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Neurobasis awamena sp. nov. from New Guinea, with a discussion of the Sulawesi and Papuan species in the genus (Odonata: Calopterygidae)

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Abstract

Neurobasis awamena, a new calopterygid species from the southern highlands of New Guinea (holotype: Pimaga area, 6°30'S, 143°30'E, 27 vii 1994, deposited at Naturalis, Leiden) is described and figured. It is distinguished from the widespread *N. australis* by its longer legs, irregular teeth on the male cerci, and the sharp demarcation of the iridescent color on the male hindwings. Its combined characters prompted a re-examination of the variability of *N. australis* throughout its range, and of the characters formerly used to distinguish the species of *Neurobasis* occurring from Sulawesi to the Bismarck Archipelago. A table comparing these species, a key, and a distribution map of the New Guinean species are provided.

Introduction

The zygopteran genus *Neurobasis* occurs throughout southeast Asia, Indonesia, the Philippines, and eastward into New Guinea and some of its satellites such as New Britain. *Neurobasis* species are large representatives of the family Calopterygidae which live in and near gravelly streams of moderate gradient. The males are characterized by brightly colored metallic hindwings (Plate V) which are displayed during courtship and in territorial disputes.

The two most significant treatments of *Neurobasis* in New Guinea and the neighboring islands were those of Lieftinck (1949, 1955). In the first paper he examined 122 male specimens of *N. australis* collected throughout New Guinea, and described *N. ianthinipennis*, which was then known only from the north-coastal drainage of what is now Irian Jaya; in this paper he also provided a key for the separation of the two species. In the second paper he described *N. australis misoolensis* from the island of Misool (off the southwestern coast of New Guinea), *N. kaupi pavo* from south and central Sulawesi (then called Celebes), and *N. kimminsi* from southeastern New Guinea and New Britain.

The capture, in southern New Guinea, of a series of specimens that did not match any published descriptions prompted a close examination of the criteria used to distinguish the known taxa. In the process several morphological criteria were discovered which might be used to separate the *Neurobasis* of New Guinea and the surrounding islands into two distinct subgroups. A full description of the new species, *N. awamena* sp. nov., follows.

Neurobasis awamena sp. nov.
(Figs 1-3, 5, Plate Vd)

Specimens studied

Holotype male: Papua New Guinea (PNG), Southern Highlands Province: Pimaga area (6°30'S, 143°30'E), first bouldery stream along Mendi-Moro Road, going from Pimaga Government School towards Mendi, 27 July 1994, J. Michalski leg., deposited at the National Natural History Museum Naturalis, Leiden, The Netherlands (RMNH). — **Paratypes**, altogether 7 ♂, 8 ♀: 3 ♂, 2 ♀, same data as in holotype male; 1 ♂, 1 ♀, Lake Kutubu area, bouldery stream along road between Gesege and Mendi-Moro Road, 26 July 1994; 2 ♂, 2 ♀, same location as previous, 18 July 2004, all J. Michalski leg. Eastern Highlands Province: 1 ♂, Crater Mountain Biological Research Station, Wara Sera study site (06°43'S; 145°05'E; 900m a.s.l.), 11 July 2004; 3 ♀, same location, 24 July 2004, S. Oppel leg. The paratypes shall also be deposited in Leiden.

Etymology

The name is a noun in apposition, and acknowledges the Awamena people of the Foi tribe, who inhabit the region in which it was first collected.

Description of male

Head: labrum black without metallic lustre, a pale spot, variable in size, on either side. Clypeus metallic green with some bluish overtones. Remainder of head iridescent green, with a pale spot on the outer edge of each lateral ocellus.
Thorax: pronotum metallic green with copper overtones in median dorsal area. Mesopleural suture black, complete. Interpleural suture very narrowly pale on middle third, black otherwise. Metapleural suture broadly black, with poorly-defined pale area in lower two-thirds over the suture itself, this paler area also bordered by black. Pale crescents at base of mesepimera and metepimera, which become increasingly blackish with maturity.
Legs: all blackish, with pale spot on inner surface of femoro-tibial joint. Legs long, hind femora 10-11 mm in length, reaching about 2 mm beyond distal margin of S2. Coxae all smokey-blackish at maturity.
Wings: as in Plate Vd. Fw very lightly enfumed yellowish ochre, as in other species of the genus. A vestigial brown spot at nodus, and often at extreme base also. Apices pigmented smokey brown to a depth of 4-6 cells at extreme tips, less so along subterminal margins. Hw relatively narrow (as in *N. australis* and *N. kimminsi*), width to length in ratio of 1:3.1 at widest point; base of Hw bearing 3 (occasionally 4) cell rows between vein A2 and posterior margin of wing (Fig. 5b). A large and easily-discernable unpigmented basal area as follows: costal series, between wing base and nodus, hyaline anteriorly; the basal cells only $^1/_5$ or less opaque, the brown pigment increasing evenly toward nodus, taking up more and more space until last antenodal cell which is nearly entirely opaque. Subcostal series mostly opaque with blue iridescence. Basal space before arculus completely hyaline. The remainder of cells between wing base and distal end of quadrilateral

hyaline with pigmented margins, these margins also showing blue iridescence. From distal end of quadrilateral outward, for the most part, the cells are opaque and the entire wing surface shows an intense, unmistakable, royal blue iridescence, which extends a little more than $^1/_3$ the distance from nodus to apex of wing, extending to roughly the 26th or 27th postnodal crossvein. The outer margin of this blue area runs perpendicular toward posterior wing margin in a fairly straight line, curving basad at about the point where it crosses veins MA and R4+5, thence tapering basad toward posterior margin of wing, finally approaching wing margin between the termini of veins 1A and CuP, however leaving a non-iridescent margin one cell thick extending to the wing base.
Abdomen: iridescent blue-green dorsally, male appendages dark brown. Cerci with large, irregularly-spaced exterior teeth (Fig. 1).
Variation: some of the specimens taken at Crater Mountain show a more pronounced bluish-green color on the hindwings than the specimens taken in the Pimaga-Kutubu area, which all display an unmistakable deep blue. The holotype and all paratype males display a distinctly blue color compared to the emerald green found in sympatric taxa.
Measurements [mm]: length of abdomen (excl. appendages) 45.8-50.3; Hw length 35-36.5; Hw breadth 11.0-11.5.

Description of female

A metallic-green insect with beige sutures; similar to that of *australis* but with very long legs, the hind femora reaching almost half-way to distal end of S3. It may also be distinguished from *N. australis* by the distinctive wedge-shaped metallic-green patch in the center of the metepimeron, and the more extensive metallic dorsal coloration of abdomen. It may be distinguished from *N. ianthinipennis* and *N. kaupi* by its narrower and paler hindwings, and by the markings of the labrum. Hw venation is orange-tan, as in *N. australis* but unlike *N. kimminsi*, which has these veins black in the type series.

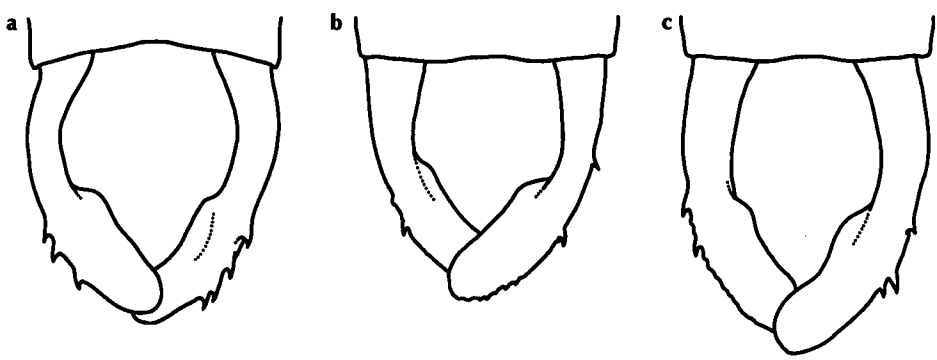

Figure 1: Male cerci of *Neurobasis awamena* sp. nov. — (a) holotype male; (b, c) examples of variation found in paratypes.

Head: labium beige, with small, blackish, median spot at base or "hinge"; tips of lateral lobes of labium also distinctly black. Rear of head black with green highlights. Labrum beige with black medio-basal spot (Fig. 2b). Upper surface of head iridescent green, antennae pale.
Thorax: pronotum iridescent green with a pale spot, which turns blackish with maturity, on each side; the anterior-ventral area just in front of this pale spot is iridescent green. Synthorax iridescent green, mesopleural suture covered by complete pale stripe bordered with black. Mesinfraepisternum mostly iridescent green, a pale crescent along posterior-ventral border. Mesepimeron iridescent green down to level of thoracic spiracle; below this level pale. Interpleural suture pale with blackish border. Metepisternum iridescent green dorsally, this green area tapering ventrally, almost reaching thoracic spiracle, which is narrowly surrounded by pale ground color; pale below spiracle, and posteriorly. Metepimeron with small, wedge-shaped patch of iridescent green surrounded by broad pale areas (Fig. 3b). Metinfraepisternum entirely pale, with dark spot where it meets metapleural suture.
Legs: dark brown exteriorly, femora distinctly lighter brown interiorly, spines blackish.
Wings: Hw not, or only very slightly, darker than Fw, both wings tinted faint brownish-amber. Base of Hw bearing 2-3 cell rows between vein A2 and posterior margin of wing. Veins of Hw orange-tan.
Abdomen: All segments dark metallic-green dorsally; however – unlike *N. australis*, which has the dorsal metallic color restricted to a narrow median stripe – this metallic color extends laterally half-way down the sides of each segment, leaving only the ventral half pale – similar to *N. kimminsi* and *N. ianthinipennis*.

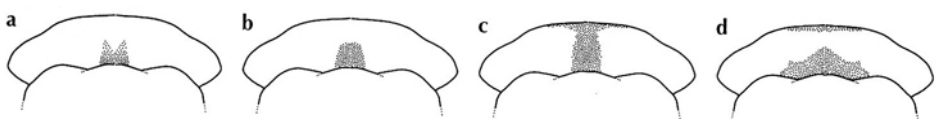

Figure 2: Female labrum of Papuan *Neurobasis* species, dorsal view — (a) as found in both *N. australis* and *N. kimminsi*; (b) *N. awamena* sp. nov.; (c) *N. ianthinipennis*; (d) *N. kaupi*.

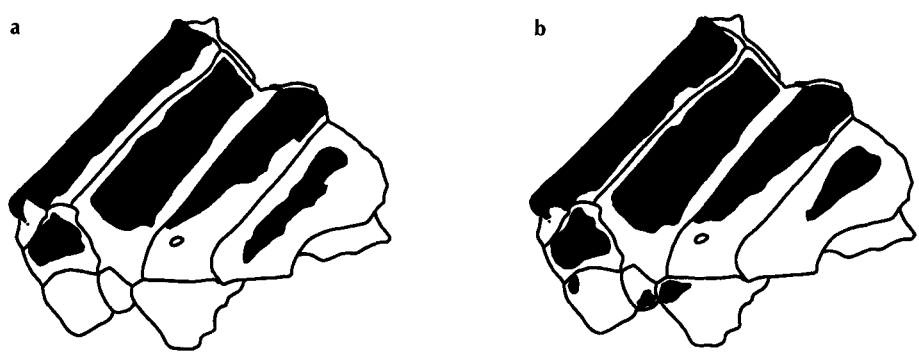

Figure 3: Female thoracic pattern of Papuan *Neurobasis* species — (a) *N. australis*; (b) *N. awamena* sp. nov.

Measurements [mm]: length of abdomen (excl. appendages) 41.2-46.2; Hw length 38-42.5; Hw breadth 10.5-12.

Habits and habitat

N. awamena sp. nov. was first taken at two localities, a few kilometers apart, in the Pimaga-Lake Kutubu area of Southern Highlands Province in PNG. Both localities were small, bouldery streams of moderate gradient, the waterway itself less than a meter across and only ankle-deep, with a gravelly bed and clear, cool water. At the 26 July 1994 site, palms and large ferns crowded the banks, creating a "tunnel" through which the collector had to pass, and the insects perched atop these overhanging plants in full sun, and were easily collected. During a subsequent visit in July 2004 the species was found to be abundant in both localities. The species was also very common in the Crater Mountain region in the Eastern Highlands and Simbu Provinces. This region is ca 200 km east of the area where the holotype was collected, and also lies on the southern side of the central New Guinean mountain range.

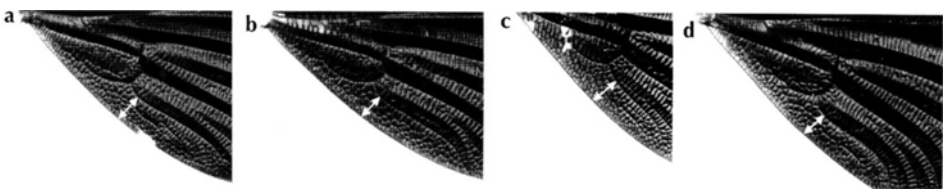

Figure 4: Anal area of hindwing in north- and west-Papuan *Neurobasis* species (Group 1), showing 5-7 cell-rows between vein A2 and posterior margin of wing — (a) *N. australis australis*, Tami River, Papua Province, Indonesia; (b) *N. australis australis*, near Lae, Morobe Province, PNG; (c) *N. ianthinipennis*, northern New Guinea; (d) *N. kaupi*, Sulawesi.

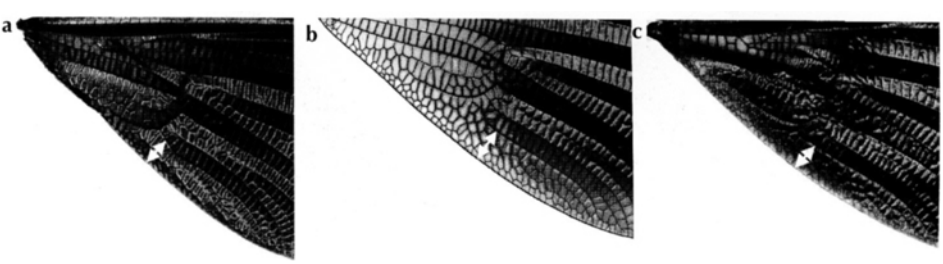

Figure 5: Anal area of hindwing in south- and east-Papuan *Neurobasis* species (Group 2), showing 3-4 cell-rows between vein A2 and posterior margin of wing — (a) *N. australis australis*, Pimaga, Southern Highlands, PNG; (b) *N. awamena* sp. nov., Pimaga, Southern Highlands, PNG; (c) *N. kimminsi*, southeastern PNG.

Discussion

Six species of *Neurobasis* are known north and west of Sulawesi and do not occur further east. These are:

N. anderssoni Sjöstedt — China
N. anumariae Hämäläinen — Philippines
N. chinensis Linnaeus — Widespread in oriental region; including ssp. *florida* Hagen in Java
N. cyaneipennis (Förster) — Borneo; placed by some authors into its own genus, *Matronoides*
N. longipes Hagen — Borneo
N. luzoniensis Selys — Philippines; including ssp. *subpicta* Hämäläinen

The remaining taxa occur in Sulawesi and further east into New Guinea and the Bismarck Archipelago (hereafter referred to as the Papuan species). These are:

N. australis australis Selys — New Guinea (not including Misool Island), Aru Islands, and New Britain
N. australis misoolensis Lieftinck — Misool Island
N. awamena sp. nov. — southern New Guinea
N. ianthinipennis Lieftinck — northern New Guinea
N. kaupi kaupi Brauer — northern Sulawesi
N. kaupi pavo Lieftinck — central and southern Sulawesi
N. kimminsi Lieftinck — southeastern New Guinea, and New Britain

Three distinct morphological criteria have been found which might prove useful in further elucidating the relationships among them.

An examination of specimens, and a review of the literature, revealed that the taxa of Sulawesi and northern New Guinea – *N. ianthinipennis*, *N. k. kaupi*, *N. k. pavo*, and northern populations of *N. a. australis* (Group 1) – have the anal area of the hindwing broader than that found in the remaining eastern taxa – southern populations of *N. a. australis*, *N. a. misoolensis*, *N. awamena* sp. nov., and *N. kimminsi* (Group 2). The taxa of the first group have 5-7 (♂) or 4-5 (♀) cell rows between vein A2 and the posterior margin of the hindwing (Fig. 4); in northern *N. a. australis*, these rows vary between 3 and 5 cells in the female. The taxa of the second group have 3-4 (♂) or 2-3 (♀) cell rows in this part of the hindwing (Fig. 5).

Recognition of this geographic distinction raises the possibility that northern and southern populations of *N. a. australis* ought to be considered as taxonomically distinct. In addition to the difference in breadth, the hindwings of northern *N. a. australis* are often metallic blue, in contrast to the bright emerald green invariably found in southern populations. Lieftinck (1949) recognized these distinctions, but acknowledged enough variation among northern individuals to preclude a formal splitting of the taxon into two subspecies at that time.

Additional morphological criteria are leg length and the teeth of the male cerci. Using these criteria it can be seen that both sexes of *N. awamena*, *N. ianthini-*

pennis, and *N. kaupi* have longer legs – the hind femora extending at least 2 mm beyond the hind margin of S2 – and that the males of these taxa have large, irregularly spaced teeth along the outer edge of the cerci. The remaining eastern taxa – *N. a. australis*, *N. a. misoolensis*, and *N. kimminsi* – have shorter legs in both sexes – the hind femora extending less than 1.5 mm beyond the hind margin of S2 – and small, regularly spaced teeth along the outer edge of the male cerci.

The division of the Papuan taxa based on leg length and the teeth of the male cerci is supported by the generally bluish color displayed on the hindwings of male *N. awamena*, *N. ianthinipennis* and *N. kaupi*, compared to the typically bright emerald green found on the remaining eastern taxa.

The new species, *N. awamena*, has the reduced cell-rows found in *N. a. australis*, *N. a. misoolensis*, and *N. kimminsi*, but can be distinguished from these taxa by the femoral, male cercal, and wing color characters described above. It has so far been found in New Guinea south of the central divide, from Lake Kutubu (Southern Highlands Province, PNG) in the west to the Crater Mountain Biological Research Station (Eastern Highlands Province, PNG) in the east. For a more detailed description of the habitat associations of *N. awamena* see Oppel (2005a, 2005b, 2006a; species listed as *Neurobasis* sp. nov.); for its behavior, see Oppel (2006b). Table 1 compares several characteristics of the Sulawesi and Papuan species of *Neurobasis*. Figure 6 shows the known distribution of the New Guinean species.

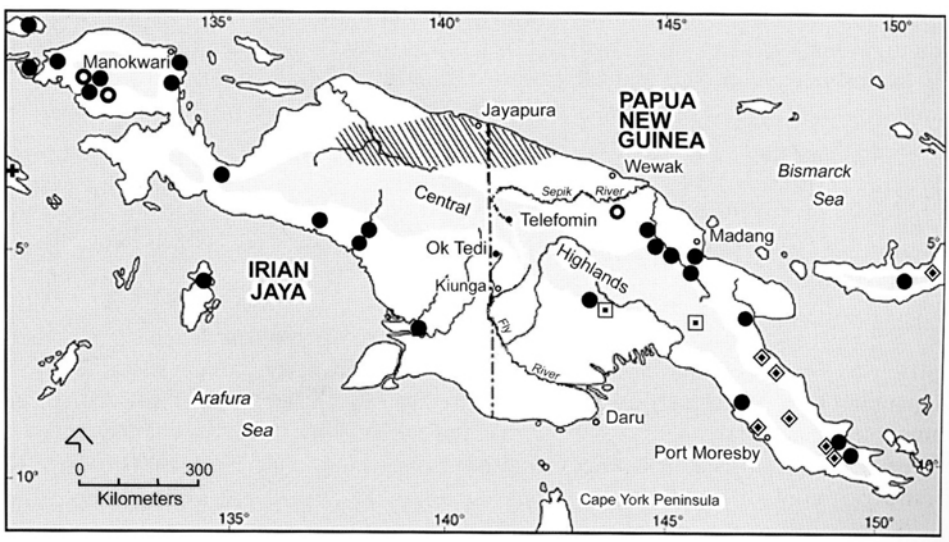

Figure 6: Distribution of New Guinean taxa of *Neurobasis* species — ●: *N. australis australis*; ✚: *N. australis misoolensis*; ▣: *N. awamena* sp. nov.; ○: *N. ianthinipennis*; ◈: *N. kimminsi*; crosshatched area indicates extensively overlapping ranges of *N. australis* and *N. ianthinipennis*.

KEY TO THE EASTERN TAXA OF *Neurobasis*

1. Legs long in both sexes, hind femora extending ≥ 2 mm beyond distal margin of S2. Male cerci with large, irregularly spaced teeth along exterior margin 2

1'. Legs shorter in both sexes, hind femora extending ≤ 1.5 mm beyond distal margin of S2. Male cerci with numerous, small, evenly-spaced teeth along exterior margin 4

2. Wings narrower, in both sexes with base of Hw not greatly expanded, 3 (occasionally 4) cell rows (♂), 2-3 (♀) between vein A2 and posterior margin of wing. Male Hw with quadrilateral mostly hyaline, and with many cells in basal area having hyaline centers. Female Hw tinted only slightly darker than Fw. New Guinea south of the central divide ..... *N. awamena* sp. nov.

2'. Wings broader, in both sexes with base of Hw expanded, 5-7 cell rows (♂), 4-5 (♂) between vein A2 and posterior margin of wing. Male Hw opaque from base to apex, hardly any of the cells in basal area, apart from the basal space, having hyaline centers. Female Hw tinted several shades darker than Fw. New Guinea north of the central divide, Sulawesi 3

3. New Guinea north of the central divide, from Biak Island and the Vogelkop to the Sepik Basin. Wings narrower than in next species, male Hw width to length in ratio of 34-36 : 100. Legs very long, hind femora extending beyond the distal margin of S2 for about that segment's length (ca 3 mm). Iridescence of mature male hindwing deep royal blue, usually without strong greenish or violet overtones. Female labrum beige with distinct median black line running from clypeus to frontal margin, which is itself narrowly lined with black in median third .... *N. ianthinipennis*

3'. Sulawesi. Wings broader than in preceding species, male Hw width to length in ratio of 38-40 : 100. Legs not as long as in *ianthinipennis*, hind femora extending beyond distal margin of S2 2.5 mm or less. Iridescence of mature male Hw blue-violet or violet-ultramarine. Female labrum beige with medio-basal black spot, half-moon-shaped ..... *N. kaupi*

4. Green basal patch of male Hw with distal margin irregular, reaching approximately half-way between nodus and pterostigma, with some rays of metallic green extending into dark opaque apices, the irregular outer limit of metallic area continuing perpendicularly towards posterior margin of Hw. New Guinea (universal); Waigeo, Salawati, Aru Islands.; New Britain ..... *N. australis australis*

4'. Green basal patch of male Hw ends abruptly approximately half-way between nodus and pterostigma, its sharply-delimited distal edge curving gently inwards towards posterior margin of Hw 5

5. Misool Island. Apex of male Fw with marginal cells entirely hyaline. Green basal patch of male Hw with distal edge less sharply delineated than in *N. kimminsi*. Base of male Hw opaque ..... *N. australis misoolensis*

Table 1. Comparison of range and morphological characters of Papuan species of *Neurobasis* — Mp-su: metapleural suture of ♂; Ex-fm: extent of hind femora beyond distal end of S2 [mm]; Teeth/cerci: teeth on ♂ cerci.

Species	Mp-su	Ex-fm	Range	Teeth/cerci
australis, northern populations			Northern New Guinea, New Britain	
	Pale	≤ 1.5		Small, regular
australis, southern populations			Southern New Guinea, Aru Island	
	Pale	≤ 1.5		Small, regular
australis misoolensis			Misool Island	
	Pale	≤ 1.5		Small, regular
awamena sp. nov.			Southern New Guinea	
	Dark	2		Large, irregular
ianthinipennis			Northern New Guinea	
	Dark	3		Large, irregular
kaupi kaupi			Northern Sulawesi	
	Dark	≤ 2.5		Small, regular
kaupi pavo			Central and southern Sulawesi	
	Dark	≤ 2.5		Small, regular
kimminsi			Southeast New Guinea, Bismarcks	
	Lower ½ pale, to entirely dark	≤ 1.5		Small, regular

Table 2. Comparison of wing characters of Papuan species of *Neurobasis* — Cr-A2: number of cell rows posterior to vein A2 in Hw; Dc Hw/Fw: degree of contrast between ♂ Hw and Fw; Ap-Fw: apex of ♀ Fw.

Species	Cr-A2	Dc Hw/Fw	Ap-Fw
australis, northern popul.	♂ 5-6, ♀ 3-4	Hw little if any darker than Fw	Clear
australis, southern popul.	♂ 3-4, ♀ 2-3	Hw little if any darker than Fw	Clear
australis misoolensis	♂ 3-4, ♀ 2-3	Hw little if any darker than Fw	Clear
awamena sp. nov.	♂ 3-4, ♀ 2-3	Hw moderately darker than Fw	Smokey border
ianthinipennis	♂ 5-7, ♀ 4-5	Hw much darker than Fw	Smokey border
kaupi kaupi	♂ 5-7, ♀ 4-5	Hw much darker than Fw	Smokey border
kaupi pavo	♂ 5-7, ♀ 4-5	Hw much darker than Fw	Smokey border
kimminsi	♂ 3-4, ♀ 2-3	Hw little if any darker than Fw	Smokey border

5'. Southeast New Guinea and New Britain. Apex of male Fw with narrow band of darkened marginal cells. Green basal patch of male Hw with distal edge more sharply delineated than in *N. australis misoolensis*. Base of male Hw partly unpigmented, in most males all cell-centres hyaline as far outwards as the distal margin of quadrilateral ..... *N. kimminsi*

Table 3. Comparison of male hindwing characters of Papuan species of *Neurobasis* — Ql-Hw: quadri-lateral Hw; Co-Hw: color of Hw; Db-Hw: distal border Hw iridescence; Ex-Hw: extent of Hw iridescence from base to apex [% of wing length].

Species	Ql-Hw	Co-Hw	Db-Hw	Ex-Hw
australis, northern populations	Hyaline	Deep blue to bluish green	Ill-defined	ca 59-62
australis, southern populations	Hyaline	Bluish green to green	Ill-defined	ca 59-62
australis misoolensis	Hyaline	Green	Sharply defined anteriorly	ca 67
awamena sp. nov.	Hyaline	Deep blue	Sharply defined	ca 63
ianthinipennis	Opaque	Deep blue	Sharply defined	ca 63
kaupi kaupi	Opaque	Blue-violet	Sharply defined	60-66
kaupi pavo	Opaque	Blue-violet	Sharply defined	60-66
kimminsi	Hyaline	Bluish green	Sharply defined throughout	ca 58-61

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