Belgian Journal of Entomology

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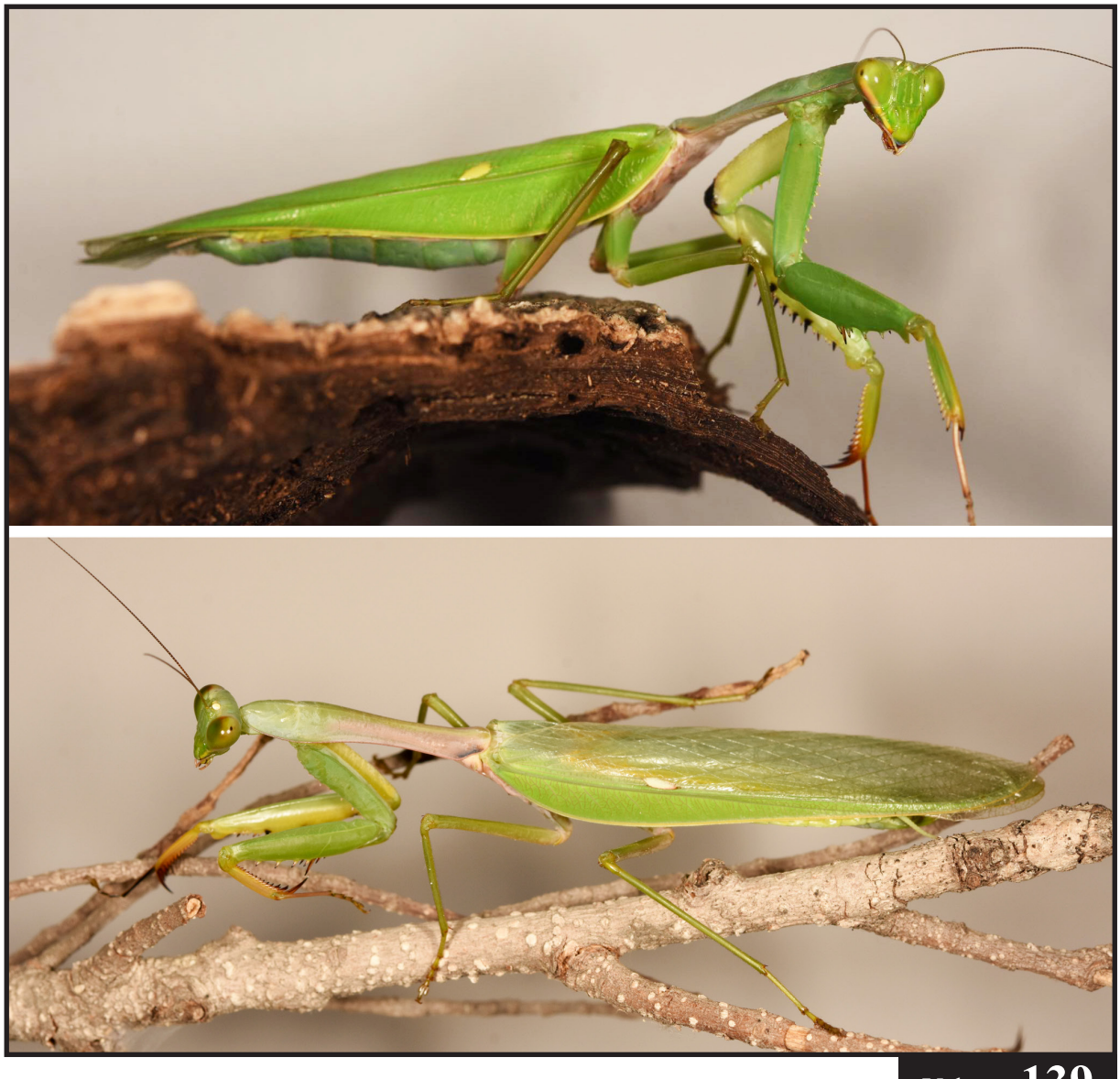
Thornthan Unnahachote & Xavier H.C. Vermeersch



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Front cover: Live images of *Hierodula kaltenbachi* sp. nov. (top) and *Hierodula insperata* sp. nov. (bottom) © T. Unnahachote.

Two new species of giant praying mantises (Mantodea: Mantidae: Hierodulinae: Hierodulini) from Thailand

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Abstract

Two new species of giant praying mantises, *Hierodula kaltenbachi* sp. nov. and *Hierodula insperata* sp. nov. from Northern and Southern Thailand respectively, are described based on recently collected material. A description of the habitus of both sexes, male genitalia, and photographs of live and mounted specimens are provided for both new species. The placement of the new species within the genus *Hierodula* is briefly discussed. A distribution map is also provided.

Keywords: *Hierodula*, South-East Asia, Oriental Region, Taxonomy

Introduction

The Mantodea family Mantidae is currently composed of 76 genera worldwide (Schwarz & Roy, 2019; Vermeersch, 2020; Shcherbakov & Vermeersch, 2020). Many of the giant praying mantises from the oriental region with a typical praying mantis appearance are currently placed in the tribe Hierodulini of the subfamily Hierodulinae (Vermeersch, 2020). *Hierodula* is, however, up to this day a taxonomically very problematic genus, with a somewhat ambiguous 'one fits all' generic diagnosis. Although many *Hierodula* species look similar to each other superficially based on their external morphology, their male genitalia structures can be vastly different between species and geographic distribution. How all these species are phylogenetically related to each other remains somewhat unclear and requires further in-depth investigation (Vermeersch, 2020; Vermeersch & Unnahachote, 2020; Wang et al., 2020; Liu et al., 2021). Phylogenetic relationships of the whole genus and other related genera should be revised using modern, including molecular, tools to obtain a more natural taxonomy for this complex group of praying mantises. Awaiting such much-needed insights, the two new species from Thailand here described are provisionally placed into *Hierodula* 'sensu lato' as *Hierodula kaltenbachi* sp. nov. and *Hierodula insperata* sp. nov.

Our investigation revealed that the recently collected specimens of *Hierodula kaltenbachi* sp. nov. matched with two male specimens stored at the Staatliches Museum für Naturkunde Karlsruhe (SMNK). These specimens had been examined many years earlier by Alfred Kaltenbach who also considered them to be a new species to science. He placed them in the genus *Rhombodera* with the proposed candidate name *Rhombodera assimilis* sp. nov. (unpublished). His findings were however never formally published and remained at the draft stage up to this day. A study of the external morphology and the male genitalia of this species by the current authors revealed that it doesn't naturally belong to *Rhombodera*, and should, according to the current understanding of the genus, be placed in *Hierodula* instead. The new species is hereby formally described as *Hierodula kaltenbachi* sp. nov. in honour of Alfred Kaltenbach, who was the first to recognise it as a new species to science.

Materials and methods

The holotype of *Hierodula kaltenbachi* sp. nov. was collected by visual search of the vegetation during the night, then shortly preserved in the freezer before mounting. The paratypes of *H. kaltenbachi* sp. nov. (SMNK), comprising two males, were loaned for study from the Mantodea collection of SMNK, along with a slide of fixated male genitalia. Holotype and male paratypes of *H. insperata* sp. nov. were captured using the light trap method. The female paratype was collected from another locality by visual inspection of the vegetation at night. All specimens were preserved in the freezer at -18° before mounting. Male genitalia were dissected as follows: the tip of the abdomen was separated from the softened specimen and macerated in a heated 10% potassium hydroxide (KOH) solution at about 70°C for 45 minutes, then thoroughly rinsed with demineralised water and placed in ethanol for examination and for making photographs. Afterwards the genitalia were placed in a small vial filled with glycerine and pinned underneath the mounted specimen for long-term preservation. Observations of the external morphology and male genitalia were made with an Optika microscope (Optika microscope, Italy) and a Leica MZ8 stereo microscope. Both mounted specimens and live aspect photographs were taken with a Nikon AF-S Micro Nikkor 60 mm lens attached to a Nikon D7200 camera. Male genitalia of *H. kaltenbachi* sp nov. and *H. insperata* sp. nov. were taken with a Leica MZ4W stereo microscope, then stacked and processed in Adobe Photoshop CS5. The morphological nomenclature follows Brannoch et al. (2017), Schwarz & Roy (2019), abbreviations and standards of measurement follow Vermeersch (2018).

Collection acronyms:

CSC	=	Christian Schwarz Collection, Germany
RBINS	=	Royal Belgian Institute of Natural Sciences, Brussels, Belgium
SMNK	=	Staatliches Museum für Naturkunde Karlsruhe, Karlsruhe, Germany
THNHM	=	Thailand Natural History Museum, Pathum Thani, Thailand

Taxonomy

Order Mantodea Burmeister, 1838
Superfamily Mantoidea Latreille, 1802
Family Mantidae Burmeister, 1838
Subfamily Hierodulinae Brunner von Wattenwyl, 1893
Tribe Hierodulini Brunner von Wattenwyl, 1893

Genus *Hierodula* Burmeister, 1838

Type-species: *Hierodula membranacea* Burmeister, 1838

Hierodula kaltenbachi Unnahachote & Vermeersch, 2023 sp. nov.

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(Figs 1, 2, 4 A–B, 5 A–C, 7)

Diagnosis.

Hierodula kaltenbachi sp. nov. can be separated from other species of *Hierodula* by the following combination of characters:

(1) The black colouration of the apical end of the ventral coxal lobe of the prothoracic legs.

(2) The unique morphology of the male genitalia (described from dorsal view): afa well-sclerotised, aafa small and tubercle-shaped, pafa large with broad sclerotised base, divided in a long and twisted right process and a very short bluntly triangular left process. Large process shaped like a long pointy spine bending dorsad and to the left about midway in an almost 90° angle.

(3) Spinal formula: F = 4DS/15AvS/4PvS; T = 13AvS/8-10PvS.

Etymology.

The species epithet is a patronym dedicated to Alfred Kaltenbach (1920−2005), an Austrian taxonomist who published numerous papers on praying mantises, and who was the first to recognise this species now named after him being new to science.

Type material.

Holotype ♂ and paratypes (2 ♂). Holotype ♂: Thailand, Kamphaeng Phet Prov., Khlong Lan Dist., Khlong Nam Lai Subdist., 21 IX.2020, leg. Jiaranaisakul K. I.G.: 34.635 (RBINS); Paratypes (2♂): Thailand, Chiang mai Prov., 5km South of the Golden Triangle [Myanmar - Laos - Thailand] (20°18ˈN, 100°05ˈE), IV.1979, leg. H. Lehmann sen. (SMNK); Thailand, Chiang mai Prov., Doi Kam (19°32ˈN, 100°18ˈE), 550m, X.2000, leg. S. Löffler. (SMNK).

Description.

Male (holotype): (Figs 1, 4 A−B, 5 A−C, 7). Ratios (all male type specimens): PL/PW: 2.87−3.13, TgL/TgW (=Tegmen Width): 3.35−3.6, TgL/PL: 2.21−2.6. Measurements see Table 1. Colouration (Fig 4 A−B): All know specimens feature a uniformly green body colouration with a magenta coloured underside of the thoracic segments. The inner sides of the raptorial legs are uniformly yellowish-green and brighter than the rest of the body. Ventral coxal lobe entirely black, dorsal coxal lobe black only apically in some specimens or entirely without black. Tip of trochanter with black spot. Black spots at base of 1st to 2nd and 10th AvS.

Head: Triangular, wider than long with large, round compound eyes; vertex flat. Antenna filiform, with rare setae. Ocellar tubercle not elevated; ocelli relatively large. Lower frons

Table 1: Measurements of *H. kaltenbachi* sp. nov. and *H. insperata* sp. nov. holotypes and paratypes (in mm.): (*) incomplete with missing tip, (**) missing, (***) wings folded.

***H. kaltenbachi* sp. nov**				***H. insperata* sp. nov.**			
Measurements	Holotype ♂	Paratype		Holotype ♂	Paratype		
		(PT1) ♂	(PT2) ♂		(PT1) ♂	(PT2) ♂	(PT3) ♀
TL	87.7	89.4	81.2	85.3	87.9	86.3	82.3
HW	9.8	9.4	9.4	8.8	9.1	8.7	10.1
HH	7.8	8.0	7.8	6.8	7.3	7.1	8.8
PL	23.8	25.0	24.6	25.0	26.5	26.0	29.2
PW	8.3	8.0	8.0	6.4	6.9	6.6	8.0
PnW	5.7	5.3	4.9	4.3	4.6	4.4	4.9
PzL	6.4	6.7	6.5	5.6	5.7	5.5	7.0
MzL	17.4	18.3	18.1	19.4	20.8	20.5	22.2
TgL	62.1	60.4 *	54.4 *	55.8	56.7	57.4	47.7
TgW	18.53	16.78	16.11	15.13	14.0	-***	22.0
AL	54.3	50.5 *	44.9 *	49.5	- **	52.0	42.0
PCL	16.5	16.0	15.6	15.1	16.3	15.4	18.9
PFL	18.5	21.2	18.8	16.7	18.2	17.2	20.9
PTL	12.6	12.8	12.7	10.5	11.9	11.0	13.5
PtL	10.5	- **	- **	11.3	11.7	11.0	12.8
MsFL	15.6	17.2	16.9	16.7	18.0	17.2	19.0
MsTL	13.0	13.7	12.9	12.6	14.3	14.1	16.2
MstL	8.9	10.0	9.0	8.8	8.7	8.2	9.0
MtFL	18.2	20.8	19.4	19.6	21.4	20.2	22.4
MtTL	17.4	18.0	17.7	18.4	20.3	20.2	23.0
MttL	11.9	10.8	10.7	11.2	12.1	10.9	12.4

transverse, pentagonal in shape, dorsal margin arched, ventral margin almost flat, with two interrupted paramedial carina forming two tubercles near ventral margin. Clypeus smooth with a medial ridge. Labrum entirely smooth.

Thorax: Pronotum more or less robust. Metazona longer than prozona, ratio MzL/PzL = 2.7, broadest point just after supracoxal dilation, narrowest point in the basal half of metazona. Supracoxal dilation not very distinct, rounded. Lateral margins of pronotum smooth with some indistinctly blunt denticulations at anterolateral margin; posterolateral margins darkened; small depressions present at anterior half of metazona near supracoxal sulcus; dorsal surface entirely smooth. Prosternum in well preserved specimens pale magenta in coloration, with a small pair of depressions at posterior half. Lateral cervical sclerites longer than wide, internal margin concave in the middle, ridged. Intercervical sclerites connected to each other, anterior and posterior margins ridged; two ventral cervical sclerites present, uninterrupted.

Prothoracic legs. Coxa with eleven to thirteen small, robust, yellowish-white spines of more or less equal size, except one or two at the most proximal and distal ends; posteroventral margin with small irregular denticles with small seta at tip of each denticle; coxal anterior surface entirely smooth; coxal lobes convergent, round, equal in shape; ventral coxal lobe entirely black, dorsal coxal lobe with more or less black mark at ventral margin and apex. Trochanter black at tip, more or less darkened posteriorly. Femur with gently curved dorsal margin, surface entirely smooth. Femoral brush elliptical. 15 AvS arranged as follows: **iIiIiIiIiIiIiiI**, 1st, 2nd, 4th, 6th, 8th, 10th, 12th, 15th entirely black, other AvS black at tip only; black patches present at base of black AvS, two larger patches at 1st to 2nd and 10th AvS; four DS, 3rd longest while others somewhat equal in length, 1st and 3rd black, others black at tip only; four PvS, black at tip; genicular lobe round with strong small genicular spur, black at tip. Tibia with 13 AvS, eight to ten PvS; all spines black at tip. Protarsi orange or reddish on anterior side while pale reddish

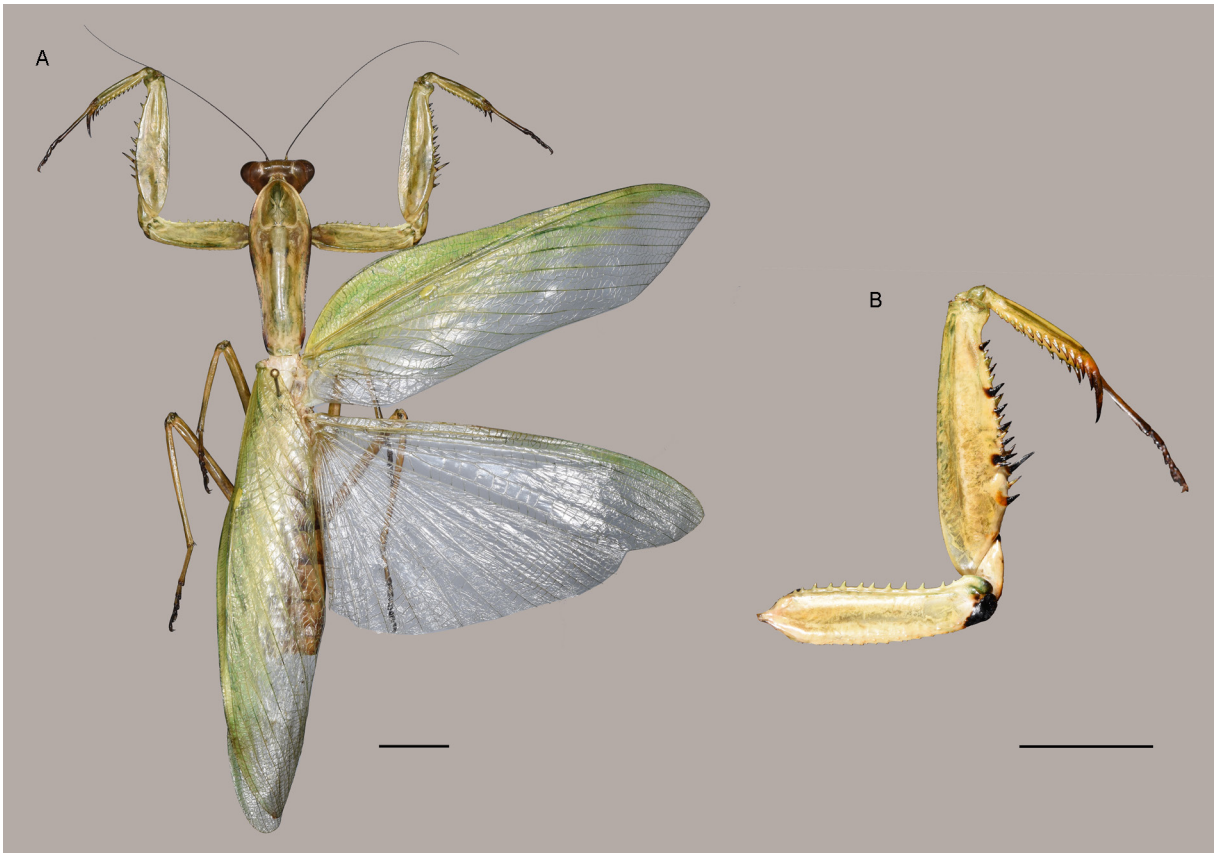

Fig. 1. *Hierodula kaltenbachi* sp. nov. A, holotype male in dorsal view; B, anterior view of male's left prothoracic leg.

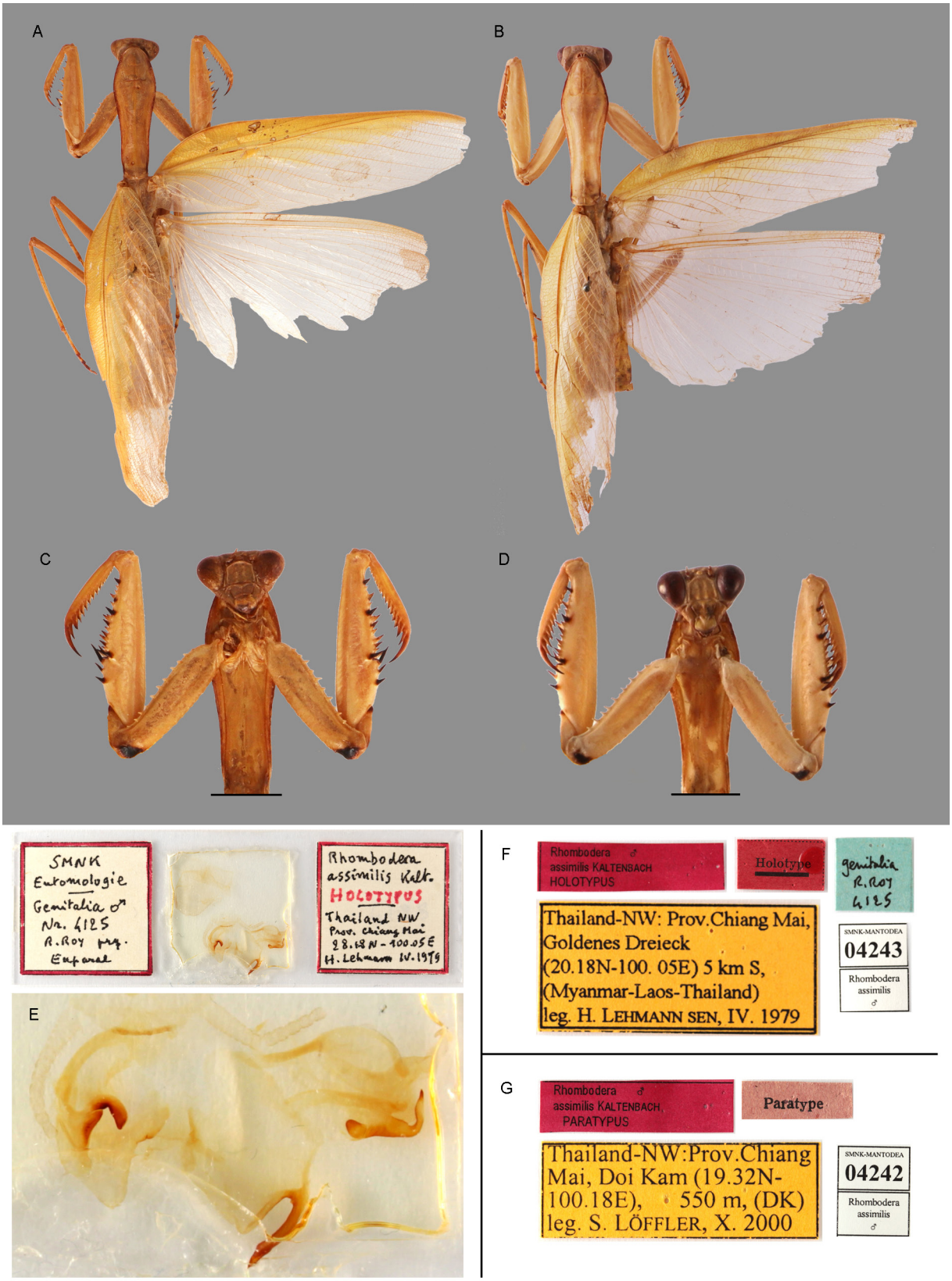

Fig. 2. *Hierodula kaltenbachi* sp. nov. **A**, paratype PT1, male in dorsal view; **B**, paratype PT2, male in dorsal view; **C**, paratype PT1, ventral view front body; **D**, paratype PT2, ventral view front body; **E**, paratype PT1, genitalia prepared in microscope slide with labels and zoomed section; **F**, paratype PT1, labels; **G**, paratype PT2, labels.

green externally (almost green in dried specimens), first segment longer than the remaining segments combined; tibial spur and 11th to 13th tibial AvS same colour as Protarsi.

Meso-, metathoracic legs. Long and slender, without dilatations or projections. Mesofemur simple with very small hairs; genicular spur present; mesotibial length shorter than mesofemoral length, with denser hairs, two mesotibial spurs present. Metafemur with hairs; metatibial length slightly shorter than metafemoral length, with denser hairs; metatarsus slightly shorter than the remaining metatarsal segments combined; tibial claws simple.

Tegmina and alae. Both wings reach beyond tip of abdomen; Tegmina with smooth costa, costal area entirely greenish, opaque; discoidal area sub-opaque green at anterior half, narrower towards the apex; remaining area hyaline; stigma yellowish, opaque, more or less sub-oval-shaped. Alae well developed with greenish transparent costal area, discoidal- and anal area hyaline.

Fig. 3. *Hierodula insperata* sp. nov. **A**, paratype female in dorsal view; **B**, holotype male in dorsal view; **C**, anterior view of female's paratype right prothoracic leg; **D**, anterior view of male holotype right prothoracic leg.

Abdomen. Uniformly greenish, seven visible coxosternites, widest at the middle of abdomen length; supra anal plate transverse, posterior margin round with dense hairs; cerci cylindrical-shaped, 18 segments, basal segments fused together, with hairs on each segment. Coxosternite IX (subgenital plate) longer than wide, with small hairs on ventral side to posterior margin; posterior margin slightly convex between styli, a few small but sclerotized black spines on the left apical side, densely present on right side; styli cylindrical-shaped with small hairs.

Male genitalia. Ventral phallomere of left phallic complex with a single long and strongly sclerotised, slightly sinuate, laterally oriented distal process (sdpl). Apical process of left phallomere (paa) broad and flattened. Phalloid apophysis (afa) with a well-sclerotised but small tubercle-shaped anterior process aafa, covered with minute tubercles. Posterior process (pafa) much larger in size compared to aafa, with broad sclerotised base, divided in a long and twisted process and a very short, blunt triangular process. Large right process shaped like a long pointy spine bending dorsad and to the left about midway of pafa in an almost 90° angle. Small left process triangular-shaped and located just before the twist of right process. Loa membranous, covered by short setae. Right phallomere widely triangular-shaped, with concave left edge, well sclerotized; lobe of fda covered by strongly short setae. Pva and pia well sclerotized. R3 moderately-sclerotized.

Female. Unknown.

Hierodula insperata Unnahachote & Vermeersch sp. nov.

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(Figs 3, 4 C–D, 5 D–F, 6, 7)

Type materials. Holotype ♂ and Paratypes (2♂, 1♀): Holotype ♂: Thailand, Surat Thani province, Ta Chana Dist., Pra Song Subdist., 9˚30′7.40″ N, 98˚55′24.43″ E, 16.VII.2020, leg. T. Unnahachote. I.G.: 34.635 (RBINS): Paratypes (2♂): Thailand, Surat Thani province, Ta Chana Dist., Pra Song Subdist., 9˚30′7.40″ N, 98˚55′24.43″ E, 16.VII.2020, leg. T. Unnahachote. (THNHM-I-00028010, 00028011). Paratype (1♀): Surat Thani province, Pha Nom Dist., Klong Sok Subdist., 10-12.I.2020, leg. T. Unnahachote. (THNHM-I-00028012).

Additional materials (2♂). Thailand, near Khao Sok, 26.IX.2017, leg. W. Hickler (CSC). Thailand, Surat Thani province, attracted to light, 8˚54′14.25″N, 98˚31′31.29″E, leg. N. Hoffmann (CSC).

Diagnosis.

Hierodula insperata sp. nov. can be separated from other species of *Hierodula* by the following combination of characters:

(1) Black colouration of the inner side of the protarsi.

(2) Morphology of the male genitalia (described from dorsal view): afa strongly sclerotised, aafa small and globular, pafa of medium length, making roughly a 45° angle to the right, with a short pointy thorn on left side of the apex that is angled 90° to the left, tip blunt, nearly flat. Sdpl very short and strongly projecting to the right in a 90° angle.

(3) Modification of the right posterior ridge of Coxosternite IX (subgenital plate) which projects dorsally in a rounded protrusion and is densely covered with very short sclerotised black spinules.

(4) spinal formula: 4DS/15AvS/4PvS; T = 15AvS/10PvS.

Etymology.

The word “insperata” means “unexpected” in Latin referring to the surprising and unforeseen finding of this large new species despite its size and the relatively good accessibility of the region where it was discovered.

Description.

Male (holotype): (Figs 3, 4 C–D, 5 D–F, 6, 7). Ratios (all male type specimens): PL/PW: 3.65–3.94, TgL/TgW (=Tegmen Width): 3.69–4.1, TgL/PL: 2.14–2.23. Measurements see Table 1. Colouration (Fig 4 C–D): All know specimens feature a uniformly green body colouration with an orange-magenta coloured underside of the thoracic segments. Long and slender pronotum. The inner sides of the raptorial legs are uniformly yellowish-green and brighter than the rest of the body, with some black markings near some of the anteroventral spines.

Head. Triangular, wider than long with large, round compound eyes; vertex flat. Antenna filiform. Ocellar tubercle not elevated; ocelli relatively large. Lower frons transverse, pentagonal in shape, round dorsal margin with two interrupted paramedial carina that form to tubercles near ventral margin. Clypeus smooth with medial ridge. Labrum entirely smooth.

Thorax. Pronotum long and relatively slender, smooth surface, covered by thin layer of whitish waxy secretion on both sides, easily removed. Metazona longer than prozona, ratio MzL/PzL =

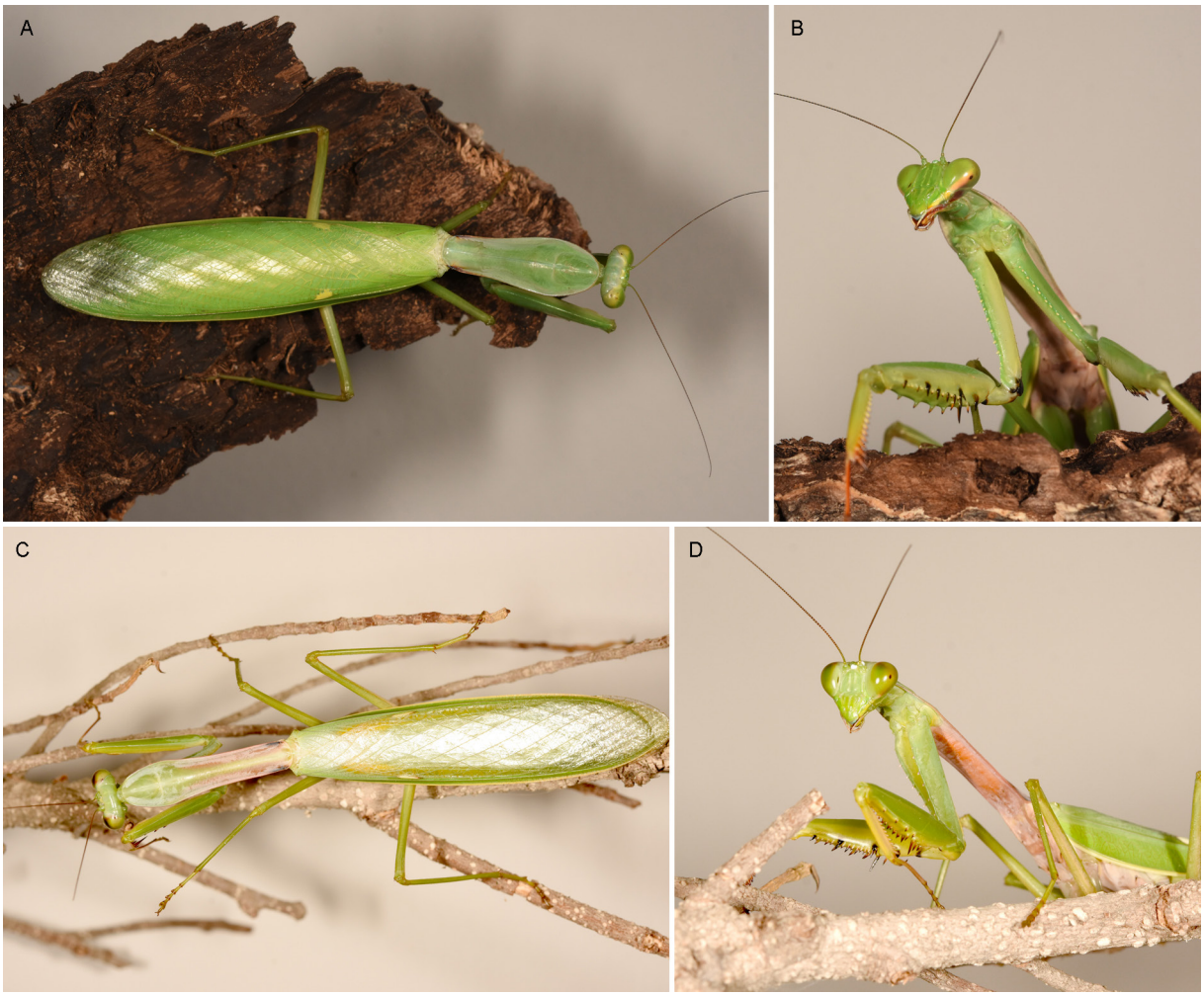

Fig. 4. Live views of the two holotypes; A-B, *H. kaltenbachi* sp. nov., holotype male; C-D, *H. insperata* sp. nov. holotype male.

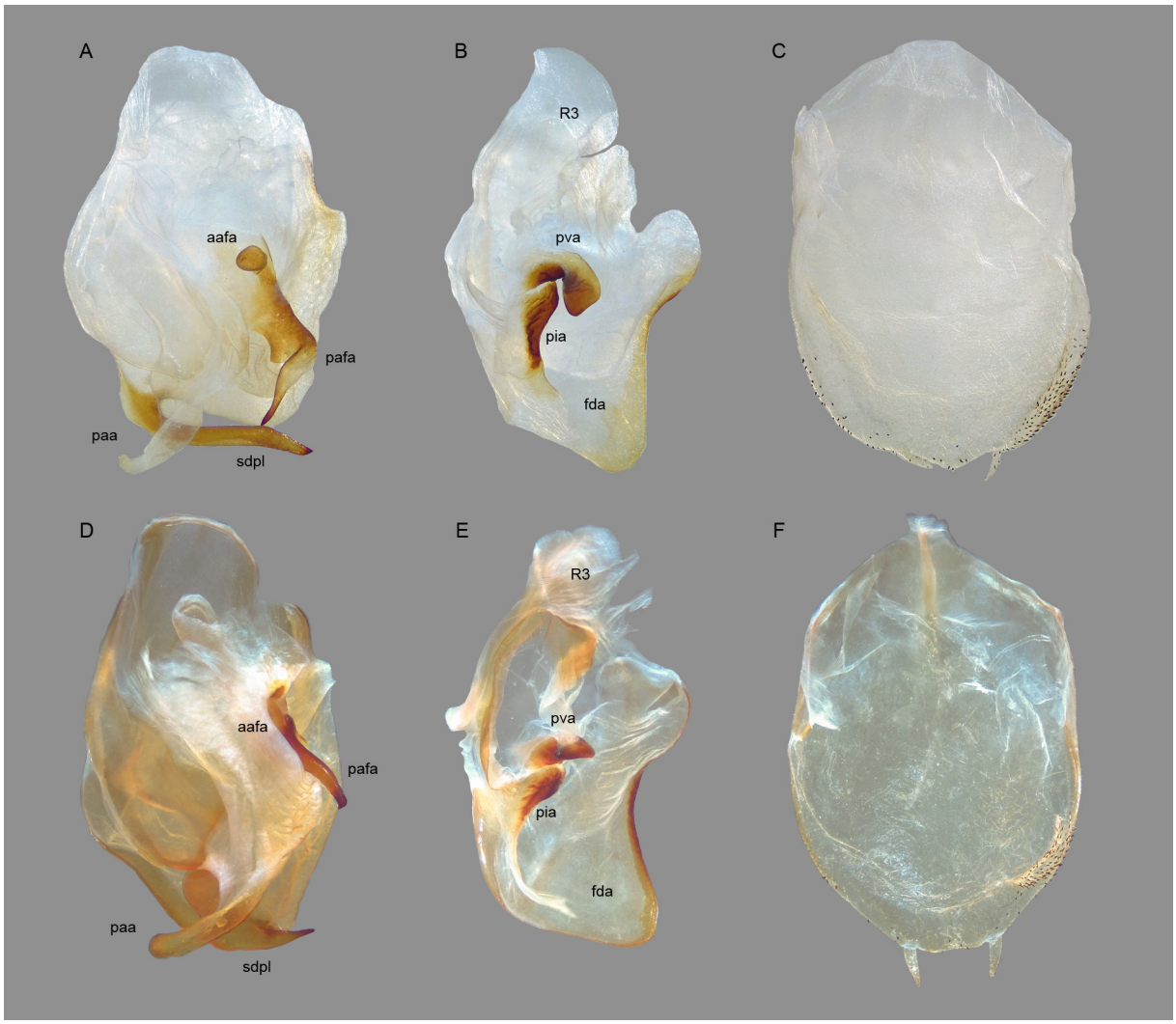

Fig. 5. Male terminalia and genitalia; **A**, **C**, **D**, **F**: dorsal view; **B**, **E**: ventral view. **A**–**C**, *H. kaltenbachi* sp. nov., holotype male; **D**–**F**, *H. insperata* sp. nov. holotype male.

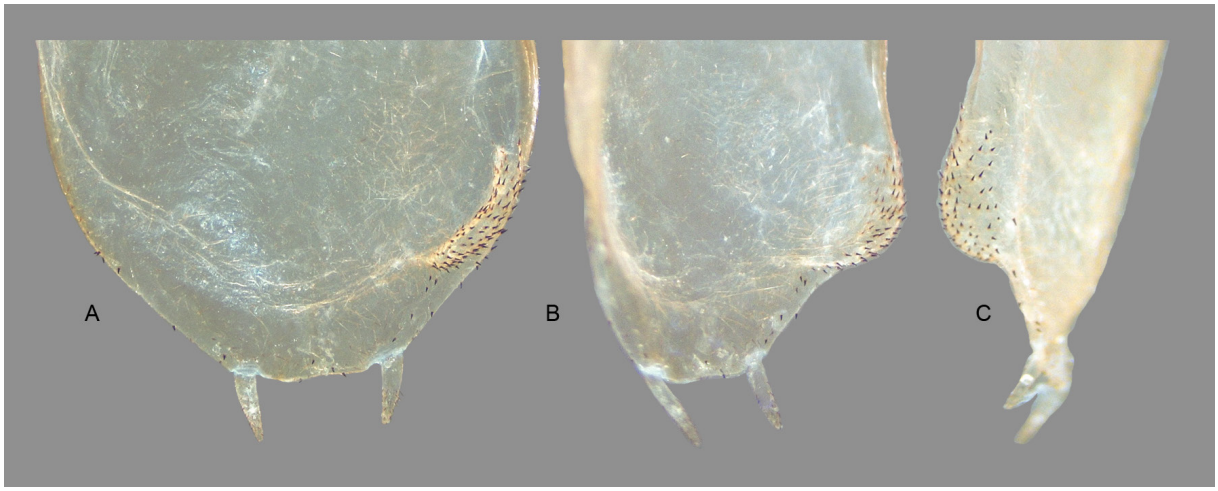

Fig. 6. *Hierodula insperata* sp. nov., male subgenital plate; **A**, dorsal view; **B**, side view from the left under 45° angle; **C**, side view from the right.

3.4−3.7. No lateral dilatation present. Ventral side of metazona with two small depressions near supracoxal sulcus and two indistinct convexities present at middle, close to posterior margin; dorsal posterolateral margins darkened. Prosternum entirely orange-magenta in colouration after the insertion site of the prothoracic legs (very distinct in live specimens), with two small depressions at posterior half; lateral cervical sclerites longer than wide, internal margin concave in the middle, ridged; intercervical sclerites connected to each other, anterior and posterior margins ridged, two ventral cervical sclerites present, uninterrupted.

Prothoracic legs. Coxa uniformely greenish, with eight to nine strong acute spines at anterior margin; posterior margin with small spine-like tubercles; coxal lobes convergent, same colour as coxa, dorsal lobe larger than ventral one. Trochanter black at the apex. Femur with genicular lobe large and round, with small genicular spurs, black apically. Fifteen AvS arranged as follows: **iIiIiIiIiIiIiiI**, 2nd, 8th, 10th, and 15th entirely black, other AvS apically infuscated, with a black tip; black patches present at base of 2nd and 10th AvS; four DS, 3rd longest while others somewhat equal in length, 1st and 3rd entirely black, others black at tip only, black spot at base of 1st DS; four PvS, black at tip; genicular lobe round with a strong, very small genicular spur, black at tip; Tibia with 13 AvS, eight to ten PvS; all spines black at tip; anterior side of protarsi entirely black on all segments, first segment longer than remaining segments combined.

Meso-, metathoracic legs. Long and slender, without dilatations or projections; genicular spur present; tibial length shorter than femoral length, two tibial spurs present; metatarsus about as long as remaining metatarsal segments combined; tibial claws simple.

Tegmina and alae. Well developed in both sexes, reaching beyond tip of abdomen. Tegmina with costa finely denticulate, costal area entirely greenish, opaque; discoidal area and anal

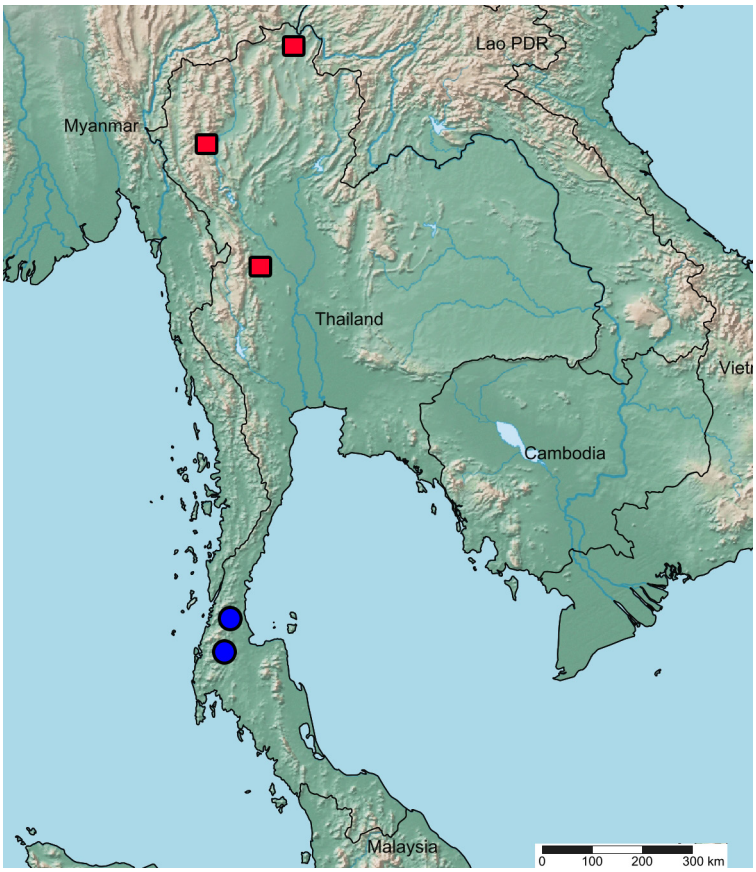

Fig. 7. Map with known distribution data in Thailand of *H. kaltenbachi* sp. nov. (red squares) and *H. insperata* sp. nov. (blue circles).

area hyaline; stigma yellowish, opaque, more or less elongate. Alae with costal area greenish transparent, discoidal area and anal area hyaline.

Abdomen. Uniformly greenish, seven visible coxosternites, widest at the middle of abdomen length; supra-anal plate transverse, posterior margin rounded; cerci cylindrical-shaped, approximately 18 segments, basal segments fused together, with fine hairs on each segment.

Male genitalia. Ventral phallomere of left phallic complex with a single very short, sclerotised and strongly laterally oriented distal process (sdpl). Apical process of left phallomere (paa) broad and flattened. Phalloid apophysis (afa) with a well-sclerotised but very small tubercle-shaped anterior process aafa. Posterior process (pafa) larger in size compared to aafa, entirely sclerotised, projecting to the right in a 45° angle, ending flat, with very small pointed apex projecting 90° to the left. Loa membranous, covered by short setae. Right phallomere broad, triangular, right edge of fda strongly sclerified, without mesal accessory lobe of fda. Pva and pia strongly sclerotized. R3 moderately-sclerotized. Coxosternite IX (subgenital plate) broad, longer than wide, with small hairs on ventral side up to posterior margin; posterior margin flat with very few small sclerotized spinules. Right posterior border densely populated with short but strongly sclerotised spinules and projecting dorsally in a rounded shape (Fig. 6); styli cylindrical-shaped with small hairs.

Female.

Very similar to male but more robust, different in the following characters:

1) Ratio PL/PW = 3.65 [3.65−3.94 in males]

2) Ratio MzL/PzL = 3.17 [3.4−3.7 in males]

3) Very small ocelli [larger in male];

4) Anterior coxal margin with longer spines [shorter in male];

5) Tegmina wider (TgL/TgW = 2.17), discoidal area sub-opaque [narrower (TgL/TgW = 3.69−4.1), discoidal area hyaline];

6) Stigma more or less sub-oval to elliptically-shaped [more elongate in male];

7) Abdomen broad and ovaliform.

Discussion

The genus *Hierodula* remains taxonomically challenging to this day, especially since members of this very speciose genus remain poorly studied and understood. Burmeister (1838) first mentions the name *Hierodula* to group together large oriental praying mantises without a lateral expansion of the pronotum. Only three species were placed in this group at the time, while the genus currently contains 104 valid species (Otte et al., Mantodea Species File Online). As other species were added to the genus by subsequent authors, no in-depth investigations on the phylogenetic relationships between all these species has been performed to this day, leaving the entire genus in dire need of revision. Most of the *Hierodula* species have been and are still placed in the ‘one fits all’ genus *Hierodula* ‘sensu lato’ based on resemblances in their external morphology. All species share a generalist praying mantis body shape without special morphological characteristics like unique shapes, expansions or protrusions. However, a more detailed analysis of the morphology and in particular the structures of the male genitalia which can be highly differentiated in some groups of Mantodea points out that the current composition of the genus is largely artificial and may not properly reflect the natural phylogeny of the group. A complete review of all relevant morphological traits and male genitalia for all known species within the tribe Hierodulini is absolutely critical to finally gain much needed insights in their correct taxonomic placement. In addition, in-depth molecular research using a combination of mitochondrial and nuclear DNA sequences is equally necessary to further strengthen and support the morphological analysis. In the meanwhile, undescribed species that by logical

attribution can only be placed in *Hierodula* at this time might turn out to not naturally belong to this genus as defined by its type species, *H. membranacea* Burmeister, 1838.

Hierodula kaltenbachi sp. nov. was previously studied by Alfred Kaltenbach who examined two male specimens from Thailand and prepared a draft to describe them as a species new to science. However, his unfinished manuscript was never officially published due to his untimely death, and his notes on the specimens remained unavailable to the scientific community. Kaltenbach proposed to put his new species in *Rhombodera* and gave them the proposed candidate name *Rhombodera assimilis* (unpublished name). He hypothesised that the genus *Rhombodera* contained two distinct morphological groups, one with a broad and laterally expanded pronotum to which the type species *Rhombodera valida* Burmeister, 1838 belongs, and a group with a relatively slender pronotum. He considered that this second group should contain *Rhombodera crassa* Goglio-Tos 1912, *Rhombodera flava* (De Haan, 1842), *Rhombodera palawanensis* Beier 1966, *Rhombodera titania* (Stal, 1877) and *Rhombodera keiana* Goglio-Tos, 1912. He also noted that according to his insights his new species appeared to be closest to *Rhombodera palawanensis,* although a comparison of the male genitalia of both species by the present authors doesn't clearly support a close relationship.

Notable about *Hierodula insperata* sp. nov. is the right posterior border of Coxosternite IX (subgenital plate) which features a unique elevated and rounded shape, densely covered by sclerotised spinules only at this location (Fig. 6). This feature has not been previously observed in other Hierodulinae. It is hypothesised that this special shape has a structural function during the mating process. The habitus and male genitalia of this species appear somewhat reminiscent of *Titanodula* species, albeit having male genitalia with only one short distal process, afa being smaller, and the left phallic complex being broader and less slender in general. Future research will be needed to investigate a possible phylogenetic relationship between these taxa.

Given the above arguments, the two newly described species from Thailand are provisionally placed in *Hierodula* based on their morphological resemblance with other species that are currently a part of that genus. The authors can, however, not exclude the possibility that future new insights may revise this attribution. Here we describe in detail two previously unknown praying mantis species from Thailand, adding to the knowledge of biodiversity in the Oriental region.

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References

Brannoch S.K., Wieland F., Rivera J., Klass K.D., Béthoux O. & Svenson G.J., 2017. - Manual of praying mantis morphology, nomenclature, and practices (Insecta, Mantodea). *Zookeys*, 696: 1–100. Doi: https://doi.org/10.3897/zookeys.696.12542

Liu Q.P., Liu Z.J., Wang G.L. & Yin Z.X., 2021. - Taxonomic revision of the praying mantis subfamily Hierodulinae of China (Mantodea: Mantidae). *Zootaxa*, 4951(3): 401-433.

Otte D., Spearman L. & Stiewe M.B.D. *Mantodea Species File Online*. Version 5.0/5.0. [15/04/2023]. <http://Mantodea.SpeciesFile.org>

Schwarz C.J. & Roy R., 2019. - The systematics of Mantodea revisited: an updated classification incorporating multiple data sources (Insecta: Dictyoptera). *Annales de la Société entomologique de France (N.S.)*, 55(2): 101–196. Doi: https://doi.org/10.1080/00379271.2018.1556567

Shcherbakov E.O., Vermeersch X.H.C., 2020. - *Dracomantis mirofraternus* gen. et sp. n., a new genus and species of Hierodulinae (Mantodea: Mantidae) from Vietnam. *Far Eastern Entomologist*, 408: 1-12. Doi: https://doi.org/10.25221/fee.408.1

Vermeersch X.H.C., 2018. - *Phasmomantella* gen. nov., a spectacular new genus of praying mantis from southern Central Vietnam (Mantodea, Mantidae, Deroplatyinae, Euchomenellini). *European Journal of Taxonomy*, 442: 1-17. Doi: https://doi.org/10.5852/ejt.2018.442

Vermeersch X.H.C., 2020. - *Titanodula* gen. nov., a new genus of giant oriental praying mantises (Mantodea: Mantidae: Hierodulinae). *Belgian Journal of Entomology*, 100: 1-18.

Vermeersch X.H.C. & Unnahachote, T., 2020. - *Hierodula confusa* sp. nov., a new "species of *Hierodula* Burmeister, 1838 (Mantodea: Mantidae: Hierodulinae: Hierodulini). *Belgian Journal of Entomology*, 103: 1-13.

Wang Y., Cheng Y.D. & Zhang Y., 2020b. - Characterization of the complete mitochondrial genome of the praying mantis *Rhombodera longa* (Mantodea: Mantidae) including a phylogenetic analysis. *Mitochondrial DNA*, part B, 5(2): 1582–1583. Doi: https://doi.org/10.1080/23802359.2020.1742612

Wang Y., Zhou S. & Zhang Y. 2020a. - Revision of the genus *Hierodula* Burmeister (Mantodea: Mantidae) in China. *Entomotaxonomia,* 42(2): 1-21.

Yang J.K., 1997. - Four new and rare species of Mantids from Yunnan China (Insecta: Mantodea). *Journal of Yunnan Agricultural University*, 12(4): 227-233.