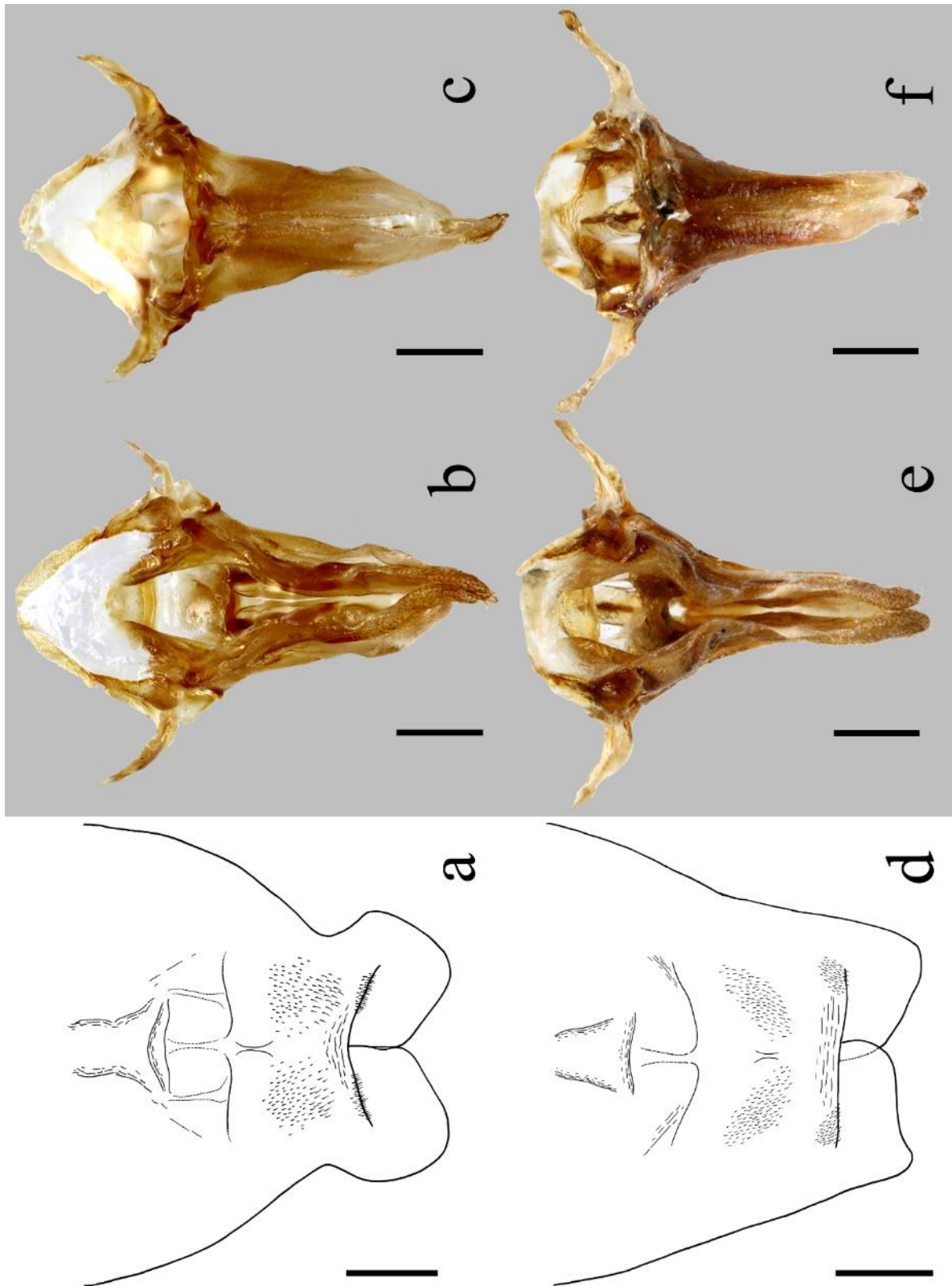


Fig. 7. Female genital complex of genus *Acromantis*. a–c, *A. japonica*; d–f, *A. satsumensis*. a, d, ventral segmental fold, dorsal view; b, e, ovipositor, ventral view; c, f, ovipositor, dorsal view. Scale bars: 1 mm.

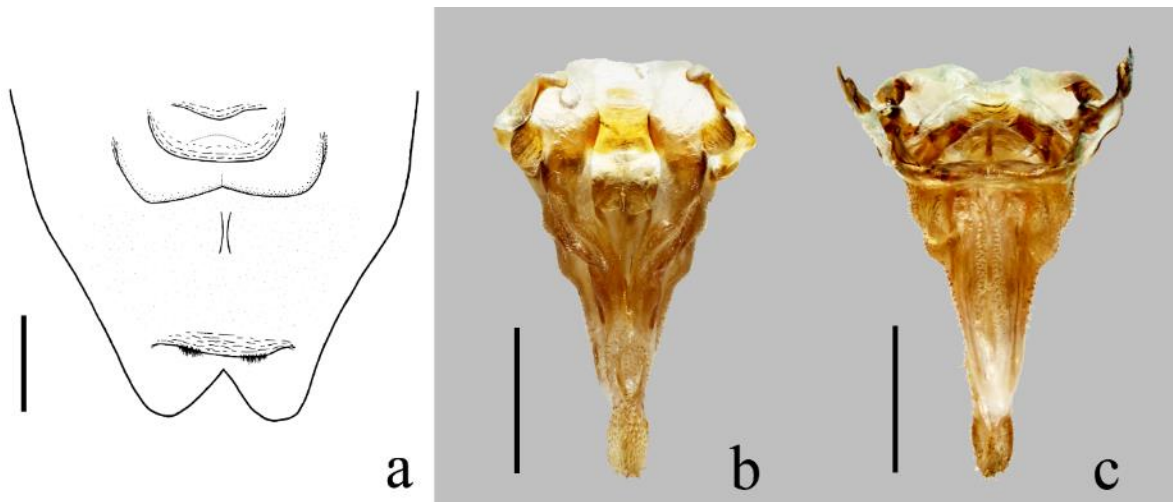


Fig. 8. Female genital complex of *Amantis nawai*. a, ventral segmental fold, dorsal view; b, ovipositor, ventral view; c, ovipositor, ventral view. Scale bars: 1 mm.

Table 1. Number of individuals and collection locality of 11 species of Mantodea.

種	採集地	個体数	種	採集地	個体数
マエモン	沖縄県島尻郡伊平屋村	6	ハラビロ	沖縄県島尻郡北大東村	5
	沖縄県島尻郡伊是名村	5		沖縄県島尻郡南大東村	5
	沖縄県島尻郡久米島町	1		沖縄県国頭郡伊江村	1
	沖縄県国頭郡伊江村	4		沖縄県宮古島市平良	4
	沖縄県宮古郡多良間村	3		沖縄県宮古島市下地	1
チョウセン	愛知県西尾市一色町佐久島	1	ムネアカ	東京都八王子市甘里町	2
	三重県津市あつの台	1		神奈川県秦野市東田原	5
	長崎県対馬市	1		京都府京都市上京区	1
	沖縄県島尻郡伊是名村	4	ココマ	山形県米沢市入田沢	2
	沖縄県島尻郡渡名喜村	2		山形県酒田市飛島	1
	沖縄県島尻郡北大東村	3		東京都世田谷区等々力	3
	沖縄県国頭郡伊江村	1	スジイリ	神奈川県厚木市船子	7
	沖縄県宮古島市平良	3		和歌山県東牟婁郡串本町大島	3
	沖縄県宮古郡多良間村	3		鹿児島県大島郡和泊町	1
オオカマ	山形県酒田市飛島	2	ウスバ	沖縄県島尻郡伊是名村	5
	東京都新宿区四谷	1		沖縄県宮古島市平良	1
	東京都昭島市拝島町	5		沖縄県石垣市川平	2
	神奈川県厚木市船子	5	ヒメ	山形県米沢市入田沢	3
	三重県津市あつの台	1		沖縄県国頭郡伊江村	6
	三重県津市片田田中町	2		沖縄県宮古島市平良	1
	和歌山県東牟婁郡串本町大島	2	サツマヒメ	東京都八王子市甘里町	1
	鹿児島県薩摩川内市上飯町	1		大阪府堺市南区	1
	鹿児島県薩摩川内市里町里	1		広島県三原市	2
ハラビロ	鹿児島県熊毛郡屋久島町	1	ヒナ	佐賀県西松浦郡有田町	1
	東京都世田谷区等々力	1		鹿児島県熊毛郡屋久島町	3
	神奈川県厚木市船子	5		サツマヒメ	京都府京都市西京区
	神奈川県厚木市温水	2	和歌山県東牟婁郡串本町大島		1
	愛知県岡崎市大門	1	兵庫県神戸市西区		8
	愛知県西尾市一色町佐久島	3	ハラビロ	高知県土佐清水市	1
	和歌山県東牟婁郡串本町大島	1		神奈川県三浦郡葉山町	2
	兵庫県神戸市西区	7		神奈川県足柄下郡湯河原町	2
	熊本県熊本市西区池上町	1		鹿児島県大島郡大和村	1
	鹿児島県熊毛郡屋久島町	1		鹿児島県大島郡検村	1
	沖縄県島尻郡伊平屋村	2		沖縄県島尻郡伊平屋村	1
沖縄県島尻郡伊是名村	2	沖縄県宮古島市城辺		1	
沖縄県島尻郡久米島町	1	沖縄県八重山郡与那国町		1	

## 第4章

### 大東諸島におけるハラビロカマキリの分類学的研究

#### 4-1 緒言

ハラビロカマキリ *Hierodula patellifera* (Audinet-Serville, 1839) は、旧北区東部および東洋区の広範囲に分布し、インド、ネパール、中国、台湾、韓国、日本、ベトナム、タイ、マレーシア、シンガポール、ニューギニア、ジャワ、スンバ、フィリピン（移入種として、イタリア、フランス、ハワイ）から記録されている (Ehrmann 2002; Leong 2009; Ehrmann & Borer 2015; Patel & Singh 2016; Mukherjee *et al.* 2017; Battiston *et al.* 2019; Moulin 2020) (Fig. 1). 日本では、本州、四国、九州、沖縄のほか、各地の離島からも記録される (Nakamine 2016; Oshima *et al.* 2020). 本種は、前脚基節に 2 から 5 個の黄色いこぶ状突起を有するため、近縁種と容易に識別が可能である (Leong 2009; Zhu *et al.* 2012; Chatterjee & Srinivasan 2013; Majumder *et al.* 2015; Nakamine 2016; Shcherbakov & Anisyutkin 2018).

ハラビロカマキリの種内分類については、これまでに大きな混乱があった。かつて Giglio-Tos (1912) は、フィリピン産の標本を基に *H. manillana* Giglio-Tos, 1912 を種として記載した。のちに *H. manillana* は、Beier (1935) によってハラビロカマキリの亜種 *H. patellifera manillana* Giglio-Tos, 1912 として扱われたが、この亜種分類の正当性は示されていない。現在 *H. manillana* は、ハラビロカマキリのシノニムとされており、同時にハラビロカマキリの種内に亜種も認められていない (Ehrmann 2002; Nakamine 2016; Otte *et al.* 2020).

大東諸島は、沖縄島の南東のフィリピン海上に位置し、5つの海洋島で構成される。これらの島々のうち、有人島の北大東島と南大東島は沖縄島から約 360 km 離れた距離にあり、その自然はいくつかの固有種が生息する独特の生態系を有する (清水 2003)。

北大東島と南大東島において、2015年から2018年にかけてカマキリ相を調査したところ、両島から既知の形態学的特徴と一致しないハラビロカマキリ属の一種が得られた。雄外部生殖器を観察したところ、国内に分布するハラビロカマキリと同種であった (Fig. 2)。しかし、最大体長や触角の節数、前脚基節のいぼ状突起の形状やその周囲の発色など、生殖器以外の形態的特徴は、ハラビロカマキリの他地域の個体群のものとは顕著に異なっていた。したがって、大東諸島の個体群は、他地域の個体群とは亜種として分類することが妥当だと結論づけた。

本研究では、大東諸島の個体群をハラビロカマキリの亜種 *Hierodula patellifera daitoana* **ssp. nov.** として記載し、成虫に加えて若虫の形態的特徴にも言及する。



## 4-2 材料および方法

検視標本は、北大東島では2016年9月と2018年6月、南大東島では2015年2月と2016年4月に採集し、採集にはスーピング法やルッキング法を用いた。採集時に若虫だった個体は成虫まで飼育したのちに乾燥標本にした。標本は実体顕微鏡 (SZ60; Olympus, 東京) で検視し、その体長 (前胸背板の後縁から翅の末端まで) は定規で計測した。標本の撮影にはデジタルカメラ (EOS8000D; Canon, 東京) を使い、乾燥標本のほかに新鮮な標本も用いた。ホロタイプ標本は東京農業大学昆虫学研究室 (LETUA: Laboratory of Entomology, Tokyo University of Agriculture) に収蔵した。

若虫の形態観察には、人工下で繁殖させた個体を用いた。南大東島で得られた雌雄を交配させ、得られた卵鞘を気温 30°C、湿度 50–70% の条件下で孵化まで管理した。若虫の飼育方法は ‘2-2-2 材料および方法’ と概ね同様である。若虫の外部形態は、初齢から終齢までの前脚基節と基節背縁突起を観察し、撮影した。

## 4-3 結果および考察

### ハラビロカマキリ大東諸島亜種

#### *Hierodula patellifera daitoana* ssp. nov.

(Figs. 2–5, 7)

*Type specimens.* —Holotype: JAPAN • ♂, “Okinawa, Shimajiri-gun, Kita-daito-jima Is., Kita-daito-son, Minato, 25°57'16"N, 131°17'17"E, 24.VI.2018, leg. K. Oshima”, LETUA-IC-2021-00001. Paratypes: JAPAN • 1 ♂ 2 ♀ (collected when they were nymphs), Okinawa, Shimajiri-gun, Kita-daito-jima Is., Kita-daito-son, Minato, 25°57'19"N, 131°17'16"E, 25–26.IX.2016, leg. K. Oshima, LETUA-IC-2021-00002–00004; 2 ♂, Okinawa, Shimajiri-gun, Kita-daito-jima Is., Kita-daito-son, Minato, 25°57'16"N, 131°17'17"E, 24–25.VI.2018, leg. K. Oshima, LETUA-IC-2021-00005–00006; 2 ♂ 2 ♀ (collected when they were nymphs), Okinawa, Shimajiri-gun, Kita-daito-jima Is., Kita-daito-son, Minato, 25°57'19"N 131°17'16"E, 24–26.VI.2018, leg. K. Oshima, LETUA-IC-2021-00007–00010; 1 ♂ (collected when that was nymph), Okinawa, Shimajiri-gun, Minami-daito-jima Is., Minami-daito-son, Kita, 25°51'59"N, 131°14'50"E, 17.II.2015, leg. K. Oshima, LETUA-IC-2021-00011; 1 ♀ (collected when that was nymph), Okinawa, Shimajiri-gun, Minami-daito-jima Is., Minami-daito-son,

Kita, 25°51'58"N, 131°14'50"E, 16.IV.2016, leg. K. Oshima, LETUA-IC-2021-00012; 1 ♀ (collected when that was nymph), Okinawa, Shimajiri-gun, Minami-daito-jima Is., Minami-daito-son, Ikenosawa, 25°49'12"N, 131°13'18"E, 17.IV.2016, leg. K. Oshima, LETUA-IC-2021-00013.

*Subspecies characters.* Adult —Differs from the nominotypical subspecies *H. patellifera patellifera* by having the following characters: Body length 64–77 mm in males and 69–79 mm in females; antenna at most 115-segmented in both sexes; procoxa (Fig. 4a, b) with a large white marking along antero-inner surface (but, a white marking may become unclear in dry specimens), and with 2 large and several small tooth-like marginal spines (not well-defined). Nymph —Procoxa of 1st-and-2nd instars (Fig. 5a, b) lacking white markings and marginal spines; procoxa of 3rd instar (Fig. 5c) with or without a small white marking, and with slightly developed, tooth-like marginal spines; procoxa of 4th instar (Fig. 5d) with 2 small, white markings, and with slightly developed, tooth-like marginal spines; procoxa of 5th instar (Fig. 5e) with 2 medium-sized, irregular, white markings, and with 2 large (somewhat developed) and several small tooth-like marginal spines; procoxa of 6th-to-last instars (Fig. 5f–h) with a large-sized, irregular, white marking, and with 2 large (well developed) and several small tooth-like marginal spines.

*Distribution.* —Kita-daito-jima Is. and Minami-daito-jima Is., the Ryukyus, Japan (Fig. 1).

*Etymology.* —This subspecific name is named after the Daito Islands, the type locality of the subspecies; an adjective.

*Ecology.* —During my surveys, adults and nymphs appeared from May to July and in all seasons, respectively. Both adults and nymphs were found in grassland adjacent to a sugarcane field (Fig. 6) and forest edges, particularly on the bushy tree *Acalypha wilkesiana* Müll. Arg. (Euphorbiaceae). Some specimens were also found in a residential area. Oothecae were laid on twigs and trunks as well as on artificial objects (Fig. 7).

4 - 4 図

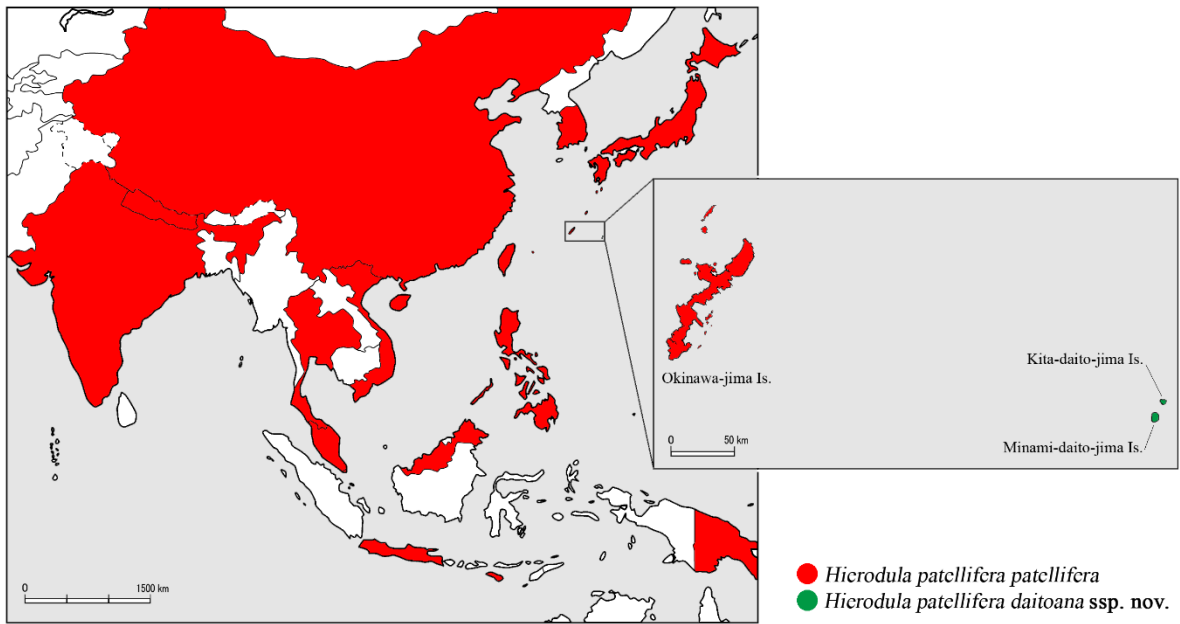


Fig. 1. Total known distribution of *Hierodula patellifera* in Asia.

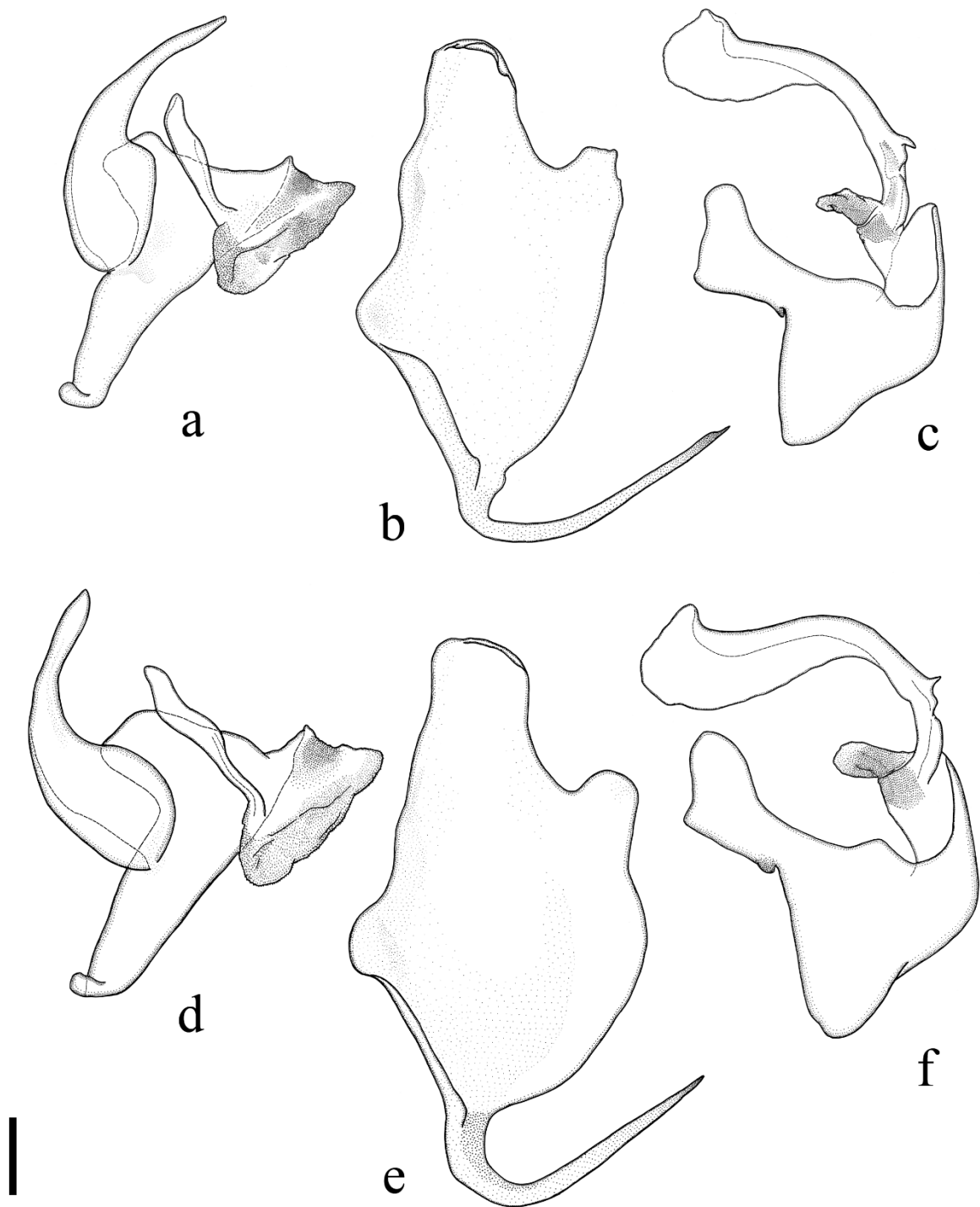


Fig. 2. Disarticulated genital complex (to isolate the individual phallomeres) of *Hierodula patellifera*, male, dorsal view: a–c. *Hierodula patellifera patellifera* from Okinawa-jima Is.; d–f. *Hierodula patellifera daitoana* **ssp. nov.**, from Kitadaito-jima Is. (holotype); a & d. left phallomere; b & e. ventral phallomere; c & f. right phallomere. Scale bar: 1 mm.



Fig. 3. *Hierodula patellifera daitoana* **ssp. nov.**, male, holotype. Habitus, dorsal view.  
Scale bar: 10 mm.



Fig. 4. Procoxa of *Hierodula patellifera daitoana* **ssp. nov.**, lateral view: A. male, holotype; B. female, paratype, before discoloration. Scale bars: 10 mm.

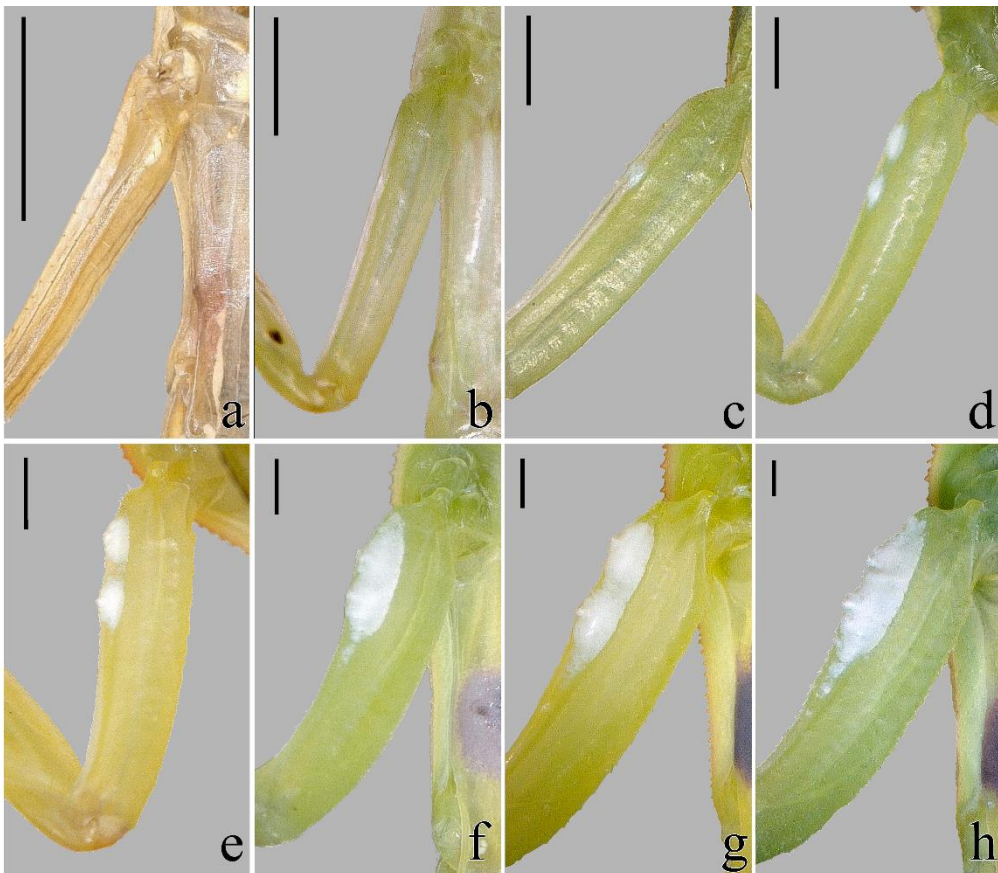


Fig. 5. Procoxa in nymphal stages of *Hierodula patellifera daitoana* **ssp. nov.**, male, lateral view. a, 1st instar; b, 2nd instar; c, 3rd instar; d, 4th instar; e, 5th instar; f, 6th instar; g, 7th (penultimate) instar; h, 8th (last) instar. Scale bars: 1 mm.



Fig. 6. Habitats of *Hierodula patellifera daitoana* **ssp. nov.** on Kita-daito-jima Island.



Fig. 7. A *Hierodula patellifera daitoana* **ssp. nov.** female and ootheca immediate after oviposition.

## 第5章

### 総合考察

#### 5-1 緒言

雄成虫と卵鞘の形態形質は、日本から記録されているカマキリ目 13 種すべてにおいて、明らかにされている（岡田 2001；青木 2008；中峰 2016）。一方で、若虫の形態形質については、岡田（2001）、Raut & Gaikwad (2016)、Nakamine *et al.* (2016) によって、それぞれ 9 種の 1 齢若虫、ウスバカマキリ *Mantis religiosa* (Linnaeus, 1758)（以下、ウスバ）の 1 齢から終齢若虫、サツマヒメカマキリ *Acromantis satsumensis* Matsumura, 1912（以下、サツマヒメ）の 1 齢から終齢若虫が明らかにされ、雌生殖器については、Brannoch *et al.* (2017) によって、オオカマキリ *Tenodera sinensis* Saussure, 1871（以下、オオカマ）が明らかにされた。しかし、残りの種においては、若虫および雌生殖器の形態形質は未解明であり、先行研究が知られる種にも解明すべき課題が残されていることから、日本産種の全発育段階における形態形質の解明度は乏しいと考えられる。

本章では、今回の研究で得られた新知見も含めて、日本産カマキリ目 13 種の形態学的研究の解明度を示す一覧表を作成した。

#### 5-2 材料および方法

これまでに明らかにされていた日本産種の若虫、成虫（外部生殖器）、卵鞘の形態情報に第 2 章の「2-1 *Tenodera* 属 3 種の若虫」、「2-2 *Hierodula* 属 2 種の若虫」、「2-3 *Statilia* 属 2 種の若虫」、および第 3 章において得られた形態学的成果を加え、解明度を Table 1 にまとめた。また、若虫および外部生殖器の形態学的研究における現在の解明度を基に、今後の課題を考察した。

#### 5-3 結果および考察

若虫の形態形質は、日本産カマキリ目 13 種のうち、カマキリ科 7 種の全齢期で明らかになった。これらの 7 種のうち、*Tenodera* 属 3 種と *Hierodula* 属 2 種は、全齢期における種同定と齢期判別が可能になった。しかし、オオカマは、国内でも地域個体群によって、成虫までの齢期が異なる（安藤 2011）ことや、チョウセンカマキリ *T. angustipennis* Saussure, 1869 やハラビロカマキリ *Hierodula patellifera* (Audinet-Serville, 1839) は、本州産と琉球産では体長や体格が異なる（岡田 2001；中峰 2016）ことから、カマキリ類の各齢における形態形質は、産地によって同齢でも異なる可能性がある。今回の研究で扱った個体群はいずれも単一の産地に由来するため、全国の各個体群に有用な種同定および齢期判別の方法の確立には、産地別の追加調査が必要だと考えられる。

今回の研究で扱わなかった 6 種のうち、ウスバとサツマヒメは、すでに若虫の形態的特徴が調べられている。ウスバは、Raut & Gaikwad (2016) によって、



1 齢から終齢（6 齢）において、体長や翅芽などの特徴が解明された。しかし、その研究で得られた雌成虫の体長の記録が、日本産の成虫の体長より相対的に大きいことや、Raut & Gaikwad (2016) が扱ったウスバの亜種は、日本に産する亜種とは異なることから、各齢期における若虫の体長をはじめとする形質が日本の個体群のものとは異なる可能性がある。したがって、日本産の亜種による再検討が必要だと考えられる。サツマヒメは、Nakamine *et al.* (2016) によって、1 齢から終齢（5 齢）において、複眼の模様による齢期判別と腹部腹板による雌雄判別が明らかにされた。しかし、渋谷 (2016) では、サツマヒメの終齢は 8 齢まで記録されており、6 齢以上の齢期を有する個体でも同様の結果が得られるかは不明である。また、Nakamine *et al.* (2016) には、ヒメカマキリ *A. japonica* Westwood, 1889（以下、ヒメ）との判別に有用とされる前脚腿節や腿節後腹側葉片の記載はなく、若虫における近縁種との形態比較は行なっていない。とくに腿節後腹側葉片は、成虫より若虫で明確に形態差が生じる可能性が示唆されている（石川 2016）ため、形態形質の追加調査が必要だと考えられる。ヤサガタコカマキリ *Statilia apicalis* (Saussure, 1871)（以下、ヤサガタ）、ナンヨウカマキリ *Orthodera ministralis* (Fabricius, 1775)、ヒメ、ヒナカマキリ *Amantis nawai* (Shiraki, 1908) は、全齢期において未解明またはごく限られた齢期しか調べられていない。

成虫（外部生殖器）の形態形質は、日本産 13 種のうち、11 種において雌雄ともに明らかになった。今回の研究で扱わなかった 2 種のうち、ヤサガタは東南アジアからオーストラリアにかけて広く分布するものの、国内における採集例が極めて少なく、日本における記録は偶産の可能性も示唆されている（河野・河野 2001）。とくに、雌個体の採集例が青木 (2008) と杉本 (2016) の 2 例のみであることから、ヤサガタの雌外部生殖器の形態的特徴の解明には、長期的な採集調査や海外の個体群を含めて行なう必要があると考えられる。

以上のことから、日本産カマキリ目の形態形質には課題が多く残されているため、分類学および生態学的な問題の解決のためにも継続的な形態学的研究が必要だと考える。

5 - 4 表

Table 1. Attainment level of clarification on the morphology of nymphs, genitalia and ootheca in Mantodea from Japan. Red: completed in this study; yellow: completed prior to this study; gray: inadequately studied; blank: not investigated.

Family	Genus	Species	sex	Nymph								Adult	Ootheca		
				1st	2nd	3rd	4th	5th	6th	7th	8th or 9th	Genitalia			
Mantidae	<i>Tenodera</i>	<i>T. fasciata</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow
		<i>T. angustipennis</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow
		<i>T. sinensis</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow
	<i>Hierodula</i>	<i>H. patellifera</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	
	<i>H. sp.</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	
		♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	
	<i>Statilia</i>	<i>S. maculata</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow
		<i>S. nemoralis</i>	♂	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow
<i>S. apicalis</i>		♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Gray	
		♀	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	
<i>Mantis</i>	<i>M. religiosa</i>	♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Yellow		
♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow			
<i>Orthodera</i>	<i>O. ministralis</i>	♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Yellow		
		♀	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow		
Hymenopodidae	<i>Acromantis</i>	<i>A. japonica</i>	♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Yellow	
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	
		<i>A. satsumensis</i>	♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Yellow	
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	
Gonypetidae	<i>Amantis</i>	<i>A. nawai</i>	♂	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Yellow	Yellow	
			♀	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	

## 謝辞

これまでの研究を通して、多くのご助言およびご指導をいただいた東京農業大学の石川忠教授、小島弘昭教授、田中幸一教授に心より感謝申し上げるとともに、各調査や実験でご支援いただいた以下の皆様に深く感謝申し上げます。

箕面公園昆虫館の中峰空博士，東京大学生態調和農学機構の山崎和久博士，西日本農業研究センターの楠本良延博士，株式会社生態計画研究所の長野宏紀氏，九州大学昆虫学分野の相馬純氏，北海道大学昆虫体系学研究室の瑤寺裕氏，那覇植物防疫事務所の重藤裕彬氏，ラオス在住の若原弘之氏，厚木市在住の山田航氏，函館市在住の工藤翔里氏，東京農業大学昆虫学研究室の金子直樹氏，嶋本習介氏，樽宗一朗氏，瀬尾朋渚氏，寺井純汰氏，林幸希氏。

## Summary

Regarding adults in the insect order Mantodea, it is easy to identify the species because the research of the morphology is progressing. However, since the morphology of the nymphal stages has been investigated only at a very limited instar, it is difficult to identify the species by nymph, and it is also difficult to distinguish the instar and sex in the same species. In some cases, it is necessary to observe the external genitalia for accurate species identification for adults, but so far only male genitalia have been investigated. Therefore, there are almost no studies on species identification using morphological characters of the female genitalia. Due to these factors, even though mantis is a well-known insect, it may not even be possible to identify species, such as the cases of investigations when only nymphs appear or when only adult females are obtained. Therefore, it is necessary to examine whether the morphological characters of nymphs and female genitalia are useful as identification characteristics in order to enable accurate species identification even in nymphs and adult females.

In the present thesis, nymphs of seven species and female external genitalia of eleven species from Japan are studied morphologically and taxonomically with the aim of establishing a method for species identification using morphological characters of mantis nymphs and female external genitalia. Furthermore, the Daito Islands population (the Ryukyus) of a widely distributed mantis species, *Hierodula patellifera* (Audinet-Serville), is reviewed from taxonomic point of view.

The nymphs of *Tenodera fasciata* (Olivier), *T. angustipennis* Saussure, *T. sinensis* (Saussure), *H. patellifera*, *H. sp.*, *Statilia maculata* (Thunberg) and *S. nemoralis* (Saussure) are described. The three species of *Tenodera* can be distinguished from each other by such morphological characters as the body length, the pronotum width, the shape of the lateral margin of the pronotum, the shape of the marginal spines, the profemur width, the pattern of the profemur, the coloration of the prosternum between the procoxal cavities and the cercus length. The two species of *Hierodula* can be distinguished from each other by such morphological characters as the body length, the pattern of the dorsal body, the pronotum width, the pattern of the furcasternite, the shape of the marginal spines, the profemur width and the pattern of the mesofemur, mesotibia, metafemur and metatibia. The two species of *Statilia* can be distinguished from each other by such morphological characters as the pattern of the profemur. In addition to these characters, the discoidal spines and wing pads are useful for identification of the instars, and 7th to 9th sternites are useful for identification of the sexes in all species.

The female external genitalia of *T. fasciata*, *T. angustipennis*, *T. sinensis*, *H.*

*patellifera*, *H. sp.*, *S. maculata*, *S. nemoralis*, *Mantis religiosa* (Linnaeus), *Acromantis japonica* Westwood, *A. satsumensis* Matsumura and *Amantis nawai* (Shiraki) are described. The three species of *Tenodera* can be distinguished from each other by such morphological characters as the epigynal lobe, the gonacoxa VIII, the caudogyne and the gonapophysis VIII. The two species of *Hierodula* can be distinguished from each other by such morphological characters as the gonacoxa VIII, the caudogyne, the spermathecal bulge and the gonapophysis VIII. The two species of *Statilia* can be distinguished from each other by such morphological characters as the epigynal lobe. The two species of *Acromantis* are not able to be distinguished from each other by the morphological characters of the female external genitalia.

A new subspecies of *H. patellifera*, *H. patellifera daitoana* ssp. nov., is described from the Daito islands, the Ryukyus, Japan. This new subspecies can be distinguished from the nominotypical subspecies *H. patellifera patellifera* by such morphological characters as the body size, the number of the antennal segments, the coloration of the procoxae and the shape and number of the marginal spines.

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