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International Journal of Odonatology

Publication details, including instructions for authors and subscription information:

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Frank Suhling & Eugène Marais^a

^a National Museum of Namibia, Windhoek, P.O. Box 1203, Windhoek, Namibia E-mail:

Available online: 28 Mar 2012

To cite this article: Frank Suhling & Eugène Marais (2010): *Crenigomphus kavangoensis* sp. nov. from the Okavango River, Namibia (Odonata: Gomphidae), *International Journal of Odonatology*, 13:2, 267-276

To link to this article: <http://dx.doi.org/10.1080/13887890.2010.9748379>

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***Crenigomphus kavangoensis* sp. nov. from the Okavango River, Namibia (Odonata: Gomphidae)**

Frank Suhling¹ & Eugène Marais²

¹Corresponding author: Institut für Geoökologie, Technische Universität Braunschweig, Langer Kamp 19c, 38106 Braunschweig. <f.suhling@tu-bs.de>

²National Museum of Namibia, Windhoek, P.O. Box 1203, Windhoek, Namibia. <insects@natmus.cul.na>

Key words: Odonata, dragonfly, Africa, *Crenigomphus*, *Paragomphus*, exuviae.

ABSTRACT

A new species of *Crenigomphus* is described and illustrated from a type series of eight males and eight females, all collected along the Okavango River in Namibia during December 2004, three non-type adult specimens and several exuviae (holotype ♂: Namibia, N'Kwazi Lodge, 19 xii 2004, deposited at NMNW). Both sexes lack foliations at S8-9 as occur in some *Crenigomphus*, but the male is peculiar in having exceptionally long cerci. The latter character is normally present in the genus *Paragomphus*. Other characters typical of *Crenigomphus* include all wings having a bright yellow costal border, S10 longer than S9 in males, colouration mostly ochreous with few darker markings, and the strong blackish serration at the posterior end of the cerci. The larval characters based on exuviae, one associated with an emerged male, do not allow clear separation from *Paragomphus*.

INTRODUCTION

The genus *Crenigomphus* Selys, 1892 is endemic to Africa, with six species known so far (Fraser 1960; Dijkstra 2003), namely *C. abyssinicus* (Selys, 1878), *C. cornutus* Pinhey, 1960, *C. denticulatus* Selys, 1892, *C. hartmanni* (Förster, 1898), *C. occidentalis* Martin, 1911, and *C. renei* Fraser, 1936. Of these *C. occidentalis* is not well defined (K.-D.B. Dijkstra pers. comm.). Here we describe a new species of *Crenigomphus* from the Okavango River in Namibia, bringing the total number of species in *Crenigomphus* s.str. to seven. The new species is very distinct within the genus *Crenigomphus*, being close to *Paragomphus* Cowley, 1934 in one principal adult character.

An earlier version of this species description was submitted to another journal some years ago and, anticipating prompt publication, the new name was previously used by Suhling & Martens (2007: 147) in the following form: "*Crenigomphus kavangoensis* Suhling & Marais, 2006". Unfortunately, the original description was never published, and it must be emphasised that the usage of the name in Suhling & Martens (2007) was never intended as a formal description. Therefore the name *C. kavangoensis* has remained invalid. The present paper aims to provide a description, holotype designation, type locality and depository, thereby establishing validity of the name as: "*Crenigomphus kavangoensis* Suhling & Marais, 2010".

The original description was not assigned specifically to the male holotype and a selected female but to the whole series of males and females, respectively. This could not be rectified, as the corresponding author (FS) was subsequently unable to access the specimens. However, the holotype is sufficiently characterised by the data given in Table 1.

Table 1. Measurements [mm] of head width (Hdw), wing length (Fw, Hw), tergite length of S8, S9 and S10, and length of superior appendages (or cerci; C) and epiproct (E) for all specimens collected. Missing values (m) are due to damage specimens. The ratios of the lengths of S10 to S9 (S10/S9), of the lengths of the right cercus to epiproct (C/E), and of the lengths of the right cercus to S10 (C/S10) are shown. ♂ 5 is the holotype.

	Hdw	Fw	Hw	S8	S9	S10	S10/S9	C	E	C/E	C/S10
♂ 1	6.46	26.64	25.25	1.96	1.18	1.31	1.11	2.81	1.24	2.26	2.15
♂ 2	m	m	24.90	2.03	1.21	1.31	1.08	2.81	1.37	2.05	2.15
♂ 3	6.36	26.80	25.40	1.90	1.18	1.31	1.11	2.75	1.37	2.00	2.10
♂ 4	6.46	26.19	24.63	2.09	1.18	1.31	1.11	2.75	1.31	2.10	2.10
♂ 5	6.46	26.12	24.84	2.16	1.30	1.44	1.11	2.75	1.24	2.21	1.91
♂ 6	6.25	26.18	m	1.96	1.19	1.31	1.10	2.68	1.37	1.95	2.05
♂ 7	6.51	27.80	25.50	2.09	1.30	1.44	1.11	2.88	1.24	2.31	2.00
♂ 8	6.46	26.80	24.90	2.09	1.21	1.31	1.08	2.81	1.31	2.15	2.15
Means ♂	6.42	26.65	25.05	2.05	1.23	1.35	1.10	2.77	1.31	2.12	2.05
♀ 1	6.67	29.50	27.20	2.42	1.50	0.98	0.65	1.44	-	-	-
♀ 2	6.46	28.15	26.07	2.22	1.44	1.05	0.73	1.44	-	-	-
♀ 3	6.67	27.54	25.92	2.09	1.24	0.92	0.74	1.44	-	-	-
♀ 4	m	27.16	26.15	m	m	m	m	m	-	-	-
♀ 5	6.67	29.20	27.35	2.22	1.44	0.98	0.68	1.57	-	-	-
♀ 6	6.67	28.95	27.10	2.22	1.44	1.05	0.73	1.57	-	-	-
♀ 7	6.67	29.25	26.90	2.35	1.50	0.92	0.61	1.70	-	-	-
♀ 8	6.57	29.09	26.90	2.29	1.44	1.05	0.73	1.70	-	-	-
Means ♀	6.62	28.61	26.59	2.26	1.43	0.99	0.69	1.55			

***Crenigomphus kavangoensis* sp. nov.**
(Figs 1-3, Plate 1b, c)

Etymology

The species is named after the colloquial name of the river where the species has first been encountered (= Kavango River).

Specimens studied

Holotype ♂: Namibia, Okavango River near Rupara (19.116°S, 17.838°E), 19 xii 2004 leg. EM. — Paratypes: total 7 ♂, 8 ♀, all collected along the Namibian banks of the Okavango River. 1 ♂, 3 ♀, Okavango R. at N'Kwazi Lodge, ca 15 km E of Rundu (19.907°S, 17.866°E), 04 xii 2004 leg. FS; 1 ♂, 1 ♀, same loc. but 05 xii 2004 leg. FS; 5 ♂, 2 ♀, same loc. but 19 xii 2004 leg. FS (1 ♂), EM (all others); 2 ♀, Okavango R. near Tondoro (18.805°S, 17.77°E), 19 xii 2004 leg. EM. Holotype and all paratypes deposited at the National Museum of Namibia, Windhoek (NMNW). — Other specimens, all collected from the Okavango River in Namibia: 1 ♀, Andara, 04 xi 1960, leg. F. Gaerdes, det. Balinsky (misidentified as *Crenigomphus cornutus*), at NMNW; 1 ♀, Gelukkie, 06 iv 1990, leg. EM, at NMNW; 1 ♂, N'Kwazi Lodge, 12 iii 2006 leg. FS, in FS priv. collection.

Additionally, several exuviae were collected at N'Kwazi Lodge, one together with a freshly emerged male. We compared these exuviae with other *Crenigomphus* and *Paragomphus* exuviae available to us.

Males

Head: Eyes light blue with a violet sheen in living mature individuals (Plate 1b); whole face light ochreous, only the dorsal part of the frons slightly darker and with dark spots; occiput bordered with several long hairs and a row of 12-18 minute black spines, in some specimens separated into two rows of 6-9 spines by a spineless gap.

Thorax: Ground colour of thorax ochraeous with three broad cream-white bands on mesepisternum, metepimeron and mesepimeron, respectively, the ones on mesepisternum less visible in immatures; the cream-coloured bands enclosed by darker brownish markings; all leg segments ochreous. Wings without anal loop; some specimens with incomplete basal antenodals.

Abdomen: Tergite 10 slightly longer than tergite 9 (on average 1.1x); no foliations on S8-9; cerci much longer than epiproct and downward curved, with the blackish posterior end folded inwards and strongly serrated (Figs 1a, b); epiproct curved upwards in lateral view; with three blackish tips, two being visible in profile. Secondary genitalia as in Figures 1c, d.

Measurements and variation: See Table 1.

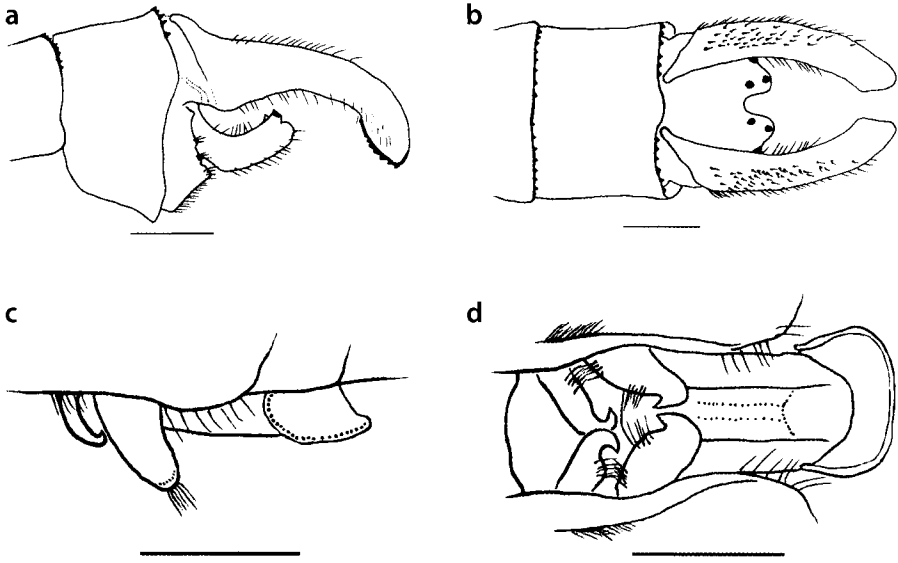


Figure 1: *Crenigomphus kavangoensis* male — (a) male terminalia, lateral view; (b) same, dorsal view; (c) secondary genitalia, lateral view; (d) same, ventral view.

Females

Head and thorax: As males, see Plate 1c.

Abdomen: Tergite 10 shorter than tergite 9 (Table 1); no foliations at S8-9. Colouration of abdomen mainly ochraceous with distinct black patterning on S3-7: dorsal black elongated spots at the posterior margins and black lines along the ventral margins of the tergites most distinct on S5 and S6; black markings on S8-10 less distinct.

Measurements and variation: See Table 1.

Larva

The larva, described from exuviae, resembles typical *Crenigomphus* and *Paragomphus* larvae in most characters (Fig. 2) and can currently only be distinguished by comparison to other known larvae (Table 2).

Diagnosis

This is a typical member of the Gomphidae (cf. Selys & Hagen 1858). Total length ca 40 mm; for other measurements see Table 1; colouration ochraceous with few darker markings and some pale cream stripes on the thorax (Plate 1b, c).

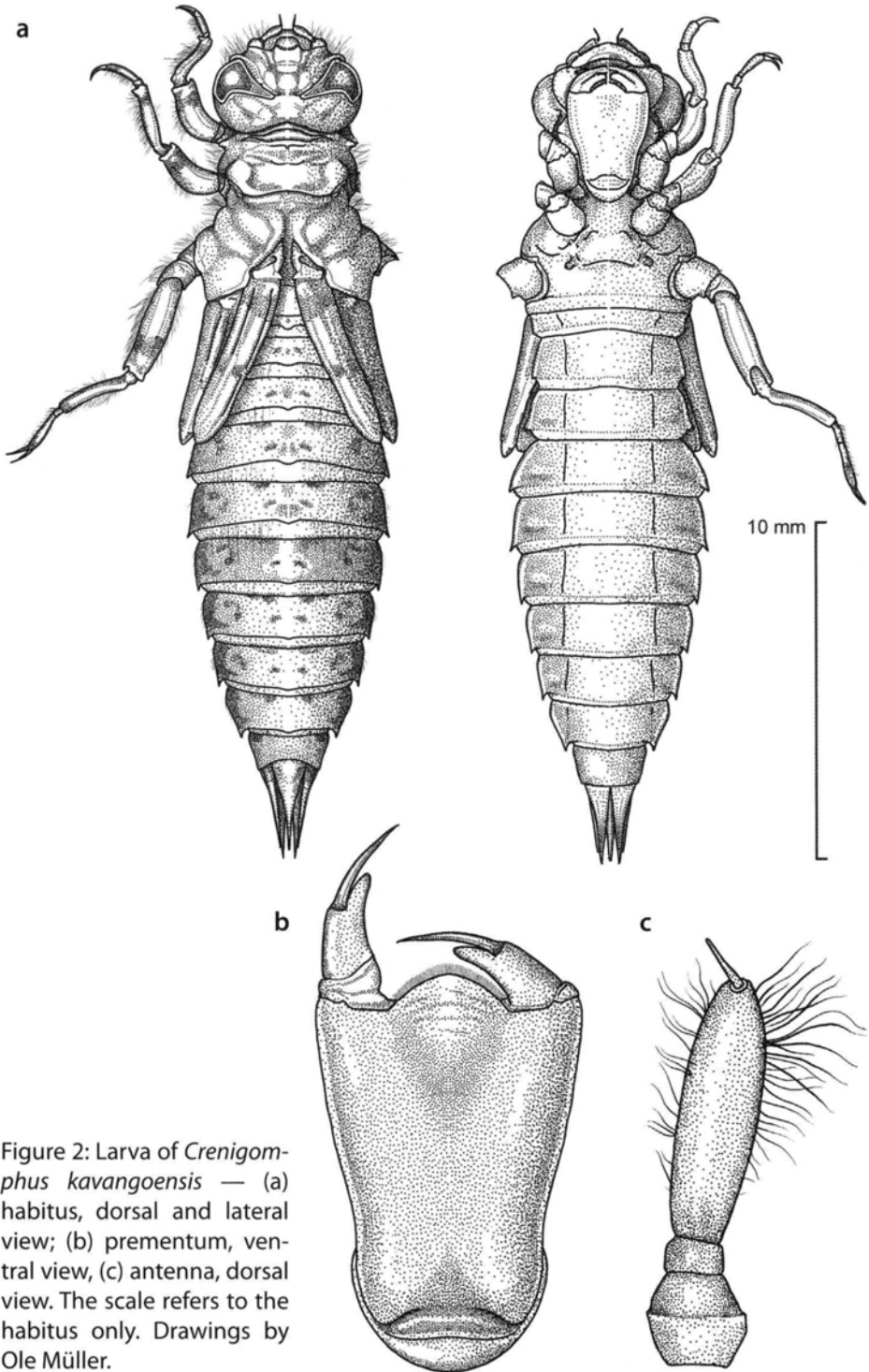


Figure 2: Larva of *Crenigomphus kavangoensis* — (a) habitus, dorsal and lateral view; (b) prementum, ventral view, (c) antenna, dorsal view. The scale refers to the habitus only. Drawings by Ole Müller.

Table 2. Diagnostic characters of exuviae of African species of the genera *Crenigomphus* and *Paragomphus*. **Head and mouth parts** — Hdw: head width; An4, An3: lengths of antennomeres 4 and 3; 4/3: ratio of antennomeres 4/3; PL: length of prementum; PW: width of prementum; L/W: prementum length/width ratio; MI: width of anterior median lobe of prementum; MI/P: median lobe width/prementum width ratio; Lp: serration of labial palps; **Abdomen** — Dors: abdominal segments with clearly visible

Species	Hdw	An4	An3	4/3	PL	PW	L/W	MI
<i>C. cornutus</i>	4.2	0.40	1.14	0.35	3.10	2.12	1.4	0.82
<i>C. hartmanni</i>	4.8	0.30	1.45	0.2	3.18	2.45	1.3	0.98
<i>C. kavangoensis</i>	4.1	0.18	1.18	0.15	2.93	2.20	1.3	0.71
<i>P. acuminatus*</i>	4.1	0.43	1.45	0.3	4.16	2.45	1.7	0.73
<i>P. alluaudi</i>	4.1	0.38	1.20	0.3	3.43	2.53	1.35	1.10
<i>P. cataractae</i>	4.1	0.28	0.90	0.3	2.73	2.29	1.2	0.73
<i>P. cognatus*</i>	4.1	0.25	0.88	0.3	3.10	2.20	1.4	0.73
<i>P. crenigomphoides</i>	4.6	0.30	1.33	0.3	3.59	2.69	1.3	1.14
<i>P. elpidius*</i>	4.1	0.25	1.05	0.2	3.10	2.22	1.4	0.69
<i>P. genei</i>	4.5	0.35	1.40	0.25	3.10	2.53	1.2	1.14
<i>P. nyasicus</i>	4.4	0.23	1.15	0.2	2.78	2.29	1.2	0.71
<i>P. sabicus*</i>	4.6	0.25	1.45	0.2	3.06	2.12	1.4	0.86

The species, especially males, of the regional southwestern African *Crenigomphus* and *Paragomphus* may be distinguished from the following key:

1. Upper appendages only slightly longer than epiproct; larger species, total length ca 50 mm 2
- 1': Upper appendages ca 2x as long as epiproct; mainly smaller species, total length < 50 mm 3
2. No foliations on S8-9 in both sexes *C. cornutus*
- 2': Foliations on S8-9 in both sexes *C. hartmanni*
3. No foliations on S8-9 in both sexes *C. kavangoensis*
- 3': Foliations on S8-9 in both sexes 4
4. Thorax bright to pale green with brown or without markings 5
- 4': Thorax yellow with brownish or black markings 7
5. Thorax bright green without markings *P. cataractae*
- 5': Thorax bright to pale green with dark (black or brown) markings 6
6. Pterostigma dark brown; thorax bright green with dark brown markings; hamulus not hammer-shaped *P. elpidius*

dorsal spines or hooks (Note: sometimes scarcely visible spines occur on segments, which were not counted); Lat: abdominal segments with clearly visible lateral spines; Setae: density of long setae at posterior edges of the tergites; S10: length of abdominal segment 10 (from ventral); P: length of paraproct; C: length of right cercus; P/10: ratio length paraproct/length S10; C/P: cercus length/paraproct length ratio. All measures are in mm. In species marked with an asterisk, larval identities are not yet confirmed.

Ml/P	Lp	Dors	Lat	Setae	S10	P	C	P/10	C/P
0.3	weak	2-9	2-9	dense	1.43	2.60	2.50	1.8	1.0
0.4	weak	2-9	6-9	single	1.47	1.88	1.88	1.3	1.0
0.3	weak	2-9	2-9	sparse	1.26	1.76	1.76	1.4	1.0
0.3	weak	2-9	2-9	sparse	0.32	3.02	2.69	9.6	0.9
0.4	weak	2(-3)	6-9	sparse	1.26	1.67	1.59	1.3	1.0
0.3	weak	2-3	2-9	very dense	1.26	2.04	1.96	1.6	1.0
0.3	weak	2-3	7-9	sparse	1.37	1.88	1.71	1.4	0.9
0.4	weak	no	5-9	sparse	1.47	1.51	1.55	1.0	1.0
0.3	weak	2-3	6-10	sparse	1.31	1.96	1.89	1.5	1.0
0.45	weak	2-3	5-9	dense	1.26	2.04	1.88	1.6	0.9
0.3	clear	2-3	5-9	sparse	1.58	2.29	1.88	1.4	0.8
0.4	strong	2-4	3-9	dense	1.16	3.10	1.59	2.7	0.5

- 6. Pterostigma pale brown; thorax mostly pale green with dull brown markings; hamulus hammer-shaped *P. genei*
- 7 Thorax as well as abdomen with clearly contrasting black markings; males with very prominent foliations, foliation span 2x as wide as the length of S8; body length >> 50 mm *P. sabicus*
- 7. Only thorax with clearly contrasting markings; males with much smaller foliations; body length < 50 mm *P. cognatus*

The larvae of the known African species of *Crenigomphus* and *Paragomphus* may be separated by morphometric characters (Table 2).

Notes on biology and distribution

Besides the type locality, *C. kavangoensis* has been encountered at seven localities all along the river section from west of Nkurenkuru, where the border between Namibia and Angola starts, downstream to Andara (Fig. 3). In the upstream area *C. kavangoensis* was often the most common gomphid. It was present along rather degraded sections of the riverbanks, where several other species of dragonflies were absent. *C. kavangoensis* may perhaps profit from deforestation along the

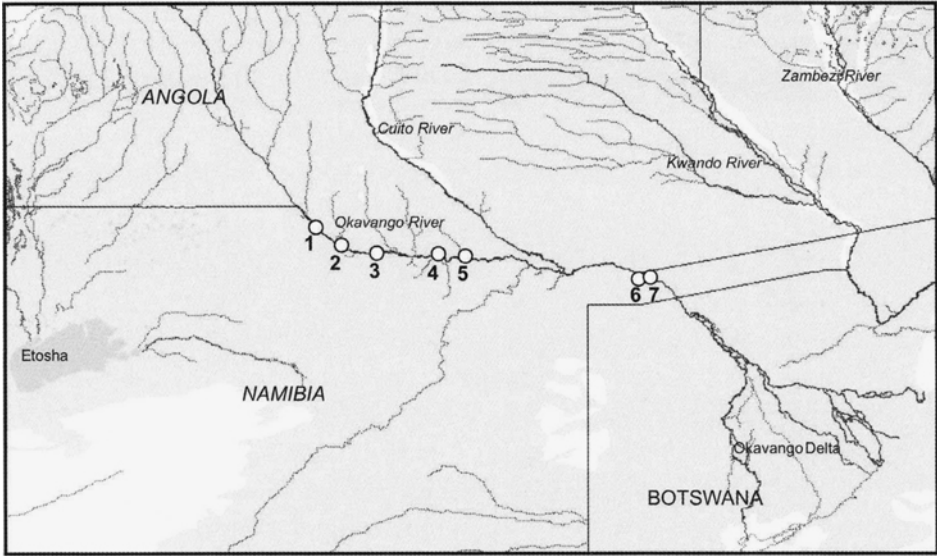


Figure 3: Distribution of *Crenigomphus kavangoensis* (white dots) known so far. The major river systems and country borders are depicted. The grey background colour indicates the Kalahari basin. Localities: (1) near Nkurenkuru, (2) near Tondoro, (3) near Rupara, (4) Hakusembe Lodge, (5) N'Kwazi Lodge, (6) Andara, (7) Gelukkie.

river. During our first visit at N'Kwazi Lodge the species was emerging and all individuals observed were rather juvenile. Two weeks later we still recorded juveniles but also mature males and females. Near Nkurenkuru we observed females ovipositing in a small sidestream in shallow, rapid flowing water over a gravely sand bottom. Several females were observed perching in shrubs ca 50 - 100 m from the banks near Tondoro. Records of adults of the species were made between December and late April.

DISCUSSION

From the characters described above *C. kavangoensis* can be clearly separated as a species. However we found it less easy to assign the species to *Crenigomphus* or *Paragomphus*. The new species fits some generic characters of *Crenigomphus* as defined by Fraser (1960) quite well:

- (1) wing venation with no anal loop, anal triangle with four cells;
- (2) all wings have yellow anterior costal border that includes the anterior border of the pterostigma;
- (3) S10 is longer than S9, only in males;

- (4) colouration pale, mostly ochreous, with few darker markings but two cream-white stripes on sides of the thorax;
- (5) no foliations on S8-9 in either sex as in *C. cornutus* and *C. renei* (but in contrast to the other known *Crenigomphus*).

However, it has to be considered how useful these characters are for defining the genus. Character 1 (wing venation) is widespread in gomphid genera, for instance in *Paragomphus*, and therefore is inconclusive. Character 2 is commonly used in keys to separate *Crenigomphus* from *Paragomphus* in that the pale colour of the anterior costal border goes across the dark pterostigma along the front in *Crenigomphus*. In *Paragomphus* either the costa is dark, or the pterostigma is pale, or the pale costa is interrupted by a dark frame around the pterostigma (or a combination of all). However, the diagnostic combination of a dark pterostigma, bordered anteriorly by a pale vein, was recently also found in *P. crenigomphoides*, thus the species' name (Clausnitzer & Dijkstra 2005). Character 3, the longer S10 in relation to S9, is present in *C. kavangoensis* but variable in other *Crenigomphus*. It is therefore not very good for separating *Paragomphus*. Character 4, the colouration of *C. kavangoensis*, fits well in the patterns of other *Crenigomphus* and differs to *Paragomphus*. *C. kavangoensis* shares character 5, the absence of foliations at S9-10, with some *Crenigomphus*, but also with at least one *Paragomphus* (*P. magnus*).

The length of the cerci of *C. kavangoensis*, which is about or more than 2x as long as the epiproct and also ca 2x as long as S10 (Table 1), is significantly different to all other known *Crenigomphus*. The length of the cerci is a character that *C. kavangoensis* shares with the genus *Paragomphus*. This was a key character used to discriminate *Crenigomphus* and *Paragomphus*, which has now been shown to be inconclusive. *C. kavangoensis* is also significantly smaller than other *Crenigomphus* and even smaller than some *Paragomphus*, for instance *P. sabicus*. A character shared with other *Crenigomphus* is the strong blackish serration at the rear end of the cerci, which is much less prominent in *Paragomphus*. Except for their length (see below) the cerci of *C. kavangoensis* are similar to those of *C. abyssinicus*. In dorsal view the epiproct is closest to that of *C. abyssinicus*. The discrimination of the female from the other *Crenigomphus* is not that clear. However, the shape of the vulva lamina may discriminate the female from at least *C. cornutus* and *C. hartmanni* (Pinhey 1961), which are sympatric to *C. kavangoensis* (Suhling & Martens 2007).

When we compared the F stadium exuviae of *C. kavangoensis* with that of *C. hartmanni* and a number of *Paragomphus* species (Table 2) we found no significant differences that allowed secure discrimination between *Crenigomphus* and most *Paragomphus* at the genus level. It is even difficult to discriminate between individual species of the two genera (Corbet 1957). By contrast, two species of *Paragomphus*, the closely related *P. acuminatus* and *P. sabicus*, clearly differ from the other species particularly in the shape of the anal pyramid. Therefore, based

on larval characters we obtain two groups, one including most *Paragomphus* and all the known *Crenigomphus*, the other being the *P. fritillarius* group, which includes *P. acuminatus* and *P. sabicus*.

We finally decided to assign the new species to *Crenigomphus* because of the serration at the posterior end of the cerci, because it resembles e.g. *C. cornutus* in general colouration, and finally because the generic name *Crenigomphus* has priority over *Paragomphus* if the genera should be combined. When considering *C. kavangoensis* described here and the recently described *P. crenigomphoides* (Clausnitzer & Dijkstra 2005), the characters specified by Fraser (1960) for the genus *Crenigomphus* do not generally provide secure discrimination from the genus *Paragomphus*. Moreover, we could not find any larval characters that allow generic discrimination. We suggest that the two genera *Crenigomphus* and *Paragomphus* should be revised.

ACKNOWLEDGEMENTS

We thank Klaas-Douwe Dijkstra for comments on the taxonomic status. Viola Clausnitzer made helpful comments on a draft of the MS. Viola Clausnitzer and KD Dijkstra allowed us to use a draft of their unpublished key to east African dragonflies. We particularly thank Ole Müller for using the unpublished larval drawings.

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