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Morphological studies and taxonomic considerations on the 'reddish-brown-winged' group of *Neurothemis* Brauer, 1867 with the description of *N. taiwanensis* sp. nov. (Odonata: Libellulidae)

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Morphological studies and taxonomic considerations on the 'reddish-brown-winged' group of *Neurothemis* Brauer, 1867 with the description of *N. taiwanensis* sp. nov. (Odonata: Libellulidae)

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Abstract

Specimens of *Neurothemis disparilis* Kirby, 1889, *N. fluctuans* (Fabricius, 1793), *N. fulvia* (Drury, 1773), *N. ramburii* (Brauer, 1866), *N. stigmatizans* (Fabricius, 1775) and *N. terminata* Ris, 1911, including their subspecies, were studied with the main focus on the morphology of the vesica spermalis, wing maculation, wing venation, abdominal markings and vulvar scales. The results were compared with species descriptions and directly with type specimens where possible.

The vesica spermalis, especially the medial process, is useful at least in separating species groups and supports the traditional differentiation methods using wing maculation and venation. The use of other characters in accessing specific status, coupled with known distribution patterns, is discussed.

The following taxonomic changes are proposed: *Neurothemis manadensis* (Boisduval, 1835) stat. nov., *Neurothemis papuensis* (Lieftinck, 1942) stat. nov. and *Neurothemis taiwanensis* sp. nov. is described (27.5.1998, Kenting, Pingtung County/Taiwan, L. M. Juang leg.; holotype is deposited at Taiwan Forestry Research Institute, Taipeh, Taiwan). The type of *Polyneura palliata* Rambur, 1842 was re-discovered at MNHN and designated as lectotype; a lectotype for *Neurothemis nicobarica* Brauer, 1867 housed at NHMW is designated. The holotype of *Neurothemis incerta* Brauer, 1867 was re-discovered and synonymized with *N. ramburii*.

Key words: Odonata; *Neurothemis*; new species; *Neurothemis taiwanensis*; morphology; taxonomy; vesica spermalis

Introduction

Members of the genus *Neurothemis* Brauer, 1867 are difficult to identify to species due to the highly variable wing maculation of males and the polymorphism of females. Many variations have been described as species and subsequently synonymized or re-classified as subspecies (Rambur 1842; Brauer 1866, 1867a & b; Hagen 1869; Selys 1879; Kirby 1889 & 1890, Krüger 1903).

Brauer (1867a) introduced the name *Neurothemis* for *Polyneura* Rambur, 1842 a junior homonym of *Polyneura* Westwood, 1840 in the Hemiptera (Steinmann 1997). Kirby (1889) designated *Libellula fulvia* Drury, 1773 as the type species for *Neurothemis* and transfered *Neurothemis gigantea* (Brauer, 1867) to his new genus *Camacinia*.

The latest comprehensive study of the genus *Neurothemis* was conducted by Ris (1911) who recognized eleven species and six subspecies, listed in alphabetical order as follows:

- *Neurothemis decora* (Brauer, 1866)
- *Neurothemis disparilis* Kirby, 1889
- *Neurothemis fluctuans* (Fabricius, 1793)
- *Neurothemis fulvia* (Drury, 1773)
- *Neurothemis intermedia* (Rambur, 1842)
  - o *Neurothemis intermedia degener* (Selys, 1879)
- *Neurothemis nesaea* Ris, 1911
- *Neurothemis oligoneura* Brauer, 1867
- *Neurothemis palliata* (Rambur, 1842)
  - o *Neurothemis palliata martini* (Krüger, 1903)
  - o *Neurothemis palliata* var. *ramburii* (Brauer, 1866)
- *Neurothemis stigmatizans* (Fabricius, 1775)
  - o *Neurothemis stigmatizans bramina* (Guérin, 1838)
  - o *Neurothemis stigmatizans manadensis* (Boisduval, 1835)
- *Neurothemis terminata* Ris, 1911
- *Neurothemis tullia tullia* (Drury, 1773)
  - o *Neurothemis tullia feralis* (Burmeister, 1839)

Ris did not examine all type specimens, but his study was based on extensive material from all over the known range and culminated in a usable and practical key.

Ris (1913) described *N. intermedia atalanta* and Fraser (1926) described *N. obscura* which was reduced to a subspecies of *N. terminata* by Lieftinck (1934b). Lieftinck (1934a) described *N. intermedia excelsa* and *N. luctuosa*, Lieftinck (1942) described *N. ramburii papuensis* and Lieftinck (1948) described *N. ramburii oceanis*. Also Lieftinck (1942) synonymized *N. palliata* with *N. fluctuans* thus elevating *N. ramburii*, formerly considered a variant of *N. palliata*, to a valid species.

All previous authors focused mainly on the wing venation and maculation and to some extent the size of the pterostigma in diagnosing taxa within *Neurothemis*.

The 'reddish-brown-winged' species, *N. disparilis*, *N. fluctuans*, *N. fulvia*, *N. ramburii*, *N. stigmatizans* and *N. terminata* plus their subspecies, have frequently been difficult to identify to species. The difficulty of properly identifying material has also been hampered by a lack of supporting figures illustrating variability or defining various populations of intermediate appearance, and supposed interbreeding between taxa from various localities (e.g. Lieftinck 1931, 1934b, 1954, Orr 2005, Kosterin 2014).

Surprisingly the vesica spermalis of *Neurothemis* species had never been compared although this is sometimes a very useful attribute to distinguish among Odonata species. Its value had already been demonstrated for other Libellulidae genera including *Erythrodiplax* Brauer, 1868 (Borror 1942), *Crocothemis* Brauer, 1868 (Lohmann 1981, Schneider 1985), *Orthemis* Hagen, 1861 (Ellenrieder 2009, 2012) and *Rhodothemis* Ris, 1909 (Kalkman & Orr 2014). The purpose of this study was to examine newly found characters of the male vesica spermalis and compare the results with traditionally used wing characters in order to see if agreement existed between the two sets of characters that would further aid in defining species.

Material and methods

About 2400 preserved specimens from different localities, including type material, housed in various European collections were examined.

Characters assessed included overall size, coloration, wing maculation and venation plus morphology of the vesica spermalis and vulvar scales. Wing venation included number of ante- and postnodals, aspects of the discoidal field, radial and medial planate, the triangle and subtriangle as well as the number of cubital crossveins.

Several vesica spermalis of each taxon (but not on any type specimen) were prepared using a 10% potassium hydroxide solution (KOH): Segment V3 and V4 of the vesica spermalis were dissected using fine needles, cut and stored in KOH for four to five days, then stored in glycerin vials associated with each specimen. One lateral lobe of segment V4 was removed in order to better examine the medial process. These structures were examined using a stereomicroscope at up to 80x magnification [NOTE: dried medial processes of the vesica spermalis are different from illustrations of this study and some details could only be seen after KOH-treatment].

Synonymy and a distribution map are included for each taxon and characters of the abdomen, the vesica spermalis, vulvar scales and some variations of the wings are illustrated.

Detailed information including range, morphological characterization and variation plus information about type specimens are given under each taxon in the species accounts. Uncertain or doubtful specifications (e.g. labelled localities) and additional information are placed in square brackets.

Wing nomenclature is explained in fig. 1 and vesica spermalis nomenclature in fig. 2. The following abbreviations used throughout the text: Tot = total length; Ab = Abdomen length; Fw = Forewing; Hw = Hindwing; Pt = Pterostigma; dc-field = discoidal field; Cux = cubital crossvein (within cubito-anal space); S1, S2, S3 etc. = first, second, third etc. abdominal segment.

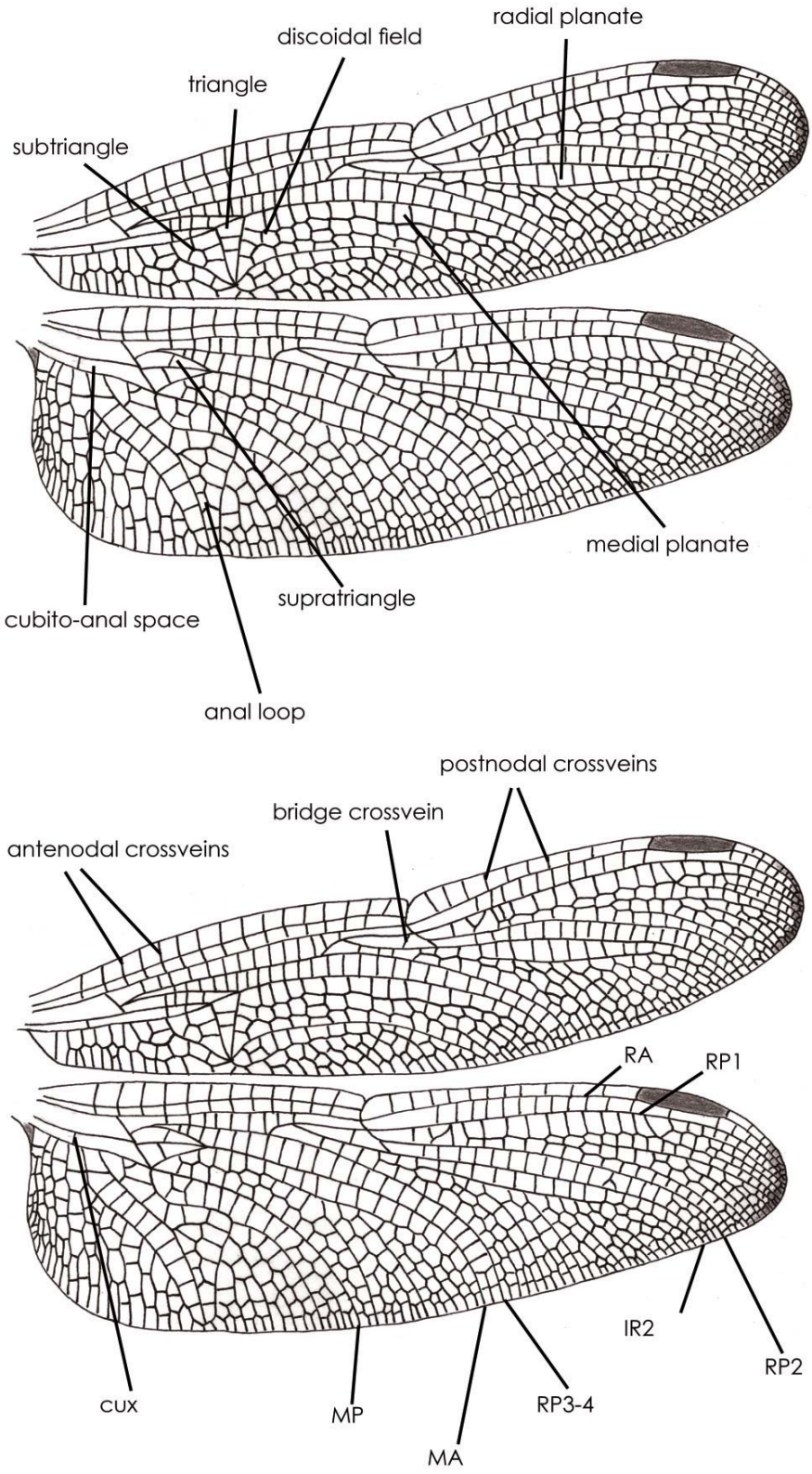

Fig. 1: Nomenclature used for the wings (female *Neurothemis ramburii martini*).

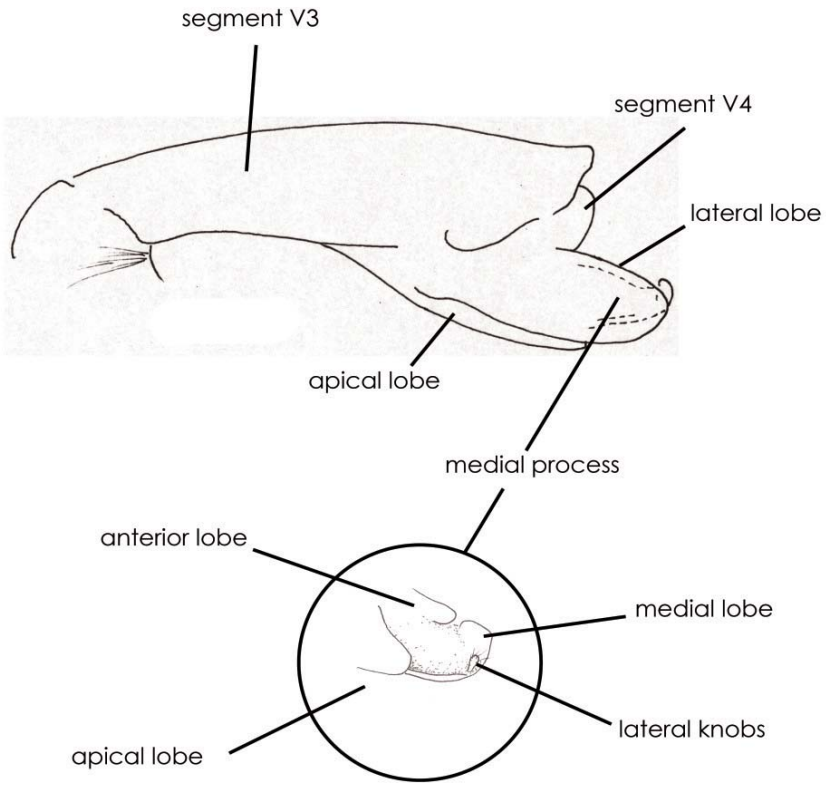

Fig. 2: Nomenclature used for the vesica spermalis (*Neurothemis fluctuans*).

The following acronyms and standard abbreviations of museums and collections are used:

AA – Private collection of Andreas Arnold, Germany
AG – Private collection of André Günther, Germany
BMNH – The Natural History Museum London, United Kingdom
HLMD – Hessisches Landesmuseum Darmstadt, Germany
MNHN – Muséum National d'Histoire Naturelle Paris, France
MNNW – Museum für Naturkunde Dortmund, Germany
MWNH – Museum Wiesbaden, Landesmuseum für Kunst und Natur, Germany
MZPW – Museum and Institute of Zoology, Polish Academy of Science, Warszawa, Poland
NHMW – Naturhistorisches Museum Wien, Austria
OLML – Oberösterreichisches Landesmuseum Linz, Austria
PMIRL – Phyllodrom e.V., Museum und Institut für Regenwaldökologie, Leibzig, Germany
RAD – Private collection of Rory A. Dow, United Kingdom

RBINS – Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium
RMNH – Naturalis Biodiversity Center Leiden, Netherlands
SMF – Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany
SMNS – Staatliches Museum für Naturkunde Stuttgart, Germany
TFRI – Taiwan Forestry Research Institute, Taipeh, Taiwan
UMB – Überseemuseum Bremen, Germany
ZFMK – Zoologisches Forschungsinstitut und Museum Alexander Koenig Bonn, Germany
ZMH – Zoologisches Museum Hamburg, Germany
ZMB – Museum für Naturkunde der Humboldt-Universität Berlin, Germany
ZSM – Zoologische Staatssammlung München, Germany

The second author only became involved in the project at a late stage and only a limited subset of the material available in RMNH has been examined (principally specimens of *Neurothemis disparilis*, *N. taiwanensis* and *N. terminata obscura*, plus some specimens of other taxa originally in collection Dow but now in RMNH).

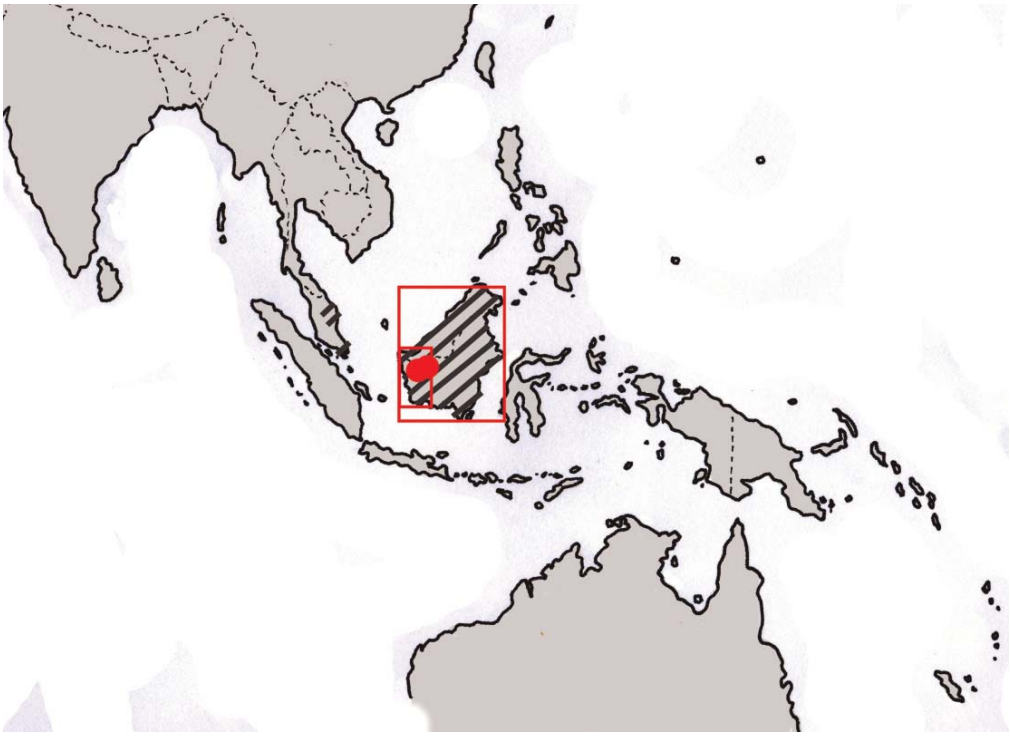

Fig. 3: Distribution of *Neurothemis disparilis*: grey stripes: range according to our studies and literature; red quadrangles: possible range of examined specimens without specified locality.

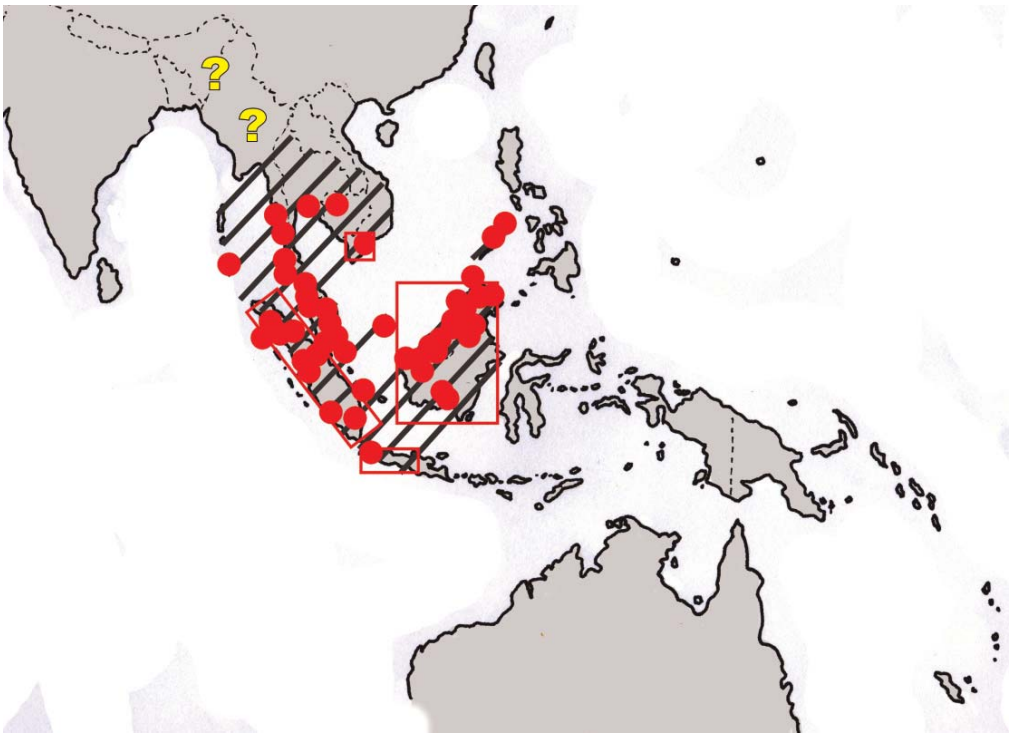

Fig. 4: Distribution of *Neurothemis fluctuans*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangles: possible range of examined specimens without specified locality; question marks: occurrence uncertain.

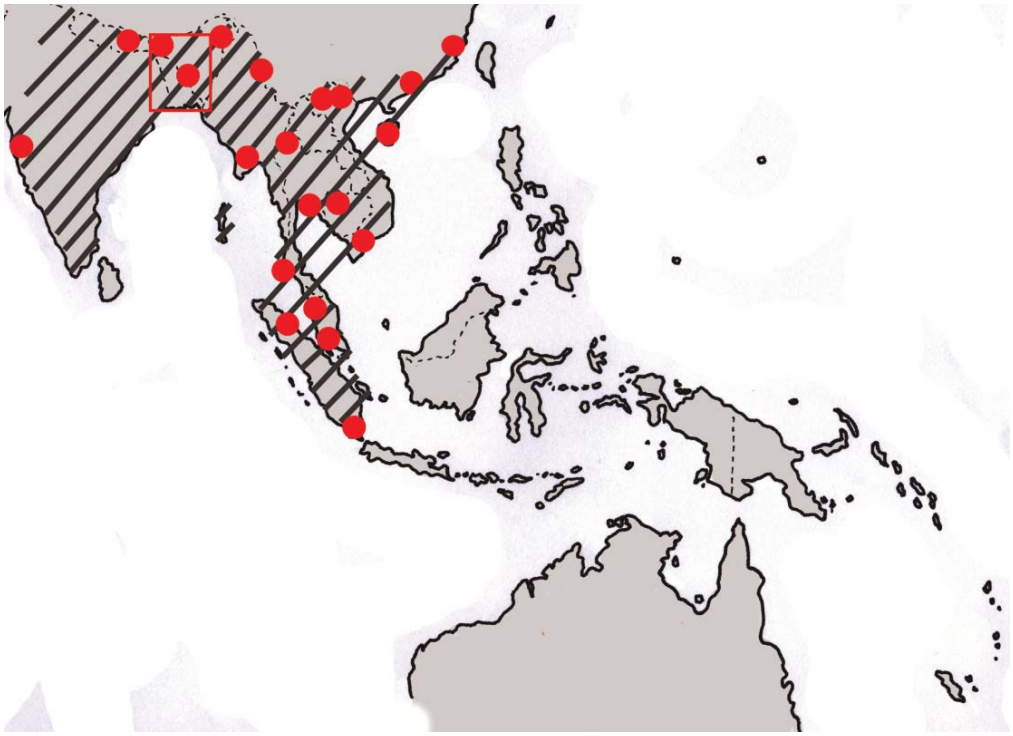

Fig. 5: Distribution of *Neurothemis fulvia*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangle: possible range of examined specimens without specified locality.

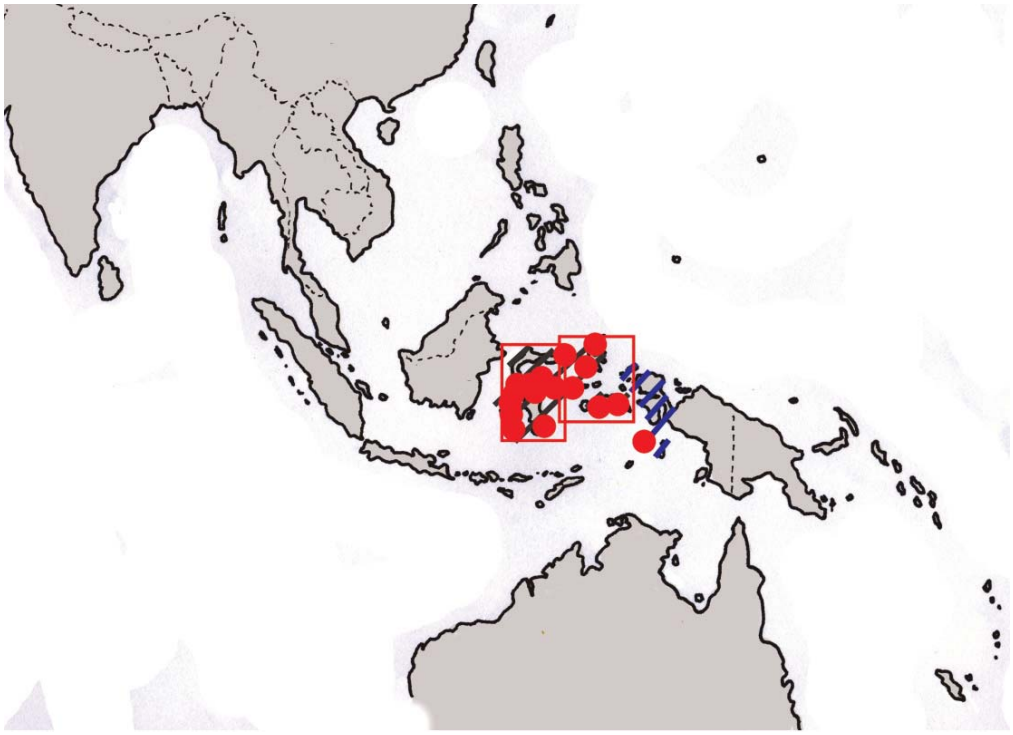

Fig. 6: Distribution of *Neurothemis manadensis*: grey stripes: range according to our studies and literature; blue stripes: intermediates between *N. manadensis* and *N. stigmatizans bramina*; red dots: localities of examined specimens; red quadrangles: possible range of examined specimens without specified locality.

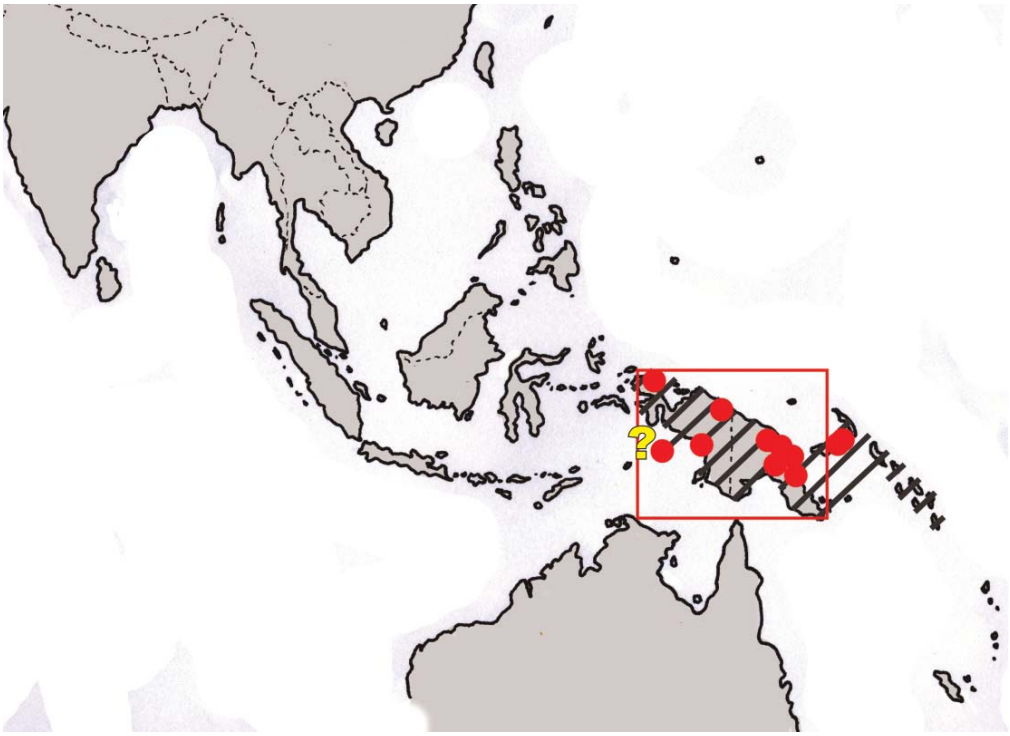

Fig. 7: Distribution of *Neurothemis papuensis*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangle: possible range of examined specimens without specified locality; question marks: occurrence uncertain.

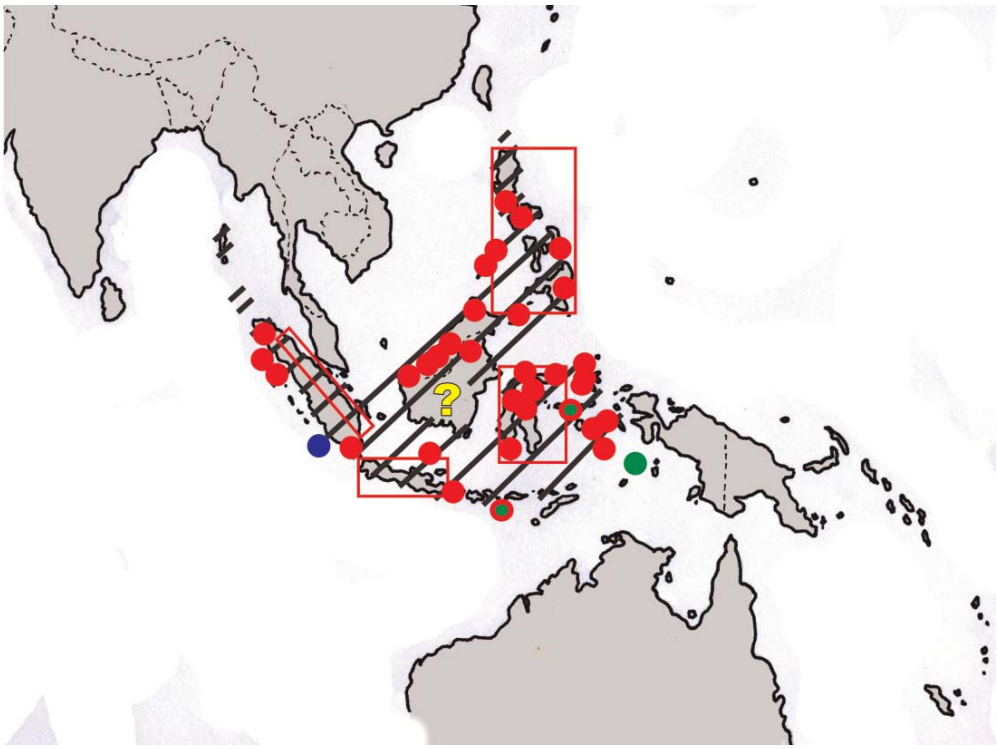

Fig. 8: Distribution of *Neurothemis ramburii*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangles: possible range of examined specimens without specified locality; green dots: Kai Island, Sanana Island & Sumba Island, localities of subspecies *N. ramburii martini*; blue dot: Enggano Island, locality of subspecies *N. ramburii oceanis*; question mark: area which needs verification because no records are known to the authors.

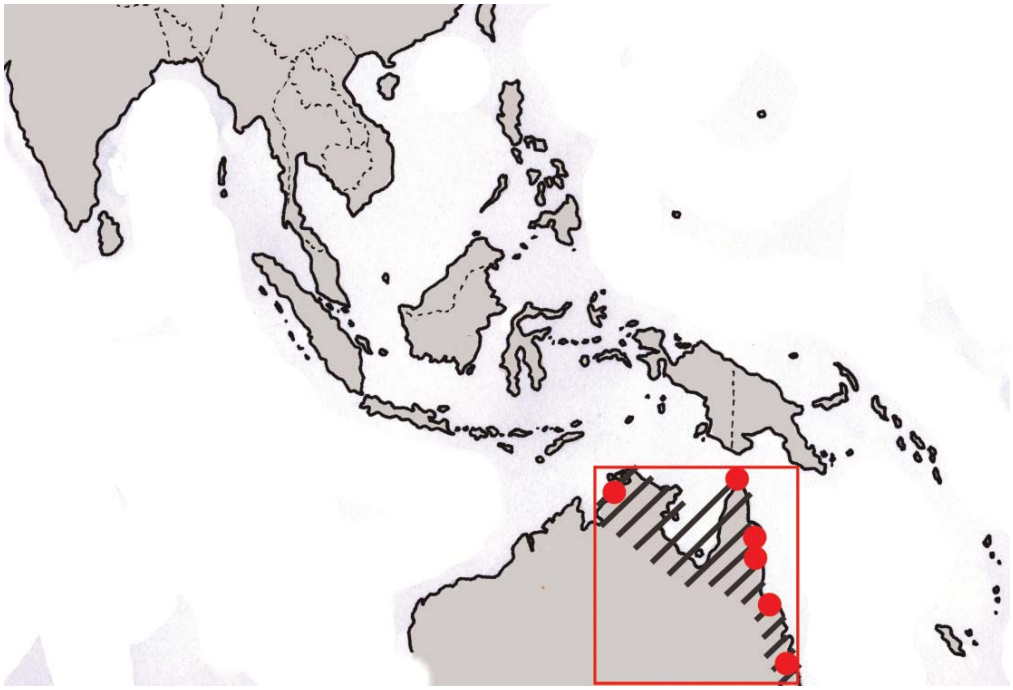

Fig. 9: Distribution of *Neurothemis stigmatizans*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangle: possible range of examined specimens without specified locality.

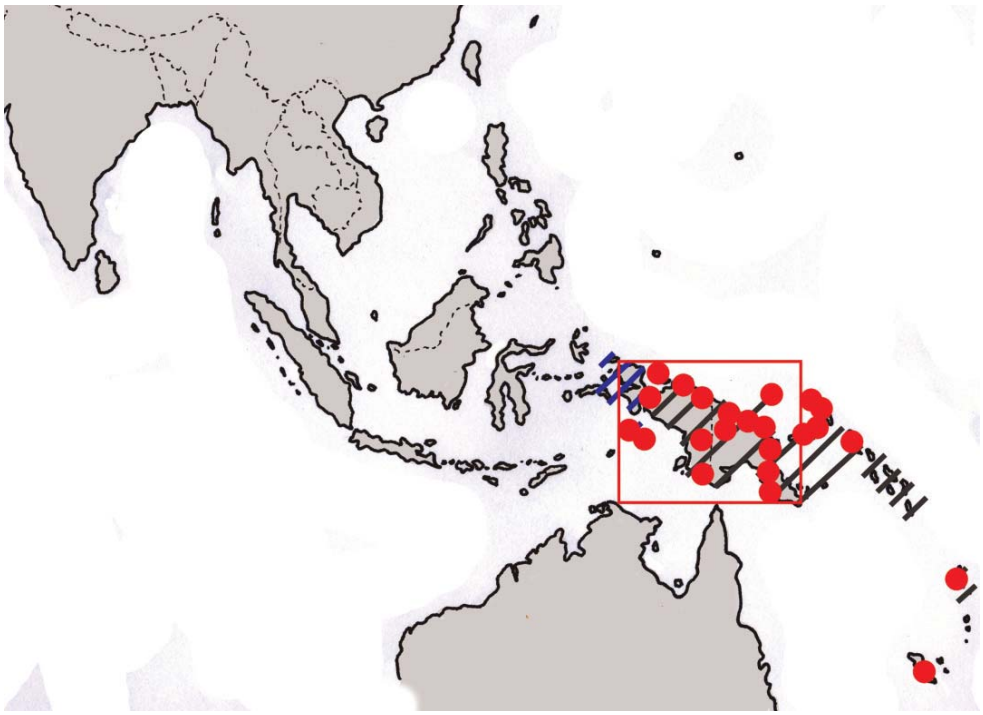

Fig. 10: Distribution of *Neurothemis stigmatizans bramina*: grey stripes: range according to our studies and literature; blue stripes: intermediates between *N. stigmatizans bramina* and *N. manadensis*; red dots: localities of examined specimens; red quadrangle: possible range of examined specimens without specified locality.

Fig. 11: Distribution of *Neurothemis taiwanensis*: grey stripes = range according to our studies and literature; red dots = localities of examined specimens.

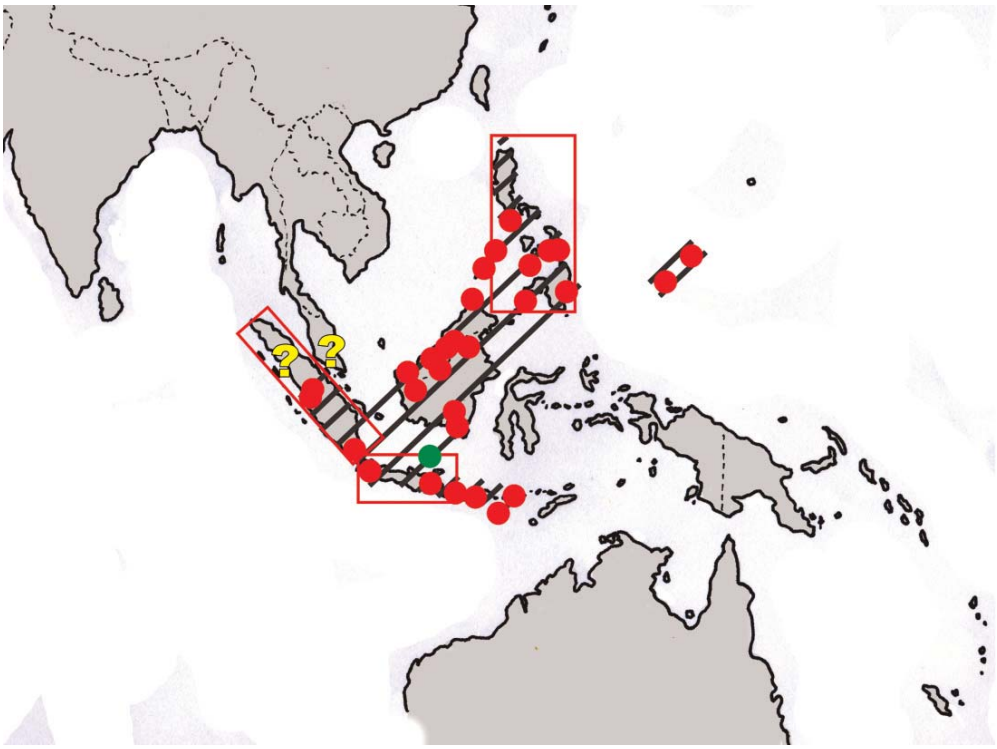

Fig. 12: Distribution of *Neurothemis terminata*: grey stripes: range according to our studies and literature; red dots: localities of examined specimens; red quadrangles: possible range of examined specimens without specified locality; green dot: Karimunjawa Island, locality of subspecies *N. terminata obscura*; question marks: occurrence uncertain.

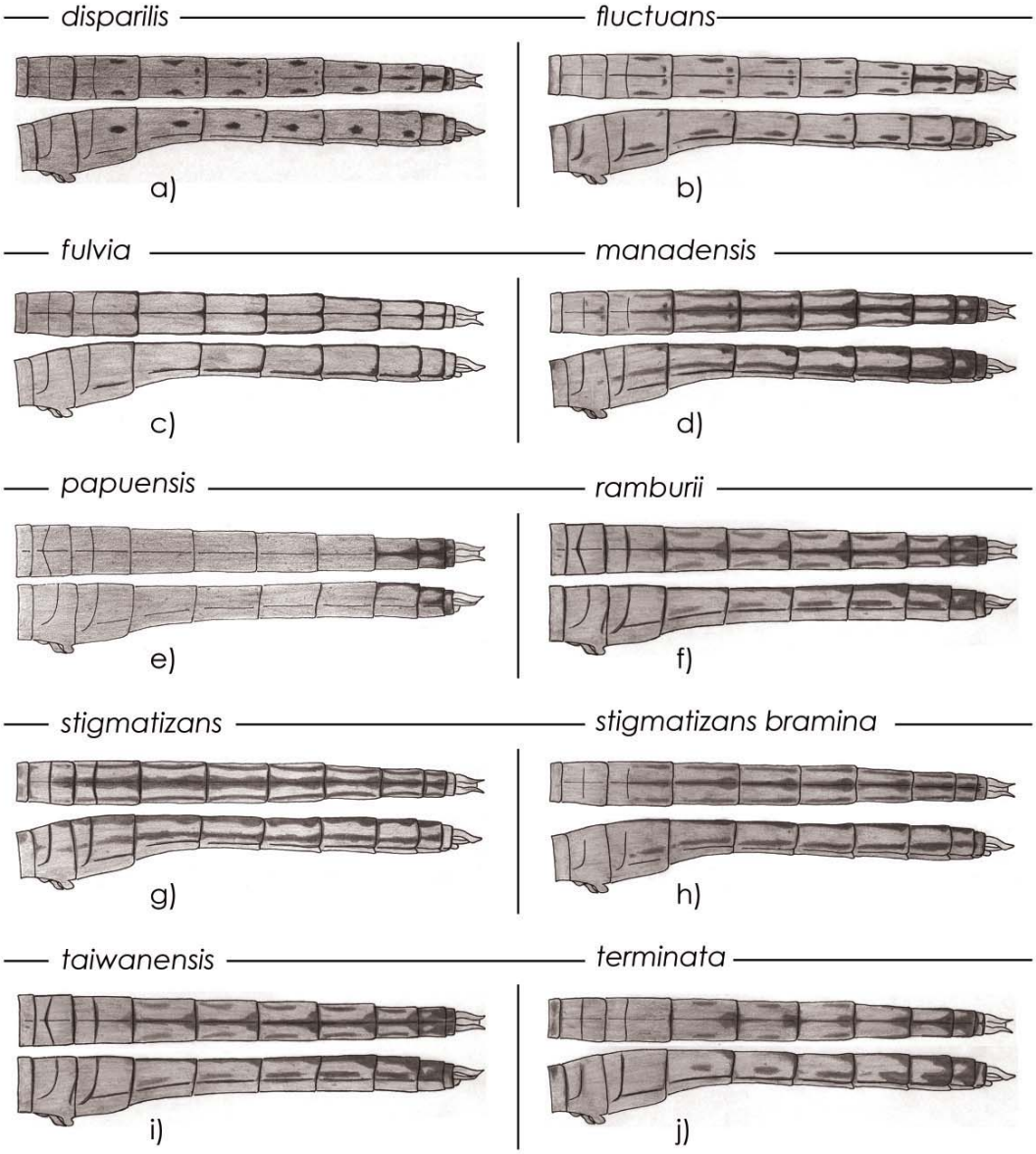

Fig. 13: *Neurothemis* male abdomen, dorsal and lateral: a) *disparilis*; b) *fluctuans*; c) *fulvia*; d) *manadensis*; e) *papuensis*; f) *ramburii*; g) *stigmatizans*; h) *stigmatizans bramina*; i) *taiwanensis*; j) *terminata*.

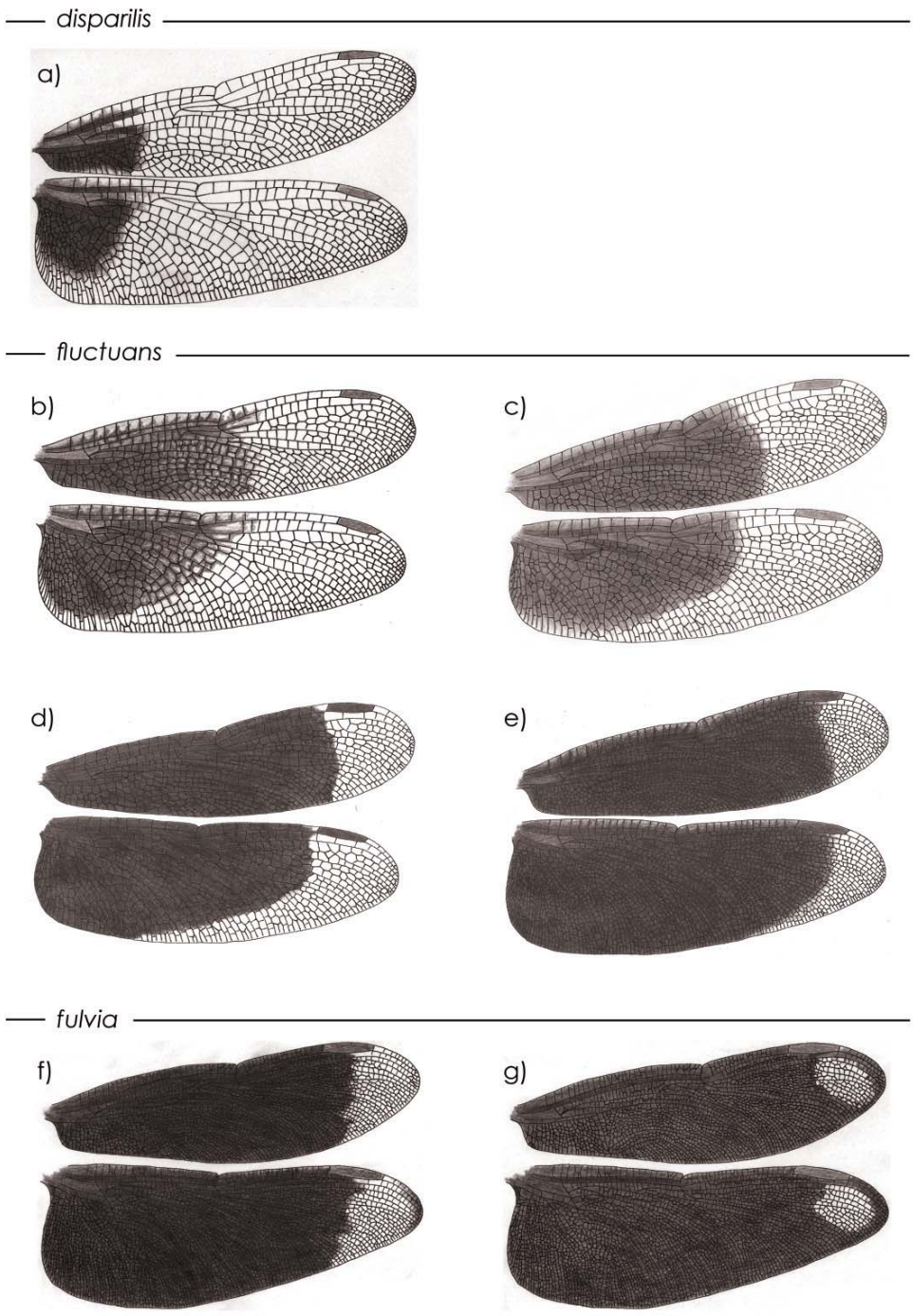

Fig 14: *Neurothemis* male wings: a) *disparilis*; b) *fluctuans* (rare variation from Borneo, intermediate appearance between *N. fluctuans* and *N. disparilis*); c) *fluctuans* from Palawan Province/Philippines; d) *fluctuans*, typical for the northern part of the range (e.g. Thailand); e) *fluctuans*, with denser venation and maculation extending further distal (e.g. Sumatra); f) *fulvia*, with hyaline apices; g) *fulvia*, with dark apices.

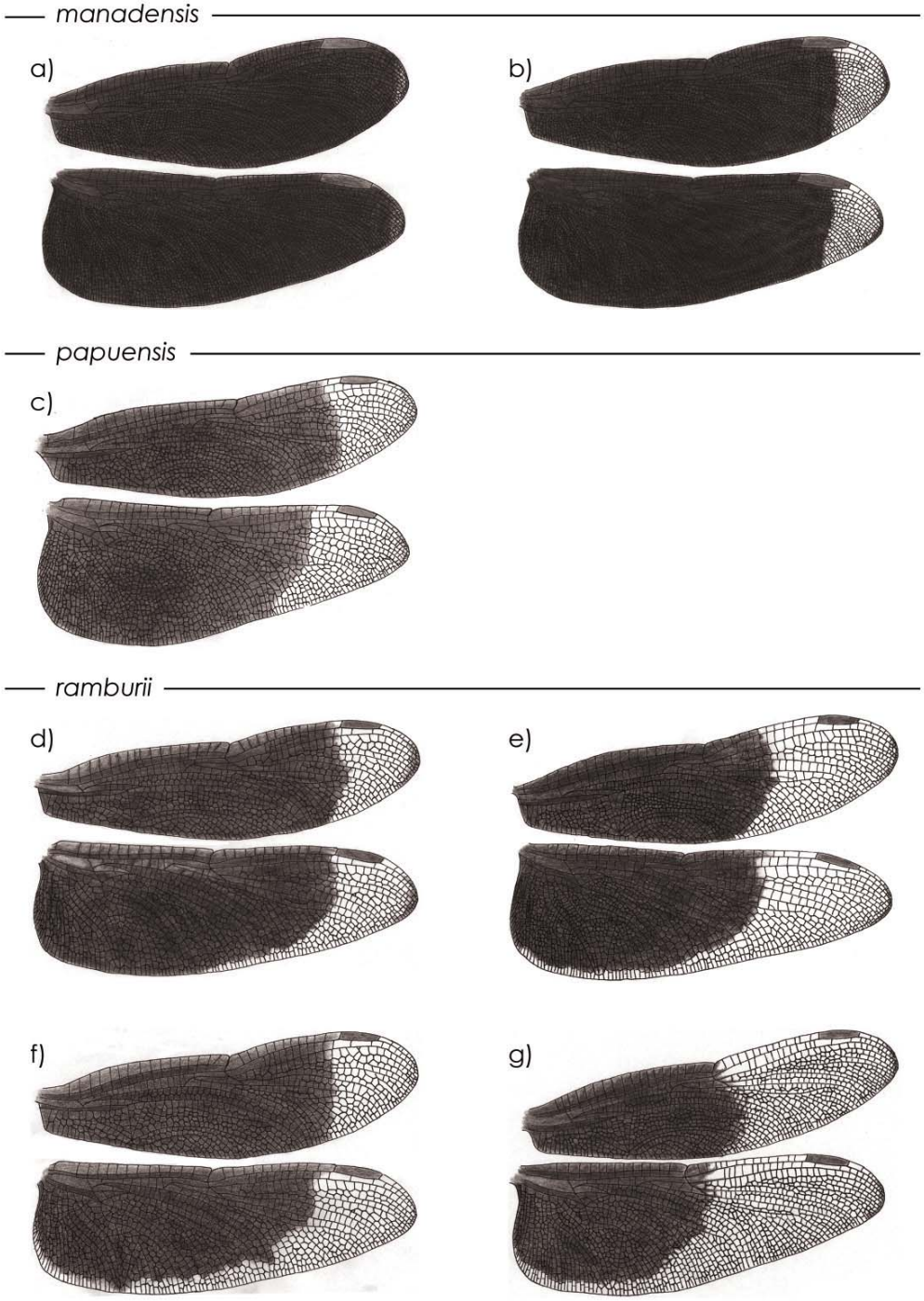

Fig. 15: *Neurothemis* male wings: a) *manadensis*, with dark apices; b) *manadensis*, typical with hyaline apices; c) *papuensis*; d) *ramburii*, with a small hyaline caudal border (e.g. Sumatra and Sanana Island; resembling the maculation of *N. ramburii oceanis*, fig. 16c); e) *ramburii* (e.g. Sanana Island), intermediate between fig. 15d and *N. ramburii martini* (Figs. 16a-b); f) *ramburii*, with fringed maculation (e.g. Marinduque and Luzon in the Philippines and Bali); g) *ramburii*, with maculation to nodus (Sulawesi and Seram Island; resembling the maculation of *N. ramburii martini*, figs. 16a-b).

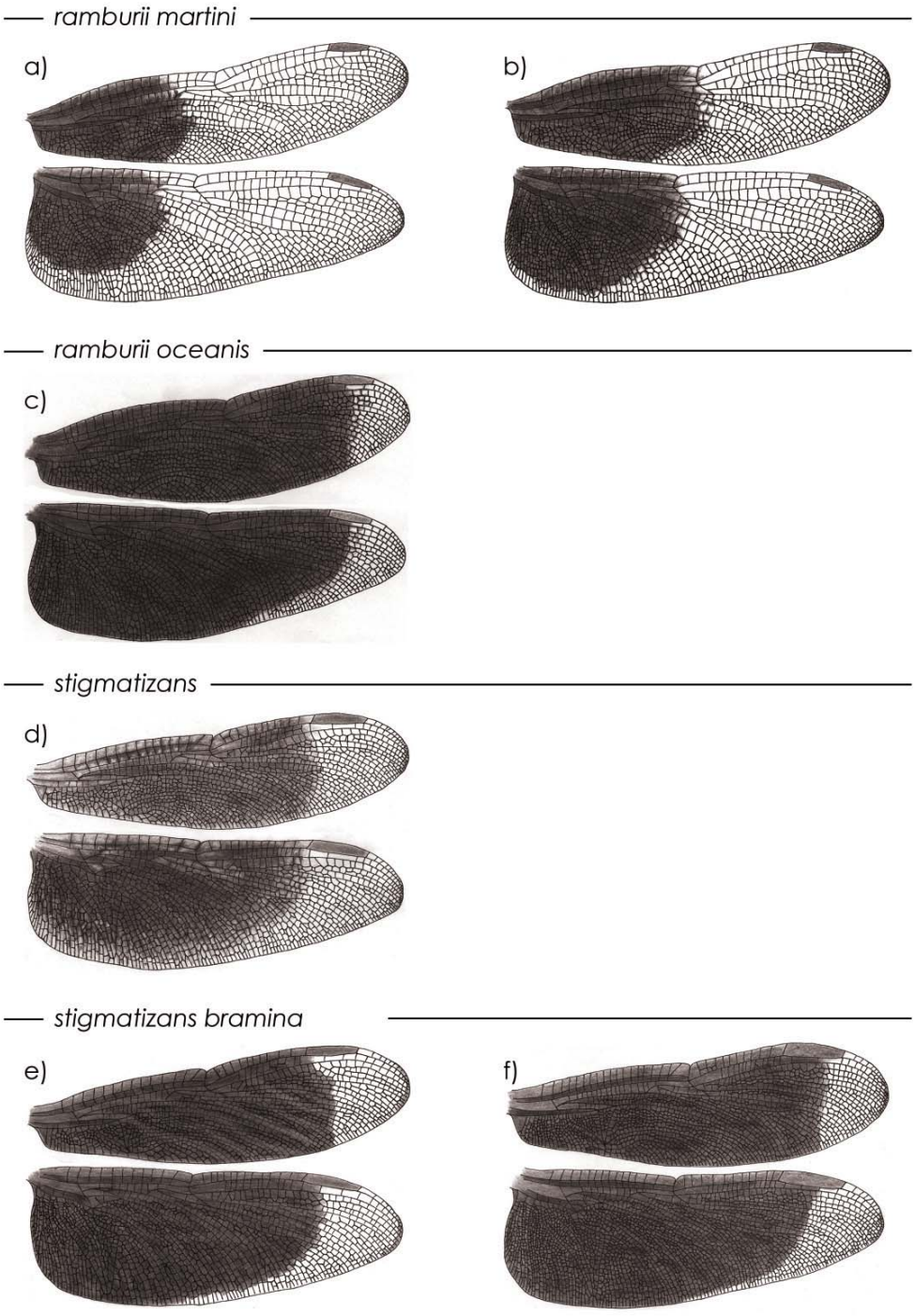

Fig. 16: *Neurothemis* male wings: a) *ramburii martini*, from the Kai Islands; b) *ramburii martini*, from Sanana and Sumba Island; c) *ramburii oceanis*; d) *stigmatizans*; e) *stigmatizans bramina*, with less dense venation; f) *stigmatizans bramina*, with denser venation (approaching *N. manadensis*, but the maculation in hindwing still curved towards base).

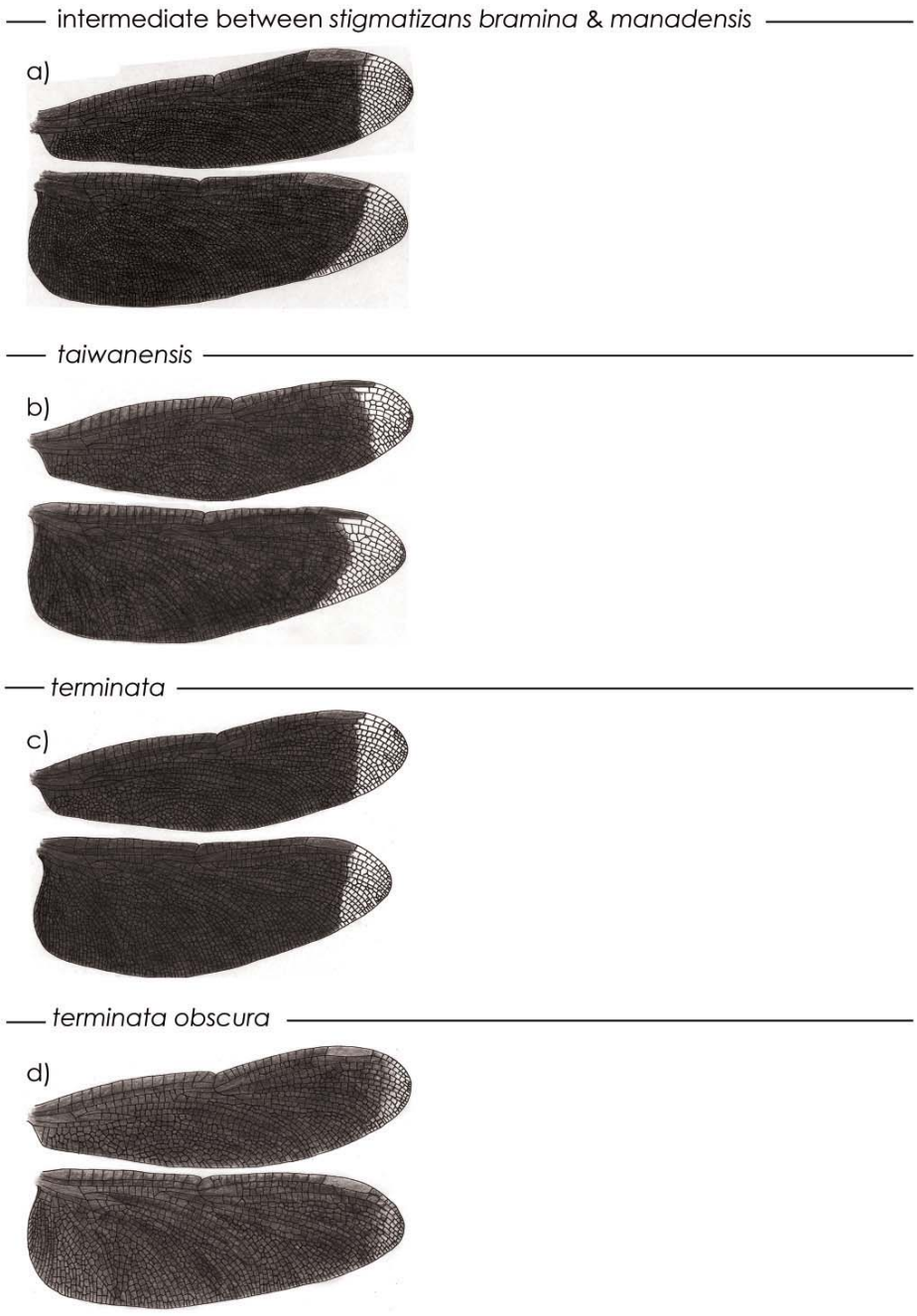

Fig. 17: *Neurothemis* male wings: a) intermediate between *manadensis* and *stigmatizans bramina* (eastern Maluku Islands and western New Guinea); b) *taiwanensis*; c) *terminata*; d) *terminata obscura*.

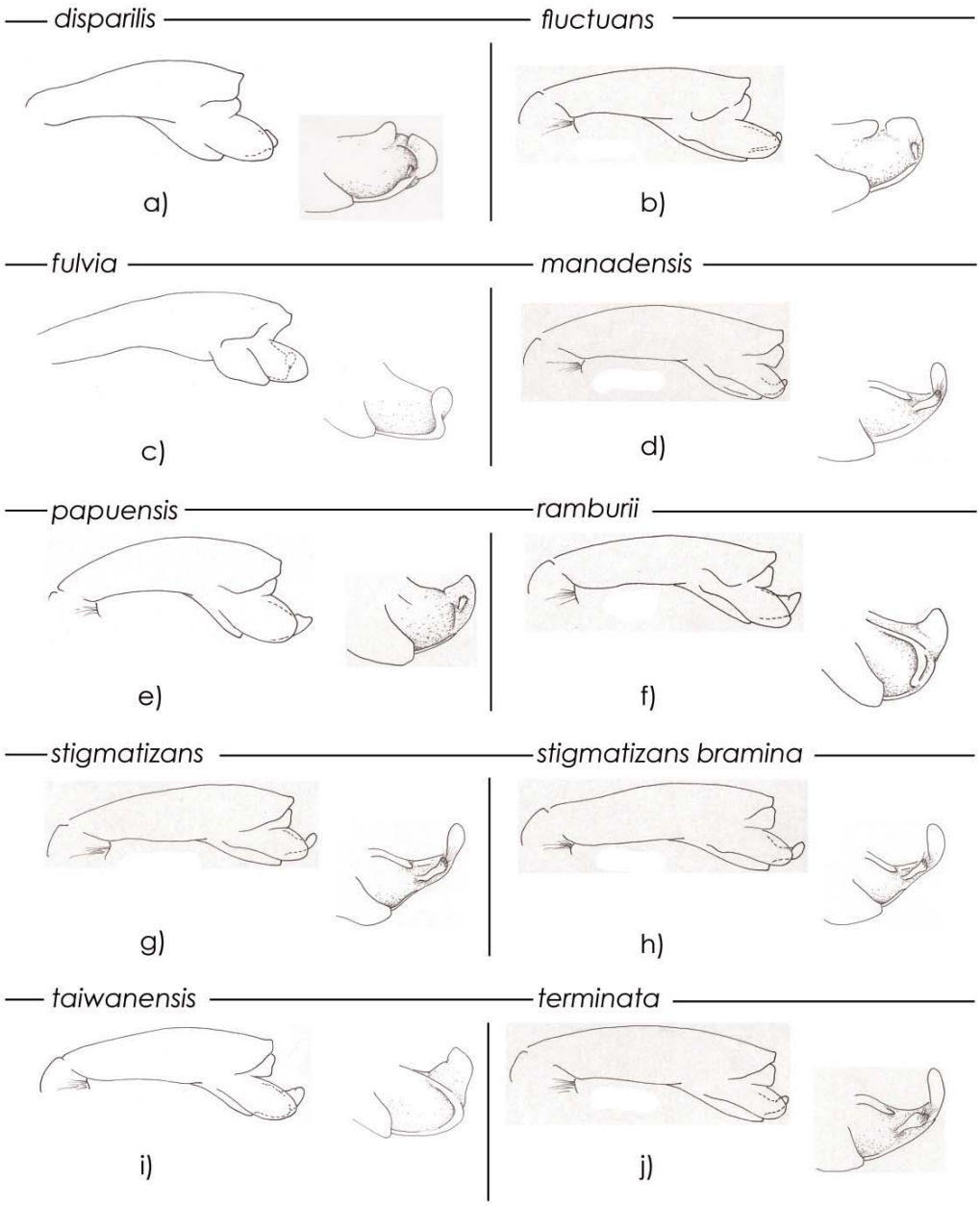

Fig. 18: *Neurothemis* vesica spermalis lateral and median process lateral: a) *disparilis*; b) *fluctuans*; c) *fulvia*; d) *manadensis*; e) *papuensis*; f) *ramburii*; g) *stigmatizans*; h) *stigmatizans bramina*; i) *taiwanensis*; j) *terminata*.

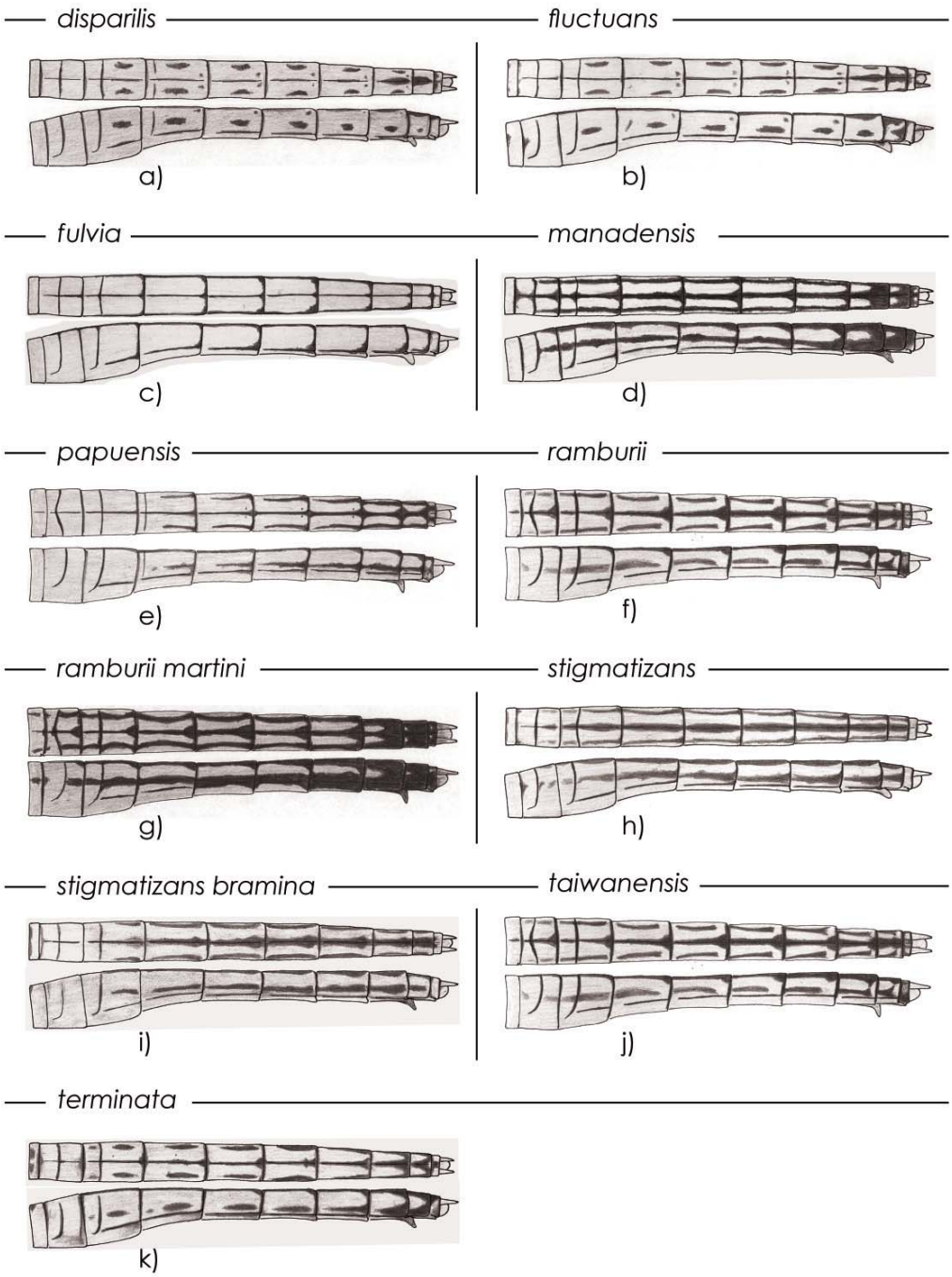

Fig. 19: *Neurothemis* female abdomen dorsal and lateral: a) *disparilis*; b) *fluctuans*; c) *fulvia*; d) *manadensis*; e) *papuensis*; f) *ramburii*; g) *ramburii martini*; h) *stigmatizans*; i) *stigmatizans bramina*; j) *taiwanensis*; k) *terminata*.

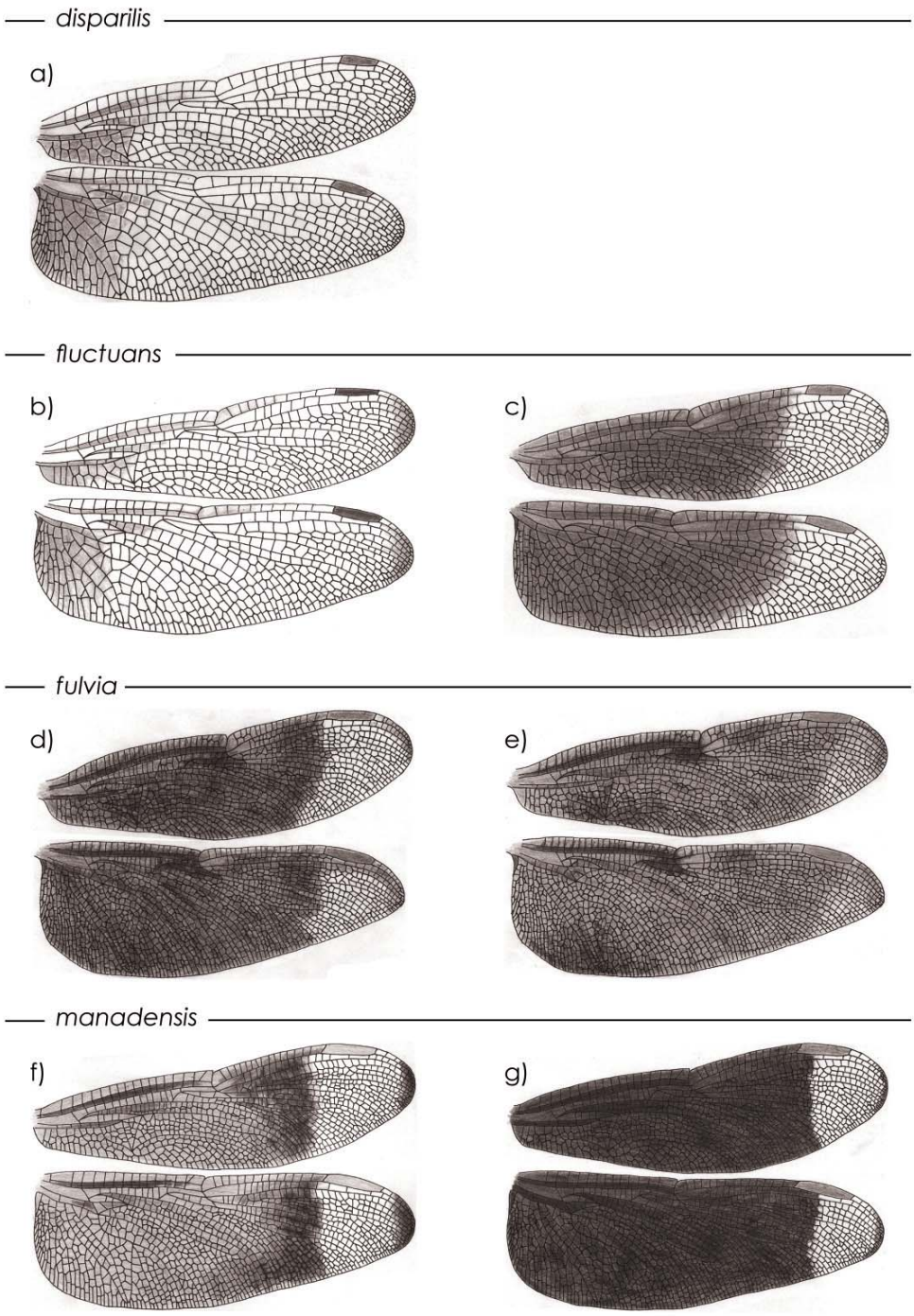

Fig 20: *Neurothemis* female wings: a) *disparilis*; b) *fluctuans*, heterochrome (hyaline); c) *fluctuans*, isochrome; d) *fulvia*, isochrome (approaching the males); e) *fulvia*, yellowish-amber isochrome; f) *manadensis*, typical belted isochrome (resembling variations of *N. ramburii*, *N. taiwanensis* and *N. terminata*; compare with figs. 21e, 22f & 23b); g) *manadensis*, isochrome.

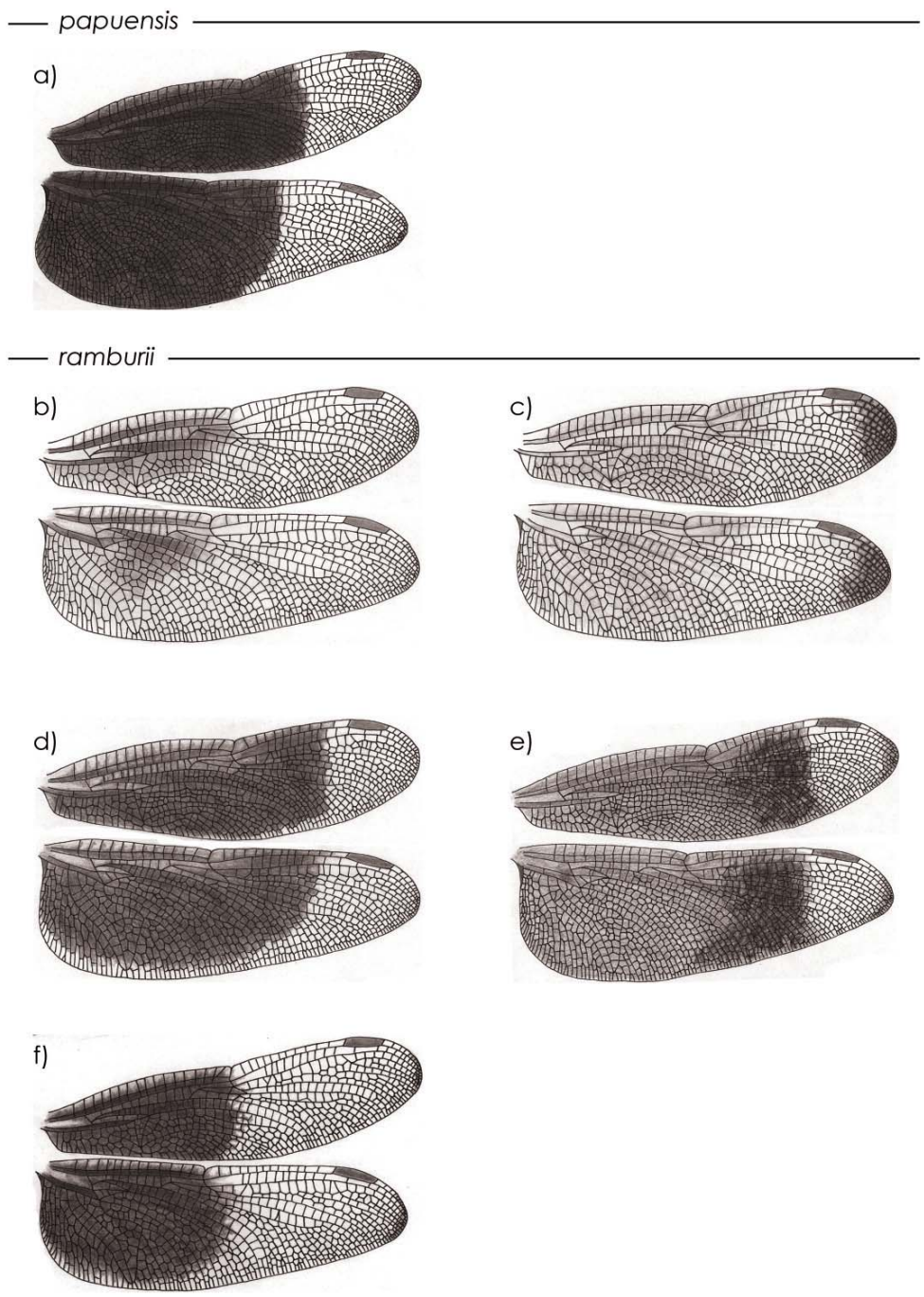

Fig 21: *Neurothemis* female wings: a) *papuensis*, isochrome wings; b) *ramburii*, heterochrome (e.g. the Philippines); c) *ramburii*, heterochrome ('*Untamo apicalis*'-variation); d) *ramburii*, main isochrome; e) *ramburii*, belted isochrome (e.g. Sulawesi and the Philippines; resembling variations of *N. manadensis*, *N. taiwanensis* and *N. terminata*; compare with figs. 20f, 22f & 23b); f) *ramburii*, isochrome with maculation to nodus.

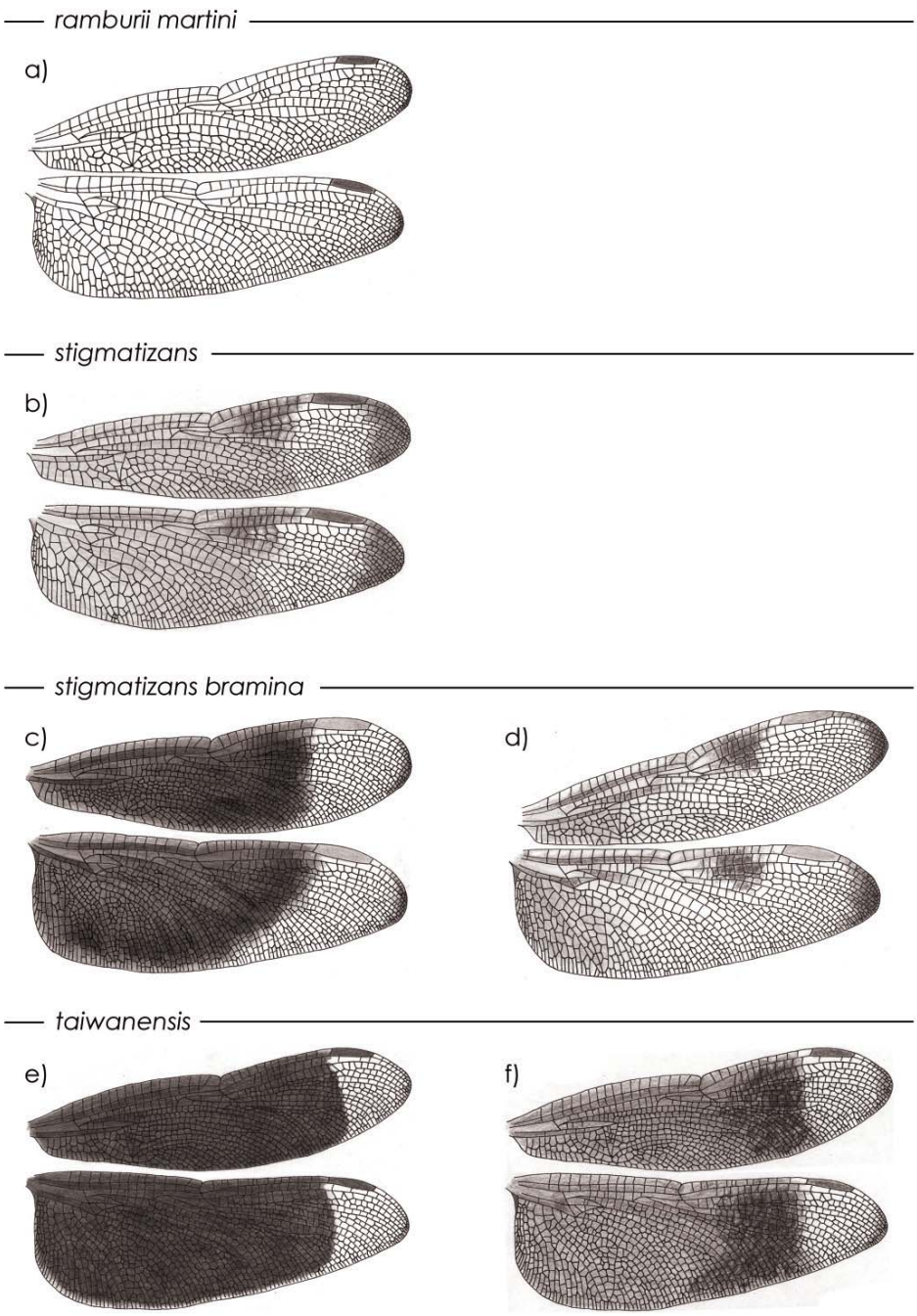

Fig 22: *Neurothemis* female wings: a) *ramburii martini*; b) *stigmatizans*; c) *stigmatizans bramina*, isochrome (e.g. Bismarck Archipelago); d) *stigmatizans bramina*, heterochrome (hyaline) (e.g. Manus Island); e) *taiwanensis*, isochrome; f) *taiwanensis*, belted isochrome (resembling variations of *N. manadensis*, *N. ramburii* and *N. terminata*; compare with figs. 20f, 21e & 23b).

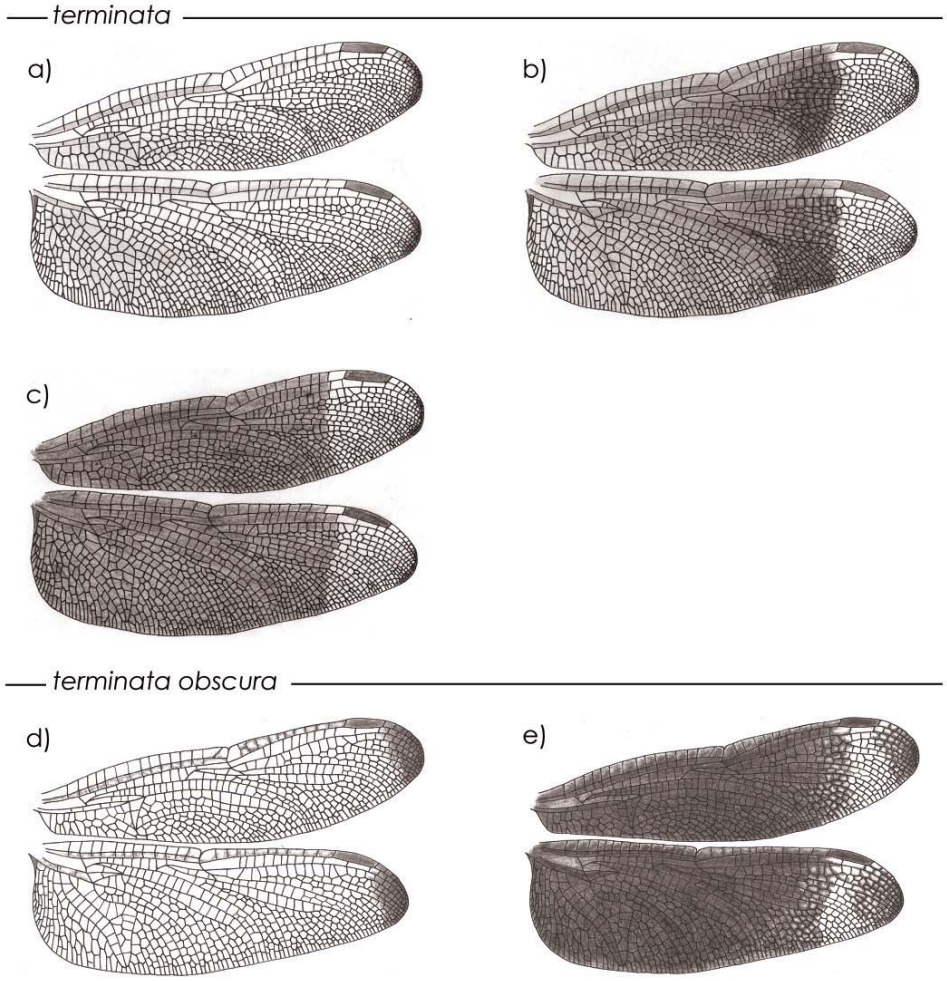

Fig. 23: N*eurothemis* female wings: a) *terminata*, heterochrome (approaching the '*Untamo apicalis*'-variation of *N. ramburii*, fig. 21c); b) *terminata*, belted isochrome (resembling variations of *N. manadensis*, *N. ramburii* and *N. taiwanensis*; compare with figs. 20f, 21e & 22f); c) *terminata*, isochrome; d) *terminata obscura*, heterochrome (approaching the '*Untamo apicalis*'-variation of *N. ramburii*, fig. 21c); e) *terminata obscura*, isochrome.

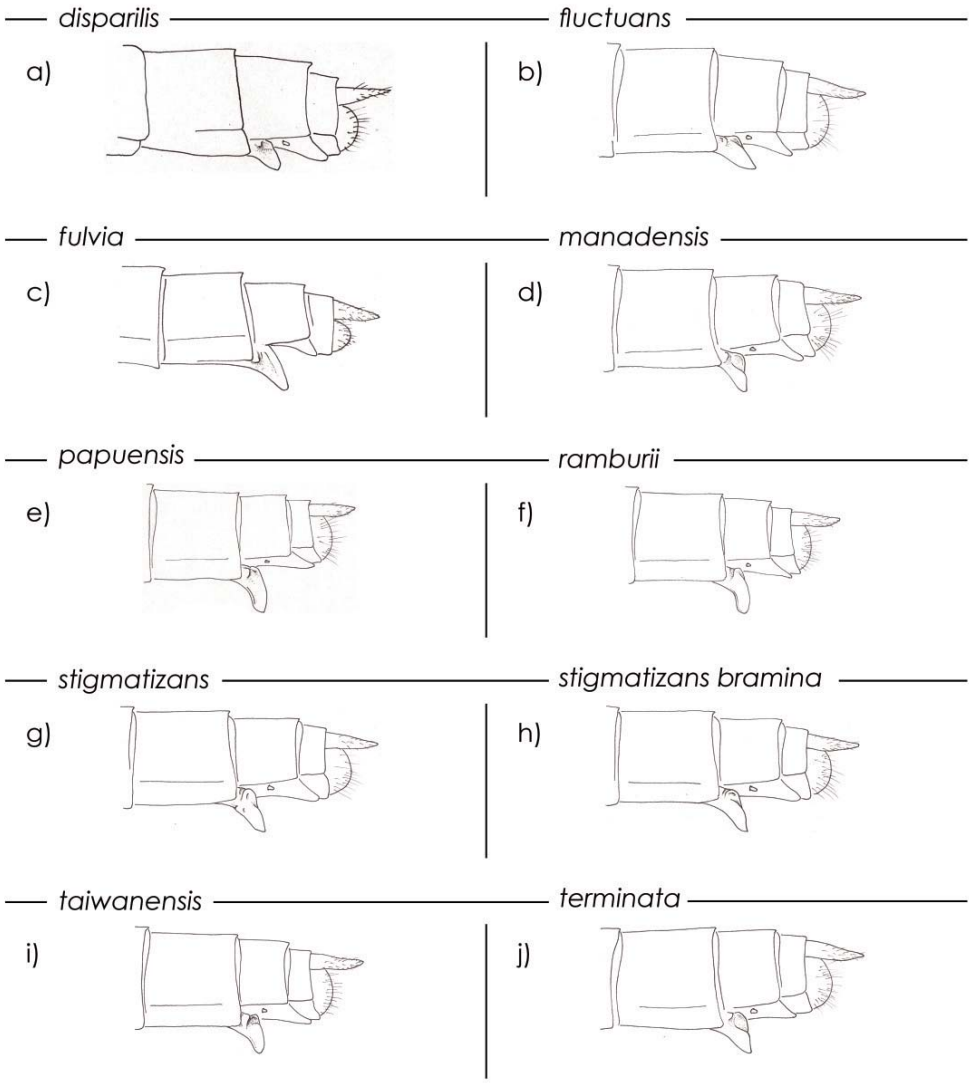

Fig. 24: *Neurothemis* vulvar scale lateral: a) *disparilis*; b) *fluctuans*; c) *fulvia*; d) *manadensis*; e) *papuensis*; f) *ramburii*; g) *stigmatizans*; h) *stigmatizans bramina*; i) *taiwanensis*; j) *terminata*.

Simplified key to the 'reddish-brown-winged' species

NOTE: Most of the 'reddish-brown-winged' species are unlikely to be mistaken with the other congeneric taxa, but within the northern range of *N. fluctuans* the poorly known *N. intermedia degener* (Selys, 1879), usually with yellow wing maculation almost reaching the Pt, and *N. intermedia atalanta* Ris, 1916, with an orange-brown wing maculation extending to around the triangles or slightly beyond, should be kept in mind when keying material. In case of doubt compare specimens with keys and description of Ris (1911, 1913) and Selys (1879). Species of the *N. intermedia*-group will be dealt with elsewhere.

Key 1: Males

1 — Wing maculation extending to middle of Pt with an irregular serrated terminus, or reaching apices and leaving just a small hyaline window; venation very dense with up to 23.5-39.5 antenodals in Fw and 21-31 in Hw (Figs. 14f-g); abdominal markings narrow, slightly broader apically on S4-9 (Fig. 13c). India across Nepal and Myanmar to China and southward across Thailand and Peninsular Malaysia to southern Sumatra (Fig. 5)..... ***fulvia***

Wing maculation different; if wing maculation extending to middle of Pt, then its terminus not irregularly serrated; venation less dense with antenodals usually less than 23.5 in Fw and 16 in Hw (Figs. 14a-e, 15a-g, 16a-f, 17a-d) ..... → **2**

2 — Only one crossvein within cubito-anal space of Hw (rarely two or three crossveins, especially in specimens from Sumatra, Java and Borneo; always check both wings for agreement and other attributes); wing maculation highly variable but always curved towards base in Hw (Figs. 15d-g, 16a-c, 17b); abdomen relatively stout (Figs. 13f & i). Sumatra across Java, Borneo, Sulawesi plus Maluku Islands to the Philippines, Taiwan and the Ryu-Kyu-Islands/Japan ..... → **3**

Two or more crossveins within cubito-anal space of Hw, wing maculation variable (Figs. 14a-e; 15a-c; 16d-f; 17c-d); abdomen relatively slender ..... → **4**

3 — Wing maculation highly variable, extending at least to nodus but mostly to midway between nodus and Pt; its terminus convex to straight in Fw and curved towards base in Hw; posterior border of Hw hyaline or colored (Figs. 15d-g, 16a-c). Sumatra across Java, Borneo, Sulawesi plus Maluku and the Kai Islands to the Philippines (Fig. 8) ..... ***ramburii* ssp.→ Key 3**

Wing maculation extending as far as middle of Pt; terminating in a convex to straight margin in Fw, only slightly curved towards base in Hw and reaching posterior wing margin around midway between vein IR2 and RP3-4 (Fig. 17b). Taiwan and the Ryu-Kyu Islands/Japan (Fig. 11) ..... ***taiwanensis***

4 — Wing maculation terminating before the nodus; abdomen with short lateral streaks on each segment; radial planate and medial planate of one cell row; predomin-

antly one cell row between veins MA plus RP3-4 and IR2 plus RP2 (Fig. 14a). Borneo, possibly Peninsular Malaysia and Singapore (Fig. 3) … ..... ***disparilis***

Wing maculation extending to or beyond nodus (Figs. 14b-e; 15a-c; 16d-f; 17c-d) ..... → **5**

5 — Wing maculation of Hw with terminus curved towards base (Figs. 14b-e; 15c; 16d-f) ..... → **6**

Wing maculation of Hw with terminus straight; apices often darkened (Figs. 15a-b; 17c-d) ..... → **8**

6 — Wing maculation extending at least as far as midway between nodus and Pt to almost reaching Pt; its terminus straight or convex in Fw, slightly curved towards base in Hw; base of Hw broad and apices slender (giving the wing a slightly triangular impression; fig. 15c); Hw approximately 2.5-2.7x as long as broad; abdomen relatively stout, lateral markings not continuous (Fig. 13e). New Guinea and surrounding Islands (Fig. 7) ..... ***papuensis***

Wing shape different (Figs. 14b-e; 16d-f); abdomen relatively slender, lateral markings continuous or short streaks on each segment ..... → **7**

7 — Wing maculation extending from about three cells distal of nodus to one cell distal of Pt; its terminus curved smoothly towards base in Hw, usually reaching the posterior margin between veins RP3-4 (sometimes slightly distal to them) and the anal loop in Hw, Fw triangle consisting of 3-11 cells and subtriangle of 4-20 cells (Figs. 14b-e); abdomen with short lateral streaks on each segment (Fig. 13b). Andaman Islands/India eastward across Myanmar to Vietnam and the Palawan Province/Philippines, southward across Malaysia, Sumatra, Borneo to Java (Fig. 4) ..... ***fluctuans***

Wing maculation extending to Pt or as far as its distal end; its terminus curved towards base in Hw, reaching the posterior margin around vein MP (Figs. 16d-f); venation variable but sometimes dense with Fw triangle consisting of up to 36 cells and subtriangle up to 69 cells; lateral markings on abdomen continuous (Figs. 13g-h). Australia and New Guinea including the Kai Islands, Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Figs. 9 & 10) … ***stigmatizans* ssp.→ Key 4**

8 — Wing maculation extending at least to middle of Pt, some specimens with wings almost entirely colored (Figs. 15a-b); venation very dense with triangle in Fw consisting of 21-47 cells and subtriangle of 37-95 cells; lateral markings on abdomen continuous, S9-10 more extensively dark (Fig. 13d). Sulawesi to Halmahera and Seram Island (Fig. 6). [NOTE: specimens of intermediate appearance between *manadensis* and *stigmatizans bramina* with a wing maculation terminating slightly curved towards base in Hw (Fig. 17a) are known from the eastern Maluku Islands and westernmost Papua Province] ..... ***manadensis***

Wing maculation extending at least to middle of Pt, some specimens with wings almost entirely colored (Figs. 17c-d); venation less dense with triangle in Fw consisting of 6-16 cells and subtriangle of 8-35 cells; lateral markings on abdomen interrupted (Fig. 13j). Philippines, Borneo, Sumatra and Java and eastwards to Timor (Fig. 12) ..... ***terminata* ssp.→ Key 5**

Key 2: Females

1 — Wing maculation extending to Pt with an irregularly serrated terminus or the wings completely amber-colored as far as apices; venation very dense with antenodals 23.5-34.5 in Fw and 19-28 in Hw; radial and medial planate consisting of 3-6 cell rows (Figs. 20d-e); abdomen markings narrow, slightly broader only on posterior end of segment (Fig. 19c). India across Nepal and Myanmar to China and southward across Thailand and Peninsular Malaysia to southern Sumatra (Fig. 5) ..... ***fulvia***

Wings almost hyaline or with different maculation; if wing maculation extending to around Pt, then its terminus not irregularly serrated; venation less dense with antenodals usually less than 20.5 in Fw and 16 in Hw; radial and medial planate consisting of 1-4 cell rows (Figs. 20a-c & f-g; 21a-f, 22a-f, 23a-e) ..... **→ 2**

2 — Only one crossvein in cubito-anal space of Hw (rarely two or three crossveins, especially in specimens from Sumatra, Java and Borneo; always check both wings for agreement and other attributes); wing maculation variable from hyaline with darkened apices to isochromatic with its terminus curved towards base in Hw and leaving the posterior wing margin hyaline (Figs. 21b-f, 22a & e-f); abdomen always relatively stout (Figs. 19f & j); vulvar scale always extending at an angle of about 90° to the abdomen (Figs. 24f & i). Sumatra across Java, Borneo, Sulawesi and the Maluku Islands to the Philippines, Taiwan and the Ryu-Kyu-Islands/Japan ..... **→ 3**

Two or more crossveins in cubito-anal space of Hw; wing maculation variable from hyaline to isochromatic (Figs. 20a-c & f-g; 21a; 22b-d; 23a-e); abdomen of almost all species relatively slender (Figs. 19a-e, h-i & k); vulvar scale usually extending in an angle less than 90° (Figs. 24a-b, d-e, g-h & j) ..... **→ 4**

3 — Wing maculation variable from almost hyaline with darkened apices to isochromatic; isochrome maculation extending as far as nodus or nearly up to Pt; its terminus curved towards base in Hw and almost leaving the posterior wing margin hyaline; also includes belted isochrome females (Figs. 21b-f, 22a). Sumatra across Java, Borneo, Sulawesi plus Maluku and the Kai Islands to the Philippines (Fig. 8) ..... ***ramburii* ssp.→ Key 3**

Wing maculation extending as far as Pt, its terminus almost straight to slightly convex in both wings; the Hw of isochrome females with wing maculation extending almost to posterior margin, then abruptly curved towards base and leaving a small edge of wing margin hyaline (Fig. 22e); belted isochrome

female similar but with a dark band-like area at terminus and without a hyaline posterior wing margin (Fig. 22f). Taiwan and the Ryu-Kyu-Islands/Japan (Fig. 11) ..... ***taiwanensis***

4 — Wings with maculation (Figs. 20c & f-g; 21a; 22c; 23b-c & e) ..... → ***5***

Wings hyaline (heterochrome), at most smoothly tinted yellow with darkened patch on midway between nodus and Pt (Figs. 20a-b; 23a & d) ..... → **10**

5 — Terminus of wing maculation straight in Hw; extending as far as Pt; often with darker band-like area around its terminus (Figs. 20f-g; 23b-c & e) ..... → ***6***

Terminus of wing maculation at least slightly curved towards base in Hw; sometimes with darker band-like area around its terminus (Figs. 20c; 21a; 22c) ... → ***7***

6 — Abdomen with lateral markings continuous (Fig. 19d); wing venation dense with triangle in Fw consisting of 6-27 cells and subtriangle of 9-43 cells, radial planate and medial planate consisting of 2-4 cell rows (Figs. 20f-g). Sulawesi to Halmahera and Seram Island (Fig. 6) ..... ***manadensis***

Abdomen with lateral markings interrupted (Fig. 19k); wing venation less dense with triangle in Fw consisting of 2-7 cells and subtriangle of 4-12 cells, radial planate and medial planate consisting of 1-2 cell rows (Figs. 23b-c & e). Philippines, Borneo across Timor to Java and middle of Sumatra (Fig. 12) ..... ***terminata* ssp. → Key *5***

7 — Abdomen with lateral markings continuous (Figs. 19h-i); wing maculation extending as far as Pt; its terminus smoothly curved towards base in Hw; triangle in Fw consisting of 6-18 cells and subtriangle of 9-37 cells (Fig. 22c). New Guinea including the Kai Islands, the Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Fig. 10) ..... ***stigmatizans*** in part→ **Key 4**

Abdomen with lateral markings usually interrupted, at least on first segments (Figs. 19b & e); wing maculation different (Fig. 21a) or wing venation less dense (Fig. 20c) ..... → ***8***

8 — Wing maculation extending as far as the midway between nodus and Pt to almost proximal end of it; its terminus straight or convex in Fw and slightly curved towards base in Hw; base of Hw broad and apices slender (giving a slightly triangular impression; fig. 21a); Hw approximately 2.5-2.7x as long as broad; abdomen relatively stout with lateral markings almost continuous on last segments but shorter and interrupted on first segments (Fig. 19e); vulvar scale extending at an angle of about 90° to the abdomen (Fig. 24e). New Guinea and surrounding Islands (Fig. 7) ..... ***papuensis***

Wing maculation extending to 1-3 cells proximal of Pt; its terminus smoothly curved towards base in Hw; triangle in Fw consisting of 2-5 cells and subtriangle

of 3-7 cells (Fig. 20c); abdomen relatively slender with short lateral streaks on each segment (Fig. 19b); vulvar scale extending at an angle of about 45° to the abdomen (Fig. 24b). Andaman Islands/India eastward across Myanmar to Vietnam and the Palawan Province/Philippines, southward across Malaysia, Sumatra, Borneo to Java (Fig. 4) ..... ***fluctuans***

10 — Abdomen with lateral markings continuous (Figs. 19h-i); wings almost hyaline but some smoothly tinted yellow; darkened patch on midway between nodus and Pt; apices often darkened (Figs. 22b & d). Northern Australia, New Guinea including the Kai Islands, the Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Figs. 9 & 10) ..... ***stigmatizans*** in part → **Key 4**

Abdomen with lateral markings interrupted (Figs. 19a-b & k); wings lacking darkened patch but some specimens may have darkened apices (Figs. 20a-b; 23a & d) ..... → **11**

11 — Wings hyaline, often with dark apices; triangle in Fw consisting of 2-7 cells and subtriangle of 4-12 cells (Figs. 23a & d); abdomen with lateral stripe interrupted (Fig. 19k). Philippines, Borneo across Timor to Java and middle of Sumatra (Fig. 12) ..... ***terminata* ssp.** → **Key 5**

Wing base usually smoothly tinted yellow; area along the costa as far as the nodus may be tinted yellow; wing venation less dense, triangle in Fw consisting of 2-5 cells and subtriangle of 3-7 cells (Figs. 20a-b); abdomen with short lateral streaks on each segment (Figs. 19a-b) ..... → **12**

12 — Venation with radial planate and medial planate consisting of 1-2 cell rows; usually a couple of doubled cells between veins MA plus RP3-4 and IR2 plus RP2 (Fig. 20b). Andaman Islands/India eastward across Myanmar to Vietnam and the Palawan Province/Philippines, southward across Malaysia, Sumatra, Borneo to Java (Fig. 4) ..... ***fluctuans***

Venation with radial planate and medial planate usually consisting of one cell row; predominantly one cell row between veins MA plus RP3-4 and IR2 plus RP2 (Fig. 20a). Borneo, possibly Peninsular Malaysia and Singapore (Fig. 3). [NOTE: Separation from *N. fluctuans* very difficult due to an interval of overlapping; if specimen is not from Borneo also considering the *N. intermedia* ssp.-group.] ..... ***disparilis***

Key 3: Subspecies of *N. ramburii*

1 — Males ..... → **2**

Females ..... → **4**

2 — Wing maculation variable, usually extending at least to midway between nodus and Pt; its terminus convex to straight in Fw and curved towards base in Hw; posterior border hyaline or colored (Figs. 15d-g, 16c) [NOTE: if maculation only reaching to nodus, than check if radial planate and medial planate consisting of at least two cell rows and if there are predominantly two and up to three cell rows between veins MA and RP3-4 plus IR2 and RP2; if there are less: check *ramburii martini*]. Sumatra across Java, Borneo, Sulawesi and the Maluku Islands to the Philippines ..... → **3**

Wing maculation usually extending to 4-5 cells proximal of the nodus but at most reaching the nodus; its terminus curved towards base in Hw and leaving the posterior wing margin hyaline; venation less dense with radial planate of one cell row and medial planate consisting of two cell rows; predominantly one cell row between veins MA and RP3-4 plus IR2 and RP2 (Figs. 16a-b). The Kai Islands, Sanana and Sumba Island (Fig. 8, green dots)
..... ***ramburii martini***

3 — Occurring from Sumatra across Java, Borneo, Sulawesi and the Maluku Islands to the Philippines (Fig. 8) ..... ***ramburii ramburii***

Occurring on Enggano Island, west of Sumatra (Fig. 8, blue dot).
..... ***ramburii oceanis***

4 — Heterochrome females (Figs. 21b-c, 22a) ..... → **5**

Isochrome females (Figs. 21d-f) ..... → **6**

5 — Wings with radial planate and medial planate consisting of 1-3 cell rows (Figs. 21b-c). Sumatra across Java, Borneo, Sulawesi and the Maluku Islands to the Philippines (Fig. 8) ..... ***ramburii ramburii***

Wings with radial planate and medial planate consisting of one cell row (Fig. 22a). The Kai Islands, Sanana and Sumba Island (Fig. 8, green dots). [NOTE: only one female examined] ..... ***ramburii martini***

6 — Occurring from Sumatra across Java, Borneo, Sulawesi and the Maluku Islands to the Philippines (Fig. 8) ..... ***ramburii ramburii***

Occurring on Enggano Island, west of Sumatra (Fig. 8, blue dot).
..... ***ramburii oceanis***

Key 4: Subspecies of *N. stigmatizans*

1 — Males ..... → **2**

Females ..... → **3**

2 — Wing maculation extending as far as Pt; its terminus curving towards base in Hw and leaving a broad posterior area hyaline; venation less dense, triangle in Fw consisting of 6-11 cells and subtriangle of 8-20 cells (Fig. 16d). Northern Australia (Fig. 9) ..... ***stigmatizans stigmatizans***

Wing maculation extending to Pt or as far as its distal end; its terminus curving towards base in Hw and reaching posterior margin around vein MP; venation more dense but very variable, triangle in Fw consisting of 10-36 cells and subtriangle of 24-69 cells (Figs. 16e-f). New Guinea including the Kai Islands, the Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Fig. 10). ..... ***stigmatizans bramina***

3 — Wings almost hyaline (heterochrome) ..... **→ 4**

Isochrome and belted isochrome females with wing maculation extending as far as Pt; its terminus smoothly curved towards base in Hw; venation dense, triangle in Fw consisting of 6-18 cells and subtriangle of 9-37 cells (Fig. 22c). New Guinea including the Kai Islands, the Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Fig. 10). [NOTE: No isochrome females of the Australian nominate subspecies are known] ..... ***stigmatizans bramina***

4 — Wings often smoothly tinted with yellow with a darkened patch on midway between nodus and Pt; apices often darkened; venation with triangle in Fw consisting of 2-4 cells and subtriangle of 4-8 cells (Fig. 22b). Northern Australia (Fig. 9) ..... ***stigmatizans stigmatizans***

Wings almost similar to *stigmatizans stigmatizans*; venation may be slightly denser with triangle in Fw consisting of 2-7 cells and subtriangle of 5-10 cells (Fig. 22d). New Guinea including the Kai Islands, the Bismarck Archipelago, the Solomon Islands to the Vanuatu Islands (Fig. 10) ..... ***stigmatizans bramina***

Key 5: Subspecies of *N. terminata*

NOTE: Heterochrome, isochrome and belted isochrome females occur (Figs. 23a-e) but no diagnostic characters to separate females of both subspecies are known; subspecies *terminata obscura* occurs only on Karimunjawa Islands north of Java and possibly at Sebesi Island south of Sumatra.

1 — Wing maculation extending to middle of Pt or as far as two cells distal of it (Fig. 17c). Philippines, Borneo across Timor to Java and around central Sumatra (Fig. 12). ..... ***terminata terminata***

Wing maculation covering almost the entire wing (Fig. 17d). Karimunjawa Islands north of Java, possibly Sebesi Island south of Sumatra (Fig. 12, green dot). ..... ***terminata obscura***

Annotated species accounts (alphabetical order)

Neurothemis disparilis Kirby, 1889

Neurothemis disparilis Kirby, 1889. Kirby (1889): 322-323 & plate LIV, fig. 8.

Figures:

3 (map); 13a (♂ abdomen); 14a (♂ wings); 18a (♂ vesica spermalis); 19a (♀ abdomen), 20a (♀ wings); 24a (♀ vulvar scale); 25 (♂ lectotype of *Neurothemis disparilis* Kirby, 1889).

Type material examined (5 ♂♂, 2 ♀♀):

3 ♂♂, 2 ♀♀ (via photograph only): West Borneo; lectotype male (Fig. 25) designated by Kimmins (1968) and paralectotypes of *Neurothemis disparilis* Kirby, 1889; deposited at BMNH.

2 ♂♂ (via photograph only): Borneo; paralectotypes of *Neurothemis disparilis* Kirby, 1889; deposited at BMNH.

Further material examined (25 ♂♂, 19 ♀♀):

BORNEO – 1 ♂: Borneo, Coll. McLachlan (BMNH); 2 ♂♂: Borneo, Coll. Selys (RBINS); 1 ♂: Westcoast, via Clément, Coll. McLachlan (BMNH); 11 ♂♂, 14 ♀♀: Westcoast, via Clément, Coll. Selys (RBINS); 1 ♂, 1 ♀: Westcoast, via Clément, Coll. Ris (SMF); 6 ♂♂, 2 ♀♀: 1886, Borneo, F. Baczes leg. (NHMW); 1 ♂: 23.8.1961, Enr. [Environs?] Ketungan, Kapuas River, West Kalimantan, exp. Jauffret (RMNH); 1 ♂, 2 ♀♀: 24.8.1961, Sungai Seberoang, Semitau, Kapuas River, 0.55° N/111.967° E, West Kalimantan, exp. Jauffret (RMNH); 1 ♂: 27.8.1961, Sungai Bunut, Bunut, Kapuas River, 0.767° N/112.5° E, West Kalimantan, exp. Jauffret (RMNH).

Distribution:

This species appears to be very local and rare. It is known from Borneo (Fig. 3), but the exact locality of most available specimens is not determinable because the locality labels give no details. However there is a small series in RMNH from locations around the Kapuas River in West Kalimantan; two of these, Bunut and Semitau, are close to Danau Sentaram National Park in areas of peat swamp forest and black water lakes. Selys (1889) mentioned that specimens by Clément were collected on the west coast of Borneo, also some of Kirby's specimens originated from west Borneo. Fraser (1932) mentioned Samarinda (on the eastcoast of Borneo within East Kalimantan/Indonesia) as a locality for a female specimen collected on 9 February 1929 but we consider this record to be unreliable because of the difficulties in separation of female *N. disparilis* from *N. fluctuans*. Laidlaw (1902 & 1930) mentioned two specimens from Kuala Aring (Peninsular Malaysia) and specimens from Singapore taken by Ridley which could indicate extinct populations. However these non-bornean specimens were not examined in this study.

Characterization:

The abdomen of *N. disparilis* males has short lateral streaks on each segment (Fig. 13a), thus resembling *N. fluctuans* (Fig. 13b). The medial process of the vesica spermalis has a tall medial lobe at the posterior end, bifid in ventral view, and a smaller, elongate one anterior of that; small hairy lateral knobs are present on each side (Fig. 18a). The wing maculation of males is distinct: it does not reach as far as the nodus, ending instead about 1-4 cells proximal to it. In the Fw the terminus is generally straight and in the Hw it is almost diagonally curved towards base without reaching the posterior wing margin (Fig. 14a). The wing venation of *N. disparilis* is less dense than that of *N. fluctuans* with just one cell row of radial and medial planate and many more single and less doubled cells beneath the veins RP2 and IR2 plus MA and RP3-4. Beside wing maculation this is a further difference from *N. fluctuans* where there are almost two rows of cells in these areas (Figs. 14b-e), as already mentioned by Kirby (1889).

Females have similar abdominal markings to the male (Fig. 19a). The vulvar scale of *N. disparilis* is small, extending at an angle of about 45° to the abdomen (Fig.

Fig. 25: Male lectotype of *Neurothemis disparilis* Kirby, 1889 with labels. Deposited at BMNH. Picture: Copyright BMNH.

24a). We are unable to positively assign females to this species by using the vulvar scale. *Neurothemis disparilis* females have no or only a few doubled cells beneath the veins RP2 and IR2 plus MA and RP3-4. The wings are hyaline and tinted with yellow from the base as far as around the triangles and along the costa as far as the nodus (Fig. 20a). They are similar to some females of *N. fluctuans* (Fig. 20b) and we are unable to find diagnostic differences between the females of these species because *N. fluctuans* can also have only a few doubled cells beneath the veins RP2 and IR2 plus MA and RP3-4.

Size and wing venation:

♂: Tot 30-33 mm; Ab 18-20 mm; Fw length 24-27 mm; Hw length 22-26 mm; Pt 2.5-3 mm.

Antenodals Fw/Hw 11.5-15.5/8-11; subnodals Fw/Hw 9-15/9-12; triangle in Fw/Hw of 3-7/2 cells; subtriangle of 5-13 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-7/2-3; cell rows of dc-field bordering Fw triangle 4-5; radial planate of 1 cell row; medial planate of 1 cell row.

♀: Tot 30-32 mm; Ab 16-20 mm; Fw length 25.5-27 mm; Hw length 19-26 mm; Pt 2.5-3 mm.

Antenodals Fw/Hw 12.5-14.5/10-11; subnodals Fw/Hw 7-10/9-11; triangle in Fw/Hw of 2-3/2 cells; subtriangle of 3-6 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-6/2-3; cell rows of dc-field bordering Fw triangle 3-4; radial planate of 1 cell row; medial planate of 1 cell row.

Neurothemis fluctuans (Fabricius, 1793)

Libellula fluctuans Fabricius, 1793. Fabricius (1793): 379.

Polyneura palliata Rambur, 1842. Rambur (1842): 129.

Neurothemis ceylanica Brauer, 1867. Brauer (1867a): 11.

Neurothemis nicobarica Brauer, 1867. Brauer (1867a): 12.

Figures:

4 (map); 13b (♂ abdomen); 14b-e (♂ wings), 18b (♂ vesica spermalis); 19b (♀ abdomen), 20b-c (♀ wings); 24b (♀ vulvar scale); 26 (♂ lectotype of *Polyneura palliata* Rambur, 1842); 27 (♂ lectotype of *Neurothemis nicobarica* Brauer 1867); 28 (♂ syntype of *Neurothemis ceylanica* Brauer, 1867).

Type material examined (7 ♂♂):

1 ♂ (via photograph only): Sumatra, Bourdas leg.; lectotype of *Polyneura palliata* Rambur, 1842 by present designation; deposited at MNHN (Fig. 26).

1 ♂: without locality label; likely a paralectotype of *Polyneura palliata* Rambur, 1842; deposited at RBINS.

Fig. 26: Male lectotype of *Polyneura palliata* Rambur, 1842 with labels, currently considered a junior synonym of *Neurothemis fluctuans* (Fabricius, 1793). Deposited at MNHN. Picture: Mélanie Turiault.

1 ♂: 1857-1859, Karnikobar [Car Nicobar]; lectotype of *Neurothemis nicobarica* Brauer 1867 by present designation; deposited at NHMW (Fig. 27).

2 ♂♂: 1857-1859, Singapore, Novara Expedition; paralectotypes of *Neurothemis nicobarica* Brauer 1867; deposited at NHMW.

2 ♂♂: [Ceylon (Sri Lanka)]; syntypes of *Neurothemis ceylanica* Brauer, 1867; deposited at NHMW (Fig. 28).

Fig. 27: Male lectotype of *Neurothemis nicobarica* Brauer, 1867 with labels, currently considered a junior synonym of *Neurothemis fluctuans* (Fabricius, 1793). Deposited at NHMW. Picture: Malte Seehausen.

Further material examined (456 ♂♂, 173 ♀♀):

BORNEO [without specification] – 4 ♂♂: Borneo, Coll. Selys (RBINS); 2 ♂♂: Borneo (NHMW); 1 ♂, 1 ♀: Borneo (MNNW); 1 ♂: North Borneo, Pagel leg. (ZMB); 10 ♂♂, 5 ♀♀: Borneo (ZMB); 2 ♂♂: Borneo, Fruhstorfer leg. (ZMB).

BRUNEI – 2 ♂♂: 4.3.2013, Kuala Belai, Belait district, R. A. Dow leg. (RAD); 1 ♂: 6.3.2013, Lumut pipeline road, Belait district, R. A. Dow leg. (RAD); 1 ♂: 11.3.2013, Rassau, Belait district, R. A. Dow leg. (RAD); 2 ♂♂: 22.5.2013, Seria area, Belait district, R. A. Dow leg. (RMNH); 1 ♂: 25.6.2013, Badas pumping station, Belait district, R. A. Dow leg. (RAD); 2 ♂♂, 1 ♀: 28.6.2013, "Sand Beach", Sungai Belait, Belait district, D. Cheah leg. (RAD); 1 ♂: 4.3.2014, oxbow lake, Sungai Ingei, Belait district, R. A. Dow leg. (RMNH).

CAMBODIA – 1 ♀: 29.5.2003, Siem Reap, 8 km north Sre Noi (road to Anlong Vaeng), J. Constant & K. Smets leg. (RBINS).

INDONESIA, Java – 2 ♂♂: Java, E. A. Fritze leg. (MWNH); 1 ♂, 1 ♀: 9.3.1904, Depok, K. Kraepelin leg. (ZMH); 1 ♂: 1913, Java, Sesoeroe leg. (BMNH).

Fig. 28: Male syntype of *Neurothemis ceylanica* Brauer, 1867 with labels. Deposited at NHMW. Picture: Malte Seehausen.

INDONESIA, Kalimantan – 1 ♀: Southeast Borneo, Wahnes leg., Coll. von Schönberg (ZMB); 6 ♂♂, 1 ♀: 31.10.-21.12.1909, Sintang, West Kalimantan, R. Martin leg. (SMF); 8 ♂♂, 2 ♀♀: 21.1.-14.4.1910, Sintang, West Kalimantan, R. Martin leg. (SMF); 1 ♂: 17.6.2012, Palangkaraya area, Kalimantan Tengah, R. A. Dow leg. (RMNH); 1 ♂: 27.6.2012, Tuanan, Kalimantan Tengah, R. A. Dow leg. (RAD); 8 ♂♂: March 2013, Malinau regency, North Kalimantan, purchase from 'Giradys Insect Supply'/Indonesia (MWNH); 12 ♂♂: May 2013, Malinau regency, North Kalimantan, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

INDONESIA, Riau Islands –1 ♀: Natuna Islands, Coll. Everett (BMNH).

INDONESIA, Sumatra – 13 ♂♂, 11 ♀♀: Deli, L. Martin leg. (ZMB); 1 ♂: Westcoast of Sumatra, von Faber leg. (ZMB); 1 ♂: Siboelangit, Deli, Jachan leg. (ZMB); 1 ♂: Sumatra, Daldorf leg. (ZMB); 1 ♂: Sumatra (ZMB); 1 ♂, 2 ♀♀: Sumatra, Dr. Mösch leg. (SMNS); 1 ♂, 1 ♀: 11.9.1891, Palembang, G. Wölber leg. (ZMH); 6 ♂♂, 9 ♀♀: May 1905, Bangka Island, Hagen leg.

(ZSM); 2 ♂♂, 1 ♀: 1912, West Sumatra, Grubauer leg. (SMNS); 2 ♂♂, 1 ♀: January 1913, Simalur Chut, E. Jacobson leg. (SMF); 1 ♂: 1921, Deli, East Sumatra, Dr. Marxs leg. (ZSM); 1 ♂: February 1926, Tandjunggadang [near Pedang], E. Jacobson leg. (ZMB); 1 ♂: September 1926, Anai Kloof [near Pedang], E. Jacobson leg. (ZMB); 26 ♂♂, 9 ♀♀: 13.4./21.5.1972, Dolok Ulu near Dolok Merangir, Roesler & Küppers leg. (ZFMK); 9 ♂♂, 4 ♀♀: 21.4.-2.5.1972, Hilisimaetanoe Surroundings, Nias Island, Roesler & Küppers leg. (ZFMK); 1 ♂: 6.12.1975, Nagaraja, North Sumatra, R. & E. Bender, E. Diehl leg. (ZFMK); 3 ♂♂, 3 ♀♀: 1.7.1983, Pulau Kayu, Province Aceh-Selatan, Klapperich leg., Coll. G. von Rosen (ZSM); 27 ♂♂, 17 ♀♀: 8.8.1983, Babahret, Province Aceh-Selatan, Klapperich leg., Coll. G. von Rosen (ZSM); 20 ♂♂, 26 ♀♀: 15.8.1983, Babahret, Province Aceh-Selatan, Klapperich leg., Coll. G. von Rosen (ZSM); 1 ♂: May 1994, Bukit Sanggul, West Sumatra, Wigado leg. (PMIRL); 1 ♂: 18.2.1995, Balingka, West Sumatra, A. Arnold leg. (AA); 1 ♂: 3.3.1995, Padang Panjang, A. Arnold leg. (AA); 2 ♂♂: 27.2.1995, Harau valley, A. Arnold leg. (AA); 4 ♂♂: 14.-17.2.2014, Riau province, R. A. Dow leg. (RAD); 3 ♂♂, 1 ♀: 14.-15.2.2015, Riau Province, R. A. Dow leg. (RMNH).

MALAYSIA, Peninsular – 1 ♂: Seremban, Malacca, R. Martin leg. (SMF); 1 ♂: Malacca, ex-Museum Godeffroy (ZMH); 1 ♂: Perak, Hartert leg. (ZMB); 3 ♂♂: Penang, Fruhstorfer leg. (ZMB); 2 ♂♂: Malacca, Weber leg. (ZMB); 1 ♂: Penang, Malacca, Hartert leg. (ZMB); 1 ♂: Tasek Cini, Pahang, G. Fleck leg. (ZFMK); 6 ♂♂, 3 ♀♀: February-March 1900, Kwala Kangsar, Perak, B. Jachan leg. (ZMH); 8 ♂♂, 2 ♀♀: 1900/1901, Penang, E. Deschamps leg. (ZMH); 4 ♂♂: 20.-23.9.2008, Cameron Highlands, Pahang, R. A. Dow leg. (RAD); 1 ♂: Sungai Bebar, Pahang, R. A. Dow leg. (RAD); 2 ♂♂: 10.-14.12.2010, Kuala Tahan, Pahang, R. A. Dow leg. (RMNH); 2 ♂♂: 17.-18.12.2010, Gelanggi Caves, Pahang, R. A. Dow leg. (RMNH); 2 ♂♂: 20.-22.8.2011, outside Sekayu Forest Reserve, Terengganu, R. A. Dow & Y.F. Yong leg. (RAD); 1 ♂: 25.8.2015, Kampung Wang Kelian, Perlis, R. A. Dow leg. (RAD).

MALAYSIA, Sabah – 5 ♂♂, 1 ♀: Labuan, Coll. Selys (RBINS); 2 ♂♂: [Pulau] Sangai, Coll. Selys (RBINS); 1 ♂, 2 ♀♀: 20.7.1894, Banguey Island, northward Borneo, W. Kedenburg leg. (ZMH); 3 ♂♂: 2.-6.8.1995, Sabah, Y. B. Feng leg. (TFRI).

MALAYSIA, Sarawak – 1 ♂, 1 ♀: Mont Mulu, Coll. Selys (RBINS); 1 ♀: Mulu, Coll. Everett (BMNH); 1 ♂: 30.1.1896, Kuching, Rolle leg. (SMF); 1 ♀: 17.3.2005, Matang Wildlife Center, Kubah National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 19.3.2005, Annah Rais, Kuching division, R. A. Dow leg. (RAD); 1 ♂, 1 ♀: 20.3.2005, between Asajaya and Kota Samarahan, Samarahan division, R. A. Dow leg. (RAD); 1 ♂: 29.3.2005, Bario, Miri division, R. A. Dow leg. (RAD); 1 ♂: 31.3.2005, between Pa'Ukat and Pa'Lungan, Miri division, R. A. Dow leg. (RAD); 1 ♂: 8.4.2005, tributary of Bakong River, Miri division, G. T. Reels leg. (RAD); 3 ♂♂: 18.4.2005, outside Gunung Mulu National Park, Miri division, R. A. Dow leg. (RAD); 3 ♂♂, 1 ♀: 20.4.2005, Gunung Mulu National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 8.5.2005, Niah National Park, Miri division, G. T. Reels leg. (RAD); 1 ♂: 11.5.2005, Lambir Hills National Park, Miri division, S. Russo leg. (RAD); 1 ♂: 26.1.2006, Annah Rais, Kuching division, G. T. Reels leg. (RAD); 1 ♂: 28.1.2006, foot of Gunung Pueh, Kuching division, G. T. Reels leg. (RAD); 1 ♂: 29.1.2006, Gunung Gading, Kuching division, R. A. Dow leg. (RAD); 2 ♀♀: 13.2.2006, Mentawei, Gunung Mulu National Park, Limbang division, J. Simun leg. (RAD); 1 ♀: 15.2.2006, Sungai Melinau, Gunung Mulu National Park, Miri division, J. Simun leg. (RAD); 1 ♂: 18.2.2006, Gunung Mulu National Park,

Miri division, L. Southwell leg. (RAD); 1 ♂: 28.2.2006, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 1.3.2006, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♀: 2.3.2006, Bukit Sarang, Bintulu division, Supiandi leg. (RAD); 1 ♂: 5.3.2006, Samarakan, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 6.3.2006, Sungai Gagak, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 10.3.2006, Binyo Penyilam, Bintulu division, R. A. Dow leg. (RAD); 2 ♂♂, 1 ♀: 26.3.2006, Long Aton, Miri division, R. A. Dow & G. T. Reels leg. (RAD); 1 ♂: 3.4.2006, Loagan Bunut National Park, Miri division, R. A. Dow leg. (RAD); 1 ♀: 2.12.2007, Batang Ai National Park, Sri Aman division, R. A. Dow leg. (RAD); 1 ♂: 21.12.2007, north Tinjar area, Miri division, L. Southwell leg. (RAD); 2 ♂♂: 22.1.2008, Samarakan, Miri division, R. A. Dow leg. (RAD); 1 ♂: Bukit Mina Wildlife Corridor, Sarawak Planted Forest Project, Bintulu division, R. A. Dow leg. (RAD); 2 ♂♂: 29.1.2008, Binyo Penyilam, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 1.2.2008, Similajau National Park, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 18.2.2008, lower slopes Gunung Pueh, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 22.2.2008, Sama Jaya Nature Reserve, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 3.10.2008, Kubah National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 7.10.2008, Binyo Penyilam, Bintulu division, R. A. Dow leg. (RAD); 2 ♂♂: 12.-13.10.2008, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♀: 14.10.2008, Bukit Sarang, Bintulu division, O. Tateh leg. (RAD); 2 ♂♂: 25.10.2008, Samarakan, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 21.8.2009, block T1F, Sarawak Planted Forest Project, Bintulu division, S. Stone leg. (RAD); 2 ♂♂: 24.-27.8.2009, Camp C, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 9.10.2009, Gunung Kalulong, Miri division, R. A. Dow leg. (RAD); 1 ♂: 12.10.2009, Lio Mato, Miri division, R. A. Dow leg. (RAD); 1 ♂: 10.5.2010, Sungai Teku, Sibu division, G. T. Reels leg. (RAD); 1 ♂: 14.6.2010, block E2N, Sarawak Planted Forest Project, Bintulu division, O. Tateh leg. (RAD); 2 ♂♂, 2 ♀♀: 20.-21.6.2010, Camp C, Bintulu division, S. Stone & J. Teo leg. (RAD); 1 ♂: 22.6.2010, Bukit Jugam, Bintulu division, R. A. Dow leg. (RAD); 1 ♂, 1 ♀: 23.6.2010, block K2L, Sarawak Planted Forest Project, S. Stone & J. Teo leg. (RAD); 1 ♀: 30.6.2010, Kakus nursery, Bintulu division, S. Stone leg. (RAD); 1 ♂: 14.7.2010, Gunung Kalulong, Miri division, W. Kebing & L. Southwell leg. (RMNH); 1 ♂: 19.7.2010, Sungai Pawan, Miri division, R. A. Dow leg. (RAD); 1 ♀: 20.7.2010, foot of Gunung Kalulong, Miri division, L. Southwell leg. (RAD); 2 ♂♂, 2 ♀♀: farm near Lambir Hills, Miri division, L. Southwell & M. Kibi leg. (RAD); 1 ♂: 10.11.2010, Kapur Camp, Bintulu division, R. A. Dow leg. (RMNH); 2 ♀♀: 12.11.2010, Kakus nursery, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 24.4.2011, Lambir Hills National Park, Miri division, L. Southwell leg. (RAD); 1 ♂: 27.4.2011, Sungai Mina, Bintulu division, L. Joseph leg. (RAD); 2 ♀♀: 28.4.2011, Kakus nursery, Bintulu division, L. Joseph & S. Stone leg. (RAD); 4 ♀♀: 5.-6.5.2011, Camp C, Bintulu division, S. Stone leg. (RAD); 1 ♂: 7.5.2011, Sungai Gagak, Bintulu division, S. Stone leg. (RMNH); 1 ♂: 8.5.2011, Samarakan, Bintulu division, S. Butler leg. (RAD); 1 ♂: 2.9.2011, Matang Wildlife Center, Kubah National Park, R. A. Dow leg. (RMNH); 4 ♂♂, 2 ♀♀: 5.-10.9.2011, Marudi area, Miri division, various leg. (RAD); 1 ♀: 8.2.2012, Niah National Park, Miri division, L. Southwell leg. (RAD); 1 ♂: 24.3.2012, block A1M, Sarawak Planted Forest Project, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 27.3.2012, Bukit Kana, Bintulu division, O. Tateh leg. (RAD); 2 ♂♂: 6.-7.7.2012, Long Banga area, Miri division, L. Southwell leg. (RAD); 1 ♂:11.7.2012, Maludam National Park, Betong division, R. A. Dow leg. (RAD); 1 ♂: 16.7.2012, Lambir Hills National Park, R. A. Dow leg. (RAD); 1 ♂: 26.7.2012, Gunung Penrissen, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 2.10.2012, Kampung

Sebako, Kuching division, R. A. Dow leg. (RMNH); 6 ♂♂, 3 ♀♀: 2.-9.10.2012, Gunung Pueh, Kuching division, various leg. (RAD); 3 ♂♂, 1 ♀: 16.6.2013, Tapak Mageh area, Kapit division, R. A. Dow & L. Southwell leg. (RAD); 2 ♂♂, 1 ♀: 2.8.2013, Kampung Sebako, Kuching division, J. Sujang & R. Sujang leg. (RAD); 1 ♂: 11.8.2013, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♂, 2 ♀♀: 20.8.2013, Nanga Bloh area, Lanjak Entimau Wildlife Sanctuary, Kapit division, various leg. (RAD); 1 ♂: 11.9.2013, Sungai Kahei area, Kapit division, R. A. Dow leg. (RAD); 1 ♂: 19.3.2014, block T2N, Sarawak Planted Forest Project, Bintulu division, R. A. Dow leg. (RMNH); 1 ♀: 25.3.2014, Camp C, Bintulu division, R. A. Dow leg. (RAD); 1 ♀: 25.3.2014, Camp C, Bintulu division, R. A. Dow leg. (RMNH); 1 ♂, 1 ♀: 10.-13.7.2014, Sungai Sii area, Miri division, *N.* Pawi leg. (RAD); 2 ♂♂: 22.-26.8.2014, Ulu Moh area, Miri division, various leg. (RAD); 1 ♂: 8.9.2014, Mount Matang, Kuching division, R. A. Dow leg. (RAD); 2 ♂♂, 1 ♀: 16.1.2015, ponds on farm, Beraya, Miri division, R. A. Dow & L. Southwell leg. (RAD); 1 ♂, 3 ♀♀: 17.1.2015, Loagan Bunut National Park, Miri division, R. A. Dow & L. Southwell leg. (RAD); 1 ♂: 20.1.2015, BLB plantation, Igan area, Sibu division, R. A. Dow leg. (RAD); 5 ♂♂, 3 ♀♀: 29.1.-2.2.2015, Ulu Sebuyau National Park and adjacent oil palm, Samarahan division, L. Southwell leg. (RAD); 2 ♂♂: 7.-10.2.2015, Sungai Lamah area, Miri division, R. A. Dow & L. Southwell leg. (RAD); 1 ♂: 22.3.2015, Bako National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 25.3.2015, Bako National Park, Kuching division, R. A. Dow leg. (RAD); 4 ♂♂, 1 ♀: 17.6.2015, GT plantation, Long Terawan area, Miri division, various leg. (RAD); 3 ♂♂: 29.6.-2.7.2015, Maludam National Park, Betong division, various leg. (RAD); 1 ♂: Ulu Sebuyau, Samarahan division, G. T. Reels leg. (RAD); 2 ♂♂: Ulu Mujok area, Sarikei division, R. A. Dow & *N.* ak. Masil leg. (RAD); 2 ♂♂: 14.-16.8.2015, Samunsam Wildlife Sanctuary, Kuching division, R. A. Dow leg. (RAD); 2 ♂♂: 5.9.2015, Nanga Gaat, Kapit division, R. A. Dow leg. (RAD).

MYANMAR – 2 ♂♂, 1 ♀: August 1887, Malawoon [Ma-li-won, Tanintharyi region], Coll. Selys (RBINS); 1 ♀: September 1921, King Island, Mergui Archipelago, F. C. Fraser leg. (SMF); 1 ♂: February 1995, Tenasserim Island, Coll. M. Hartung (PMIRL).

PHILIPPINES – 1 ♀: 15.6.1985, Palawan Province, Port Baton, Th. Borromeo leg., Coll. R. A. Müller (RMNH); 2 ♂♂: 1.8.1990, Palawan Province, Busuanga Island, Busuanga, Th. Borromeo leg., Coll. R. A. Müller (RMNH); 5 ♂♂, 2 ♀♀: 2.8.1990, Palawan Province, Busuanga Island, Coron, Th. Borromeo leg., Coll. R. A. Müller (RMNH); 5 ♂♂, 1 ♀: 3.8.1990, Palawan Province, Busuanga Island, Concepcion, Th. Borromeo leg., Coll. R. A. Müller (RMNH); 5 ♂♂: 4./7.5.1991, Palawan Province, Busuanga Island, Coron, Mabentangen river, Th. Borromeo leg., Coll. R. A. Müller (RMNH); 1 ♂: 4.-8.5.1991, Palawan Province, Busuanga Island, Coron, Mabentangen river, Th. Borromeo leg., Coll. R. A. Müller (RMNH).

SINGAPORE – 4 ♀♀: Singapore, H. N. Ridley leg. (BMNH); 2 ♂♂: 15.2.1892, Singapore (ZSM); 2 ♂♂: 11.2.1995, Zoological Garden, A. Arnold leg. (AA); 4 ♂♂: 12.2.1995, Botanical Garden, A. Arnold leg. (AA); 2 ♂♂: 23.11.2010, Nee Soon, R. A. Dow leg. (RAD).

THAILAND – 1 ♂: 21.7.1935, Trang waterfall, South Siam [Trang province], Dajak Layang Gaddi leg. (RBINS); 1 ♂: 1.8.1935, Trang waterfall, South Siam [Trang province], Dajak Layang Gaddi leg. (RBINS); 1 ♂: 5.12.1971-1.2.1972, Pattaya, Province Chonburi, P. Siepen leg. (ZFMK); 3 ♂♂: 4.4.1989, Phuket, F. Kelschinske leg. (UMB); 2 ♂♂: 6.4.1989, Phuket, F. Kelschinske leg. (UMB); 1 ♂: 22.-31.12.1999, Ao Bang Rong, East coast of Phuket Island, T.

Osten leg. (SMNS); 3 ♂♂, 2 ♀♀: 13.2.2001, Bang Liang, Khao Lak, 8°40'17.1" N/98°15'53.2"E, Phangnga, A. Günther leg. (AG); 2 ♀♀: 13.2.2001, Bang Liang, Khao Lak, 8°39'39.7" N/98°16'52.6"E, Phangnga, A. Günther leg. (AG); 1 ♂: 10.4.2009, Ban Bang Khaya Nai, Khao Lak, 8°40'17.1" N/98°15'53.2" E, Phangnga, A. Günther leg. (AG); 5 ♂♂: 26.3.2015, around Thon Tam Waterfall, 8°44'28.8" N/98°18'24.3"E, Phangnga, A. Günther leg. (AG).

UNKNOWN ORIGIN – 2 ♂♂: 'Ind. orient.' [East India or East Indies] (ZMB).

VIETNAM – 12 ♂♂: June 24, Bienhoa, Conchinchina (RBINS); 5 ♂♂: Saigon, Conchinchina (RBINS); 3 ♂♂: Conchinchina, Coll. Le Moult (ZMH).

Distribution:

Neurothemis fluctuans ranges from the Andaman and Nicobar Islands of India across southern Myanmar and northern Thailand westward to Vietnam and Palawan Province of the Philippines, south across Peninsular Malaysia, Sumatra and Borneo to Central Java (Fig. 4). The occurrence of *N. fluctuans* in East India was stated by Hagen (1869) based on the type specimen of *N. fluctuans* (Fabricius, 1793). We have not seen any specimen of *N. fluctuans* from northern Myanmar or eastern India, thus we are unable to give annotations. However it appears likely that *N. fluctuans* does not occur in mainland India and Bangladesh. Subramanian (2009) listed this species but the records that this is based on are all from the Andaman and Nicobar Islands (K. A. Subramanian, pers. comm.). Nair (2011) has not listed *N. fluctuans*. There are no records of *N. fluctuans* known from eastern Java, Bali or Indonesian islands further east except for a male from 'Dongola/Celebes' [Sulawesi] mentioned by Karsch (1903) and also treated as *N. fluctuans* by Krüger (1903), and two specimens from North Sulawesi mentioned by Askew et al. (1989). Ris (1911) supposed that the original locality 'Celebes' [Sulawesi] was incorrect and we acknowledge that it diverges from the main range of this species. But we were not able to examine these Sulawesian specimens so we could neither confirm nor rebut these data. But if these specimens truly represent *N. fluctuans*, then they might possibly be vagrants from Borneo. The occurrence of *N. fluctuans* within Palawan province in the Philippines was first published by Hämäläinen & Müller (1997), recently the species occurs on three Philippine islands: Palawan, Busuanga and Cuyo (Reagan Villanueva, pers. comm.). Records from Japan likely represent vagrants due to typhoons (Sugano & Umeda 2006; Ishikawa & Yano 2006).

Characterization:

Males of *N. fluctuans* have typical short lateral streaks on each abdominal segment (Fig. 13b) which are different from those of other examined species except *N. disparilis* (Fig. 13a). Compared to the related *N. ramburii* the abdomen is more elongate and slender. The medial process of the vesica spermalis of *N. fluctuans* (Fig. 18b) approaching *N. disparilis* (Fig. 18a) with a small medial lobe, bifid in ventral view, a bifid anterior lobe extending laterally; small hairy lateral knobs present on each side. The extent of wing maculation within male *N. fluctuans* appears to be very variable: Three males from Borneo (deposited at RBINS and NHMW) have a wing maculation of intermediate appearance between *N. disparilis* and *N. fluctuans*

(Fig. 14b); typically it extends from about three cells proximal to one cell distal of Pt, with its terminus almost straight to convex in the Fw and always curving towards the wing base, but to different degrees, in the Hw. The wing maculation usually reaches the posterior wing margin between veins RP3-4 and the anal loop, sometimes even distal of veins RP3-4 (Figs. 14d-e). *Neurothemis fluctuans* from the Philippines have a wing maculation extending as far as three to four cells distal of nodus in Fw and five to six cells distal of nodus in Hw; its terminus slightly convex, reaching posterior wing margin around vein MP in Fw and curved towards base and reaching posterior wing margin around wing base in Hw leaving wing margin hyaline (Fig. 14c). The density of the wing venation as well as body size differs from north to south: the smallest body sizes and wing venation densities are found within mainland populations from southern Myanmar across Thailand to Vietnam and on the Philippines (Figs. 14c-d); body size as well as wing venation density increases to the southern islands. Specimens from Sumatra usually have the longest body sizes with a wing maculation and wing venation density approaching that of *N. ramburii* (Fig. 14e) as Krüger (1903) and Ris (1911) already mentioned. Specimens from Singapore, Borneo and Java are ordinarily intermediate in body size and wing venation density between those from the northern part of the range and those from Sumatra, as mentioned by Ris (1911).

Females of *N. fluctuans* resemble males in having short lateral streaks on each abdominal segment (Fig. 19b) and a more elongated and slender abdomen compared to *N. ramburii*. The female vulvar scale of *N. fluctuans* is small and extends at an angle of about 45° to the abdomen (Fig. 24b) instead of about 90° as seen in the female of *N. ramburii* (Fig. 24f). Heterochrome and isochrome females of *N. fluctuans* occur; heterochrome females with wing bases usually yellow tinted to differing intensities and smoky apices (Fig. 20b) are the most common all over the range. The isochrome female variation was found predominantly in Java, Sumatra and the surrounding islands, but also in Borneo, the Philippines and Cambodia. The wing maculation of isochrome females extends almost as far as one cell proximal of the Pt, curving towards the base in Hw as in the males, and reaching the posterior wing margin around vein MP (Fig. 20c). Their wing venation is usually denser than the venation of heterochrome females: e.g. the triangle of heterochrome females is usually two-celled in Fw and Hw and that of isochrome females usually four- to five-celled.

Size and wing venation:

♂: Tot 27-37 mm; Ab 17-23 mm; Fw length 20-28 mm; Hw length 19-27 mm; Pt 2-4 mm.

Antenodals Fw/Hw 10.5-15.5/8-13; subnodals Fw/Hw 8-14/8-14; triangle in Fw/Hw of 2-11/2-6 cells; subtriangle of 4-20 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3-7/2-5; cell rows of dc-field bordering Fw triangle 3-7; radial planate of 1-3 cell rows; medial planate of 1-3 cell rows.

♀: Tot 26-32.5 mm; Ab 16-20.5 mm; Fw length 20-27.2 mm; Hw length 19-28 mm; Pt 2-4 mm.

Antenodals Fw/Hw 10.5-14.5/9-12; subnodals Fw/Hw 8-11/8-13; triangle in Fw/Hw of 2-5/2-4 cells; subtriangle of 3-7 cells; cross veins in cubito-anal space of Fw/Hw

(Cux) 3-6/2-4; cell rows of dc-field bordering Fw triangle 2-4; radial planate of 1-2 cell rows; medial planate of 1-2 cell rows.

Remarks:

There is puzzling data concerning Fabricius type specimen of *Libellula fluctuans*. Fabricius (1793) gave 'India orientali' as the locality for a specimen from Niels Tønder Lund's collection. This collection was given to the Museum Copenhagen (ZMUC) in 1810 (Horn et al. 1990). Hagen (1869) gives a description of a specimen deposited at ZMUC which he asserted to be Fabricius's type, but this specimen had no label and therefore it is uncertain whether it truly represents Fabricius's type. Nevertheless, the locality 'India orientali' was considered to represent East India by Hagen (1869). But 'India orientali' might also stand for the East Indies, which is the type-locality for *Libellula fluctuans* given by Kirby (1890), Bridges (1994) and Steinmann (1997). The descriptions of Fabricius (1793) were very short, but in several species he differentiated between 'India' and 'India orientali'; thus we consider that present day eastern India is not likely to be the correct type locality, which might be the East Indies.

Currently there is no type specimen to be found at ZMUC (Henrik Enghoff, pers. comm.) and also Zimsen (1964) did not mention a specimen deposited in Copenhagen. Additionally Fabricius's collections at Kiel (ZMUK) and London (BMNH) were checked, but none include a type specimen of *Libellula fluctuans* (Jana Willkommen and Ben Price, pers. comm.). According to Steinmann (1997) the type is stored at ZMB but the authority for this claim remains unclear. Within the collection at ZMB there are two males of *N. fluctuans* labelled with 'Ind. or.' which is very likely an abbreviation for 'India orientali' or 'Indes orientales'. It is possible that the ZMB specimens were collected by Ingobert (Dagobert) Karl Daldorff, because according to an unpublished catalogue of the ZMB collections, a few other dragonflies with labels stating 'Ind. Or.' were collected by him. Daldorff gave several dragonflies to Fabricius, Ove Sehestedt and Niels Tønder Lund (Zimsen 1964), so it is possible that Fabricius got the type specimen directly from Daldorff. However the males at ZMB do not fit with Hagen's redescription of Fabricius's type. In conclusion the type specimen of *Libellula fluctuans* Fabricius, 1793 seems to be lost.

Lieftinck (1942) mentioned the type of *Polyneura palliata* Rambur, 1842 from the collection at MNHN, and that it belongs to *N. fluctuans*. Recently a male labelled as '*P. palliata*' and '*Libell… palliata*' was found at MNHN by Mélanie Turiault and André Nel (Fig. 26). This specimen fits with the description of Rambur (1842), e.g. in the presence of only five abdominal segments, the first of them crumpled, and wing maculation meeting the posterior wing margin around the middle of the wing. Also Sumatra as the given locality corresponds with the locality given by Rambur (1842) and the label '*Libell… palliata*' was handwritten by Rambur. This male is designated here as the lectotype of *Polyneura palliata* Rambur, 1842. According to Rambur (1842) there were additional specimens labelled as from 'Indes orientales' and stored at the collection of Pierre François Dejean. Dejean's collection ended up, via Selys Longchamps, at RBINS (Horn et al. 1990). The first author found a male bearing a handwritten '*palliata*' label of Rambur in the collection at RBINS; this specimen is considered likely to be from the original series.

St. Quentin (1970) listed a lectotype and 'paratypoid' of *Neurothemis ceylanica* Brauer, 1867 and *Neurothemis nicobarica* Brauer, 1867. The first author found two males labelled as types of *N. ceylanica* and three males labelled as types of *N. nicobarica* at NHMW. In each case one male among these syntypes has a blank red tag which might be a label placed by St. Quentin to mark his choice of a lectotype. According to article 74.5 of the ICZN (1999) an author must have unambiguously labelled a particular syntype to act as the unique, name-bearing type of the taxon by using the term 'lectotype' or an equivalent expression. This was not done by St. Quentin and the inventory number he mentioned is a spurious one because numbers in the so called 'old catalogue' did not always refer to single specimens and the pinned specimens did not bear individual numbers (Ernst Bauernfeind, pers. comm.), hence we consider neither of St. Quentin's designations to be a valid lectotype designation. In order to clarify the taxonomic status of *N. nicobarica* we designate the male specimen, labelled 'Karnikobar', as lectotype. It is stored at the NHMW, 2. Zool. Dept., Insecta varia collection, Odonata: drawer 6/37 (Fig. 27).

Concerning *N. ceylanica*, we do not consider a lectotype designation as useful because the synonymization with *N. fluctuans* is for pragmatic reasons only. The origin of these specimens remains unknown, but Scherzer (1864) notes that the Novara sailed from Sri Lanka across Madras to Car Nicobar and further across the Malacca Strait to Singapore. However, the name is misleading, because it implies occurrence within 'Ceylon' (Sri Lanka). Kirby (1884) listed them as a 'local race' of *N. fluctuans* in 'Ceylon' and Krüger (1903) also included 'Ceylon' within the range of *N. fluctuans*. Ris (1911) first surmised that the type locality was incorrect and we agree since no *Neurothemis* species have been recorded from Sri Lanka except *N. intermedia* (Rambur, 1842) and *N. tullia* (Bedjanic et al. 2014). The taxonomic history of *N. ceylanica* is confusing as well: Brauer (1864) mentioned five males of *Polyneura apicalis* Rambur, 1842 collected by the Novara Expedition at Sri Lanka, Car Nicobar and Singapore. In 1867 he described *N. ceylanica* and *N. nicobarica* from these specimens (Brauer 1867a), but Brauer (1867b) assigned *N. ceylanica* to *N. palliata* (Rambur, 1842). Hagen (1869) assigned *N. ceylanica* (and *N. nicobarica* as well) to *N. palliata*; Kirby (1890) assigned *N. ceylanica* to *N. fluctuans*, which was assumed by Ris (1911). Interestingly Krüger (1903) again assigned *N. ceylanica* to Rambur's *N.* (*Polyneura*) *apicalis*, which is a synonym of *N. terminata* (see the taxonomic explanation under *N. terminata*), alike Brauer (1864). After examination of both males the first author found similarities to the specimens from the Mentawai Archipelago mentioned by Laidlaw (1926). These specimens are labeled as *N. terminata* 'forma' and stated to be intermediate between *N. fluctuans* and *N. terminata*. We cannot positively assign the specimens from the Mentawai Archipelago to one species, but they may present an undescribed taxon. Both syntype males of *N. ceylanica* (Fig. 28) resemble these specimens from the Mentawai Archipelago; thus we consider that more intensive studies are needed to verify the status of the *N. ceylanica* types and the Mentawai Archipelago taxon.

Bridges (1994) and Steinmann (1997) assigned the type of *Neurothemis incerta* Brauer, 1867 (Fig. 38) to *N. fluctuans*. This female was re-discovered at NHMW and found to be synonym of *N. ramburii* (see under *N. ramburii*).

Neurothemis fulvia (Drury, 1773)

Libellula fulvia Drury, 1773. Drury (1773): 46, fig. 2.

Libellula sophronia Drury, 1773. Drrury (1773): 46, fig. 4.

Libellula apicalis Guérin, 1838. Guérin Méneville (1838): 194-195.

Neurothemis sophronia var. sumatrana Krüger, 1903. Krüger (1903): 263.

Figures:

5 (map); 13c (♂ abdomen); 14f-g (♂ wings), 18c (♂ vesica spermalis); 19c (♀ abdomen), 20d-e (♀ wings); 24c (♀ vulvar scale); 29 (♂ holotype of *Libellula apicalis* Guérin, 1838); 30 (♂ syntypes of *Neurothemis sophronia* var. *sumatrana* Krüger, 1903).

Type material examined (4 ♂♂):

1 ♂: [Ambon Island, Maluku Islands/Indonesia], Coll. Selys; holotype of *Libellula apicalis* Guérin, 1838; deposited at RBINS (Fig. 29).

Fig. 29: Presumed male holotype of *Libellula apicalis* Guérin, 1838 with labels, currently considered a junior synonym of *Neurothemis fulvia* (Drury, 1773). Deposited at RBINS. Picture: Jérôme Constant, courtesy of RBINS.

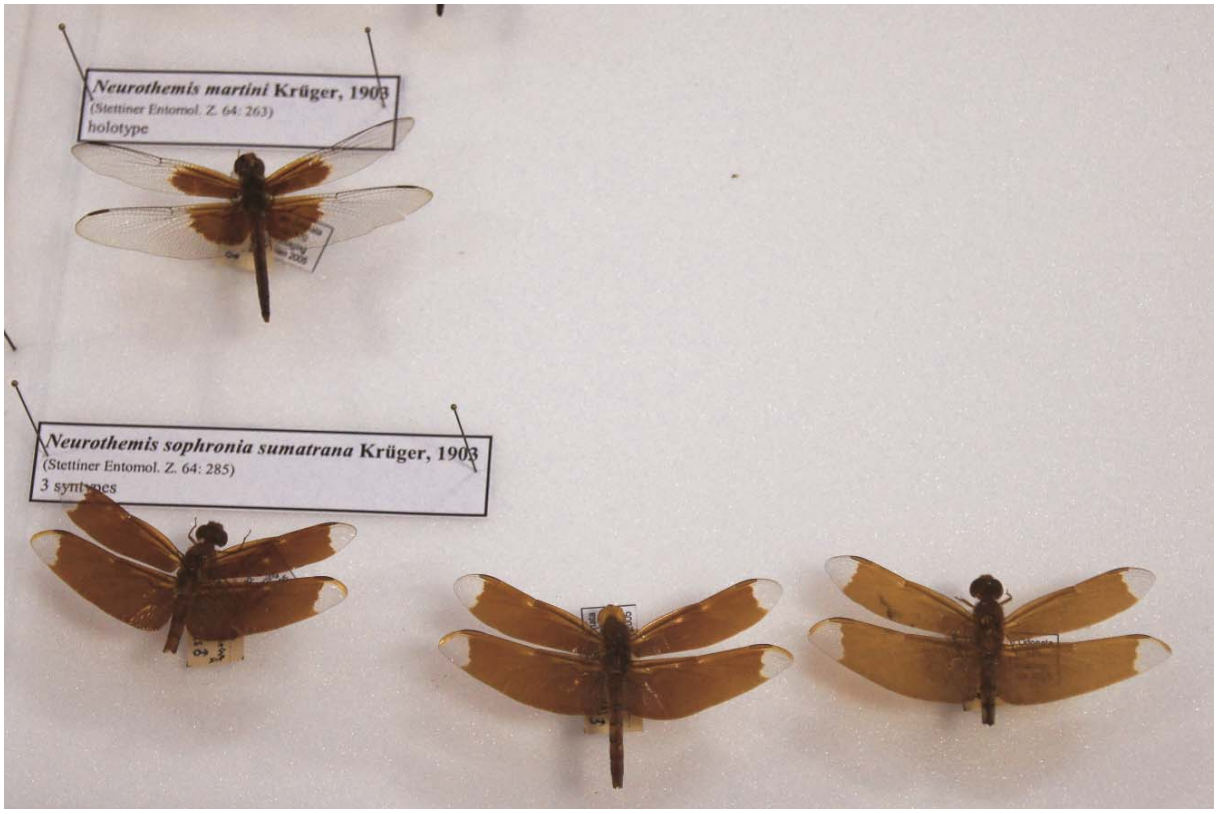

Fig. 30: Drawer with three syntypes of *Neurothemis sophronia sumatrana* Krüger, 1903 and holotype of *Neurothemis martini* Krüger, 1903. Deposited at MZPW. Picture: Robert Rozwalka.

3 ♂♂ (via photograph only): Soekaranda, Sumatra, Dohrn leg.; syntypes of *Neurothemis sophronia* var. *sumatrana* Krüger, 1903; deposited at MZPW (Fig. 30).

Further material examined (98 ♂♂, 62 ♀♀):

BANGLADESH – 1 ♀: Sylhet, ex-Museum Godeffroy (ZMH).

CAMBODIA – 1 ♂: 25.5.2003, Phnom Kulen, Siem Reap, J. Constant & K. Smets leg. (RBINS).

CHINA – 1 ♂: 'Amoi', Stevens leg. (ZMB); 1 ♂: Hainan, Zobrys leg. (ZMB); 1 ♀: 9.11.1906, Fujian Province, G. Siemssen leg. (ZMH); 3 ♂♂, 2 ♀♀: July - September 1910, Tsha-Jiu-San, Guangdong, Mell leg. (ZMB); 1 ♂, 1 ♀: June 1911, Tsha-Jiu-San, Guangdong, Mell leg. (ZMB); 1♀: June 1911, Canton, Guangdong, Mell leg. (ZMB); 1 ♂, 1 ♀: 4.8.1911, Tsha-Jiu-San, Guangdong, Mell leg. (ZMB); 1 ♂: 6.8.1911, Tsha-Jiu-San, Guangdong, Mell leg. (ZMB); 2 ♂♂, 1 ♀: May - June 1912, Tsha-Jiu-San, Guangdong, Mell leg. (ZMB); 1 ♂: December 1912, Canton, Guangdong, Mell leg. (ZMB); 1 ♂: 1912, Canton, Guangdong, Mell leg. (ZMB); 1 ♀: 28.5.1980, Tri Ping Fung, 7 km eastward Mung Lung, Yunnan, E. J. Fittkau leg. (ZSM).

INDIA – 1 ♂: Bengal, Coll. Selys (RBINS); 1 ♂, 1 ♀: Sikkim, Coll. Bingham (ZMB); 3 ♂♂, 4 ♀♀: August 1952, Baragolai, Assam, H. Neuhaus leg. (ZSM); 22 ♂♂, 3 ♀♀: September 1952, Baragolai, Assam, H. Neuhaus leg. (ZSM); 5 ♂♂, 2 ♀♀: 15.10.1955, Panvel, near Mumbai (ZMH); 5 ♂♂: 1.3.1902, Darjeeling, S. Gutmann leg. (ZMH).

INDONESIA, Sumatra – 1 ♀: 7.5.1928, Tandjung Karang, Reichwein leg. (MWNH).

MALAYSIA, Peninsular – 1 ♂: Malacca, Weber leg. (ZMB); 3 ♂♂, 2 ♀♀: February-March 1900, Kwala Kangsar, Perak, B. Jachan leg. (ZMH).

MYANMAR – 4 ♂♂, 2 ♀♀: 1913, Irrawaddy River, upstream Yangon, H. Schrader leg. (ZMH).

NEPAL – 1 ♀: 1.4.1962, Bhimpedi Valley, G. Ebert & H. Falkner leg. (ZSM); 1 ♂: 24.4.1962, Province 1 East, Sankhu La, G. Ebert & H. Falkner leg. (ZSM); 1 ♂: 4.8.1962, Province 2 East, Tamba Kosi Valley, G. Ebert & H. Falkner leg. (ZSM); 1 ♂: 8.8.1962, Province 1 East, Banepa, G. Ebert & H. Falkner leg. (ZSM); 5 ♂♂, 2 ♀♀: 20.8.1964, Huxe, Province No. 1 East, W. Dierl leg. (ZSM); 2 ♂♂: 26.8.1964, Kathmandu, W. Dierl leg. (ZSM); 1 ♂: 21.4.1967, Kathmandu Valley, Godavari, Dierl & Schacht leg. (ZSM); 1 ♂, 2 ♀♀: 25.4.1967, Kathmandu Valley, Nagarjong, Dierl, Forster & Schacht leg. (ZSM); 2 ♀♀: 30.4.1967, Kathmandu Chauni, Dierl, Forster & Schacht leg. (ZSM); 2 ♀♀: 1.5.1967, Kathmandu Valley, Nagarjong, Dierl, Forster& Schacht leg. (ZSM); 2 ♂♂: 3.7.1967, Kathmandu Valley, Nagarjong, Dierl & Schacht leg. (ZSM); 1 ♂: 6.7.1967, Kathmandu Valley, Nagarjong, Dierl & Schacht leg. (ZSM); 4 ♂♂, 4 ♀♀: 27. & 28.7.1967, Kathmandu Valley, Nagarjong, Dierl, Forster & Schacht leg. (ZSM); 1 ♂: 16.8.1977, Kathmandu Valley, Godavari, G. von Rosen leg. (ZSM).

THAILAND – 11 ♂♂, 10 ♀♀: December 1971-February 1972, Pattaya, Chonburi Province, P. Siepen leg. (ZFMK); 1 ♂, 15 ♀♀: 18.8.1973, Mae Sa, Chiang Mai, G. von Rosen leg. (ZSM); 2 ♂♂: 6.9.1973, Mae Sa, Chiang Mai, G. von Rosen leg. (ZSM); 1 ♂: 1.4.1989, Phuket, F. Kelschinske leg. (UMB).

VIETNAM – 3 ♂♂: June 24, Bienhoa, Conchinchina (RBINS); 1 ♂: Lao Cai, Tonkin, Coll. Le Moult (ZMH); 1 ♂: June-July [without year], Than-Moi, Tonkin, H. Fruhstorfer leg. (HLMD).

Distribution:

Neurothemis fulvia ranges from southern and western India to Nepal and northeastern India eastwards across Myanmar to southern China and southwards across Thailand, Peninsular Malaysia to southern Sumatra (Fig. 5). Asahina (1966) considered a specimen from Foochow, Fujian Province/China to represent the northernmost record for the species. Its occurrence in Taiwan is documented by Lieftinck et al. (1984) but he considered the single female to be a vagrant from mainland China. 'Amboina' is given as the type locality for *Libellula apicalis* Guérin, 1838 which was already considered to be incorrect by Ris (1911); this seems to be confirmed as no other records of *N. fulvia* are known from this region.

Characterization:

Males of *N. fulvia* have typical narrow dorsal and lateral streaks on the abdomen (Fig. 13c). Kirti & Singh (2004) already published illustrations of the medial process of the vesica spermalis. The species is distinct and homogenous in the morphology of the vesica spermalis, with a laterally arched dorsal edge which resembles an 'S' posteriorly (Fig. 18c). The wing venation is very dense with partly doubled cells within the antenodal, bridge and supratriangle spaces. The wing maculation of *N. fulvia* males usually extends to the middle of Pt and ends apically with an irregular serrated terminus. There are males with colored

as well as with hyaline wing apices and intermediates (Figs. 14f-g). For example the types of *N. sophronia* var. *sumatrana* Krüger, 1903 have hyaline apices with a yellow area only between vein RP1 and anterior wing margin of the Hw (Fig. 30).

Neurothemis fulvia females have abdominal markings similar to the males (Fig. 19c). The vulvar scale usually extends at an angle of about 45° to the abdomen (Fig. 24c). Females are variable but always have colored wings. There are two main variants: one approaching the males with wing maculation extending to Pt, sometimes with a darkened band along the costal border at apices and also sometimes darker at nodus (Fig. 20d); the other main variation has wings completely amber-yellow, usually darker at nodus and subcostal areas (Fig. 20e). Additionally several intermediate forms between these two occur.

Size and wing venation:

♂: Tot 33.5-40 mm; Ab 21-27 mm; Fw length 26.2-31.4 mm; Hw length 26.4-33 mm; Pt 3.5-4.5 mm.

Antenodals Fw/Hw 23.5-39.5/21-31; subnodals Fw/Hw 12-21/17-26; triangle in Fw/Hw of 12-30/5-11 cells; subtriangle of 22-62 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 7-12/4-9; cell rows of dc-field bordering Fw triangle 7-12; radial planate of 4-7 cell rows; medial planate of 4-7 cell rows.

♀: Tot 30.4-37 mm; Ab 19-24 mm; Fw length 26.4-31.4 mm; Hw length 26-32 mm; Pt 3.8-4.8 mm.

Antenodals Fw/Hw 23.5-34.5/19-28; subnodals Fw/Hw 11-19/11-22; triangle in Fw/Hw of 6-18/3-7 cells; subtriangle of 15-32 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 6-11/3-6; cell rows of dc-field bordering Fw triangle 5-13; radial planate of 3-5 cell rows; medial planate of 3-6 cell rows.

Remarks:

Fraser (1936) mentioned that the type specimens of *Libellula fulvia* Drury, 1773 and *Libellula sophronia* Drury, 1773 were likely lost. Most of Drury's collection was auctioned in 1805 via J. C. Stevens (Horn et al. 1990). Thus it is most likely that the type specimens were sold and ended up in some unknown collection.

Neurothemis manadensis (Boisduval, 1835) stat. nov.

Libellula manadensis Boisduval, 1835. Boisduval (1835): 651.

[?] *Libellula elegans* Guérin, 1838. Guérin Méneville (1838): 194 & plate 10, fig. 3.

[?] *Neurothemis pseudosophronia* Brauer, 1867. Brauer (1867a): 15-16.

Neurothemis innominata Brauer, 1867. Brauer (1867a): 17-18.

Neurothemis unicolor Selys, 1878. Selys (1878): 301-302.

Figures:

6 (map); 13d (♂ abdomen); 15a-b (♂ wings), 18d (♂ vesica spermalis); 19d (♀ abdomen), 20f-g (♀ wings); 24d (♀ vulvar scale); 31 (♂ holotype of *Libellula elegans* Guérin, 1838); 32 (♀ lectotype of *Neurothemis pseudosophronia* Brauer, 1867); 33 (♀ holotype of *Neurothemis innominata* Brauer, 1867); 34 (♂ holotype of *Neurothemis unicolor* Selys, 1878); 35 (♂ with aberrant wing maculation).

Type material examined (6 ♂♂, 4 ♀♀):

1 ♂: Amboina, Durville leg., Coll. Selys; holotype of *Libellula elegans* Guérin, 1838; deposited at RBINS (Fig. 31).

Fig. 31: Male holotype of *Libellula elegans* Guérin, 1838 with labels; currently assigned to *Neurothemis manadensis* (Boisduval, 1835) for pragmatic reasons. Deposited at RBINS. Picture: Jérôme Constant, courtesy of RBINS.

Fig. 32: Female lectotype of *Neurothemis pseudosophronia* Brauer, 1867 with labels; currently assigned to *Neurothemis manadensis* (Boisduval, 1835) for pragmatic reasons. Deposited at NHMW. Picture: Malte Seehausen.

2 ♀♀: 1867, Seram Island, Coll. Kaup; lectotype (Fig. 32) and paralectotype of *Neurothemis pseudosophronia* Brauer, 1867; deposited at NHMW as published by St. Quentin (1970) and Schneider (2004).

4 ♂♂, 1 ♀: Seram, Coll. Kaup; paralectotypes of *Neurothemis pseudosophronia* Brauer, 1867; deposited at HLMD.

1 ♀: Seram, Coll. Kaup; holotype of *Neurothemis innominata* Brauer, 1867; deposited at HLMD (Fig. 33).

1 ♂: Manado, Sulawesi, Coll. Selys; holotype of *Neurothemis unicolor* Selys, 1878; deposited at RBINS (Fig. 34).

Fig. 33: Female holotype of *Neurothemis innominata* Brauer, 1867 with labels, currently considered a junior synonym of *Neurothemis manadensis* (Boisduval, 1835). Deposited at HLMD. Picture: Malte Seehausen.

Further material examined (202 ♂♂, 81 ♀♀):

INDONESIA, Maluku Islands – 2 ♂♂, 1 ♀: Seram Island, Remesse leg., Coll. Selys (RBINS); 8 ♂♂, 3 ♀♀: Seram Island [?], Remesse leg. [?], Coll. Selys (RBINS); 2 ♂♂: Ambon Island, W. de Haan leg. (ZMB); 1 ♂: Maluku Islands, P. J. M. Lorquin leg., ex-Coll. Selys (ZMB); 36 ♂♂, 9 ♀♀: Ambon Island, Ribbe leg. (ZMB); 1 ♂: Seram Island (ZMB); 1 ♀: Kai Islands [?] (ZMB); 1 ♂, 1 ♀: Bacan Island, North Maluku Province (SMF); 13 ♂♂, 11 ♀♀: March 2013, Waifara, Sanana Island, North Maluku, purchase from 'Exotic Insects'/Indonesia (MWNH); 9 ♂♂: August 2013, Mount Ibu, Halmahera, North Maluku, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

INDONESIA, Sulawesi – 1 ♂: Celebes, Ribbe leg. (MNHN); 1 ♀: Mirabassa [Minahassa] (MNHN); 1 ♀: Celebes, I. Pfeiffer leg. (NHMW); 4 ♂♂, 4 ♀♀: Toli-Toli, Central Sulawesi (SMF); 7 ♂♂, 3 ♀♀: Minahana, North Sulawesi (ZMB); 3 ♀♀: Solibaboe (ZMB); 2 ♀♀: Makassar, South Sulawesi (ZFMK); 17 ♂♂, 9 ♀♀: 1882, Tombugu, Central Sulawesi, C. Ribbe leg.

Fig. 34: Male holotype of *Neurothemis unicolor* Selys, 1878 with labels, currently considered a junior synonym of *Neurothemis manadensis* (Boisduval, 1835). Deposited at RBINS. Picture: Jérôme Constant, courtesy of RBINS.

(ZMB); 2 ♂♂, 1 ♀: March 1896, Lompat Battau, South Sulawesi, H. Fruhstorfer leg. (ZMH); 15 ♂♂, 1 ♀: 1898, Pic Bonthain, South Sulawesi, H. Fruhstorfer leg. (NHMW); 1 ♀: 20.8.-3.9.1904, Makassar, South Sulawesi, E. Lorenz-Meyer leg. (ZMH); 5 ♂♂, 1 ♀: 12.-16.3.1912, Palu, Central Sulawesi, R. Martin leg. (SMF); 5 ♂♂: 6.-14.2.1913, Kalawara, Palu, Central Sulawesi, R. Martin leg. (SMF); 2 ♂♂: 13.1.1913, Palu, Central Sulawesi, R. Martin leg. (SMF); 18 ♂♂, 2 ♀♀: July-September 1926, Tondano-Manado, North Sulawesi (ZMH); 1 ♂: 5.2.1981, Palopo, South Sulawesi, Kager leg. (ZSM); 1 ♂: 7.3.1993, Gimpu, 1°39' S/120°02' E,, Sulawesi Tengah, A. Günther leg. (AG); 2 ♂♂, 2 ♀♀: 8.3.1993, Lawua, 1°37' S/120°02' E, Sulawesi Tengah, A. Günther leg. (AG); 3 ♂♂, 1 ♀: 13.3.1993, Doda, 1°43'36" S/120°15'19" E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♀: 14.3.1993, Doda, 1°43'36" S/120°15'19" E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♂, 1 ♀: 17.3.1993, Kamarora PHPA Guestcamp, 1°12' S/120°08' E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♀: 18.3.1993, Kamarora PHPA Guestcamp, 1°12' S/120°08' E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♂: 21.3.1993,

Tentena, 1°46'21" S/120°32'29" E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♀: 25.3.1993, Lemo, 3°02'26" S/119°52'23" E, Sulawesi Selatan, A. Günther leg. (AG); 1 ♂: 28.3.1993, Bantimurung, 5°01'06" S/119°40'37" E, Sulawesi Selatan, A. Günther leg. (AG); 2 ♂♂: 24.7.1994, Tonuso, Tentena, 1°45'10.8" S/120°32'41.4" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 1 ♀: 26.7.1994, Poso river, Sulewana, Tentena, 1°38'54" S/120°39'48" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 1 ♂: 27.7.1994, Danau Poso Lake, 1°47'22" S/120°35'47" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 1 ♀: 8.8.1994, Danau Poso Lake, 1°52'29" S/120°30'26" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 1 ♂, 1 ♀: 13.8.1994, Wakai, Batudaka Island, 0°25'01" S/121°51'27" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 3 ♂♂, 1 ♀: 14.8.1994, Kadoda, Malenge Island, 0°16'28" S/122°02'58" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 2 ♂♂, 1 ♀: 14.8.1994, Wakai, Batudaka Island, 0°25'01" S/121°51'27" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 3 ♂♂, 2 ♀♀: 19.8.1994, Buntao, 3°02'42" S/119°57'30" E, Sulawesi Selatan, A. Günther & F. Randow leg. (AG); 2 ♂♂: 23.8.1994, Bantimurung, 5°03'59.0" S/119°43'11.2 E, Sulawesi Selatan, A. Günther & F. Randow leg. (AG); 3 ♂♂, 1 ♀: 23.2.1997, Tonuso, Tentena, 1°45'10.8" S/120°32'41.4" E, Sulawesi Tengah, A. Günther leg. (AG); 2 ♀♀: 25.2.1997, Tonuso, Tentena, 1°47'06" S/120°31'31" E, Sulawesi Tengah, A. Günther leg. (AG); 4 ♂♂, 2 ♀♀: 29.8.1999, Kadidiri Island, 0°21'21.3" S/121°50'40.9" E, Sulawesi Tengah, A. Günther & F. Randow leg. (AG); 1 ♂, 1 ♀: 2.8.2000, Soroako, 2°31'17.7" S/121°20'36.1" E, Sulawesi Selatan, A. Günther leg. (AG); 1 ♂: 6.8.2011, Danau Linow, Tomohon, 1°16'08.8" N/124°49'23.7" E, Sulawesi Utara, A. Günther leg. (AG); 2 ♂♂: Talawaan, 1°34'08.0" N/124°58'42.6" E, Sulawesi Utara, A. Günther leg. (AG); 3 ♂♂: 22.8.2011, Sonder, 1°16'56.9" N/124°43'45.5" E, Sulawesi Utara, A. Günther leg. (AG); 1 ♀: May 2006, Salue Island (MWNH); 9 ♂♂, 3 ♀♀: March 2012, Kamarora village, Palolo, Central Sulawesi, A. Corso leg. (RAD); 2 ♂♂: 8.7.2013, Air Terjun Tunan, Manado, Sulawesi Utara, R. A. Dow leg. (RMNH); 1 ♀: 10.7.2013, Air Terjun Tunan, Manado, Sulawesi Utara, H. Cahilog leg. (RAD); 1 ♂: 10.7.2013, Air Terjun Tunan, Manado, Sulawesi Utara, R. A. Dow leg. (RAD); 1 ♂: 16.7.2013, Sungai Pattunuang Asue, Sulawesi Selatan, H. Cahilog leg. (RMNH); 1 ♂: 19.7.2013, Mangkoso area, Sulawesi Selatan, R. A. Dow leg. (RMNH); 1 ♀: 8.5.2014, Wonco, Buton Island, Southeast Sulawesi, A. Müller leg. (MWNH).

UNKNOWN ORIGIN – 1 ♂: [Senegal, specimen mentioned by Rambur (1842) under *Polyneura manadensis* Boisduval], Coll. Selys (RBINS); 1 ♀: [Melanesia], Ribbe leg. (ZMB).

Distribution:

The range of *N. manadensis* extends from Sulawesi across North Maluku, Seram, Ambon and apparently to Cenderawasih Bay in Papua Barat (Fig. 6). One female stored at ZMHB is labeled from Kai Island together with *N. stigmatizans bramina*. Records from West Papua are mentioned by Ris (1911), and within this area *N. manadensis* seem to overlap with the range of *N. stigmatizans bramina*. According to Ris (1911) specimens from Salawati, Andai (Papua Barat) and Cenderawasih Bay (formerly Geelvink Bay) are smaller than the western ones, but the wings correspond to *N. manadensis*. During examination of the specimens in Ris's collection labelled as originating from 'Geelvink Bay', the first author found specimens of *N.*

manadensis as well as of *N. terminata*. The latter species does not occur within New Guinea and this makes the locality questionable for *N. manadensis* as well. Fraser (1932) listed five males of *N. manadensis* from Manoembai Island which would be the only record of this species from the Aru Islands. But his short description (wing maculation extending to five cells proximal of Pt, mostly two cubital crossveins in Hw) argues against a correct determination and we suppose that these specimens might actually represent *N. papuensis*.

Characterization:

The abdomen of male *N. manadensis* has dark markings almost continuous from at least S3-9 (Fig. 13d) and S8-10 is usually darker than in *N. stigmatizans* ssp. (Figs. 13g-h). The vesica spermalis of *N. manadensis* (Fig. 18d) is slightly different from that of *N. stigmatizans* ssp. (Figs. 18g-h), with the lateral lobes of segment V4 shorter and the medial process more compressed. But *N. manadensis* and *N. stigmatizans* ssp. share the pointed medial lobe with elongated, latererally developed, anterior lobes and comparatively tall and elongated hairy lateral knobs. We were unable to distinguish between *N. manadensis* and *N. terminata* (Fig. 18j) based on vesica spermalis morphology. The wing maculation of male *N. manadensis* extends to at least the middle of Pt and often to its distal end or beyond (Figs. 15a-b). Its terminus is almost straight in Fw and Hw, usually reaching the posterior wing margin in both wings around veins IR2 to Rspl. The venation of *N. manadensis* is always very dense and this is, together with characters of the abdominal markings, the main character separating *N. manadensis* from *N. terminata*.

Female *N. manadensis* have abdominal markings similar to the males (Fig. 19d). The vulvar scale of *N. manadensis* (Fig. 24d) has no distinct features, it extends at an angle of about 45° to the abdomen and is similar to that of *N. stigmatizans* ssp. (Figs. 24g-h) and *N. terminata* (Fig. 24j). Two main female variations occur in *N. manadensis*: a more common one which we call 'belted isochrome' with brighter yellowish wings and a darkened band-like area at apical end of the maculation (Fig. 20f) and an isochrome variant with wings similar to the male (Fig. 20g). The terminus of the maculation of both variations is straight and the apices are usually slightly darkened. The venation is much denser compared to *N. terminata* ssp. (Figs. 23a-e) and, as in the males of both species, this together with characters of the abdominal markings is the main differences used to separate female of *N. manadensis* from *N. terminata*.

Size and wing venation:

♂: Tot 33-44.2 mm; Ab 20.9-27.1 mm; Fw length 26-33.4 mm; Hw length 24-33 mm; Pt 3.7-5.3 mm.

Antenodals Fw/Hw 14.5-21.5/12-16; subnodals Fw/Hw 11-20/11-18; triangle in Fw/Hw of 21-47/2-7 cells; subtriangle of 37-95 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 5-11/3-5; cell rows of dc-field bordering Fw triangle 7-15; radial planate of 3-4 cell rows; medial planate of 3-6 cell rows.

♀: Tot 31.2-37.8 mm; Ab 19-24.1 mm; Fw length 26.1-32.3 mm; Hw length 24-32 mm; Pt 3.9-5 mm.

Antenodals Fw/Hw 14.5-20.5/10-15; subnodals Fw/Hw 10-15/10-16; triangle in Fw/Hw of 6-27/2-5 cells; subtriangle of 9-43 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 5-8/2-4; cell rows of dc-field bordering Fw triangle 4-8; radial planate of 2-3 cell rows; medial planate of 2-4 cell rows.

Remarks:

A series in Coll. Selys at RBINS consisting of ten males and four females show a spotted aberration in the wing maculation (Fig. 35). Three of these specimens are

Fig. 35: Aberrant male *Neurothemis manadensis* from a series of 14 specimens with such spotted wing maculation. Deposited at RBINS. Picture: Malte Seehausen.

labelled as from Seram Island while the others bear no label, but we suppose that the whole series is from the same locality.

Kirby (1890) synonymized *Libellula manadensis* Boisduval, 1835 with *N. stigmatizans* (Fabricius, 1775), later Ris (1911) raised its status to *Neurothemis stigmatizans manadensis* (Boisduval, 1835). This arrangement was considered valid until now. However Lieftinck (1926) suggested that *N. stigmatizans bramina* and *N. stigmatizans manadensis* might be synonymized in the future because of the problems of identification of specimens within the eastern Maluku Islands and western New Guinea. Nevertheless Boisduval (1835) gave a usable description and a drawing of his type male which was collected at 'Manado/Celebes'. This description corresponds exactly with specimens we have examined from this region; the Sulawesian specimens are distinct. Therefore we consider *N. manadensis* to represent a valid species, likely resulting from allopatric

speciation. We agree that there are difficulties in identification of specimens within the eastern parts of the Maluku Islands and western New Guinea which may be due to interbreeding with *N. stigmatizans bramina*. This is indicated by several specimens of intermediate appearance (Fig. 17a) recently collected e.g. on Batanta Island, Sorong and Manokwari (West Papua Province/Indonesia) to Nabire (Papua Province/Indonesia) and also by historical records e.g. from Ambon as well as from Seram Island, which were already published by Ris (1911). The exact area of occurrence of both taxa within western New Guinea and the eastern Maluku Islands need to be verified critically in the context of further studies concerning the classification of *N. stigmatizans bramina*.

The type specimen of *Libellula manadensis* Boisduval, 1835 seems to be lost. The collection of Boisduval was shared and according to Horn et al. (1990) some parts should be at BMNH and RBINS but other parts where auctioned to different collectors. Rambur (1842) transferred *Libellula manadensis* to his new genus *Polyneura* and mentioned a specimen from Serville's collection which is labelled as originating from Senegal. This male is stored at RBINS, but the first author was unable to find Boisduval's specimen there.

Libellula elegans Guérin, 1838 (Fig. 31), described from the male holotype, was synonymized with *N. stigmatizans manadensis* by Ris (1911). Bridges (1994) followed Ris' classification whereas Steinmann (1997) lists it as synonym of *N. stigmatizans stigmatizans*. Based on wing characters we are unable to positively assign this specimen to either taxon; our assignement to *N. manadensis* is for pragmatic reasons and may be questioned. The specimen has intermediate attributes between *N. stigmatizans bramina* and *N. manadensis*, like other specimens collected within this area of the eastern Maluku Islands. Thus the classification of *Libellula elegans* needs further study.

A lectotype of *Neurothemis pseudosophronia* Brauer, 1867 (Fig. 32) was first listed by St. Quentin (1970) and confirmed by Schneider (2004). This specimen does not represent typical females of *N. manadensis* (none do so within the paralectotype series), so there is a need for further verification. As with *Libellula elegans* Guérin, 1838 the whole series is labelled as collected within the supposed hybrid zone between *N. manadensis* and *N. stigmatizans bramina*. However the first author found a male *N. terminata* within the paralectotypes of *Neurothemis pseudosophronia* depostited at HLMD. Since *N. terminata* is not otherwise known to occur in the Maluku Islands, we suppose that this is a case of mislabeling and that it suggests that not all other given localities for the paralectotype sequence of *N. pseudosophronia* are reliable.

Neurothemis papuensis (Lieftinck, 1942) stat. nov.

Neurothemis ramburii papuensis Lieftinck, 1942. Lieftinck (1942): 482-484.

Figures:

7 (map); 13e (♂ abdomen); 15c (♂ wings), 18e (♂ vesica spermalis); 19e (♀ abdo-

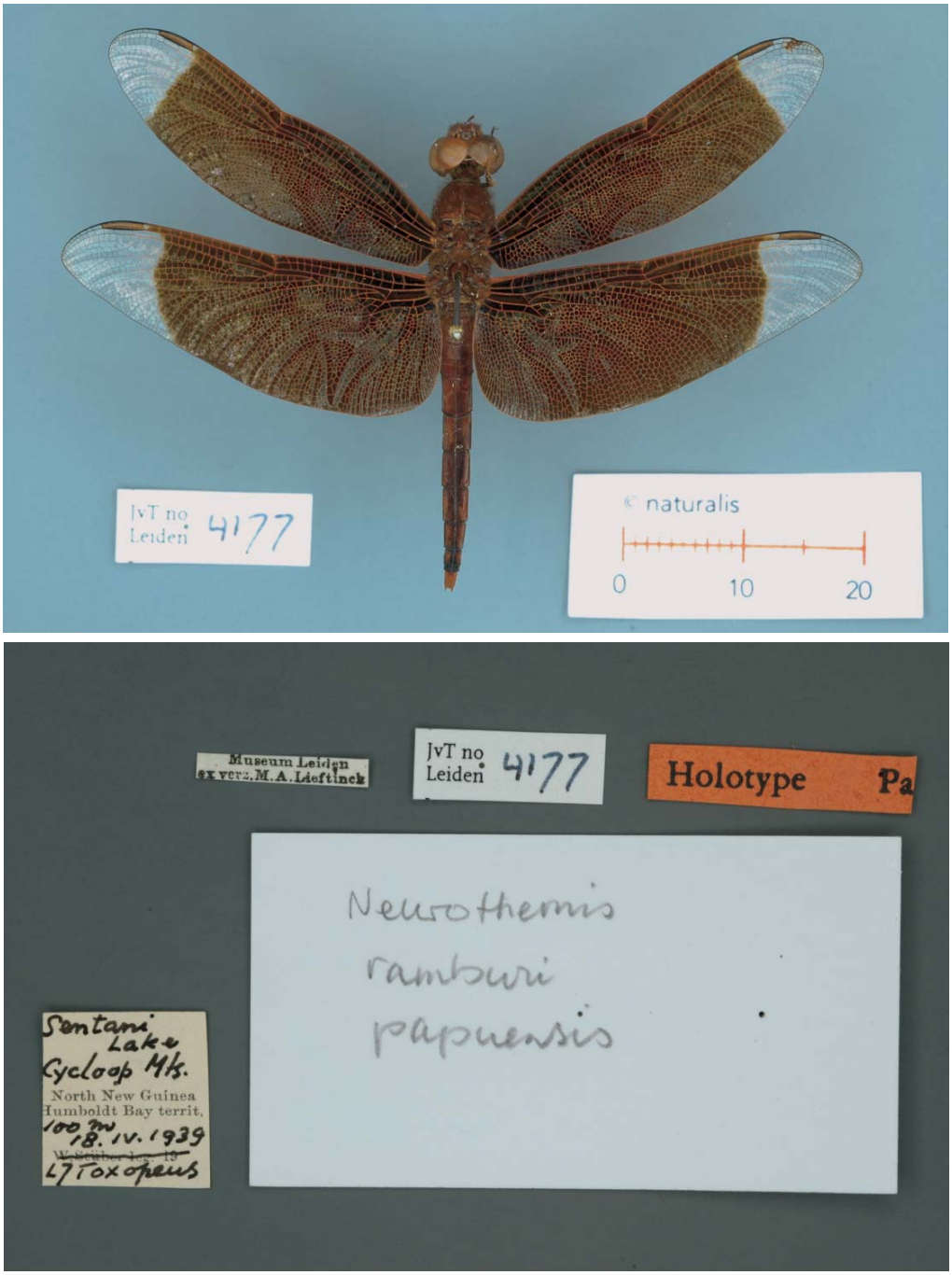

Fig. 36: Male holotype of *Neurothemis ramburii papuensis* Lieftinck, 1942 with labels. Deposited at RMNH. Picture: Copyright by RMNH.

men), 21a (♀ wings); 24e (♀ vulvar scale); 36 (♂ holotype of *Neurothemis ramburii papuensis* Lieftinck, 1942).

Type material examined (1 ♂):

1 ♂ (via photograph only): 18.4.1939, Sentani Lake, Cycloop MK/Papua New Guinea, Toxopeus leg.; holotype of *Neurothemis ramburii papuensis* Lieftinck, 1942; deposited at RMNH (Fig. 36).

Further material examined (33 ♂♂, 19 ♀♀):

INDONESIA, Maluku Islands – 1 ♀: 1884, Ureiuning, Aru Islands, C. Ribbe leg., Coll. Selys (RBINS); 1 ♀: 27.11.1910, Aru Island, Elgner leg. (SMF); 1 ♀: 29.11.1910, Aru Island, Elgner leg. (SMF); 1 ♀: 9.12.1910, Aru Island, Elgner leg. (SMF); 1 ♂: 10.12.1910, Aru Island, Elgner leg. (SMF); 1 ♀: 29.12.1910, Aru Island, Elgner leg. (SMF); 1 ♀: 15.10.1911, Aru Island, Elgner leg. (SMF); 1 ♂: 24.12.1911, Aru Island, Elgner leg. (SMF); 2 ♀♀: 2.3.1912, Aru Island, Elgner leg. (SMF); 1 ♀: 6.3.1912, Aru Island, Elgner leg. (SMF); 3 ♀♀: 15.3.1912, Aru Island, Elgner leg. (SMF).

INDONESIA, West Papua – 1 ♂, 1 ♀: March 1913, Kloof-Biwak, Lorentz river, Papua province (SMF); 1 ♂: February 1936, Jutefa Bay, Pim. [near Jayapura], L. E. Cheesman leg. (BMNH); 1 ♂: 29.1.1996, Waterfall stream, Sentani, Jayapura, 2°32'15" S/140°30'46" E, Papua Province, A. Günther & F. Randow leg. (AG); 2 ♂♂: 14.2.1996, small stream west of Manokwari, 0°52' S/134°03' E, Papua Barat, A. Günther & F. Randow leg. (AG); 2 ♂♂: 17.2.1996, Nuni, Manokwari, 0°46'57" S/134°00'46" E, Papua Barat, A. Günther & F. Randow leg. (AG).

NEW GUINEA [without specification] – 6 ♂♂, 1 ♀: New Guinea (ZMB); 1 ♀: New Guinea, Fruhstorfer leg. (ZMB); 1 ♂: New Guinea, Dr. Hagen leg., Coll. G. von Rosen (ZSM).

PAPUA NEW GUINEA – 1 ♂: Mioko, Neu-Lauenburg [Duke of York Islands, Bismarck Archipelago], C. Ribbe leg., Coll. Selys (RBINS); 1 ♂: Bongu [Madang Province], Wahnes leg., Coll. Selys (RBINS); 1 ♀: Vailala River, J. P. de Verteuil leg. (BMNH); 1 ♂: December 1929, Finisterre Range, Morobe Province, Nagel leg. (SMF); 2 ♀♀: December 1936-February 1937, Garaina, F. Shaw-Mayer leg. (BMNH); 1 ♂: 30.4.1982, Awar point [Madang Province], P. Grootaert leg. (RBINS); 2 ♂♂: 22.5.1982, Mumeng [Morobe Province], P. Grootaert leg. (RBINS); 1 ♂: 30.4.1996, Madang Province, 5.33328° S/144.90299° E, M. Graul leg. (PMIRL); 2 ♂♂: 6.5.1996, Begesin Missionsstation, 5.72453° S/144.84128° E, Jiwaka Province, H. Deumer leg. (PMIRL); 4 ♂♂: 18.5.1997, Gobari Plantation, Morobe Province, M. Wiemers & D. Gassmann leg. (RMNH); 1 ♀: 23.5.1997, Creek near Mearambi River, Morobe Province, D. Gassmann leg. (RMNH); 1 ♂: 28.5.1997, Road between Heldsbach and Finschhafen, Huon Peninsula, Morobe Province, D. Gassmann leg. (RMNH); 1 ♂: 2.7.1997, Behir creek near Ohu Community School, 05°14'59.7" S/145°41'24.4" E, Madang Province, D. Gassmann leg. (RMNH); 1 ♂: 9.-10.6.2003, Queen Emmas bath', 5 km westward Kokopo, 4°28' S/152°19'E, New Britain, T. Osten leg. (SMNS).

UNKNOWN ORIGIN – 1 ♂: [Nias Island, Sumatra/Indonesia, Hans. leg.] (MWNH).

Distribution:

This species is known from the Aru Islands across New Guinea to the Solomon Islands (Fig. 7).

Characterization:

Males of *N. papuensis* have a predominantly red abdomen with no well defined lateral markings; only S8-10 have dark markings dorsally and less distinct ones laterally (Fig. 13e). The medial process of the vesica spermalis has small hairy lateral

knobs alongside the tall medial lobe (Fig. 18e). Within its range, the wing maculation of *N. papuensis* males seems to be homogenous, extending midway from nodus and Pt to almost the proximal end of Pt. The terminus is more or less straight to convex in Fw and slightly curved towards the base in Hw. The maculation reaches the posterior wing margin around vein Rspl in Fw and vein MA to RP3-4 in Hw and there is consistently more than one crossvein within the cubito-anal space (Fig. 15c). Lieftinck (1942) already mentioned that the ratio of Hw length to width of *N. papuensis* differs from *N. ramburii*. Michalski (2012) gave the difference as follows: Hw of *N. papuensis* is 2.5x as long as broad and *N. ramburii* 3x as long as broad. This was partly confirmed in this study, but its range is wider and we note that specimens of *N. papuensis* from the western part of its range have less broad Hw (2.7x to 2.8x as long as broad) thus approaching *N. ramburii*.

The wing ratio values given above also apply to female *N. papuensis*. We have seen only isochrome females of *N. papuensis* with wing maculation extending to about midway between nodus and Pt. As with males the maculation reaches the posterior wing margin around vein Rspl in the Fw and vein RP3-4 to Mspl in Hw; there is persistently more than one crossvein within the cubito-anal space (Fig. 21a). The female abdomen has dark markings laterally and dorsally from S3-10 (Fig. 19e). As with females of *N. ramburii*, the markings are distinct on the last abdominal segments but can be less distinct on basal segments. Compared to *N. ramburii* (Fig. 19f) it seems that the lateral markings of *N. papuensis* on some segments vanish near the base of the segment but in *N. ramburii* it is the otherway around. The vulvar scale of *N. papuensis* extends at an angle of about 90° to the abdomen (Fig. 24e) as in *N. ramburii* (Fig. 24f) and we were unable to find a morphological means for separation of females of the two species.

Size and wing venation:

♂: Tot 36-41.4 mm; Ab 22-26 mm; Fw length 30-34.5 mm; Hw length 27-33.5 mm; Pt 2.5-3.8 mm.

Antenodals Fw/Hw 16.5-23.5/12-16; subnodals Fw/Hw 10-14/11-14; triangle in Fw/Hw of 11-22/3-7 cells; subtriangle of 23-47 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 2-6/2-4; cell rows of dc-field bordering Fw triangle 6-10; radial planate of 2-3 cell rows; medial planate of 2-4 cell rows.

♀: Tot 34.4-36.7 mm; Ab 21-22.5 mm; Fw length 31.5-33.5 mm; Hw length 30-33 mm; Pt 3-3.7 mm.

Antenodals Fw/Hw 15.5-18.5/11-15; subnodals Fw/Hw 8-11/10-14; triangle in Fw/Hw of 7-13/2-4 cells; subtriangle of 12-20 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 2-6/2-3; cell rows of dc-field bordering Fw triangle 4-8; radial planate of 1-2 cell rows; medial planate of 2 cell rows.

Remarks:

Ris (1911) already mentioned that one of the main characters of *N. ramburii*, the

presence of only one cubital crossvein in the Hw, breaks down in specimens from New Guinea. Subsequently Lieftinck (1942) described these specimens as *N. ramburii papuensis*.

The similarity between *N. ramburii* and *N. papuensis* is remarkable: both have a stouter abdomen and possess a broader Hw base than other examined taxa of the genus *Neurothemis*. These attributes might indicate a common origin of these taxa, but the two species are distinct in the differing wing maculation and venation as well as in the medial process of the vesica spermalis. Thus we consider *N. papuensis* to represent a valid species, likely resulting from allopatric speciation. Using the above mentioned differences the first author was able to assign a dubious male labelled from Nias Island (west of Sumatra), which was already reported by Ris (1911) and stored at MWNH, unambiguously to *N. papuensis*. Thus the labelled locality of this specimen is wrong.

Fig. 37: Male holotype of *Polyneura ramburii* Brauer, 1866 with labels. Deposited at HLMD. Picture: Malte Seehausen.

Neurothemis ramburii (Brauer, 1866)

Polyneura ramburii Brauer, 1866. Brauer (1866): 568-569.

Neurothemis incerta Brauer, 1867. Brauer (1867a): 12-13. Syn. nov.

Untamo apicalis Kirby, 1889. Kirby (1889): 331 & plate LIII, fig. 4.

Figures:

8 (map); 13f (♂ abdomen); 15d-g (♂ wings), 18f (♂ vesica spermalis); 19f (♀ abdomen), 21b-f (♀ wings); 24f (♀ vulvar scale); 37 (♂ holotype of *Polyneura ramburii* Brauer, 1867); 38 (♀ holotype of *Neurothemis incerta* Brauer, 1867); 39 (♀ holotype of *Untamo apicalis* Kirby, 1889).

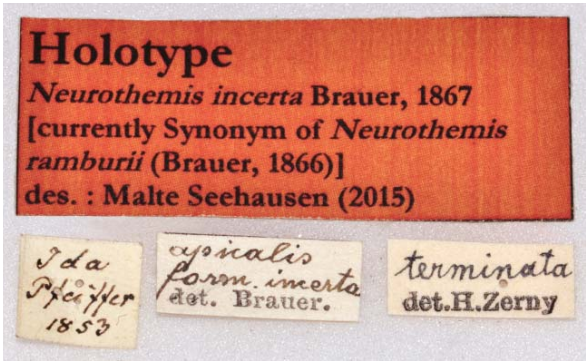

Fig. 38: Female holotype of *Neurothemis incerta* Brauer, 1867 with labels, currently considered a junior synonym of *Neurothemis ramburii* (Brauer, 1866). Deposited at NHMW. Picture: Malte Seehausen.

Type material examined (1 ♂, 2 ♀♀):

1 ♂: Celebes, Coll. Kaup; holotype of *Polyneura ramburii* Brauer, 1867; deposited at HLMD (Fig. 37) as noted by Schneider (2004).

Fig. 39: Female holotype of *Untamo apicalis* Kirby, 1889 with labels, currently considered a junior synonym of *Neurothemis ramburii* (Brauer, 1866). Deposited at BMNH. Picture: Copyright by BMNH.

1 ♀: 1853, Celebes, I. Pfeiffer leg.; holotype of *Neurothemis incerta* Brauer, 1867; deposited at NHMW (Fig. 38).

1 ♀ (via photograph only): Sula Island, North Maluku; holotype of *Untamo apicalis* Kirby, 1889; deposited at BMNH as Kimmins (1968) published (Fig. 39).

Further material examined (188 ♂♂, 59 ♀♀):

INDONESIA, Java – 2 ♂♂: Java (BMNH); 1 ♀: East Java, Fruhstorfer leg. (ZMB); 1 ♀: Java, Fruhstorfer leg. (ZMB); 2 ♂♂, 1 ♀: 27.5.1954, Bawean Island, East Java (ZSM).

INDONESIA, Kalimantan – 2 ♂♂: May 2013, Malinau regency, North Kalimantan, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

INDONESIA, Lesser Sunda Islands – 1 ♂: 3.8.1949, West Sumba (ZSM); 1 ♀: 9.8.1949, West Sumba (ZSM); 2 ♂♂: 27.8.1994, Les, 8°09'01.1" S/115°21'51.0" E, Bali, A. Günther, F. Randow leg. (AG); 1 ♀: 28.12.1997, Tetebatu, 8°32'05.5" S/116°25'15.5" E, Lombok, A. Günther leg. (AG); 1 ♂: 18.8.2000, Les, 8°09'01.1" S/115°21'51.0" E, Bali, A. Günther leg. (AG).

INDONESIA, Maluku Islands – 2 ♂♂: Seram Island, Remesse leg., Coll. Selys (RBINS); 1 ♂: Bacan Island, North Maluku (SMF); 5 ♂♂: Seram Island, Coll. Kaup (HLMD); 1 ♂: Ambon Island, Ribbe leg. (ZMB); 1 ♂: Ternate, North Maluku, von Martens leg. (ZMB); 4 ♂♂: 1895, Amboina, Adensamer leg. (NHMW); 1 ♂: Tobelo, Halmahera, Coll. LeMoult (ZMH); 2 ♂♂: 20.5.1904, Saparua Island, vend. H. Rolle (ZMH); 2 ♂♂, 1 ♀: 26.12.1929, Banda Neira, Banda Islands, Longfield leg. (BMNH); 1 ♂: 30.12.1929, Ambon Island, Longfield leg. (BMNH); 13 ♂♂: March 2013, Sanana Island, North Maluku, purchase

from 'Exotic Insects'/Indonesia (MWNH); 1 ♂: August 2013, Mount Ibu, Halmahera, North Maluku, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

INDONESIA, Sulawesi – 1 ♂: Manado, Coll. Selys (RBINS); 3 ♂♂, 1 ♀: Toli-Toli, Central Sulawesi (SMF); 3 ♂♂, 2 ♀♀: Manado, Coll. McLachlan (BMNH); 1 ♂, 1 ♀: Togian Islands, Meyer leg. (ZMB); 1 ♂: Celebes, I. Pfeiffer leg. (NHMW); 1 ♀: 1898, Pic Benthain, South Sulawesi, H. Fruhstorfer leg. (NHMW); 10 ♂♂, 3 ♀♀: 9.-16.3.1912, Palu, Central Sulawesi, R. Martin leg. (SMF); 2 ♂♂: 17.3.1993, Kamarora PHPA Guestcamp, 1°12' S/120°08' E, Sulawesi Tengah, A. Günther leg. (AG); 1 ♂: 21.3.1993, Tentena, 1°46'21" S/120°32'29" E, Sulawesi Tengah, A. Günther leg. (AG); 3 ♂♂: 24.7.1994, Tonuso, Tentena at three places: 1°46'21" S/120°32'29", 1°45'10.8" S/120°32'41.4" E and 1°46'22" S/120°32'22" E, Sulawesi Tengah, A Günther, F. Randow leg. (AG); 1 ♂: 26.7.1994, Poso river, Sulewana, Tentena, 1°38'54" S/120°39'48" E, Sulawesi Tengah, A. Günther leg. (AG); 3 ♂♂: 7.8.1994, Danau Poso Lake, 1°47'44" S/120°31'56" E, Sulawesi Tengah, A. Günther, F. Randow leg. (AG); 1 ♂: 13.8.1994, Batudaka Island, 0°26' S/121°52' E, Sulawesi Tengah, A. Günther, F. Randow leg. (AG); 3 ♂♂: 14.8.1994, Batudaka Island, 0°25'01" S/121°51'27" E, Sulawesi Tengah, A. Günther, F. Randow leg. (AG); 1 ♂: 24.8.1994, Bantimurung, 5°00'59.9" S/119°40'57.0" E, Sulawesi Selatan, A. Günther, F. Randow leg. (AG); 1 ♂: 3.8.2000, Danau Matano, Soroako, 2°27' S/121°13' E, Sulawesi Selatan, A. Günther leg. (AG); 1 ♂: 1.8.2011, Bantimurung, 5°03'59.0" S/119°43'11.2" E, Sulawesi Selatan, A. Günther leg. (AG); 1 ♂: 12.8.2011, Dolodua, 0°34'22.9" N/123°54'07.4" E, Sulawesi Utara, A. Günther leg. (AG); 2 ♂♂: 22.8.2011, Sonder, 1°16'56.9" N/124°43'45.5" E, Sulawesi Utara, A. Günther leg. (AG); 1 ♂: 8.7.2013, Air Terjun Tunan, Manado, Sulawesi Utara, R. A. Dow leg. (RMNH); 1 ♂: 10.7.2013, Air Terjun Tunan, Manado, Sulawesi Utara, H. Cahilog leg. (RMNH); 1 ♂: 14.7.2013, rice fields near Tincep, Sulawesi Utara, R. A. Dow leg. (RMNH); 1 ♂: 16.7.2013, Sungai Pattunuang Asue, Sulawesi Selatan, H. Cahilog leg. (RAD); 1 ♀: 18.7.2013, Sungai Pattunuang Asue, Sulawesi Selatan, H. Cahilog leg. (RMNH).

INDONESIA, Sumatra – 1 ♀: 1885, Bangkei Island [eastward Enggano Island], H. Kühn leg. (ZMB); 1 ♀: April 1913, Babi Island, Simalur, E. Jacobson leg. (SMF); 1 ♀: 1919, East Sumatra, A. Heyne leg. (SMF); 2 ♀♀: 22.5. & 24.5.1928, Tandjongkarang, Reichwein leg. (MWNH); 4 ♂♂, 2 ♀♀: 21.4.-2.5.1972, Hilisimaetanoe Surroundings, Nias Island, Roesler & Küppers leg. (ZFMK); 11 ♂♂, 6 ♀♀: 8.8. & 15.8.1983, Babahret, Province Aceh-Selatan, Klapperich leg., Coll. G. von Rosen (ZSM).

MALAYSIA, Sabah – 1 ♂: 22.9.2012, ponds, Mahua, Crocker Range National Park, R. A. Dow leg. (RMNH).

MALYSIA, Sarawak – 1 ♂: 16.3.2005, Matang Wildlife Center, Kubah National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 8.5.2005, trail to Sungai Tangas Longhouse, Niah National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 16.5.2005, pond at park headquarters, Lambir Hills National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 28.5.2005, stream at foot of Gunung Santubong, Kuching division, R. A. Dow leg. (RAD); 2 ♂♂: 29.5.2005, pond outside Semenggoh Orangutan Rehabilitation Center, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 28.2.2006, Sungai Sarang, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 3.4.2006, park headquarters, Loagan Bunut National

Park, Miri division, G. T. Reels leg. (RAD); 1 ♂: 22.2.2008, Sama Jaya Nature reserve, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 28.2.2008, Red Bridge, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 9.9.2009, Matang Wildlife Center, Kubah National Park, Kuching division, R. A. Dow leg. (RMNH); 1 ♂: 2.9.2011, Matang Wildlife Center, Kubah National Park, Kuching division, R. A. Dow leg. (RMNH); 1 ♂: 2.10.2012, vicinity of Kampung Sebako at foot of Gunung Pueh complex, Kuching division, R. A. Dow leg. (RMNH); 4 ♂♂, 1 ♀: 2.10.2012, vicinity of Kampung Sebako at foot of Gunung Pueh complex, Kuching division, E. ak Rowmina & T. ak Neyam leg. (RAD, 1 ♂ RMNH); 1 ♂:10.8.2013, Sungai Sarang, Bukit Sarang, Bintulu division, B. Giman leg. (RAD); 1 ♂: 11.8.2013, Sungai Sarang, Bukit Sarang, Bintulu division, B. Giman leg. (RMNH); 1 ♂: 18.3.2014, large pond at Samarakan acacia nursery, Sarawak Planted Forest Project, Bintulu division, R. A. Dow leg. (RMNH); 2 ♂♂: 16.1.2015, ponds on farm, Beraya, Miri, Miri division, R. A. Dow leg. (RAD); 1 ♂: 14.2.2015, Loop Trail, Gunung Santubong, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 6.8.2015, Ulu Mujok, Sarikei division, N. ak Masil leg. (RAD).

PHILIPPINES – 2 ♂♂, 2 ♀♀: Palawan, H. Fruhstorfer leg. (BMNH); 1 ♀: Manila, Luzon (HLMD); 3 ♂♂, 1 ♀: Luzon Island, Jagor leg. (ZMB); 1 ♀: Sulu Archipelago, Semper leg. (ZMB); 1 ♀: Manila, Luzon, Rodbertus leg. (ZMB); 1 ♀: 1868, Philippines, Semper leg. (NHMW); 2 ♀♀: 1888, Manila, Luzon, Thiefsen leg. (UMB); 2 ♂♂, 2 ♀♀: 12.-17.12.1913, Bacuit, Palawan, G. Boettcher leg. (SMF); 1 ♂, 2 ♀♀: 1923, Los Banos, Luzon, P. I. Baker leg. (BMNH); 1 ♂: 6.4.1937, Manila, Antipolo, Luzon (ZFMK); 1 ♀: 28.3.1978, Montalban River, Luzon, G. von Rosen leg. (ZSM); 1 ♂: 17.3.1991, Baguio, 7°11'06.4" N/125°24'55.8" E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 1 ♀: 18.3.1991, Baguio, 7°11'06.4" N/125°24'55.8" E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 1 ♂: 22.3.1991, Caramay river, 10°10'37.4" N/119°11'05.7" E, Palawan Island, A. Günther, I. Hiekel, F. Randow leg. (AG); 2 ♂♂, 1 ♀: 1.4.1991, Puerto Princesa, 9°51'51.3" N/ 118°43'45.4" E, Palawan Island, A. Günther, I. Hiekel, F. Randow leg. (AG); 1 ♂: 7.3.1992, Sabang, 10°10'47.2" N/118°53'34.4" E [?], Palawan Island, A. Günther leg. (AG); 1 ♂: 15.3.1992, Quezon, Palawan Island, A. Günther leg. (AG); 25 ♂♂, 1 ♀: January-February 1997, Buenavista, Batingon River, Marinduque, Coll. G. von Rosen (ZSM); 1 ♂: 2002, Philippines, Mohagan leg. (ZFMK); 15 ♂♂, 13 ♀♀: 5.6.2002, Leyte Island, Mohagan leg. (ZFMK); 2 ♂♂: 7.6.2012, Sodako area, Davao City, Mindanao, R. A. Dow leg. (RAD); 2 ♂♂: 7.6.2012, Sodako area, Davao City, Mindanao, R. A. Dow leg. (RMNH); 1 ♂: 9.6.2012, Cambaleon, San Isidro, Mindanao, R. A. Dow leg. (RAD); 1 ♂: 21.3.2013, stream in coconut and disturbed forest, Loreto, Dinagat, H. Cahilog leg. (RAD).

Distribution:

Neurothemis ramburii ranges from the Andaman and Nicobar Islands across Sumatra, Borneo, Java, Sumba and north to the Philippines (Fig. 8). The first records from the Andaman and Nicobar Islands were published by Hämäläinen et al. (1999). Lieftinck (1954) and Orr (2005) listed Peninsular Malaysia in the range of *N. ramburii*. Re-examination of some supposed *N. ramburii* from the Cameron Highlands by the second author showed that they belong to *N. fluctuans*. Thus we suggest that *N. ramburii* may not actually occur in Peninsular Malaysia.

Characterization:

Both sexes of *N. ramburii* are highly variable as to wing maculation and venation. The abdomen is always relatively stout, as in *N. papuensis* and *N. taiwanensis*. A most important diagnostic character of this species is the presence of only one cubito-anal crossvein (rarely two or three crossveins; check both wings for agreement) in the Hw versus always more than one in congeneric species except *N. taiwanensis*.

The abdomen of male *N. ramburii* has dark dorsal markings on the caudal end of each segment at least from S3-10 and a lateral stripe that becomes larger on progressive segments and joins with the dorsal mark apically on S8-9, leaving only a small basal red section on S9 (Fig. 13f). There are infrequent male *N. ramburii* with less intensive dark markings on the anterior abdominal segments; thus approaching the abdomen of *N. papuensis* (Fig. 13e). The medial process of the vesica spermalis has a tall medial lobe, bifid in ventral view; hairy lateral knobs are lacking (Fig. 18f).

There are roughly three variations in the male wing maculation of *N. ramburii*, all of which can grade into one another. The terminus of the maculation is always straight to convex in the Fw and curves more or less towards the base in the Hw. The maculation of *N. ramburii* usually extends to Pt in both wings, meeting the posterior wing margin of the Hw between veins RP3-4 and the anal loop (Fig. 15d). This most common variant was found throughout its entire range. Sulawesian males are the longest with a total length of 40-44.5 mm, a Pt up to 4.5 mm and a very dense venation with the triangle in Fw consisting of up to 18 cells and the subtriangle of up to 40 cells. The wing maculation usually extending to the proximal end of Pt, reaching the posterior margin of Hw around the anal loop. The second variant is presented by the holotype of *N. ramburii* (Fig. 37), which resembles the Sulawesi specimens in size and density of wing venation, but has maculation extending only as far as the nodus (Fig. 15g), as in *N. ramburii martini* (Figs. 16a-b). Only four males of this second variant were found, from Sulawesi and Seram Island. The third variation in *N. ramburii* was found in material from Marinduque and Luzon on the Philippine Islands; some *N. ramburii* from Bali also have this type of maculation. These specimens have the posterior margin of the Hw hyaline and the terminus of the maculation is smoothly serrated (Fig. 15f). This variation includes the smallest specimens of *N. ramburii* with a total length of 33-39 mm, a Pt of 3-3.8 mm, the triangle of Fw consisting of up to 12 cells and the subtriangle of up to 21 cells. Occassionaly there are specimens with two cubital crossveins in all of these variations. Villanueva (2009) also mentioned a variation with a hyaline posterior wing margin found on Itbayat Island/Philippines but we were unable to examine these specimens.

The abdominal markings of *N. ramburii* females are similar to the male but are slightly more intensive (Fig. 19f). Some females from Sulawesi and the Philippines have a continuous lateral and dorsal stripe (as in fig. 19g for *N. ramburii martini*), thus approaching *N. manadensis* (Fig. 19d). The female vulvar scale of *N. ramburii* extends at an angle of about 90° to the abdomen (Fig. 24f), thus it appears more

erect than in other species and is a diagnostic character to separate e.g. *N. fluctuans* (Fig. 24b), *N. manadensis* (Fig. 24d) and *N. terminata* (Fig. 24j) from *N. ramburii*.

We have observed four to five wing variations and intermediate forms within female *N. ramburii*. An apparently rare variation with almost hyaline wings was found only in the Philippines. These females have a yellowish tinted area from the wing base to nodus, with the subcostal field and proximal area between vein MA and RP3-4 darker orange (Fig. 21b). A second heterochrome variation of *N. ramburii* was described by Kirby (1889) as *Untamo apicalis*. These females have slightly yellowish tinted wings of differing intensities but always with distinctly dark wing apices (Fig. 21c). This variation was found from the Philippines across the Maluku region, Sulawesi, Java to Bangkei Island (eastwards of Enggano Island and Sumatra). There is a similar colored variation in females of *N. terminata* ssp. (Figs. 23a & d) but this differs in the number of cubito-anal crossveins (more than one Cux in *N. terminata*), the shape of the abdomen (relatively slender in *N. terminata*) and the vulvar scale (at about a 45° angle to the abdomen in *N. terminata*).

The most common isochrome variation of *N. ramburii* is found in the Philippines, Sulawesi, Bawean Island, Java to Sumatra and Nias Island. The wing maculation extends almost to the Pt in both wings, its terminus is straight in the Fw and curves towards the wing base in the Hw, meeting the wing margin around the wing base so that there is a hyaline edge along the posterior margin (Fig. 21d). Such females occur as 'light' and 'dark' morphs. In the lighter morph the maculation is yellowish-brown with a more darkened distal area, which is why we call it a 'belted isochrome' (Fig. 21e). These belted isochrome females occur in the Philippines and Sulawesi and can approach variations of *N. manadensis* (Fig. 20f), *N. taiwanensis* (Fig. 22f) and *N. terminata* (Fig. 23b). A female collected by André Günther in Sulawesi in tandem with a male *N. ramburii* displays the belted isochrome wing pattern as well as continuous lateral abdominal markings as for *N. manadensis* (Fig. 19d), but the vulvar scale and the wing venation places it with *N. ramburii*. An isochrome female of *N. ramburii* from Lombok has three cubital crossveins thus approaching *N. terminata*, but wing maculation is that of *N. ramburii*. These intermediate forms may indicate interbreeding as e.g. Kosterin (2014) supposed or they could just be rare extremes of variation. A rare variant of isochrome *N. ramburii* females has a wing maculation extending only to the nodus (Fig. 21f), thus resembling male *N. ramburii martini* (Figs. 16a-b). We have seen only six females of this variation: four collected in Sulawesi and two collected in the Philippines.

Size and wing venation:

♂: Tot 33-44.5 mm; Ab 20.4-28 mm; Fw length 27.4-36 mm; Hw length 27-32.5 mm; Pt 3-4.5 mm.

Antenodals Fw/Hw 13.5-23.5/11-16; subnodals Fw/Hw 9-16/10-16; triangle in Fw/Hw of 6-20/2-6 cells; subtriangle of 11-40 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 2-7/1(-3); cell rows of dc-field bordering Fw triangle 5-10; radial planate of 2-3 cell rows; medial planate of 2-4 cell rows.

♀: Tot 31.7-38.3 mm; Ab 19-24.5 mm; Fw length 27.3-33.8 mm; Hw length 26-34 mm; Pt 3-4.4 mm.

Antenodals Fw/Hw 14.5-18.5/11-16; subnodals Fw/Hw 9-14/9-13; triangle in Fw/Hw of 2-9/2-4 cells; subtriangle of 5-16 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 2-5/1(-2); cell rows of dc-field bordering Fw triangle 4-7; radial planate of 1-2 cell rows; medial planate of 1-3 cell rows.

Remarks:

Neurothemis incerta Brauer, 1867 (Fig. 38), described from a female, was tentatively treated as a synonym of *N. stigmatizans manadensis* by Ris (1911). Bridges (1994) and Steinmann (1997) assign *N. incerta* to *N. fluctuans*. However the pattern of lateral markings on the relatively stout abdomen (not continuous as for *N. manadensis*, nor short streaks as for *N. fluctuans*, abdomen not relatively slender as in *N. manadensis* and *N. fluctuans*), the short Pt (not as long as is typical for *N. manadensis*) and especially the upright vulvar scale (at about a 45° angle to the abdomen in *N. manadensis* and *N. fluctuans*), as well as wing venation (less dense than usually seen in *N. manadensis*) place this species as a junior synonym of *N. ramburii*. Although St. Quentin (1970) did not mention this type specimen, it was re-discovered at NHMW by the first author.

Fig. 40: Male holotype of *Neurothemis martini* Krüger, 1903, currently treated as subspecies of *Neurothemis ramburii* (Brauer, 1866). Deposited at MZPW. Picture: Robert Rozwalka.

Neurothemis ramburii martini (Krüger, 1903)

Neurothemis martini Krüger, 1903. Krüger (1903): 263-264.

Neurothemis palliata martini (Krüger, 1903). Ris (1911): 557.

Figures:

8 (map); 16a-b (♂ wings), 19g (♀ abdomen), 22a (♀ wings); 40 (♂ holotype of *Neurothemis martini* Krüger, 1903).

Type material examined (1 ♂):

1 ♂ (via photograph only): Kai Islands, R. Martin leg.; holotype of *Neurothemis martini* Krüger, 1903); deposited at MZPW (Fig. 40).

Further material examined (9 ♂♂, 1 ♀):

INDONESIA, Lesser Sunda Islands – 1 ♂: September 1896, Sumba Island, Everett leg. (SMF).

INDONESIA, Maluku Islands – 1 ♂: Kai Islands, Coll. Selys (RBINS); 1 ♂, 1 ♀: Kai Islands, R. Martin leg. (SMF); 6 ♂♂: March 2013, Sanana Island, North Maluku, purchase from 'Exotic Insects'/Indonesia (MWNH).

Distribution:

This subspecies was only known from the Kai Islands but during this study we examined similar specimens from Sanana and Sumba Islands (Fig. 8, green dots).

Characterization:

The abdominal markings of *N. ramburii martini* males as well as the vesica spermalis resemble those of *N. ramburii* (Figs. 13f, 18f). The wing maculation of male *N. ramburii martini* extends as far as the proximal end of the bridge in both wings in specimens from the Kai Islands (Fig. 16a). Specimens from Sanana Island and a male labelled as from Sumba Island have maculation extending to the nodus (Fig. 16b). Its terminus is always convex in Fw and curving towards the base in Hw, leaving a broad posterior hyaline area. The veins of the hyaline area bordering the wing maculation are black rather than red, unlike the nominate subspecies and *N. ramburii oceanis*. The wing venation is less dense compared to the nominate subspecies: In *N. ramburii martini* the radial planate usually subtends one cell row and many single and less doubled cells occur beneath veins RP2 and IR2 and, on average, beneath MA and RP3-4, while in *N. ramburii* the radial planate consisting of at least two cells and the cells beneath veins RP2 and IR2 and MA and RP3-4 are almost exclusively doubled or consisting of three cell rows. Specimens from Sanana Island include some matching *N. ramburii martini* as well as specimens with the most common wing maculation of the nominate subspecies; some specimens with

intermediate appearance between the two were examined (compare figs. 15d-e with figs. 16a-b).

The only female of *N. ramburii martini* examined has a continuous dark lateral and dorsal stripe on the abdomen (Fig. 19g), thus differing from the main females of the nominate subspecies (Fig. 19f) but approaching females of *N. manadensis* (Fig. 19d) or *N. stigmatizans* ssp. (Figs. 19h-i). Similar females were rarely found e.g. in Sulawesi in the range of the nominate subspecies. The female vulvar scale is the same as in *N. ramburii* (Fig. 24f). The female *N. ramburii martini* has hyaline wings with slightly brownish apices (Fig. 22a) as stated by Ris (1911). As in the males the wing venation is less dense with a radial planate and medial planate consisting of one cell row and many single and less doubled cells occur beneath veins RP2 and IR2 and beneath MA and RP3-4.

Size and wing venation:

♂: Tot 36-39 mm; Ab 22-24.5 mm; Fw length 29-33.3 mm; Hw length 27-32.5 mm; Pt 3,5-4 mm.

Antenodals Fw/Hw 14.5-19.5/11-14; subnodals Fw/Hw 10-13/10-15; triangle in Fw/Hw of 7-13/2-4 cells; subtriangle of 11-28 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 2-4/1(-2); cell rows of dc-field bordering Fw triangle 6-8; radial planate of 1-2 cell rows; medial planate of 2-3 cell rows.

♀: Tot 36 mm; Ab 22 mm; Fw length 32 mm; Hw length 31 mm; Pt 3.5 mm.

Antenodals Fw/Hw 15.5/12; subnodals Fw/Hw 10/11; triangle in Fw/Hw of 3/2 cells; subtriangle of 5-6 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3/1; cell rows of dc-field bordering Fw triangle 3-4; radial planate of 1 cell row; medial planate of 1 cell row.

Remarks:

Steinmann (1997) incorrectly stated that the holotype of *Neurothemis martini* Krüger, 1903 is at ZMB, but it is deposited in the MZPW.

Neurothemis ramburii oceanis Lieftinck, 1948

Neurothemis ramburii oceanis Lieftinck, 1948. Lieftinck (1948): 297-298.

Figures:

8 (map); 16c (♂ wings); 41 (♂ holotype of *Neurothemis ramburii oceanis* Lieftinck, 1948).

Fig. 41: Male holotype of *Neurothemis ramburii oceanis* Lieftinck, 1948 with labels. Deposited at RMNH. Picture: Copyright RMNH.

Type material examined (1 ♂):

1 ♂ (via photograph only): 5.6.1936, Buahbuah, Enggano Island, J. K. de Jong leg.; holotype of *Neurothemis ramburii oceanis* Lieftinck, 1948; deposited at RMNH (Fig. 41).

Further material examined (1 ♂):

INDONESIA, Sumatra – 1 ♂: Malakoni, Enggano Island, H. Kähler leg. (ZHM).

Distribution:

This taxon is known from Enggano Island west of southern Sumatra (Fig. 8, blue dot).

Characterization:

The abdominal markings of both males of *N. ramburii oceanis* examined resemble those of the nominate subspecies (Fig. 13f). The wing maculation extends to about the

middle of the Pt with its terminus straight to convex in Fw and curving towards base in Hw (Fig. 16c); it cannot be used to distinguish *N. ramburii oceanis* from the nominate subspecies (Fig. 15d) since there are several specimens with similar maculation, especially within the western part of its range. The wing venation of *N. ramburii oceanis* is denser than in the mean of specimens of the nominate subspecies.

Size and wing venation:

♂: Tot 35-40.1 mm; Ab 21-26 mm; Fw length 33-33.6 mm; Hw length 27-31 mm; Pt 3 mm. Antenodals Fw/Hw 20.5-21.5/14-18; subnodals Fw/Hw 15/12-15; triangle in Fw/Hw of 12-16/6-8 cells; subtriangle of 25-39 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 5-6/1(-2); cell rows of dc-field bordering Fw triangle 7-9; radial planate of 3 cell rows; medial planate of 3 cell rows.

♀, according to Lieftinck (1948): Ab 20-22 mm; Hw length 27-30 mm.

Cross veins in cubito-anal space of Hw (Cux) 1.

Remarks:

Males of *N. ramburii* from Bawean Island (north of East Java) are similar to *N. ramburii oceanis* in appearance but are listed under the nominate subspecies here. A heterochrome female *N. ramburii* from Bangkei Island (eastcoast of Enggano Island; resembling fig. 21c) is geographically linked with *N. ramburii oceanis;* but Lieftinck (1948) listed only isochrome females which is why this specimen was listed under the nominate subspecies here.

Although further work is needed, it seems likely that *N. ramburii oceanis* would be better considered as a junior synonym to *N. ramburii* rather than as a subspecies.

Neurothemis stigmatizans (Fabricius, 1775)

Libellula stigmatizans Fabricius, 1775. Fabricius (1775): 421.

Libellula oculata Fabricius, 1775. Fabricius (1775): 421.

Figures:

9 (map); 13g (♂ abdomen); 16d (♂ wings), 18g (♂ vesica spermalis); 19h (♀ abdomen), 22b (♀ wings); 24g (♀ vulvar scale); 42 (♀ holotype of *Libellula stigmatizans* Fabricius, 1775); 43 (♂ holotype of *Libellula oculata* Fabricius, 1775).

Type material examined (1 ♂, 1 ♂):

1 ♀ (via photograph only): Australia; holotype of *Libellula stigmatizans* Fabricius, 1775; deposited at BMNH as Campion (1917) published (Fig. 42).

1 ♂ (via photograph only): Australia; holotype of *Libellula oculata* Fabricius, 1775; deposited at BMNH as Campion (1917) published (Fig. 43).

Fig. 42: Female holotype of *Libellula stigmatizans* Fabricius, 1775 with labels. Deposited at BMNH. Picture: Copyright BMNH.

Fig. 43: Male holotype of *Libellula oculata* Fabricius, 1775 with labels, currently considered a junior synonym of *Neurothemis stigmatizans* (Fabricius, 1775). Deposited at BMNH. Picture: Copyright BMNH.

Further material examined (45 ♂♂, 19 ♀♀):

AUSTRALIA – 10 ♂♂, 1 ♀: Cape York, Queensland (NHMW); 1 ♂: Victoria, Queensland (SMNS); 2 ♂♂, 2 ♀♀: Bowen, Queensland, Coll. Selys (RBINS); 1 ♂, 2 ♀♀: Bowen,

Queensland, ex-Museum Godeffroy (ZMH); 2 ♂♂: Gayndah, Queensland, ex-Museum Godeffroy (ZMH); 2 ♂♂, 1 ♀: Redlynch, Queensland (ZMB); 2 ♂♂, 2 ♀♀: Atherton, Queensland, E. Mjöberg leg. (ZMB); 1 ♂: Yarrabah, Queensland, E. Mjöberg leg. (ZMB); 1 ♂, 2 ♀♀: Cape York, Queensland, Dämel leg. (ZMB); 2 ♂♂, 2 ♀♀: October-December 1881, Torres Strait, Cape York, Queensland, O. Finsch leg. (ZMB); 2 ♂♂, 1 ♀: January 1908, Cooktown, North Queensland, R. J. Tillyard leg. (SMF); 1 ♂: 18.3.1910, Thursday Island, Torres strait, Elgner leg. (SMF); 2 ♂♂: 19.3.1910, Thursday Island, Torres strait, Elgner leg. (SMF); 3 ♂♂, 1 ♀: 21.3.1910, Thursday Island, Torres strait, Elgner leg. (SMF); 1 ♂: 22.3.1910, Thursday Island, Torres strait, Elgner leg. (SMF); 1 ♂: 29.3.1910, Thursday Island, Torres strait, Elgner leg. (SMF); 1 ♂: 14.7.1910, Cape York, Queensland, Elgner leg. (SMF); 1 ♂, 1 ♀: 15.7.1910, Cape York, Queensland, Elgner leg. (SMF); 1 ♂, 1 ♀: 16.7.1910, Cape York, Queensland, Elgner leg. (SMF); 1 ♀: 17.7.1910, Cape York, Queensland, Elgner leg. (SMF); 2 ♂♂, 1 ♀: 9.11.1910, Cape York, Queensland, Elgner leg. (SMF); 2 ♂♂: 8. & 10.10.1959, Gordonvale, Queensland, 'E. Sicreen' leg. (ZFMK); 1 ♂, 1 ♀: March 1969, Cairns, Queensland, Müller leg. (OLML); 3 ♂♂: 29.-31.10.1984, Minjil Beach, Darwin, Northern Territory, L. Börzsöny leg. (ZSM).

Distribution:

This taxon occurs in northern Australia and ranges from Thursday Island to southern Queensland and along the coastal areas of Northern Territory (Fig. 9). According to Michalski (2012) *N. stigmatizans stigmatizans* occurs within New Guinea as well, but this could not be confirmed with the specimens examined in this study.

Characterization:

Male *N. stigmatizans stigmatizans* have dark dorsal and lateral abdominal markings that are almost continuous from S3-9 (Fig. 13g). The overal size as well as the wing maculation of *N. stigmatizans stigmatizans* (Fig. 16d) approaches that of *N. fluctuans* (Figs. 14b-e). The wing maculation extends from about four cells proximal of the Pt to its beginning. The terminus is straight or convex in the Fw, usually reaching the posterior wing margin around veins RP3-4 and MA. In the Hw the terminus is strongly curved towards the wing base, reaching the posterior wing margin in the region from the anal loop to the base and leaving a broad sector of up to five cells hyaline. The vesica spermalis of *N. stigmatizans stigmatizans* has a pointed medial lobe, elongated and laterally developed anterior lobes and comparatively tall and elongated hairy lateral knobs (Fig. 18g). We were unable to separate the nominate subspecies from *N. stigmatizans bramina* (Fig. 18h) using the vesica spermalis morphology, but compared to *N. manadensis* (Fig. 18d) and *N. terminata* (Fig. 18j) the lateral lobes of segment V4 are usually slightly longer. These four taxa share the pointed medial lobe with comparatively tall and elongated hairy lateral knobs.

Abdominal markings of female *N. stigmatizans stigmatizans* (Fig. 19h) are similar to the male. The vulvar scale extends at an angle of about 45° to the abdomen (Fig. 24g) and we were unable to find diagnostic characters here. Only heterochrome

females occur in *N. stigmatizans stigmatizans*; the wings are usually tinted yellowish as far as around midway between the nodus and the Pt, with a dark patch distal of the nodus and dark apices (Fig. 22b).

Size and wing venation:

♂: Tot 33.4-39.2 mm; Ab 21.5-25.4 mm; Fw length 25-30.3 mm; Hw length 23-29.4 mm; Pt 3.8-5.2 mm.

Antenodals Fw/Hw 12.5-16.5/11-12; subnodals Fw/Hw 9-12/9-13; triangle in Fw/Hw of 6-11/2-4 cells; subtriangle of 8-20 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-7/2-4; cell rows of dc-field bordering Fw triangle 4-7; radial planate of 2-3 cell rows; medial planate of 2-3 cell rows.

♀: Tot 31.7-35.5 mm; Ab 18-22.5 mm; Fw length 25.6-29.7 mm; Hw length 21-29 mm; Pt 3-5 mm.

Antenodals Fw/Hw 12.5-15.5/9-13; subnodals Fw/Hw 9-11/8-11; triangle in Fw/Hw of 2-4/2 cells; subtriangle of 4-8 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-6/3; cell rows of dc-field bordering Fw triangle 3-4; radial planate of 1-2 cell rows; medial planate of 1-2 cell rows.

Remarks:

Steinmann (1997) listed *Libellula elegans* Guérin, 1838 as a junior synonym of *N. stigmatizans stigmatizans*, but this is erroneous.

Neurothemis stigmatizans bramina (Guérin, 1838)

Libellula bramina Guérin, 1838. Guérin Méneville (1838): 195.

Neurothemis diplax Brauer, 1867. Brauer (1867a): 18.

Figures:

10 (map); 13h (♂ abdomen); 16e-f (♂ wings), 18h (♂ vesica spermalis); 19i (♀ abdomen), 22c-d (♀ wings); 24h (♀ vulvar scale); 44 (♂ holotype of *Libellula bramina* Guérin, 1838); 45 (♀ holotype of *Neurothemis diplax* Brauer, 1867).

Type material examined (1 ♂, 1 ♀):

1 ♂: Port Praslin, New Ireland, Durville leg., Coll. Selys; holotype of *Libellula bramina* Guérin, 1838; deposited at RBINS (Fig.44).

1 ♀: New Guinea, Coll. Kaup; holotype of *Neurothemis diplax* Brauer, 1867; deposited at HLMD (Fig. 45).

Fig. 44: Male holotype of *Libellula bramina* Guérin, 1838 with labels. Deposited at RBINS. Picture: Jérôme Constant, courtesy of RBINS.

Further material examined (154 ♂♂, 98 ♀♀):

INDONESIA, Maluku Islands – 1 ♂, 4 ♀♀: Kai Islands (ZMB); 2 ♂♂, 2 ♀♀: 1884, Jillo, Seram Island [?], Ribbe leg. (ZMB); 1 ♀: 20.3.1903, Obi Island [?], vend. H. Rolle (ZMH); 9 ♂♂, 10 ♀♀: 18.-28.11.1910, Aru Island, Elgner leg. (SMF); 7 ♂♂, 3 ♀♀: 11.-31.7.1911, Aru Island, Elgner leg. (SMF).

INDONESIA, West Papua – 2 ♂♂, 1 ♀: 21.6.1904, Merauke, Papua Province, Coll. Ris, via Museum Leiden (SMF); 1 ♀: 4.3.1905, Digoel, Papua Province, Coll. Ris, via Museum Leiden (SMF); 1 ♀: 20.-30.5.1910, Teba, M. Moszkowski leg. (ZMB); 2 ♂♂: 20.-25.6.1910, Samberi, M. Moszkowski leg. (ZMB); 2 ♀♀: 28.-30.6.1910, Samberi, M. Mosz-

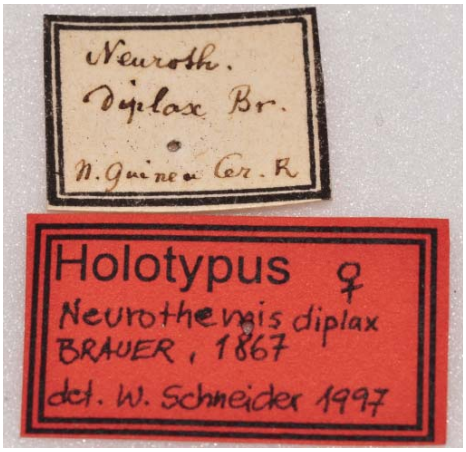

Fig. 45: Female holotype of *Neurothemis diplax* Brauer, 1867 with labels, currently considered a junior synonym of *Neurothemis stigmatizans bramina* (Guérin, 1838). Deposited at HLMD. Picture: Malte Seehausen.

kowski leg. (ZMB); 1 ♂, 1 ♀: 10.-13.7.1910, Taua, M. Moszkowski leg. (ZMB); 1 ♂: 26.10.1912, Kaimana, Elgner leg. (SMF); 2 ♀♀: 31.10.1912, Kaimana, Elgner leg. (SMF); 1 ♂: 4.11.1912, Kaimana, Elgner leg. (SMF); 1 ♂, 4 ♀♀: 10.11.1912, Kaimana, Elgner leg. (SMF); 1 ♂: 31.1.1996, Stream near Sabro Sari, Sentani, Jayapura, 2°28'52" S/140°22'24" E, Papua Province, A. Günther & F. Randow leg. (AG); 3 ♂♂: 2.2.1996, Lake Sentani, Jayapura, 2°35'56" S/140°30'42" E, Papua Province, A. Günther & F. Randow leg. (AG); 4 ♂♂: 24.2.1996, waste water pool near Demta, Sentani, Jayapura, 2°21'30" S/140°08'50" E, Papua Province, A. Günther & F. Randow leg. (AG); 2 ♂♂, 1 ♀: 25.2.1996, Stream at Lake Sentani, Jayapura, 2°35'56" S/140°30'42" E, Papua Province, A. Günther & F. Randow leg. (AG); 1 ♂: 1998, Adoki, 20 km west of Biak, Biak Island, M. Selwanus leg. (PMIRL); 1 ♂, 1 ♀: 14.4.1998, Nurwar, 20 km north of Biak, Biak Island, N. Naidenow leg. (PMIRL); 2 ♂♂, 5 ♀♀: February 2013, Nabire, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

NEW CALEDONIA – 2 ♂♂: New Caledonia (MNNW).

NEW GUINEA [without specification] – 1 ♂, 1 ♀: New Guinea (MNNW); 2 ♂♂, 1 ♀: New Guinea, Ramu Expedition (ZMB); 5 ♂♂, 3 ♀♀: New Guinea, H. Fruhstorfer leg. (ZMB); 1 ♂, 1 ♀: New Guinea, Dr. Hagen leg. (ZSM).

PAPUA NEW GUINEA – 1 ♂: Papua New Guinea (MWNH); 1 ♂: Deutsch-Neuguinea, Coll. Wiedenfeld (ZSM); 1 ♀: Rubiana, Solomon Islands (ZMB); 1 ♂: New Britain, Bismarck Archipelago, O. Finsch leg. (ZMB); 1 ♂: New Britain, Bismarck Archipelago (ZMB); 6 ♂♂, 3 ♀♀: Astrolabe Bay, Stichel leg. (ZMB); 5 ♂♂, 6 ♀♀: New Ireland, Bismarck Archipelago (ZMB); 2 ♂♂: New Ireland, Bismarck Archipelago (ZFMK); 4 ♂♂: 27.4.1882 & May 1882, Port Moresby, SE-Papua New Guinea, O. Finsch leg. (ZMB); 1 ♂, 1 ♀: 10.9.1896, Matupit, New Britain, M. Thiel leg. (ZMH); 8 ♂♂, 10 ♀♀: December 1896 - March 1897, Ralum and surroundings, Gazella Peninsula, New Britain, F. Dahl leg. (ZMB); 2 ♂♂, 3 ♀♀: 20.5.1904, Nusa Island, vend. H. Rolle (ZMH); 1 ♂: 18.4.1909, Huon Gulf (ZMB); 6 ♂♂, 1 ♀: 1912, Aitape, L. Cohn leg. (UMB); 2 ♀♀: 1912, Manus, L. Cohn leg. (UMB); 3 ♂♂, 1 ♀: 16.-18.4.1913, 'Standlager am Töpferfluss' [Keram River], Bürgers leg. (ZMB); 2 ♂♂: 20.-21.4.1913, 'Lager am Töpferfluss' [Keram River], Bürgers leg. (ZMB); 2 ♀♀: 14.5.1913, 'Standlager am Töpferfluss' [Keram River], Bürgers leg. (ZMB); 1 ♂: 19.-31.7.1913, Mäanderberg, East Sepik, Bürgers leg. (ZMB); 1 ♀: December 1919, Stephansort, Astrolabe Bay (ZSM); 1 ♂, 1 ♀: 1939, Bougainville Island, Coll. R. Oberthür (ZSM); 3 ♂♂, 4 ♀♀: 1939, Bougainville Island, Coll. R. Oberthür (ZFMK); 8 ♂♂: March 1963, Port Moresby, 40 miles north of Javarere (ZSM); 2 ♂♂, 1 ♀: 15.3.1963, Port Moresby, 40 miles north of Javarere (ZSM); 15 ♂♂, 6 ♀♀: 19.3.1963, Port Moresby, 40 miles north of Javarere (ZSM); 2 ♀♀: 16.7.1963, Bulldog, Gulf Province (ZSM); 2 ♂♂: 1.10.1986, Kavieng, New Ireland, Bismarck Archipel (ZSM); 2 ♂♂: 4.10.1986, Lavongai (New Hanover), Bismarck Archipel, N. J. leg. (ZSM); 1 ♂, 1 ♀: 22.10.1963, May River (Patrol Post), Sandaun Province (ZSM); 1 ♀: 29.4.1996, Ramu valley, Madang Province, T. F. leg. (PMIRL); 1 ♀: 21.5.1997, Bualu and Gobari Creeks, Morobe Province, D. Gassmann leg. (RMNH); 2 ♂♂: 26.5.1997, Creeks near Heldsbach, Huon Peninsula, Morobe Province, D. Gassmann leg. (RMNH); 1 ♂: 5.6.1997, Little Wau Creek, 7°20'36.7" S/146°42'25.9" E, Morobe Province, D. Gassmann & K. Yalamu leg. (RMNH); 1 ♂, 1 ♀: 13.6.1997, Swamp near Gaulim, 4°26'46.0" S/152°08'36.5 E, East New Britain Province, D. Gassmann leg. (RMNH); 1 ♂: 26.6.1997, Creek at connection road West/East coast, ca. 13 km southeast of Kavieng, 2°42'31.7" S/150°56'15.1" E, New Ireland Province, D. Gassmann leg. (RMNH); 1 ♂: 26.6.1997, Creek at connection road West/East coast, ca. 13 km southeast of Kavieng, 2°41'51.2" S/150°56'38.9" E, New Ireland Province, D. Gassmann leg. (RMNH); 2 ♂♂: 9.-10.6.2003, ‚Queen Emmas bath', 5 km westward Kokopo, 4°28' S/152°19'E, New Britain, T. Osten leg. (SMNS).

VANUATU – 7 ♂♂, 1 ♀: New Hebrides, Coll. R. Oberthür (ZFMK); 1 ♂, 1 ♀: New Hebrides, Coll. R. Oberthür (ZSM); 2 ♂♂: 9.11.2006, Mamasa River, 15.20976° S/166.67705° E, Espiritu Santo Island, A. Staniczek leg. (SMNS); 1 ♂: 10.11.2006, Mamasa River, 15.21343° S/166.67004° E, Espiritu Santo Island, A. Staniczek leg. (SMNS); 4 ♂♂, 2 ♀♀: 13.11.2006, Penaoru River, 14.96105° E/166.63319° E, Espiritu Santo Island, A. Staniczek leg. (SMNS).

Distribution:

The range of this taxon extends from the Kai Islands and Saonek Island (south of Waigeo) eastward across New Guinea and the Solomon Islands to Vanuatu (Fig. 10). Records from New Caledonia are considered to represent vagrants (Grand 2004); neither Campion (1921) nor Lieftinck (1975) mentioned *Neurothemis* species from New Caledonia. There are several specimens labelled as from Seram, Ambon and Obi Island corresponding to *N. stigmatizans bramina* although these islands are in the range of *N. manadensis*. All of these records concern historical material so that it may be that some of the locality labels are wrong. This possibility was considered by Ris (1911) and, e.g. the female labelled as from Obi Island was bought from the insect supplier H. Rolle; other problems with label data are known with material purchased from Rolle. Furthermore we found *N. stigmatizans bramina*, *N. manadensis* and specimens of intermediate appearance labelled as from the Kai Islands; recently collected specimens from Batanta Island, Sorong and Manokwari (West Papua, Indonesia) to Nabire (Papua, Indonesia) are of intermediate appearance as well (Fig. 17a). Thus the exact range of *N. stigmatizans bramina* and *N. manadensis* in western New Guinea and eastern Maluku islands needs further study.

Characterization:

Male *N. stigmatizans bramina* have the dark dorsal and lateral markings on the abdomen almost continuous from S3-9 (Fig. 13h), as in the nominate subspecies (Fig. 13g). The vesica spermalis of *N. stigmatizans bramina* (Fig. 18h) resemble the vesica spermalis of the nominate subspecies (Fig. 18g) and is very similar to those of *N. manadensis* (Fig. 18d) and *N. terminata* (Fig. 18j). The male has wing maculation extending to the proximal end of Pt or up to two cells distal of it. Its terminus is straight or convex and reaches the posterior wing margin usually around vein Rspl in the Fw; it is always curved toward the wingbase, reaching the posterior margin between vein Rspl and the anal loop (usually around veins RP3-4 and MP) in the Hw (Figs. 16e-f). *Neurothemis stigmatizans bramina* males from Vanuatu, the Solomon Islands and the Bismarck Archipelago (Fig. 16f) are usually the largest and have a denser wing venation (especially within the subtriangle) compared to the mainland specimens. In this character they are near to the western *N. manadensis* (Figs. 15a-b) and Krüger (1903) therefore concluded that *N. manadensis* occurs in the Solomon Islands and the Bismarck Archipelago. Specimens of *N. stigmatizans bramina* with such dense venation were also found in the western range (e.g. Biak Island) and within a heterogeneous series from Port Moresby; some of these specimens are of intermediate appearance (Fig. 17a) between *N. manadensis* and *N. stigmatizans bramina*.

Neurothemis stigmatizans bramina females have dark abdominal markings almost continuous from S3-9 on dorsal and lateral side (Fig. 19i), as in the males. The vulvar scale of *N. stigmatizans bramina* (Fig. 24h) is similar to the nominate subspecies (Fig. 24g) and without diagnostic features.

Heterochrome and isochrome females of *N. stigmatizans bramina* occur. Both are variable; Marinov & Pickacha (2013) showed an undescribed female variation

occuring on the Solomon Islands. We also found this female variant and suggest calling them isochrome as well, but it might be useful to introduce the term 'belted isochrome'. The wing venation of isochrome females is denser in the triangle (heterochrome 2-7/2-3 cells; isochrome 6-18/2-4 cells), subtriangle (heterochrome 5-10 cells; isochrome 9-37 cells), dc-field (heterochrome 3-5 cells; isochrome 4-8 cells) as well as in the radial and medial planate (heterochrome 1-2 cell rows; isochrome 2-3 cell rows). The terminus of the wing maculation in the Hw of isochrome *N. stigmatizans bramina* females is curved toward base, reaching the posterior wing margin around veins RP3-4 or near to the anal loop (Fig. 22c). Some isochrome specimens of *N. stigmatizans bramina* from the western part of the range approach the belted isochrome females of *N. manadensis* but the terminus in the Hw is always straight in *N. manadensis* (Figs. 20f-g) and at least slightly curved in *N. stigmatizans bramina*. Nevertheless the separation of both species may be difficult in the westernmost part of *N. stigmatizans bramina*'s range and several specimens appear intermediate. Heterochrome females of *N. stigmatizans bramina* (Fig. 22d) occur throughout the whole range, but especially in mainland New Guinea. They resembling females of the nominate subspecies (Fig. 22b) by having a yellow tinted wing base, dark apices and a dark patch around midway between nodus and Pt.

Size and wing venation:

♂: Tot 30-40 mm; Ab 18-24.8 mm; Fw length 22.8-30 mm; Hw length 22.6-29 mm; Pt 3.3-5.2 mm.

Antenodals Fw/Hw 13.5-20.5/10-15; subnodals Fw/Hw 10-17/10-18; triangle in Fw/Hw of 10-36/2-8 cells; subtriangle of 24-69 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-10/1-5; cell rows of dc-field bordering Fw triangle 7-13; radial planate of 2-4 cell rows; medial planate of 2-5 cell rows.

♀: Tot 27.4-36 mm; Ab 17-22.6 mm; Fw length 23.5-30.4 mm; Hw length 22-29.8 mm; Pt 3.3-4.9 mm.

Antenodals Fw/Hw 11.5-16.5/9-13; subnodals Fw/Hw 9-13/10-13; triangle in Fw/Hw of 2-18/2-4 cells; subtriangle of 5-37 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3-7/3-4; cell rows of dc-field bordering Fw triangle 3-8; radial planate of 1-2 cell rows; medial planate of 1-3 cell rows.

Remarks:

As currently understood *N. stigmatizans bramina* is very heterogenous. Since *Libellula bramina* Guérin, 1838 (Fig. 44) and *Neurothemis diplax* Brauer, 1867 (Fig. 45) were synonymized and classified as *Neurothemis stigmatizans bramina* by Ris (1911) there are specimens with dense venation approaching *N. manadensis* as well as specimens with less dense venation combined in one taxon (*Libellula bramina* represents, as Ris (1911) already mentioned, the form with very dense wing venation, occuring usually in the Bismarck Archipelago and the Solomon Islands whereas *Neurothemis diplax*

represents mainland New Guinea specimens with less dense venation). A heterogenous series of *N. stigmatizans bramina* from Port Moresby includes very small specimens, thus approaching *N. stigmatizans stigmatizans*; however we have not seen any specimen of *Neurothemis* from New Guinea and surroundings which have the distinct wing maculation of the Australian nominate subspecies. Since such small specimens are found in other areas, e.g. at Jayapura and surroundings in northeastern Papua Province of Indonesia, the idea that these small sized specimens may represent a hybrid zone with *N. stigmatizans* stigmatizans is unlikely and we consider them to be simply a small form of *N. stigmatizans bramina*.

There are some problems with the correct date of Guérin's descriptions of *Libellula elegans*, *Libellula apicalis* and *Libellula bramina*. The cover of the 'Voyage autour du monde', where Guérin published his descriptions, gives the year 1830, but a reference to *Libellula manadensis* Boisduval, 1835 is given in the description of *Libellula bramina*, indicating that this part at least was written later. Therefore the year 1832 as the date of description of these three taxa given by Kirby (1890) is already rebuted at least for *Libellula bramina*. Krüger (1903) dated Guérin's paper as from 1832-1838 and Ris (1911) gave the year 1838. Bridges (1994) again dated it 1832 and Steinmann (1997) gave the year 1838 for the descriptions of *Libellula elegans*, *Libellula apicalis* and *Libellula bramina* but the year 1830 for the description of *Agrion australis* Guérin which is found directly after the description of *Libellula bramina*. This confusing problem with the exact date of Guérin's publications was also mentioned by Bequaert (1926) and Evenhuis (2011). We follow Ris (1911) and Steinmann (1997) and consider the year 1838 for the descriptions of *Libellula elegans*, *Libellula apicalis* and *Libellula bramina* as best supported because Guérin dated his introduction as 15 November 1838. The same date could also be suggested for *Agrion australis* Guérin. Finally Guérin's name was Guérin Méneville since 1836 (Evenhuis 2011) and this name is also given in Duperrey's 'Voyage autour du monde'. Therefore it might be argued that 'Guérin Méneville' should be used as the authority. But we found both notations within the publication and Guérin himself only added 'Guérin' behind his taxa, thus we consider that no modification is needed.

Neurothemis taiwanensis sp. nov.

Figures:

11 (map); 13i (♂ abdomen); 17b (♂ wings), 18i (♂ vesica spermalis); 19j (♀ abdomen), 22e-f (♀ wings); 24i (♀ vulvar scale); 46 (♂ holotype of *Neurothemis taiwanensis* sp. nov.).

Etymology: Named according to the main distribution.

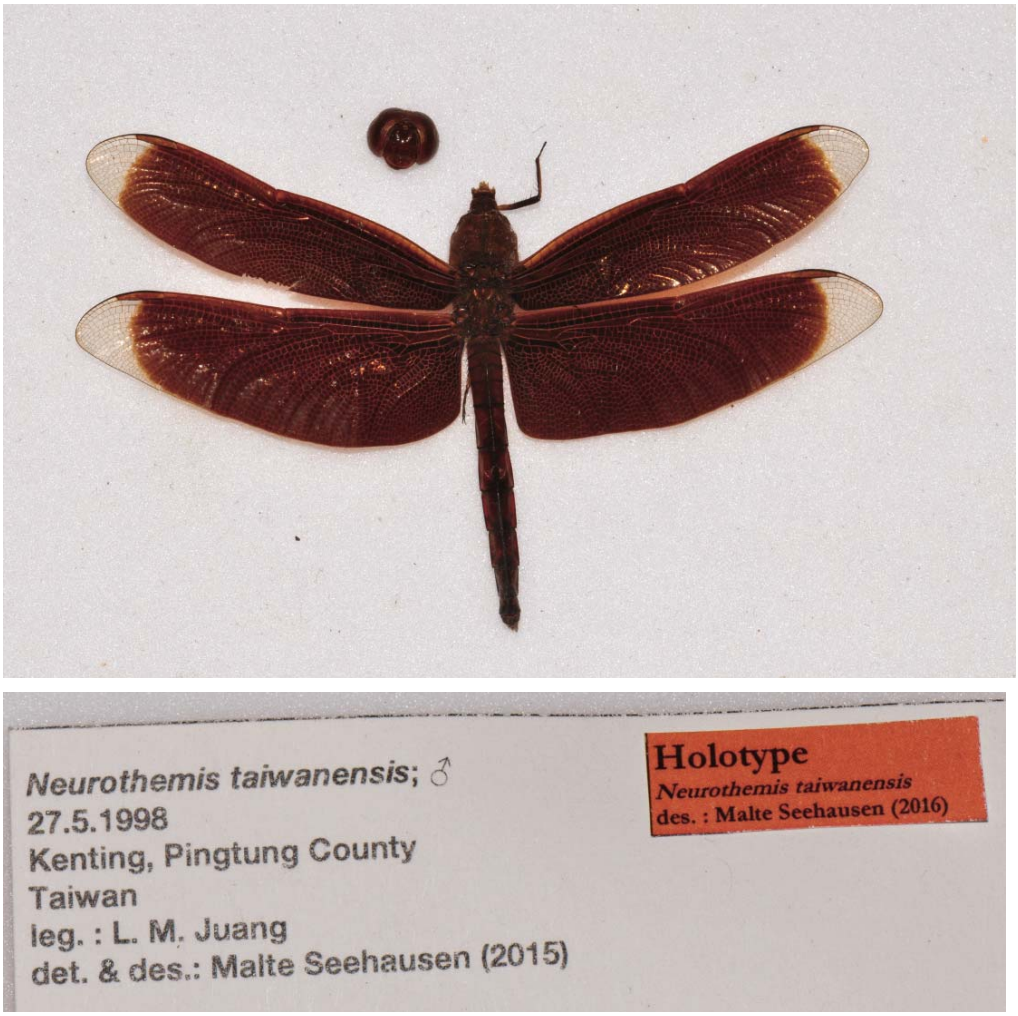

Fig. 46: Male holotype of *Neurothemis taiwanensis* with labels. Deposited at TFRI. Picture: Malte Seehausen.

Holotype:

1 ♂: 27.5.1998, Kenting, Pingtung County/Taiwan, L. M. Juang leg.; deposited at Taiwan Forestry Research Institute (TFRI), Taipei (Fig. 46).

Paratypes (37 ♂♂, 12 ♀♀):

TAIWAN – 1 ♂: 28.5.1904, Pilam [Taitung], Haberer leg. (ZMB); 5 ♂♂, 1 ♀: August 1908, Koshun [Hengchun, Pingtun County], H. Sauter leg. (RMNH); 1 ♂: 30.8.1907, Kagi [Chayi], H. Sauter leg. (ZMB); 1 ♂: 30.8.1907, Zentai [Tainan], H. Sauter leg. (ZMB); 1 ♂: January 1908, Kosempo, H. Sauter leg. (ZMH); 1 ♂: 20.5.1908, Kanshirei [Kuantzuling, Tainan], H. Sauter leg. (UMB); 1 ♀: 20.7.1908, Taihanroku [Kenting National park, Pingtung County], H. Sauter leg. (UMB); 1 ♂: 3.-10.8.1908, Taihanroku [Kenting National park, Pingtung County], H. Sauter leg. (ZMB); 1 ♂: August 1908, Taihanroku [Kenting National park, Pingtung County], H. Sauter leg. (ZMB); 14 ♂♂, 3 ♀♀: August 1908, Taihanroku [Kenting National park, Pingtung County], H. Sauter

leg. (SMF); 6 ♂♂, 4 ♀♀: April 1910, Tainan, Rolle leg. (SMF); 2 ♂♂: 9.4.1932, Kotombo [?] (RMNH); 1 ♂: 27.5.1998, Kenting, Pingtung County, L. M. Juang leg. (MWNH); 1 ♂: 6.9.1998, Taipei City, W. C. Yeh leg. (MWNH); 1 ♀: 6.11.1999, Dajianpingshan Hsitzu, Xizhi, Taipei, W. C. Yeh leg. (MWNH); 1 ♀: 25.10.2003, Donhu, Taipei City, W. C. Yeh leg. (TFRI); 1 ♂, 1 ♀: 26.8.2013, Lanyu Island, Taitung, W. C. Yeh leg. (TFRI).

Description of male holotype (Fig. 46)

Head: Vertex, frons and clypeus reddish; labrum with more orange impression; labium ocher.

Thorax: Brownish-ocher without distinct markings.

Legs: Femur and tibia light ocher; tarsus slightly darker ocher; dark brown around joints; spines blackish.

Wings: Brown wing maculation extending as far as middle of Pt; its terminus in Fw slightly convex and reaching posterior wing margin at vein IR2; its terminus in Hw slightly curved towards base and reaching posterior margin midway between veins IR2 and RP3-4; wing venation reddish as far as the apices where venation of outermost cells black; costa of both wings reddish to Pt where becomes black; Pt reddish-ocher. Antenodals Fw/Hw 19.5-20.5/14-16.5; subnodals Fw/Hw 10-11/11-12; triangle in Fw/Hw of 12-13 cells/3-4 cells; subtriangle of 16-19 cells; crossveins in cubito-anal space of Fw/Hw (Cux) 4-5/1; cell rows of dc-field bordering Fw triangle 7-8; radial planate of 2-3 cell rows; medial planate of 3 cell rows.

Abdomen: Red with black markings as follows; S4-S8 laterally with a dark stripe around middle of each segment distinct on last segments but fading on anterior segments; S9 laterally with broad dark stripe fusing with dorsal markings; S4-S9 dorsal with dark medial stripe expanding to cup-like shape apically on each segment; S10 dorsal completely black; carina and ridges black; appendages light ocher.

Measurements: Tot 41.5 mm; Ab 26.5 mm; Fw length 34 mm; Hw length 33 mm; Pt Fw 3.6 mm.

Variation within males: The dark abdominal markings of *N. taiwanensis* (Fig. 13i) are almost homogenuous. The wing maculation of *N. taiwanensis* males (Fig. 17b) extends at least to the proximal end of Pt, but usually up to the middle of Pt with the terminus slightly curved towards the wing base, reaching the posterior wing margin around vein IR2 to midway between veins IR2 and RP3-4. Some males have up to three cubital crossveins in Hw. The medial process of the vesica spermalis of *N. taiwanensis* (Fig. 18i) has a tall medial lobe, bifid in ventral view, and lacks lateral knobs.

Size and wing venation of male paratypes:

Tot 37.4-42 mm; Ab 23.7-25.6 mm; Fw length 31-33.7 mm; Hw length 30-33.3 mm; Pt 3.6-4.6 mm.

Antenodals Fw/Hw 15.5-20.5/12-15; subnodals Fw/Hw 10-14/10-12; triangle in Fw/Hw of 7-12/2-5 cells; subtriangle of 10-22 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3-7/1(-3); cell rows of dc-field bordering Fw triangle 5-8; radial planate of 2-3 cell rows; medial planate of 2-3 cell rows.

Description of female

Head: Vertex, frons and clypeus brownish; labrum and labium light ocher.

Thorax: Brownish-ocher without distinct markings.

Legs: Femur and tibia light ocher; tarsus slightly darker ocher; dark brownish around joints; spines blackish.

Wings: Brown wing maculation of isochrome females (Fig. 22e) extending to one cell proximal of Pt or as far as Pt in Fw, its terminus almost straight to convex and meeting the posterior wing margin around midway between veins IR2 and RP3-4; in Hw the maculation extending as far as the Pt and its terminus slightly convex, around midway between veins IR2 and RP3-4 abruptly curving towards base and leaving a small edge of posterior wing margin hyaline. Venation reddish as far as the apices where the venation of outermost cells is black; apices often tinted smoky brown; costa of both wings reddish to Pt were it is turning black; Pt reddish-ocher. One female has belted isochrome wings with a dark band around the terminus of the wing maculation (Fig. 22f).

Abdomen: Usually the abdomen of *N. taiwanensis* females is yellow-ocher with black markings as follows (Fig. 19j): S3-S8 lateral with a dark stripe interrupted towards posterior end of each segment; S9 laterally with broad dark stripe fused with dorsal markings; S3-S9 dorsal with dark medial stripe expanding to cup-like shape apically on each segment; S10 dorsal completely black, carina and ridges black; appendages light ocher; vulvar scale extending at an angle of about 90° to the abdomen (Fig. 24i).

Size and wing venation of female paratypes:

Tot 35-36.5 mm; Ab 21-22.4 mm; Fw length 31-33.5 mm; Hw length 29.5-32.4 mm; Pt 3.5-4.5 mm.

Antenodals Fw/Hw 15.5-17.5/12-16; subnodals Fw/Hw 10-13/11-12; triangle in Fw/Hw of 4-8/2-4 cells; subtriangle of 4-11 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3-5/1(-3); cell rows of dc-field bordering Fw triangle 4-6; radial planate of 1-2 cell rows; medial planate of 1-2 cell rows.

Distribution:

This species occurs in Taiwan and Lan Yu Island (Lieftinck et al. 1984) and was recently recorded from Yonaguni-jima (Ozono et al. 2007) and Iriomote-jima (Kobayashi 2014) of the Japanese Ryu-Kyu Islands (Fig. 11).

Diagnosis:

Compared to the other species, except *N. ramburii*, males as well as females of the Taiwanese species differ in the the presence of usually only one crossvein in the cubito-anal space, the wing maculation, in an upright vulvar scale as well as in the vesica spermalis.

The best character to separate male *N. taiwanensis* from *N. ramburii* is the homogenuous wing maculation, which appears intermediate between *N. ramburii* and

N. terminata. Males of *N. taiwanensis* and of *N. ramburii* have a wing maculation extending to the Pt. But compared to *N. ramburii* the terminus of the wing maculation in the Hw of *N. taiwanensis* is only slightly curving towards the base, reaching the posterior margin around midway between the vein IR2 and RP3-4 (Fig. 17b). In *N. ramburii* the wing maculation reaching the posterior margin of the Hw between veins RP3-4 and anal loop or even proximal of it (Figs. 15d-g). We are unable to separate *N. ramburii* and *N. taiwanensis* by using vesica spermalis morphology.

In isochrome females of *N. taiwanensis* (Fig. 22e) the wing maculation is less curved towards base compared to *N. ramburii* (Figs. 21d-f). Females of *N. taiwanensis* with belted isochrome wing maculation (Fig. 22f) approaching the corresponding variations of *N. ramburii* (Fig. 21e), *N. terminata* (Fig. 23b) and *N. manadensis* (Fig. 20f). Diagnostic differences compared to *N. terminata* and *N. manadensis* are the upright vulvar scale of *N. taiwanensis* as well as the presence of usually only one crossvein in the cubito-anal space. Belted isochrome females of *N. ramburii* and *N. taiwanensis* may not be separable except by geography.

Remarks:

The occurence of a 'reddish-brown-winged' *Neurothemis* species in Taiwan was first noted by Ris (1911) who assigned them to '*N. palliata*' but mentioned that they have intermediate attributes between '*N. palliata*' and *N. terminata*. According to Ris the wing venation of the Taiwanese specimens refers to '*N. palliata*' (usually one Cux), but they have a wing maculation approaching *N. terminata* in that it extends more distally than in '*N. palliata*' and its terminus is not strongly curved towards the wing base. Ris (1916) referred to them as '*N. palliata* forma'. Lieftinck et al. (1984: 54) mentioned that the Taiwanese specimens look 'almost exactly intermediate between typical *ramburii* Brauer (type-loc.: Celebes) and *terminata* Ris (type-loc.: Java)'. But Lieftinck et al. (1984: 54) also stated that the Taiwanese specimens 'approaches most closely a Philippine subspecies of *terminata* occurring in Luzon, which itself comes nearest typical *terminata*'. This is confusing because there is no subspecies of *N. terminata* described from the Philippines. However, Lieftinck et al. (1984) concluded that the Taiwanese specimens approach *N. terminata*; they listed them as *Neurothemis ramburii* vers. *terminata*. Wang & Heppner (1997) listed the Taiwanese specimens as *N. ramburii* and do not refer to any intermediate appearance.

We have only examined isochrome and belted isochrome females; also Wen-Chi Yeh mentions that he never seen females with hyaline wings (Wen-Chi Yeh, pers. comm.) although Lieftinck et al. (1984) stated their occurrence.

We were unable to separate *N. taiwanensis* and *N. ramburii* by using characters of the vesica spermalis, thus *N. taiwanensis* might be just a subspecies. But the other evidence available at present favours classifying these Taiwanese *Neurothemis* as a separate species. Molecular studies might shed further light on the relationship of *N. taiwanensis* to *N. ramburii* and further studies into the vesica spermalis could be made using SEM or Micro-CT images.

Neurothemis terminata Ris, 1911

Polyneura apicalis Rambur, 1842. Rambur (1842): 127.

Neurothemis terminata Ris, 1911. Ris (1911): 569-572.

Figures:

12 (map); 13j (♂ abdomen); 17c (♂ wings), 18j (♂ vesica spermalis); 19k (♀ abdomen), 23a-c (♀ wings); 24j (♀ vulvar scale); 47 (♂ holotype of *Polyneura apicalis* Rambur, 1842); 48 (♂ syntype of *Neurothemis terminata* Ris, 1911).

Type material examined (3 ♂♂):

1 ♂: without locality label, Coll. Selys; holotype of *Polyneura apicalis* Rambur, 1842; deposited at RBINS (Fig. 47).

1 ♂: Indes orientales [Malay Archipelago], Coll. Selys; syntype of *Neurothemis terminata* Ris, 1911; deposited at RBINS (Fig. 48).

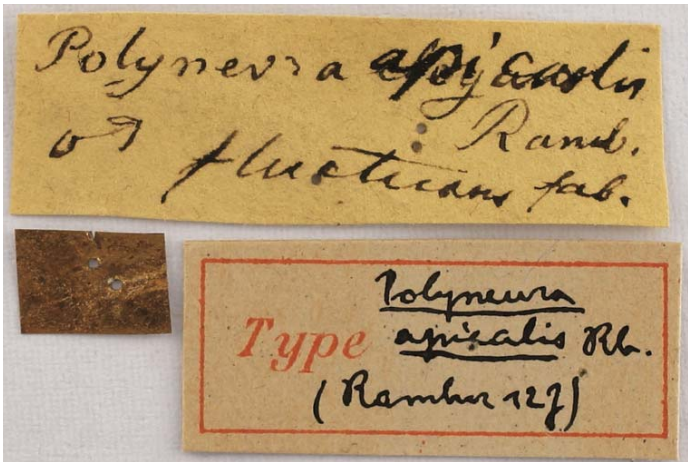

Fig. 47: Male holotype of *Polyneura apicalis* Rambur, 1842 with labels, currently *Neurothemis terminata* Ris, 1911. Deposited at RBINS. Picture: Jérôme Constant, courtesy of RBINS.

Fig. 48: Male syntype of *Neurothemis terminata* Ris, 1911 with labels. Deposited at RBINS. Picture: Malte Seehausen.

1 ♂: without locality label, Coll. Selys; syntype of *Neurothemis terminata* Ris, 1911; deposited at RBINS.

Further material examined (360 ♂♂, 104 ♀♀):

INDONESIA, Java – 4 ♂♂: Batavia [Jakarta], Coll. Selys (RBINS); 2 ♂♂, 1 ♀: Java (ZSM); 2 ♂♂: Java, de Haan leg. (ZMB); 5 ♂♂: East Java, Fruhstorfer leg. (ZMB); 1 ♂: Java, Fruhstorfer leg. (ZMB); 28 ♂♂, 2 ♀♀: Batavia [Jakarta], Zobrys & Wolter leg. (ZMB); 38 ♂♂, 14 ♀♀: Sukabumi, West Java, Coll. Le Moult (ZMH); 1 ♂: Java, Ploem leg., ex-Coll. Selys (UMB); 1 ♂: Java, ex-Coll. Norwich (UMB); 4 ♂♂: Buitenzorg [Bogor], Lambreth leg. (NHMW); 1 ♀: August 1892, Mons Gede, Fruhstorfer leg. (ZMB); 4 ♂♂: 1893, Sukabumi, H. Fruhstorfer leg. (ZMB); 1 ♂: 1895, Buitenzorg [Bogor], Adensamer leg. (NHMW); 7 ♂♂: 1895, Java, Dr. Arnold leg. (SMNS); 2 ♂♂: 1902, Java (ZSM); 1 ♂:

21.7.1909, Tjastana, South Preanger, West Java, Roepke leg. (SMF); 2 ♂♂: 1913, Java, Sesoeroe leg. (BMNH); 3 ♂♂: 15.-22.10.1924, Bogor, West Java, H. Winkler leg. (ZHM); 1 ♂: 10.8.1930, Buitenzorg [Bogor], Coll. Karny (NHMW); 1 ♂: 30.9.1939, Buitenzorg [Bogor] (ZSM); 1 ♀: 23.9.1951, Panaitan Island, Sunda Strait (ZSM); 2 ♂♂: 2.5.1954, Bawean Island (ZSM); 1 ♂: 1.6.1954, Bawean Island (ZSM); 3 ♂♂: 6.6.1954, Bawean Island (ZSM); 2 ♂♂: 7.10.1960, Kebun Raya Bogor, Province Jawa Barat, Hamann leg. (OLML); 2 ♂♂: 9.10.1960, Gunung Salak, Province Jawa Barat, Hamann leg. (OLML); 10 ♂♂, 5 ♀♀: 4.12.1960 (1 ♂, 1 ♀), 22.12.1960 (1 ♀), 26.12.1960 (1 ♀), 8.1.1961 (1 ♂), 15.1.1961 (1 ♂, 1 ♀), 18.1.1961 (3 ♂♂, 1 ♀) & 30.4.1961 (4 ♂♂), Salak, Province Jawa Barat, Manis leg. (OLML); 3 ♂♂: 22.12.1960 (1 ♂), 13.1.1961 (1 ♂) & 21.4.1961 (1 ♂), Kebun Raya Bogor, Province Jawa Barat, Manis leg. (OLML); 1 ♂: 26.4.1961, proper locality non-readable, Manis leg. (OLML); 5 ♂♂: 22.8.1973, Botanical Garden of Bogor, West Java, G. von Rosen leg. (ZSM).

INDONESIA, Kalimantan – 1 ♂: 11.5.1893, Amuntai Province, South Kalimantan, Burchard leg. (ZMH); 2 ♂♂: 31.12.1895, Tanjung, South Kalimantan, F. Suck leg. (ZMH); 3 ♂♂: 1.-7.1.1925, Lebang Hara, West Kalimantan, H. Winkler leg. (ZMH); 2 ♀♀: April-May 1948, Ampah, SE Borneo, Central Kalimantan, L. S. Liong leg. (ZSM); 1 ♂: May 2013, Malinau regency, North Kalimantan, purchase from 'Giradys Insect Supply'/Indonesia (MWNH).

INDONESIA, Lesser Sunda Islands – 1 ♂, 2 ♀♀: December 1896, Sumba Island, Coll. Selys (RBINS); 10 ♂♂, 5 ♀♀: Sumbawa Island, R. Martin leg. (SMF); 5 ♂♂, 4 ♀♀: April 1896, Sambalin, Lombok, H. Fruhstorfer leg. (ZMH); 12 ♂♂, 7 ♀♀: April 1896, Sapit, Lombok, H. Fruhstorfer leg. (ZMH); 1 ♂: November 1896, Flores Island, Everett leg. (SMF); 1 ♂: 1.9.1973, Tampaksirin, Bali, G. von Rosen leg. (ZSM); 1 ♂: 26.3.1994, Upud, 8°30'13.9" S/115°15'37.1" E, Bali, A. Günther leg. (AG); 3 ♂♂, 1 ♀: 25.8.1994, Sebatu, 8°27'31.1" S/115°16'31.0" E, Bali, A. Günther & F. Randow leg. (AG); 1 ♂: 29.12.1997, Tetebatu, 8°32'05.5" S/116°25'15.5" E, Lombok, A. Günther leg. (AG); 1 ♂: 30.12.1997, Tetebatu, 8°31'56.4" S/116°23'58.0" E, Lombok, A. Günther leg. (AG); 1 ♂: 31.12.1997, Tetebatu, 8°31'11.6" S/116°24'42.4" E, Lombok, A. Günther leg. (AG); 1 ♀: 18.8.2000, Upud, 8°31'11" S/115°15'34" E, Bali, A. Günther leg. (AG); 1 ♂: 11.9.2010, Sebatu, 8°23'34.4" S/115°17'33.1" E, Bali, A. Günther leg. (AG).

INDONESIA, Sumatra – 14 ♂♂, 5 ♀♀: Sumatra (NHMW); 2 ♂♂: 2.5. & 20.5.1928, Tandjung Karang, Reichwein leg. (MWNH); 1 ♂: 19.2.1995, Simpang Sompur, Lake Singkarak, A. Arnold leg. (AA); 1 ♀: 28.2.1995, Sicincin, A. Arnold leg. (AA); 1 ♀: 1.3.1995, Pangian Cave, Lintau, A. Arnold leg. (AA).

MALAYSIA, Sabah – 3 ♂♂: Banggi Island (ZMB); 6 ♂♂, 1 ♀: 20.7.1894, Banguey Island, northward Borneo, W. Kedenburg leg. (ZMH); 1 ♂: 30.8.1998, Mount Kinabalu Park, 6°12' N/116°33' E, D. Bartsch & C. Häuser leg. (SMNS).

MALAYSIA, Sarawak – 6 ♂♂, 1 ♀: 21.3. (3 ♂♂), 25.3. (1 ♂), 29.3. (1 ♀) & 30.4.1994 (2 ♂♂), Damai, Kuching, F. Kelschinske leg. (UMB); 1 ♂: 18.3.2005, Gunung Serapi, Kubah National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 22.3.2005, Bako National Park, Kuching division, G. T. Reels leg. (RAD); 1 ♂: 14.4.2005, Gunung Serapi, Kubah National Park, Kuching division, R. A. Dow leg. (RAD); 2 ♂♂, 1 ♀: 8.5.2005, Niah National Park, Miri

division, G. T. Reels leg. (RAD); 1 ♂: 29.1.2006, Gunung Gading National Park, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 3.2.2006, Lambir Hills National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 13.2.2006, Mentawei, Gunung Mulu National Park, Limbang division, J. Simun leg. (RAD); 1 ♂: 1.3.2006, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 5.3.2005, Samarakan, Bintulu division, R. A. Dow leg. (RAD); 2 ♀♀: 6.3.2005, Samarakan, Bintulu division, C. S. Yun leg. (RAD); 1 ♂: 26.3.2006, Long Aton, Miri division, R. A. Dow & G. T. Reels leg. (RAD); 1 ♂: 21.12.2007, north Tinjar area, Miri division, R. A. Dow leg. (RAD); 1 ♂: 1.2.2008, Similajau National Park, R. A. Dow leg. (RAD); 2 ♂♂: 1.2.2008, Similajau National Park, G. T. Reels leg. (RAD); 1 ♂: 22.2.2008, Sama Jaya Nature Reserve, Kuching division, R. A. Dow leg. (RAD); 1 ♂: 25.2.2008, UNIMAS, Samarahan division, R. A. Dow leg. (RAD); 1 ♂: 12.10.2008, Bukit Sarang, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: Kemena camp, Tubau, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 24.10.2008, Samarakan, Bintulu division, B. Giman leg. (RAD); 1 ♂: 16.5.2010, foot of Hose Mountains, Kapit division, G. T. Reels leg. (RMNH); 1 ♀: 14.6.2010, Tubau, Bintulu division, R. A. Dow leg. (RAD); 1 ♂: 17.11.2010, Anap Muput, Bintulu division, R. A. Dow leg. (RMNH); 1 ♂: 4.4.2011, outside house by Baleh river, Kapit division, R. A. Dow leg. (RAD); 1 ♂: 5.5.2011, Camp C, Bintulu division, S. Stone leg. (RAD); 1 ♂: 7.10.2011, Semenggoh, Kuching division, R. A. Dow leg. (RAD); 1 ♀: 8.2.2012, Niah National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 5.10.2012, Kampung Sebako, Kuching division, J. ak Sujang leg. (RMNH); 2 ♀♀: 5.10.2012, Kampung Sebako, Kuching division, E. ak Rowmina & T. ak Neyam leg. (RAD); 1 ♂: 2.8.2013, Kampung Sebako, Kuching division, R. A. Dow leg. (RAD); 3 ♂♂: 13.1.2015, ponds, Loagan Bunut National Park, Miri division, R. A. Dow leg. (RAD); 1 ♂: 13.1.2015, ponds, Loagan Bunut National Park, Miri division, L. Southwell leg. (RAD); 1 ♀: 16.1.2015, ponds, farm at Beraya, Miri division, R. A. Dow leg. (RAD); 1 ♂: 16.1.2015, ponds, farm at Beraya, Miri division, L. Southwell leg. (RAD); 1 ♂: 11.2.2015, pond in oil palm, Sungai Lamah, Miri division, R. A. Dow leg. (RAD); 1 ♂: 5.7.2015, Mount Matang, Kuching division, G. T. Reels leg. (RAD); 1 ♂: 17.7.2015, Borneo Highlands Resort, Gunung Penrissen, Kuching division. R. A. Dow leg. (RAD).

MICRONESIA – 1 ♂, 1 ♀: Palau Islands, Coll. Selys (RBINS); 1 ♂: Palau Islands (NHMW); 1 ♂: Palau Islands, Semper leg. (NHMW); 2 ♂♂: Palau Islands, ex-Museum Godeffroy (ZMH); 1 ♂, 1 ♀: Yap Islands, Coll. Selys (RBINS); 1 ♂, 1 ♀: Yap Islands, Caroline Islands, ex-Museum Godeffroy (ZMH); 2 ♂♂: Palau Islands, Semper leg. (ZMB); 7 ♂♂, 3 ♀♀: December 1899, Yap Islands, Caroline Islands, Volkens leg. (ZMB).

PHILIPPINES – 1 ♂: Luzon, Jagor leg. (ZMB); 4 ♂♂: Palawan Island (ZMB); 5 ♂♂: Mindoro Island (ZMB); 1 ♂: Manila, Luzon, M. Deglau leg. (ZMB); 1 ♂, 1 ♀: Cebu Island, Coll. Semper (ZMH); 2 ♂♂: Mindoro Island (ZFMK); 1 ♂: 2.3.1898, Basilan Island, Doherty leg., ex-Coll. H. Fruhstorfer (ZFMK); 1 ♂: 2.3.1898, Basilan Island, Doherty leg., ex-Coll. H. Fruhstorfer (MNNW); 3 ♂♂, 2 ♀♀: 6.12.1913, Binaluan, northern Palawan, W. Boettcher leg. (SMF); 2 ♂♂, 2 ♀♀: 24.-26.3.1978, Davao, Mindanao Island, G. von Rosen leg. (ZSM); 4 ♂♂, 2 ♀♀: 14.3.1991, Baguio, 7°11'06.4" N/125°24'55.8" E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 1 ♂, 6 ♀♀: 15.3.1991, Baguio, 7°11'06.4" N/125°24'55.8" E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 1 ♀: 16.3.1991, Tambobong, 7°11' N/125°20' E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 2 ♂♂, 1 ♀: 17.3.1991, Baguio, 7°11'06.4" N/125°24'55.8" E, Mindanao, A. Günther, I. Hiekel & F. Randow leg. (AG); 4 ♂♂:

22.3.1991, Caramay river, 10°10'37.4" N/119°11'05.7" E, Palawan Island, A. Günther, I. Hiekel & F. Randow leg. (AG); 2 ♂♂: 28.3.1991, El Nido, 11°10'06.1" N/119°23'48.0" E, Palawan Island, A. Günther, I. Hiekel & F. Randow leg. (AG); 2 ♂♂, 1 ♀: 29.3.1991, El Nido, 11°10'06.1" N/119°23'48.0" E, Palawan Island, A. Günther, I. Hiekel & F. Randow leg. (AG); 1 ♀: 23.2.1992, Caramay river, 10°10'37.4" N/119°11'05.7" E, Palawan Island, A. Günther leg. (AG); 2 ♂♂: 25.2.1992, Lake Manguao, Taytay, 10°46'03.2" N/119°32'06.1" E, Palawan Island, A. Günther leg. (AG); 3 ♂♂, 1 ♀: 26.2.1992, El Nido, 11°12'14.2" N/119°24'38.6" E, Palawan Island, A. Günther leg. (AG); 1 ♀: 27.2.1992, El Nido, 11°10'06.1" N/119°23'48.0" E, Palawan Island, A. Günther leg. (AG); 1 ♀: 6.3.1992, Sabang, 10°11'51.4" N/118°54'12.4" E, Palawan Island, A. Günther leg. (AG); 1 ♂: 7.3.1992, Sabang, 10°10'47.2" N/118°53'34.4" E [?], Palawan Island, A. Günther leg. (AG); 1 ♂, 1 ♀: 12.3.1992, Sabang, 10°11'27.3" N/118°53'55.0" E, Palawan Island, A. Günther leg. (AG); 2 ♂♂, 2 ♀♀: 14.3.1992, Quezon, 9°16' N/118°03' E, Palawan Island, A. Günther leg. (AG); 3 ♂♂: 16.10.2001, Negros Island (ZFMK); 1 ♂, 1 ♀: 17.10.2001, Negros Island (ZFMK); 2 ♂♂, 2 ♀♀: 18.10.2001, Negros Island (ZFMK); 3 ♂♂, 1 ♀: 21.10.2001, Negros Island (ZFMK); 3 ♂♂, 1 ♀: 22.10.2001, Negros Island (ZFMK); 3 ♂♂, 1 ♀: 23.10.2001, Negros Island (ZFMK); 5 ♂♂: 14.11.-16.11.2001, Mount Apo, Mindanao Island, Mohagan leg. (ZFMK); 1 ♂: 5.12.2001, Leyte Island, Mohagan leg. (ZFMK); 2 ♂♂: 2002, Philippines, Mohagan leg. (ZFMK); 20 ♂♂, 6 ♀♀: 5.6.2002, Leyte Island, Mohagan leg. (ZFMK); 1 ♂: 10.6.2012, Kinablangan, Bagangga, Davao Oriental, Mindanao, H. Cahilog leg. (RAD); 1 ♂: 21.3.2013, near Loreto, Dinagat, H. Cahilog leg. (RMNH); 1 ♂: 21.3.2013, near Loreto, Dinagat, R. A. Dow leg. (RMNH).

UNKNOWN ORIGIN – 1 ♂: [Seram, Maluku Islands/Indonesia], Coll. Kaup, paralectotype of *Neurothemis pseudosophronia* Brauer, 1867 (HLMD); 2 ♂♂: 1883, [Bantimurung, South Sulawesi/Indonesia], C. Ribbe leg. (ZMB); 1 ♂: [6.9.1973, Mae Sa, Chiang Mai/Thailand], G. von Rosen leg. (ZSM).

Distribution:

Neurothemis terminata ranges from the Palau and Yap Islands to the Philippines across Borneo to Bali, Java and Sumatra (Fig. 12). Lieftinck (1935) stated that *N. terminata* is common in southern Sumatra, but northern Sumatra seems to be outside of its main distribution. Ris (1911) supposed Malacca to be outside of the main distribution and in this study we found that his male from Seremban (Peninsular Malaysia) is not *N. terminata*. Thus we agree with Ris (1911) and suggest that *N. terminata* is not native to Peninsular Malaysia. Records of Laidlaw (1930) and Orr (2005) need verification or might concern vagrants like the records of *N. terminata* from the Japanese Ryu-Kyu Islands (Watanabe & Inagawa 1981).

The locality in northern Thailand given on the label of a male stored at ZSM seems wrong, unless it represents a vagrant far outside of the normal range of *N. terminata*. Similarly the locality 'Ceram' of a male within the paralectotype series of *Neurothemis pseudosophronia* Brauer, 1867 seems incorrect. Kaup also got dragonflies from the East Indies (Schneider 2004), so maybe this is the true origin of this specimen. Additionally the given locality 'Bantimurung, South Sulawesi' of two males collected by Ribbe and stored at ZMB might be wrong or they might have been vagrants because this location is in the range of *N. manadensis*.

Characterization:

The size of *N. terminata* is not very variable but specimens from Borneo, Bali and Lombok seem to be the largest and those from the Philippines are usually the smallest.

Males of *N. terminata* have dorsal black abdominal markings at least on S4-10 and dark lateral stripes on S7-9, on the anterior segments these are joining caudally with the dorsal mark (Fig. 13j). The vesica spermalis has a pointed medial lobe, elongated and laterally developed anterior lobes and comparatively tall and elongated hairy lateral knobs (Fig. 18j). The lateral lobes of segment V4 are slightly shorther than in *N. stigmatizans* ssp. (Figs. 18g-h), resembling those of *N. manadensis* (Fig. 18d). The straight terminating wing maculation of *N. terminata* males extends to Pt, sometimes up to one cell distal of it; usually reaching the posterior wing margin around sector of Rspl to vein IR2 (Fig. 17c). *Neurothemis terminata* males from Borneo usually come close to *N. manadensis* (Figs. 15a-b) with a wing maculation extending as far as the distal end of Pt or beyond instead of extending only to the proximal end or the middle of Pt in specimens e.g. from Java, Bali and the Philippines. This agrees with Ris (1911), Laidlaw (1931) and Lieftinck (1954). The wing venation of specimens from Borneo is typical for *N. terminata* and is less dense than in *N. manadensis*. A few males of *N. terminata* from Java and the Philippines have the terminus of the wing maculation in the Hw slightly curving towards the base, approaching *N. fluctuans* (Figs. 14d-e) or *N. ramburii* (Fig. 15d). A male from Leyte Island of the Philippines has the wing maculation of *N. terminata* but only one cubital crossvein in the Hw, as usual for *N. ramburii*. These specimens might indicate crossbreeding or are just rare extremes of variation. Lieftinck (1934b) listed a possible hybrid between *N. terminata* and *N. fluctuans* from Mid-Java and Kosterin (2014) stated possible hybrids with *N. ramburii* from Bali and Lombok. Ris (1911) mentioned a male from Seremban (Peninsular Malaysia) which he assigned to *N. terminata* but he was in doubt of his own determination because it could also be a large specimen of *N. fluctuans*. An examination of the vesica spermalis of this male showed that it does not belong to *N. terminata*.

The abdominal markings of *N. terminata* females (Fig. 19k) resemble those of the males. The vulvar scale is extends at an angle of about 45° to the abdomen (Fig. 24j). The most frequent female variation of *N. terminata* has hyaline wings, often with dark apices (Fig. 23a); resembling a female variant of *N. ramburii* (Fig. 21c). To separate between both species a combination of characters of the wing venation in the cubito-anal space (one Cux in *N. ramburii*), the shape of the abdomen (stouter in *N. ramburii*) and the vulvar scale (upright in *N. ramburii*) is useful. Be aware that there are occasional females with only one cubital crossvein in some wings, whereas other characters refering to *N. terminata*. Females of intermediate appeareance might indicate crossbreeding or they simply represent rare infraspecific variants; they were found e.g. on Java and Lombok. Two variations of isochrome female *N. terminata* occur: a truly isochrome with the terminus of the wing maculation always straight and approaching that of the male (Fig. 23c), and a belted isochrome with the maculation lighter yellowish and a darkened band-like area at its distal end (Fig. 23b), thus resembling females of *N. manadensis* (Fig. 20f). These belted isochrome *N. terminata* females seem to occur particularly in the Philippine Islands and Borneo,

but were also found in Lombok and Sumatra. Differentiation of these *N. manadensis*-like females of *N. terminata* from true *N. manadensis* is difficult and their biogeography seems to be easiest attribute to separate them. There are differences between females of both species in the abdominal markings (continuous in *N. manadensis*) and in the wing triangles and subtriangles (usually denser in *N. manadensis*), but the density of wing venation is sufficiently variable that there is an overlap between the two species.

Fig. 49: Male paralectotype of *Neurothemis pseudosophronia* Brauer, 1867 with labels; generally known as a junior synonym of *N. manadensis* (Boisduval, 1835) but this specimen was identified as *Neurothemis terminata* Ris, 1911. Deposited at HLMD. Picture: Malte Seehausen.

Size and wing venation:

♂: Tot 32-43 mm; Ab 20.5-27.2 mm; Fw length 24.4-32 mm; Hw length 24.5-31.4 mm; Pt 3-4.5 mm.

Antenodals Fw/Hw 13.5-20.5/10-16; subnodals Fw/Hw 9-15/10-14; triangle in Fw/Hw of 6-16/2-6 cells; subtriangle of 8-35 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 3-8/2-4; cell rows of dc-field bordering Fw triangle 5-9; radial planate of 2-3 cell rows; medial planate of 2-4 cell rows.

♀: Tot 31.4-38.4 mm; Ab 19.6-25 mm; Fw length 26.9-33.4 mm; Hw length 25.7-32.5 mm; Pt 3-4.5 mm.

Antenodals Fw/Hw 13.5-18.5/11-15; subnodals Fw/Hw 9-12/10-14; triangle in Fw/Hw of 2-7/2-3 cells; subtriangle of 4-12 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-7/2-4; cell rows of dc-field bordering Fw triangle 3-5; radial planate of 1-2 cell rows; medial planate of 1-2 cell rows.

Remarks:

It may be useful to summarize the taxonomical history of *N. terminata*: presumably in 1838 (see the remarks under *N. stigmatizans bramina*) Guérin described *Libellula apicalis*, a junior synonym of *N. fulvia*. In 1842 Rambur described *Polyneura apicalis*, which is not identical with Guérin's *Libellula apicalis*, thus Rambur's *Polyneura apicalis* was in need of a replacement name. This was established by Ris (1911) who named this taxon *Neurothemis terminata* according to a manuscript name used by Rambur for corresponding specimens.

Within the paralectotype series of *Neurothemis pseudosophronia* Brauer, 1867 a male *N. terminata* was found (venation of the Fw: triangle 10-11 cells, subtriangle 15-18 cells, radial & medial planate both two cell rows, dc-field starts with 6-7 cell rows; fig. 49) as well as *N. manadensis*. This again makes the validity of some localities of historical records uncertain because there is no other record of *N. terminata* from the Maluku Islands, which are well outside of its range.

Neurothemis terminata obscura (Fraser, 1926)

Neurothemis obscura Fraser, 1926. Fraser (1926): 472.

Neurothemis terminata obscura (Fraser, 1926). Lieftinck (1934b): 416.

Figures:

12 (map); 17d (♂ wings); 23d-e (♀ wings).

Type material examined:

According to Lieftinck (1971) the male lectotype of *Neurothemis obscura* Fraser, 1926 is deposited at RMNH, but it could not be found there by the second author.

Further material examined (7 ♂♂, 4 ♀♀):

INDONESIA, Karimunjawa Islands – 1 ♀: May 1926, K. W. Dammerman leg. (RMNH); 3 ♂♂, 3 ♀♀: 22.11.1930, Karimundjawa, M. A. Lieftinck leg. (RMNH); 1 ♂: 25.11.1930, P. Kemudian, M. A. Lieftinck leg. (RMNH); 2 ♂♂: 1.12.1930, Karimundjawa, M. A. Lieftinck leg. (RMNH); 1 ♂: December 1991-January 1992, Karimunjawa (ZSM).

Distribution:

This taxon occurs on the Karimunjawa Islands north of Java (Fig. 12, green dot). Lieftinck (1934b) added a male from Sebesi Island south of Sumatra, but this specimen could not be found at RMNH.

Characterization:

No clear differences between the nominate subspecies and *N. terminata obscura* in size or wing venation were found in the males examined, although Lieftinck (1934b) stated a closer venation, on average smaller size, the wings comparatively broader and the tips more rounded. The main defining character of *N. terminata obscura* is the maculation covering almost the entire wings (Fig. 17d).

We are unable to distinguish the vesica spermalis from that of the nominate subspecies (Fig. 18j) or from those of *N. manadensis* (Fig. 18d).

The abdominal markings of *N. terminata obscura* females resembling those of the nominate subspecies (Fig. 19k). Two female color forms occur: The heterochrome has hyaline wings with dark apices (Fig. 23d), similar to the heterochrome females of the nominate subspecies (Fig. 23a). The isochrome female of *N. terminata obscura* differs slightly from those of the nominate subspecies by having wing maculation extending to Pt with intensely dark wing apices (close to the males); there are only a few hyaline cells below of the Pt (Fig. 23e).

Size and wing venation:

♂: Tot 35 mm; Ab 22-23 mm; Fw length 27.6 mm; Hw length 26.6-27 mm; Pt 3.7 mm.

Antenodals Fw/Hw 12.5-18.5/12-16; subnodals Fw/Hw 14-15/12-15; triangle in Fw/Hw of 10-12/4-6 cells; subtriangle of 15-28 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 6-8/2-4; cell rows of dc-field bordering Fw triangle 6-8; radial planate of 2-3 cell rows; medial planate of 2-3 cell rows.

♀: Antenodals Fw/Hw 14.5-15.5/12-14; subnodals Fw/Hw 10-11/11; triangle in Fw/Hw of 2-5/2-3 cells; subtriangle of 4-6 cells; cross veins in cubito-anal space of Fw/Hw (Cux) 4-5/2-3; cell rows of dc-field bordering Fw triangle 4-5; radial planate of 1-2 cell rows; medial planate of 1-2 cell rows.

Discussion

There are no diagnostic differences of the genital lobes, hamules, anterior lamina and the anal appendages within the examined 'reddish-brown-winged' taxa of *Neurothemis*. But this study demonstrates that there are differences in the vesica spermalis, especially in the medial process. By using these differences together with other characters we were able to check the intraspecific variability and confirm, or in some cases modify, the classification of the examined taxa of the genus. We recognize four main groupings within, and propose the following taxonomy for, the 'reddish-brown-winged' group for the present:

1st group:
- *Neurothemis disparilis* Kirby, 1889
- *Neurothemis fluctuans* (Fabricius, 1793)

2nd group:
- *Neurothemis fulvia* (Drury, 1773)

3rd group:
- *Neurothemis manadensis* (Boisduval, 1835) stat. nov.
- *Neurothemis stigmatizans* (Fabricius, 1775)
  - o *Neurothemis stigmatizans bramina* (Guérin, 1838)
- *Neurothemis terminata* Ris, 1911
  - o *Neurothemis terminata obscura* (Fraser, 1926)

4th group:
- *Neurothemis papuensis* (Lieftinck, 1942) stat. nov.
- *Neurothemis ramburii* (Brauer, 1866)
  - o *Neurothemis ramburii martini* (Krüger, 1903)
  - o *Neurothemis ramburii oceanis* Lieftinck, 1948
- *Neurothemis taiwanensis* sp. nov.

Variability within some of these *Neurothemis* species is an ambiguous phenomenon and it is difficult to interpret if some more of the apparant variation might actually represent separate species. In particular the variation in the extent of the wing maculation of the *N. ramburii* ssp.-complex requires further study. Detailed analyses with fresh samples and comparisons of morphological data among different populations might increase our knowledge of all these variations. Further studies would preferably include e.g. SEM or Micro-CT images of the vesica spermalis and molecular studies. Ecology as well as behavior within mixed populations would be useful to study. As in the European *Libellula quadrimaculata* Linnaeus, 1758, of which a variation of the wing maculation was described as *Libellula praenubila* Newmann, 1833, it might be possible that some variations in *Neurothemis* are generated by temperature or other ecological factors; however many are likely to have a genetic origin. The distribution of variations according to altitudes is poorly known as well; it is

possible that altitude might be a factor. Last but not least Asahina (1981) mentioned that the springform of *N. tullia* (Drury, 1773) in Taiwan lacks the white opal area in the wings. This white band was described as one of the main characters to separate *N. tullia tullia* and *N. tullia feralis* (Burmeister, 1839), thus the seasonal occurrence of variations in this genus might need further study too.

Some variations in the *N. ramburii* ssp.-complex approach other congeneric taxa. For example in the eastern part of the range of *N. ramburii* the wing maculation as well as the markings on the abdomen of some females approximates *N. manadensis*. Only the presence of just one cubital crossvein, the upright vulvar scale and the usually stouter abdomen show that such specimens belong to *N. ramburii*. In Sulawesi such a female with belted isochrome wings approaching *N. manadensis* was collected in copulation with a typical Sulawesian male of *N. ramburii* (stored at AG). Furthermore it is conspicuous that specimens of *N. ramburii* from Sulawesi, are very large with a denser wing venation and usually a longer pterostigma than e.g. *N. ramburii* from the western part of the range or from the Philippines, thus even approaching *N. manadensis* in these characters.

Within the western range of *N. ramburii* the more frequent presence of up to three cubital crossveins might be interpreted as crossbreeding with *N. fluctuans* or *N. terminata*, but the vesica spermalis of all examined males is that of *N. ramburii*; this suggests that the other characters merely represent infraspecific variability. Compared to other populations of *N. ramburii* in the western part of range, the wing maculation of the supposed subspecies *N. ramburii oceanis* does not seem to be distinct to us. Without knowing the locality where the specimens originate, it seems to be impossible to separate this taxon from *N. ramburii* from mainland Sumatra and other localities by using the wing maculation. In our opinion *N. ramburii oceanis* might be best synonymized with *N. ramburii*. Unfortunately we were unable to study many specimens of *N. ramburii oceanis*, which would be needed to get a sufficiently good overview and to verify the classification.

The conspicuous subspecies *N. ramburii martini* was only known from the Kai Islands until now. The recent finding that such males also occur on Sanana Island together with 'typical' *N. ramburii* as well as with specimens of intermediate appearance may indicate an origin of this taxon in the eastern Maluku Islands, with a hybrid zone towards the western border.

The almost Sulawesian *N. manadensis* is closer to *N. terminata* rather than to *N. stigmatizans*. Both species have similar wing maculation in the males (with its terminus straight) and in some isochrome females. The size of the pterostigma of *N. manadensis* and *N. terminata* overlaps at least within the range of 3.7-4.5 mm, and we were not able to find significant differences in the vesica spermalis. For separation between *N. manadensis* and *N. terminata* the most important, and sometimes the only attribute beside the biogeography, is the denser wing venation of *N. manadensis* and differences in the abdomen markings. Hence *N. terminata* might possibly be a western subspecies or form of *N. manadensis*, although we consider both as valid species here.

Considerable further work on *N. stigmatizans* and *N. stigmatizans bramina* is needed, especially with regards to the status of populations from eastern New Guinea and the eastern Maluku islands. We propose further studies of *N. stigmatizans* sensu latu including SEM or Micro-CT images of the vesica spermalis and molecular analysis.

Isolated populations (e.g. on smaller islands or on the margins of a species range) sometimes possess unusual characteristics or an apperance intermediate between species. However when such isolated populations are not within the contact zones of different species, the occurrence of hybrids seems unlikely, and the pecularities these populations are more likely to result from genetic drift and inbreeding, or possibly in some cases from speciation (e.g. *N. taiwanensis*).

Potential hybrids (e.g. specimes with an intermediate appearance) are sometimes found in the contact zones of *Neurothemis* species; but they might also be just extreme infraspecific variations. As already mentioned such zones with apparently intermediate specimens are especially recognized in the eastern Maluku Islands and western Papua for *N. stigmatizans bramina* and *N. manadensis*; in Borneo with single males of intermediate appearance between *N. disparilis* and *N. fluctuans* and in Sulawesi with single apparent intermediates between *N. manadensis* and *N. ramburii*. Furthermore André Günther collected a male *N. papuensis* in copula with a supposed *N. stigmatizans bramina* around Manokwari (West Papua/Indonesia) so that there might be crossbreeding between these taxa.

Ris (1911) assumed that *N. fluctuans* from the northern part of its range might approach *N. intermedia degener* (Selys, 1879). As mentioned above (see under *N. fluctuans*) the northernmost *N. fluctuans* specimens examined in this study are from South Myanmar (Ma-li-won & Tenasserim, Tanintharyi-Division); this is where the range of *N. intermedia degener* starts, it extends at least from Tenasserim (Tanintharyi-Division) northward to East India (e.g. Siliguri, West Bengal). However, the vesica spermalis of *N. intermedia degener* appears to be distinct from that of *N. fluctuans*. But the northern records of *N. fluctuans*, as well as the *N. intermedia*-group, need further studies.

The presence of further undescribed taxa seems possible. For instance a *Neurothemis* species photographed in northern Cambodia (Roland et al. 2011) has not been reliably assigned to any known species; the authors suppose that it is most likely a color variation of *N. fluctuans* but beside the wing maculation also the abdomen markings, especially that of the female, do not really match this species. Unfortunately these specimens were not collected and therefore could not be examined.

DNA barcoding data for some *Neurothemis* taxa, using the standard COI marker, has been obtained at RMNH and will be published in the not-too-distant future. It is not appropriate to say much about this molecular data here, but, in as far as it goes, it does provide support for the taxonomy presented here, for instance *N. manadensis* as sister taxa to *N. terminata* rather than a subspecies of *N. stigmatizans*.

This study shows that the examined taxa from the 'reddish-brown-winged' group of *Neurothemis* could be separated by using characters of wing maculation, wing venation and abdominal markings, at least within the main area of each species.

An examination of the vesica spermalis is not needed in general, but can be useful for dubious specimens.

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