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DISTINGUISHING BETWEEN THE EAST-ASIATIC REPRESENTATIVES OF *PARACERCION* WEEKERS & DUMONT (ZYGOPTERA: COENAGRIONIDAE)

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Eight species occurring in Japan and continental East Asia are separated by the morphology of their ♂ terminalia and by the structure of the ♀ pronotum and adjacent laminae mesostigmales. *Paracercion barbatum* is confirmed as a good species, probably restricted to China, where it co-occurs with *P. impar* and other spp. The continental East Asian *P. v-nigrum* is suggested to share a common ancestor with the Japanese *P. sieboldii*. On chorological grounds, the latter should not exist in Taiwan. Both sexes of all spp. are keyed.

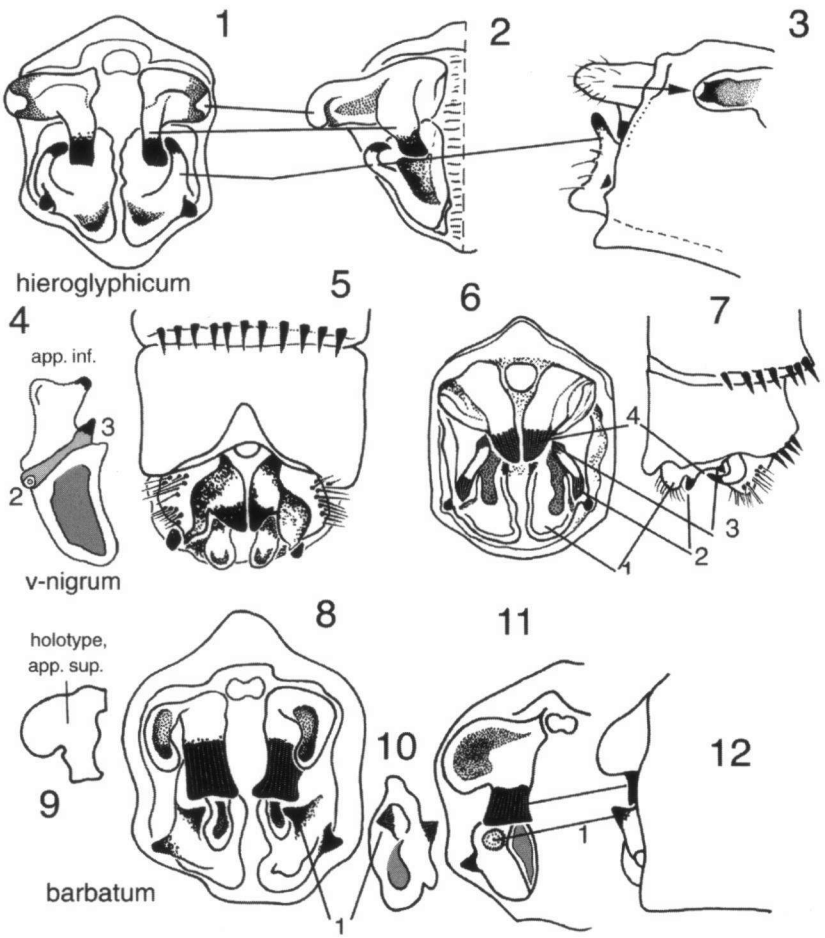
INTRODUCTION

WEEKERS & DUMONT (2004) confirmed the claim by HEIDEMANN & SEIDENBUSCH (1993) that *Cercion lindenii* (Selys, 1840) belongs in *Erythromma*. Because *lindenii* is the type species of *Cercion*, and because a molecular study showed it to be monotypic, they proposed the name *Paracercion* as a substitute for its "eastern" species. Eight *Paracercion* species occur in what is essentially palaearctic East Asia. Five of these were examined by molecular methods (the rDNA operon) and found to form a monophyletic group with large interspecies genetic distances, suggesting their age to be considerable.

In examining their morphology, it was found that a number of details of male structure had previously been overlooked or wrongly represented, and that structural features of females had hardly ever been used. In contrast, colour patterns have been well described in either original descriptions or later faunal handbooks, and need not be repeated. Here, we offer a description of the male terminalia and female pronotum for the eight species that occur between the Amur catchment in the North, across the Japanese islands, to South-West China. Not included are the Philippine *Coenagrion luzonicum* Asahina, 1968 and the Malaysian *Enallagma malayanum* (Selys, 1876).

METHODS

All species were examined under a stereoscopic microscope, equipped with a drawing attachment. The male appendages were figured in dorsal, lateral, and posterior views; the female pronotum and adjacent anterior zone of the synthorax (laminae mesostigmales and carinal fork) were figured in dorsal view only. In the "material examined" section, whenever more than ten specimens of both sexes were seen, this is listed as "series". Material for which no particular collector is listed was collected by myself.



Figs 1-12. Terminal appendages of *Paracercion* males in dorsal, lateral and posterior views, with corresponding structures identified by numbers directly on the plate: (1-3) *P. hieroglyphicum* (Wuliangsuhai, China); – (4-7) *P. v-nigrum* (Chasan lake, Russia) (4: appendix inferior); – (8-12) *P. barbatum* (Lijiang, China) (9: appendix superior of holotype, 10: appendix inferior).

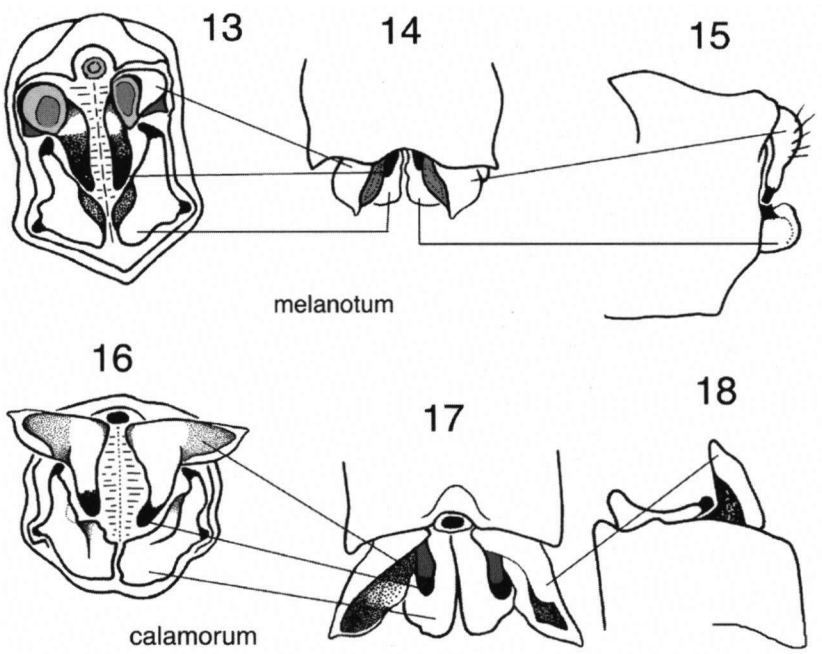
SPECIES DESCRIPTIONS

PARACERCION HIEROGLYPHICUM (BRAUER, 1865)

Material examined. – Wuliangsuhai wetlands, Inner Mongolia, series, 22-VI-1999; – Manzhouli, Inner Mongolia, series, 22-VII-2000; – River outside Bejing, 3 ♂, 28-VII-2000; – Lake Daihai, Inner Mongolia, 10-VIII-2002, 3 ♂, A. Brancelj leg.; – Lake Biwa, Japan, 1-X-2000, 2 ♂, O. Tabata leg.

MALE (Figs 1-3). – Supperior appendages rather slender in dorsal view; distinctly longer than the inferiors; apex somewhat curled inwardly, overhanging smooth, somewhat hollowed-out internal surface of appendix; a strong basal tooth, directed downwards, apically squared. Inferior appendages squarish, with strong upright lateral spine, curved inwardly, overarching the basal spine of the appendix superior.

FEMALE (Fig. 32). – Hind ridge of pronotum broadly arched but not wavy, with short median ventral apophysis about 3 times as wide as long. Laminae mesostigmales triangular, not particularly wide, with hind ridge raised externally, and median third deeply depressed into carinal hollow, such that the space ahead of the carinal fork is unusually broad and deep (Fig. 32).



Figs 13-18. Terminal appendages of *Paracercion* males in dorsal, lateral and posterior views: (13-15) *P. melanotum* (Lijiang, China); – (16-18) *P. calamorum* (Taeju, Korea).

PARACERCION MELANOTUM (SELYS, 1876) syn. *AGRION SEXLINEATUM* SELYS, 1883
Figures 13-15, 30

Material examined. – Lijiang, N of Dali, Yunnan, China, 25-VII-1989, 4 ♂, 1 ♀.

MALE (Figs 13-15). – Superior appendages shortish, about as long as inferior appendages, tapering towards apex into a slight apical ridge, separating a smooth internal from a hairy external surface. In dorsal view, the ridge appears as an apical point. Basal tooth long, tapering towards rounded apex. Inferior appendages triangular, terminating dorsally in a long spine on either side. This spine runs counter to and flanks the downwardly turned spine of the app. sup., and is almost identical to *P. calamorum*.

FEMALE (Fig. 30). – Hind ridge of pronotum strongly wavy, widened most strongly at about 1/3 from midline, where its width suddenly contracts above a median apophysis which is narrow and pointed. In contrast to *P. barbatum*, the lips of the hind ridge are not concave beyond the base of the apophysis. Laminae triangular, rounded externally, depressed internally into a rather narrow carinal space. Carinal fork shallow; carinal depression small.

PARACERCION BARBATUM (NEEDHAM, 1930)
Figures 8-12, 29

Material examined. – Lijang, China, 28-VII-1989, 5 ♂, 1 ♀; – ♂ holotype, Chengdu, China, in collection of Cornell University, USA.

MALE (Figs 8-12). – Superior appendix short, in lateral view only slightly extending beyond the appendix inferior (Fig. 12), its apex smoothly rounded, and interior surface smooth and shiny. Basal tooth especially robust, apically widened. Inferior appendix with an internal furrow and a short strong external spine about halfway its length (posterior view, Figs 8-11), just below the basal tooth of the appendix superior.

FEMALE (Fig. 30). – Hind ridge of pronotum wavy, widened at mid-length, deeply and strongly contracted at midline, with long and sharp median apophysis: the portion of the hind ridge flanking the apophysis distinctly concave beyond the base of the apophysis. Laminae mesostigmales broadly triangular, carinal fork rather widely opened.

PARACERCION CALAMORUM (RIS, 1916)
Figures 16-18, 28

Material examined. – Taijon River, Korea, series, 1-VIII-2002; – Ikenobe, Hirai-cho, Kida Gun, Kagawa Pref., Shikoku, Japan, 20-IV-1950, M. Chujo leg.; – Osaka, Japan, 28-VII-2000, 3 ♂, 1 ♀; – Chejo Island, Korea, 2-VIII-2002, series; – Asan Lake, Dehra Dun, North India, 25-III-1999 (ssp. *dyeri*), series; – Tau Daha, Katmandu valley, Nepal, 10-V-1973 (ssp. *dyeri*), 4 ♂.

MALE (Figs 16-18). – Superior appendages long and divaricate, apically constricted, with elongated smooth internal surface, bulging at mid-length, and the usual long basal tooth. Inferior appendages similar to those of *P. melanotum*.

FEMALE (Fig. 28). – Hind ridge of pronotum simply arched, with short, rounded and rather broad apophysis at midline. Laminae mesostigmales narrow, raised anteriorly and externally. Carinal depression not noticeably widened.

PARACERCION V-NIGRUM (NEEDHAM, 1930)
Figures 4-7, 31

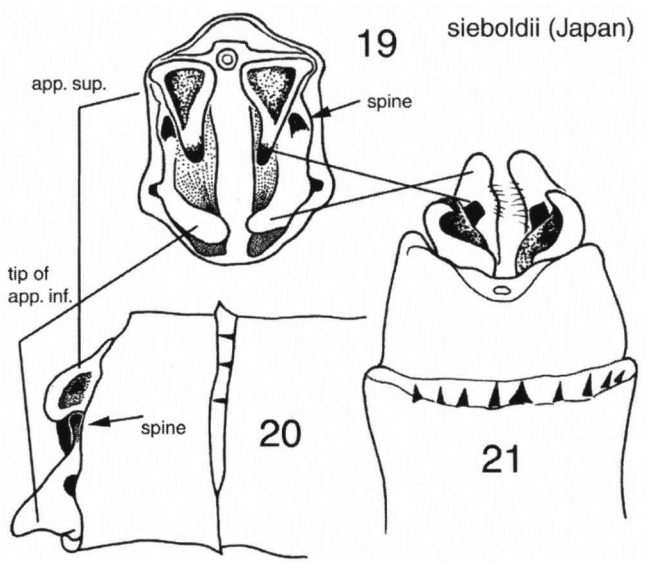
Material examined. – Lake Chasan, Primoriye, Russia, 4-VI-1962, 5 ♂, 1 ♀.

MALE (Figs 4-7). – Superior appendages short, apically pointed, and with a sinuous divide between the outer, spiny zone and the inner smooth surface (Fig. 5). Strong basal spine apically tapering, almost pointed (Figs 5-6). Inferior appendages slightly shorter, rather massive and squarish, with an internal furrow and with an oblique raised ridge about midway, ending in two spines: one external, one internal (Figs 4, 6).

FEMALE (Fig. 31). – Hind ridge of pronotum triangularly widened, with a narrow and pointed median apophysis. Laminae mesostigmales triangular, with hind ridges slightly raised and anterior-external pointed angle spinulated; median apophysis narrow and rather long and pointed.

PARACERCION SIEBOLDII (SELYS, 1883)
Figures 19-21, 35

Material examined. – Pond at Kitayama, Sasayama, Hyogo Pref, Japan, 12-V-2002, 3 ♂, 2 ♀, K. Inoue leg. ; – Minachi, Hongu-cho, Higashi-Muro-Gun, Wakayama Pref., Japan, 16-V-1982, 2 ♂, 2 ♀, Osamu Tabata leg.

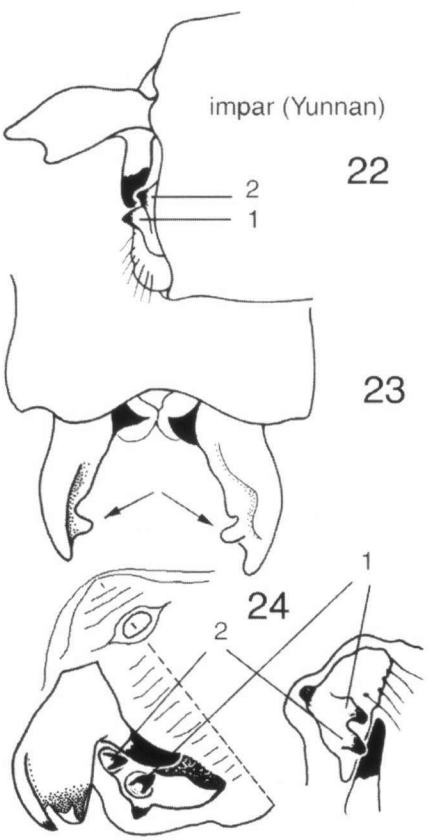


Figs 19-21. Terminal appendages of male *Paracercion sieboldii* (Japan) in dorsal, lateral and posterior views.

MALE (Figs 19-21). – Superior appendages short, apically tapering in dorsal view, with a sinuous divide between the outer "hairy" portion, and the inner, hollowed-out shiny portion. Basal spine of moderate size but broad-based and apically tapering but not really pointed. Inferior appendix massive, its ventral portion strongly drawn out, extending beyond appendix superior (arrowed as "1"). Thus, inferior appendix is in lateral view longer than superior appendix.

FEMALE (Fig. 35). – Hind ridge of pronotum only slightly wavy; median apophysis medium-sized. Laminae mesostigmales triangular, deepened medially, their anterior--external angle spinulated.

PARACERCION IMPAR (NEEDHAM, 1930)
Figures 22-24, 33



Figs 22-24. Terminal appendages of male *Paracercion impar* (Lijiang, China) in dorsal, lateral, and oblique posterior views.

A little known species, with type locality Suifu, Sichuan, China. Its morphology is so distinctive that, although undoubtedly a *Paracercion*, it stands apart from all other species, including *P. plagiosum*.

Material examined. – Liyang, Yunnan, West China, 25-VII-1989, 2 ♂, 2 ♀.

MALE (Figs 22-24). – Superior appendages as long as segment 10, strong, subapically widened and appearing to be bifid, its lower portion bearing a squarish outgrowth, looking like an apically upturned leaf in oblique posterior view (Fig. 24). Basal spine long and apically pointed. Inferior appendages short, triangular and with two spines (1, 2), partly overarching the basal spine of the appendix superior.

FEMALE (Fig. 33). – Hind ridge of pronotum straight, but with a foliate expansion on either side (arrowed). Median apophysis unusually broad, pointed medially. Laminae mesostigmales two broad and flat triangles. Carinal space rather large, with carinal heads rounded and separated by a rather broad embayment.

PARACERCION PLAGIOSUM (NEEDHAM, 1930)
Figures 25-27, 34

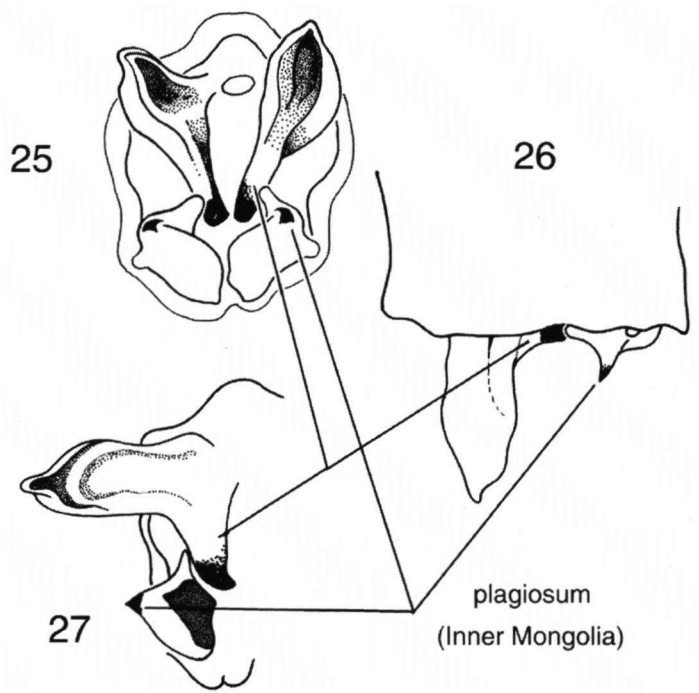
Material examined. – Wuliangsuhai wetlands, Inner Mongolia, China, 19-VI-1999, series.

MALE (Figs 25-27). – Superior appendages as long as segment 10, robust, apically tapering in lateral view. Seen in posterior view, the inner surface is smooth and somewhat hollowed out. Basal tooth long and robust, apically tapered. Inferior appendages a small, short triangle, with a short, curved lateral spine at about mid-length.

FEMALE (Fig. 34). – Hind ridge of pronotum simple; median apophysis rather small, not particularly pointed apically. Laminae mesostigmales triangular, with grooves at their bottom, and medio-anterior angle finally draw out. Carinal space rather broad.

DISCUSSION

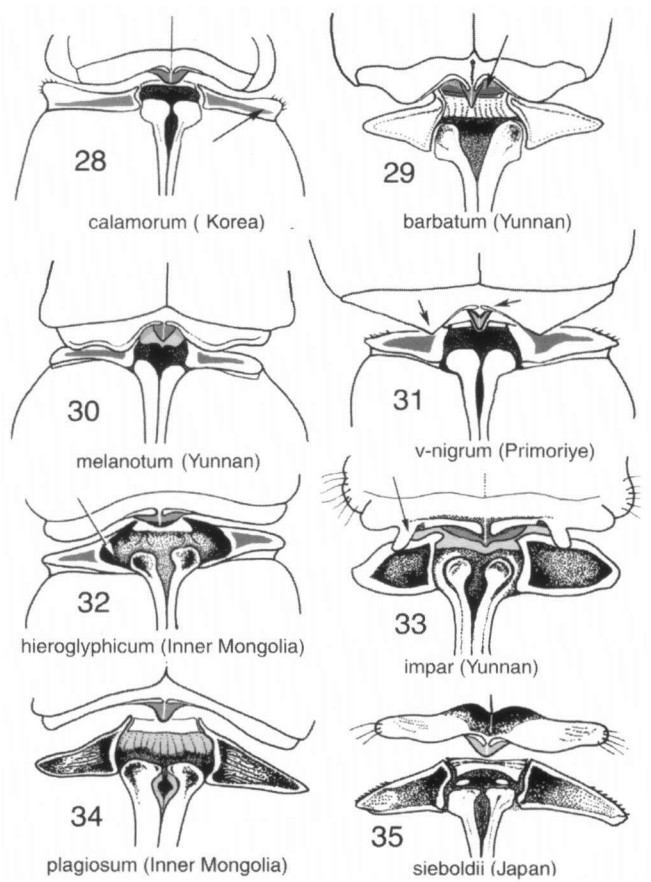
As suggested by WEEKERS & DUMONT (2004), some male characters that may define the genus *Paracercion* include a strong, ventrally directed basal tooth on the superior appendices, and an undivided tip of these appendages (*P. impar* is not really an



Figs 25-27. Terminal appendages of male *Paracercion plagiosum* (Wuliangsuhai, China) in dorsal, lateral and posterior views.

exception to this rule, since its superior appendix really has a ventral outgrowth, not a true bifurcation). In females, we can now add the simply arched or wavy hind ridge of the pronotum, converging in the middle to form a ventral apophysis. Further analysis will be needed to test whether these characters suffice in delimiting *Paracercion* from other coenagrionid genera.

Further, it is tempting to look for relationships inside this geographically coherent group of species. We find that only between two species, *P. v-nigrum* and *P. sieboldii*, such an exercise seems currently justified, since in the molecular analysis of WEEKERS & DUMONT (2004) they keyed out as close relatives. Looking at geographical distribution, there appears to be some logic here: *P. sieboldii* is endemic to the Japanese islands, whereas *P. v-nigrum* extends over much of the East Asian continent, but



Figs 28-35. Hind ridge of pronotum, laminae mesostigmales and carinal fork of *Paracercion* females, in dorsal view: (28) *P. calamorum* (Korea); – (29) *P. barbatum* (China); – (30) *P. melanotum* (China); – (31) *P. v-nigrum* (Russia); – (32) *P. hieroglyphicum* (China); – (33) *P. impar* (China); – (35) *P. sieboldii* (Japan).

does not occur in Japan. This complementary of ranges suggests a common ancestor that evolved independently in an insular and continental setting.

On the same geographical grounds, it seems illogical that *P. sieboldii* would occur in Taiwan, where it has indeed not been found after RIS' (1916) record, in spite of much detailed work on the island (WANG, 1999). The male and two females reported from Taihorin under *Agrion sauteri* must either be considered to have been mislabelled specimens of *P. sieboldii*, or less probably, represent an as yet undiscovered *Paracercion* endemic to Taiwan.

Of *P. barbatum*, of which NEEDHAM (1930) had received quite a few examples beside his type, there appear to have been no reliable later records. ASAHINA (1956, 1961) originally could not make up his mind regarding the identity of this species, but suspected it to be "the same with *v-nigrum*" (1961: 11). In more recent writings, ASAHINA (1989, 1992) formally listed *barbatum* in the synonymy of *v-nigrum*. However, he seems not to have seen the type, which I obtained from the collection of Cornell University, N.Y., and compared with my catches from Yunnan in 1989. I found my species to conform with the type, and they were so distinct from *v-nigrum* that I suspect they are not even closely related.

A final word needs to be said regarding the South-East Asian *Enallagma parvum* (Selys, 1876), tolerably well figured by FRASER (1933). On at least two occasions, ASAHINA (1965, 1970) listed this under *Cercion*, without explaining his motives. I examined a series of males from India, and found that they lack all structural characters of a *Paracercion*, in particular the basal tooth of the superior appendix and the undivided apex thereof. What genus this small zygopteran belongs to must remain undetermined for the time being, since DNA-examination in my laboratory has shown that it is neither an *Enallagma* nor a *Coenagrion*.

KEY TO THE EAST-ASIATIC *PARACERCION* SPECIES

1 Males 2
– Females 9
2 Superior appendage subapically bifid, with a flange-like outgrowth projecting from the lower arm ..... **impar**
– Superior appendix not bifid; inner side of apical zone of the appendix either slightly hollowed out, or a smooth surface 3
3 Lower apex of inferior appendix extending beyond tip of super appendix ..... ***sieboldii***
– Appendix inferior shorter or, at best, about as long as superior appendix 4
4 Inferior appendix with an oblique ridge with a spine at either end ..... ***v-nigrum***
– Inferior appendix with only one spine 5
5 Spine on inferior appendix, inserted about half way its length, arching over basal spine of superior appendix ..... ***hieroglyphicum***
– Spine on inferior appendix, if inserted halfway its length, too short to overarch superior appendix, or inserted in apical position 6
6 Spine at dorsal tip of inferior appendage 7
– Spine in lateral position, on body of inferior appendage 8
7 Superior appendages widely divaricate, about as long as segment 10 ..... ***calamorum***

– Superior appendages parallel, not divaricate, shorter than segment 10 ..... ***melanotum***
8 In side view, superior appendage at least twice as long as inferior appendage; its basal spine long and apically tapering ..... ***plagiosum***
– In side view, superior appendage not much longer than inferior appendage; basal spine of superior appendage robust, squared or even widening at tip ..... ***barbatum***
9 A foliate outgrowth on either side of hind ridge or pronotum ..... ***impar***
10 Hind ridge of pronotum widened before median constriction 11
– Hind ridge of pronotum not widened before median constriction 13
11 Bulge in hind ridge triangular, not wavy ..... ***v-nigrum***
– Bulge in hind ridge of pronotum wavy 12
12 Central constriction in hind ridge deep and concave ..... ***barbatum***
– Constriction in hind ridge medially more or less straight, not concave ..... ***melanotum***
13 Bottom of triangles of laminae mesostigmales grooved ..... ***plagiosum***
– Bottom of triangles of laminae mesostigmales not grooved 14
14 Zone in front of carinal fork unusually wide, with median third of laminae mesostigmales depressed into the carinal hollow ..... ***hieroglyphicum***
– Zone in front of carinal forks not unusually wide 15
15 Triangles of laminae mesostigmales narrow, with raised anterior-external margins ..... ***calamorum***
– Triangles of laminae mesostigmales wider, their anterior-external margins not raised ..... ***sieboldii***

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