

## Problems in *Chlorocypha* classification: four cases from West Africa and a discussion of the taxonomic pitfalls (Odonata: Chlorocyphidae)

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### Abstract

The taxonomy of *Chlorocypha* species is problematic due to variability and the paucity of morphological characters. Subspecies *radix* of *C. glauca* is raised to specific rank. *C. sharpae* is found to be a synonym of *C. luminosa*. The synonymy of *C. jejuna* with *C. luminosa* is rejected. The former species is similar to the Southern African *C. consueta* and differences are stated. *C. dispar ovulosa*, *Libellago dispar fraseri* and *C. mutans* are synonyms of *C. pyriformosa*, although the lost type series of *fraseri* appears to have contained immature specimens of *C. dispar*. Trends in African chlorocyphid variation, subsequent taxonomic pitfalls and suggested guidelines to deal with them are discussed. The main problems are age and environment related melanization intensity, dark patterns caused by reversible temperature-induced colour change, especially in teneral, and the switch between reddish and bluish colours in species with bicoloured abdomens.

### Introduction

Species limits are notoriously difficult to define in the genus *Chlorocypha* Fraser, 1928. Structural distinctions are very limited and taxonomy is based largely on colour patterns. The latter is complicated by strong variation in melanization, related to age and environment, an issue many authors have called to mind (e.g. Longfield 1959; Pinhey 1967; Cammaerts 1978; Legrand & Couturier 1985) and that led Fraser (1949) to remark that "there is good evidence that these wide changes in colour and markings have been responsible for the same species being described under several names". In the course of identifying material from Ghana, several new and incorrect synonymies were encountered. It proved necessary to review the status of the Upper Guinean relatives of *C. glauca* (Selys, 1879) once more, despite (but thanks to) the efforts of Liefinck (1973) and Gambles (1975). The paper concludes with a discussion of the taxonomic treatment

of variation and its pitfalls, as applied to chlorocyphid taxonomy in particular, and to Odonata taxonomy in general.

The following abbreviations for collections are used: BMNH – Natural History Museum, formerly British Museum (Natural History), London; MNHN – Muséum National d'Histoire Naturelle, Paris; RMNH – Nationaal Natuurhistorisch Museum Naturalis, formerly Rijksmuseum voor Natuurlijke Historië, Leiden; USNM – National Museum of Natural History (Smithsonian Institution), Washington; ZMB – Museum für Naturkunde, Humboldt-Universität zu Berlin.

*Chlorocypha radix* Longfield, 1959 stat. nov.  
(Figs 1K–M, 3A)

*Libellago rubida* nec Hagen in Selys, 1853. — Karsch (1893: 35).

*Chlorocypha glauca radix* Longfield, 1959: 28 [type: Ado Ekiti, Nigeria; BMNH].

*Chlorocypha pavo* Liefstinck, label name; nomen nudum.

*Chlorocypha pavonis* Liefstinck, 1973: 34 [type: Bismarckburg, German Togo; ZMB]; new synonymy.

*Specimens studied*

Holotype ♂ *radix* – with labels: round, white, red-bordered, printed “Holotype”; white, hand-written “Nigeria: Ado Ekiti. 19.iii.1954. R.M. Gambles.”; white, hand-written and printed “Brit. Mus. 1957-377”; white, hand-written and printed “Chlorocypha glauca radix Type ♂ det. Miss C. Longfield.” (in BMNH). Allotype ♀ *radix* – with labels: white, hand-written and printed “Ado Ekiti W. Nigeria 19.iii.'54. R.M. Gambles.”; round, white, red-bordered, hand-written “Allotype Ch. radix” and “T 21 19iii54”; white, printed and hand-written “R.M. Gambles BM 1991-3” (in BMNH). Holotype ♂ *pavonis* – with labels: blue, printed “Togo, Bismarckburg, 1.11.-15.12.90, R. Büttner S.”; white, hand-written “Libellago rubida Selys”; white, hand-written “ist dies glauca Selys?”; white, hand-written “[jenspricht] nicht ganz der Rubida Karsch 1891”; red “Holotype, C. pavo Liefst.”; white “Chlorocypha pavo Liefert., det. MA Liefstinck 1972, HOLOTYPE” (in ZMB).

Numerous ♂ from Ghana (including four paratypes of *radix*), Liberia, Nigeria (including eight paratypes of *radix*) and Sierra Leone (one paratype of *radix*), and one with labels “Chl. glauca radix locality label wrong? det. R.M. Gambles 1971.” and “C. glauca (Selys) Cameroons, Bipindi, 14.viii.31. [Fraser's hand-writing]” (in BMNH, RMNH and coll. J. Lempert).

Additional taxa studied for reference were *aphrodite* (seven ♂ from Uele: Bambesa, Belgian Congo), *glauca* (two paratype ♂ from Mongoma Lobah, Cameroon, two ♂ from near Mamfe, Cameroon and three ♂ from Budo, Belgian Congo) and *seydelli* (four paratype ♂ from Luulaba: Kabongo, Belgian Congo, and one ♂ from same locality (all in BMNH)).

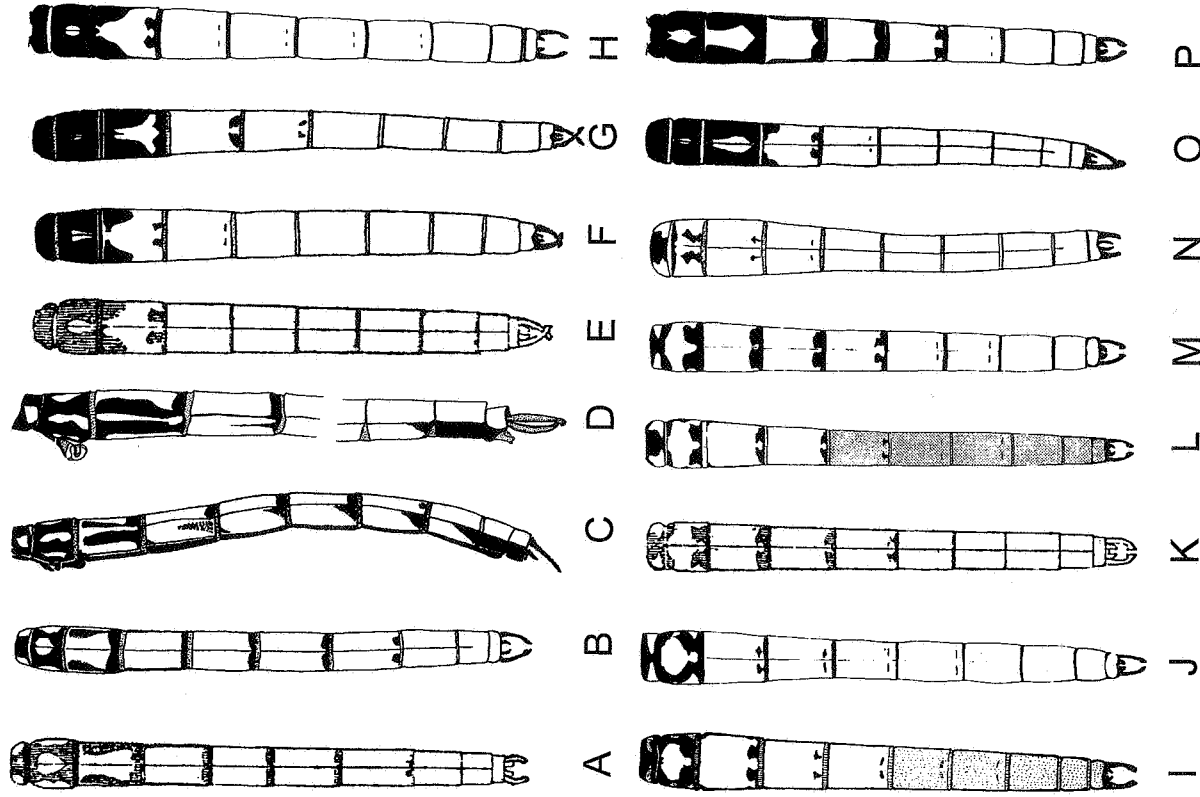


Figure 1. Gallery of history drawings of the abdomen of *Chlorocypha* species by Karsch 1893 (A, E, K), Schmidt 1951 (B, C, F, G, N, O), Pinhey 1972 (D), Liefstinck 1973 (I, L), Gambles 1975 (J, M) and Legrand & Couturier 1985 (H, P) representing *C. luminosa* (A, B, C, D), *C. dispar* (E, F, G, H), possible *C. pyriformosa* (O), *C. pyriformosa* (P), *C. jejuna* (N), *C. glauca* (I, J) and *C. radix* (K, L, M). All dorsal views, except C and D, lateral views.

Their black markings not only differ in extent, but also in their configuration: there are inverse intensity trends in *glauca* and *radix*, the first being blacker on the synthorax and abdominal S2, while the second is blacker on the remaining segments. The four taxa differ in the extent of red colour on the terminal abdominal segments. The four taxa could either be regarded as subspecies of *glauca*, or as four distinct species. They appear to be allopatric, though their potential areas of overlap are poorly sampled. With discrete colour patterns in the four taxa being present, and with only one of them presently regarded as a subspecies, it appears justified to follow Liefinck (1973), raising *radix* to specific rank. Liefinck also describes morphological differences in the appendages between *glauca* and *radix*, but these differences are very slight, and appear not to be of much use.

*C. radix* has been reported (often just as *C. glauca*) from Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Guinea and Nigeria (Longfield 1959; Legrand & Couturier 1985; Lempert 1988; Legrand & Girard 1992). A male in the BMNH from Cameroon may either indicate overlap with *C. glauca*, or mislabelling. The species inhabits larger streams and rivers in forest (Dijkstra & Lempert 2003).

*Chlorocypha luminosa* (Karsch, 1893)  
(Figs 1A-D, 3F)

*Libellago luminosa* Karsch, 1893: 33 [type: Bismarckburg, German Togo; ZMB].

*Chlorocypha dispar luminosa* (Karsch). — Fraser (1947: 23).

*Chlorocypha luminosa* (Karsch). — Fraser (1947: 37).

*Chlorocypha sharpae* Pinhey, 1972: 1 [type: Mt. Coffee, Liberia; USNM]; new synonymy.

*Specimens studied*

Lectotype ♂ *luminosa* — with labels: blue, printed "Togo, Bismarckburg, 15.12.-31.12.90, R. Büttner S."; red, printed "Typus"; white, hand-written "luminosa Karsch\*"; white, hand-written and printed "Libellago luminosa Karsch, 1893, Typus ♂, det. Dr. Erich Schmidt 1943"; white, hand-written "Lectotypus" (in ZMB). Paralectotype ♂ *luminosa* — with labels: blue, printed "Bismarckburg, Togoland, R. Büttner S."; red, printed: "Typus"; white, hand-written and printed "Libellago luminosa Karsch, 1893, Typus ♂, det. Dr. Erich Schmidt 1943"; white, hand-written "Paralectotypus" (in ZMB).

Various specimens from Liberia and Ghana (in RMNH, coll. J. Lempert and coll. H.A. Olsvik). Holotype ♂ *sharpae* not seen.

*Discussion*

Karsch (1893) reported five *Libellago* (now *Chlorocypha*) species from German Togo. Although he used different names, they are identifiable from his descriptions and drawings as *C. curta* (Selys, 1853), *C. dispar* (Beauvois, 1805), *C. luminosa*, *C. radix* (see above) and *C. selysi* (Karsch, 1899). My material from the area, nowadays in the Volta Region of Ghana, contains the same quintet. The *luminosa* specimens perfectly fit Karsch's description and drawings. This species has remained obscure and unrecorded

*Discussion*

*C. glauca* was described from the highlands of Cameroon and Longfield (1959) described *radix* as a lowland subspecies of it occurring in Sierra Leone, Ghana and Nigeria. Liefinck (1973) examined *glauca* specimens reported as *rubida* by Karsch (1891; 1893) from Cameroon and German Togo. Realising they were distinct, he described the Togo specimen as *pavonis*, suggesting the type series of *radix* might include his new species. Gambles (1975) compared the type material of *glauca* and *radix* thoroughly, noting in the postscript that *radix* and *pavonis* were indeed the same. *Pavonis* was simply sunk into synonymy with the subspecies *radix* of *glauca* (e.g. Gambles 1980; Bridges 1994), disregarding Liefinck's conclusion that it was specifically distinct from *glauca*.

Pinhey (1967) established the Glauca-group of *Chlorocypha*, which includes all species with the abdomen partly blue. This heterogeneous assemblage holds entirely blue, red-based and red-tipped species. Within this group, *glauca* and *radix* appear to be closely related to *C. aphrodite* le Roi, 1915 and *C. seydéli* Fraser, 1958 (Figs 3A-D). All are rather large species (Hw 22-25 mm), with blue-based abdomens and similar synthoracic and abdominal markings. A comparison of the four reveals that all are about equally distinct (Table 1).

Table 1. Differences between *Chlorocypha glauca* and related species, following Fraser (1958), Gambles (1975), Liefinck (1973), Longfield (1959) and Pinhey (1967). Development of markings is given only in relative terms, because their description is too complex (Figs 1I-M, 3A-D).

	<i>radix</i>	<i>glauca</i>	<i>aphrodite</i>	<i>seydéli</i>
Distribution	Sierra Leone to S Nigeria	East Nigeria to W of Congo Basin	most of Congo Basin	E of Congo Basin
Branches of pale U-shaped antehumeral band	broad, narrowly joined to severed	narrow, broadly severed	very broad, broadly joined	very broad, broadly joined
Anterior side of mid and hind tibiae white	no	no	yes	yes
Development of black marks on S2	quite strong	strong	quite weak	weak
Development of black marks on S3-5	strong	weak	weak	weak
Colour of S5	red	blue (rarely red)	blue	blue
Colour of S6-10	red	red	blue	red

## Discussion

*C. jejuna* was described by Baumann (1898) from a single male, which can thus be regarded as the holotype. It was said to be closest to *C. luminosa*, described from a locality only some 150 km away. The species and *C. consueta* were synonymized with *C. luminosa* by Fraser (1949). When Pinhey (1967) separated *consueta* again, *jejuna* was left in synonymy with *luminosa*. Because of the confusion surrounding *C. luminosa* described above, this synonymy demands a reassessment. Both Fraser (1949) and Schmidt (1951) believed the holotype is immature ("ein noch jüngerer Stadium" than *luminosa* according to the latter author), despite the fact that Baumann (1898) said it was "ein ausgefärbtes Männchen". The holotype is in fact fully mature, with dark brown pterostigmata and a clearly red abdomen. The synthoracic and abdominal markings, as illustrated excellently by Schmidt (1951), are unlike those in *luminosa* (these markings are already distinct in the teneral state of that species), as are the red abdomen and the yellow restricted to the wing bases. Synonymy with that species can thus be ruled out.

The *C. jejuna* holotype is actually remarkably similar to the third party in the historic confusion, *C. consueta* (Fig. 1K). One year after the description of *C. jejuna*, *C. consueta* was described from Southern Tanzania, from where it ranges West into Angola and South to South Africa. Both share the large size (Hw 24 mm in *jejuna*; 23-25 mm in *consueta*) and the broad red abdomen with restricted black markings and both have a black head with a similar pattern of brown blotches. Unlike typical *consueta* the black markings on S2 are not complete from base to apex, but are severed subbasally. The extent of anterior white on the tibiae (35%, 55% and 100% of the length of the fore, mid and hind tibiae respectively) may fall within the variation of *consueta* (30-60%, 65-100% and 100% in six specimens examined). *C. consueta* has a complete broad black band below the humeral suture, even when teneral, whereas only the anterior portion of this marking is present in the *jejuna* holotype.

No conclusion can be drawn about these two taxa with only a single specimen of one of them available. Pinhey (1967) states that *consueta* also occurs in "Southern Nigeria, Togoland (overlapping with *luminosa*)". Gambles (1980) listed *consueta* for Nigeria, and his remark "= *luminosa* of authors, not of Karsch 1893" suggests that he specifically meant this species, despite the resulting gap in distribution of more than 2000 km. There are no Nigerian specimens of *consueta* in the BMNH, where Gambles' collection is housed, and the species is also not mentioned in the unpublished manuscript of his "The Nigerian dragonflies". Neither author says what the source of the West African records is. Following all the confusion, they might be based purely on misinterpretation. Perhaps they are *jejuna*, but for now all that can be done is to make that name available for future revision by revoking the incorrect synonymy with *luminosa*.

*Chlorocypha pyriformosa* Fraser, 1947 stat. nov.

(Figs 1O-P, 2, 3G)

*Chlorocypha dispar pyriformosa* Fraser, 1947: 23 [type: Ivory Coast; BMNH].*Chlorocypha dispar ovulosa* Fraser, 1947: 23 [type: Old Calabar; BMNH]; simultaneously introduced; relative precedence of *pyriformosa* defined by present act as first revisor.

since its description, because of confusion with *C. consueta* (Karsch, 1899) and *C. dispar*. Fraser (1947) made *luminosa* one of several ill-defined subspecies of *dispar*, but later Fraser (1949) went on to regard it a distinct species with *consueta* as a synonym. Schmidt (1951) maintained *luminosa* as a subspecies of *dispar*, repeating Fraser's characters, but also provided excellent drawings of a *luminosa* type, which he regarded as a "nicht völlig ausgefärbtes" male of Fraser's subspecies. Pinhey (1967) clarified the mix-up, showing *consueta*, *dispar* and *luminosa* were all distinct, and stating the unique characters of the latter. He went on to describe *sharpae* five years later.

Comparison of the lectotype and paralectotype of *luminosa* with Pinhey's detailed description and topotypical material of *sharpae* shows no marked differences. The abdomen has characteristic black markings: S3 is marked with a thick, inverted U. S4-6 have an apical black cross-bar. Dark specimens have a thin or incomplete U on S4 and an apical bar on S7 too. These markings are already recognisable in the teneral state. The markings on the head, synthorax and legs are yellow (the latter white in other species). The wings are conspicuously all-yellow, instead of hyaline, a feature repeatedly stressed by Karsch (1893, 1899) and Pinhey (1967). The type material of both taxa was probably interpreted as being discoloured or immature, as their describers assumed they were red in life. This might explain the origin of all the confusion. Pinhey (1972) remarks, rather cryptically, that "the brownish yellow abdominal colour appears superficially to be of a pale red colour." In fact, the mature adult differs from the modus in the genus in having an orange, not red, abdomen in life (own observations; Legrand 1985; Lempert 1988). When treated with acetone, the abdomen may become a bit reddish, especially ventrally. As *luminosa* and *sharpae* agree in all characters, they are regarded synonymous.

*C. luminosa* has been reported (as *sharpae*) from Guinea and Liberia (Pinhey 1972; Legrand 1985; Lempert 1988). It is found throughout Southern Ghana, occurring close to the Ivorian and Togolese borders (K.D.B. Dijkstra & H.A. Olsvik unpublished). Records from in-between Côte d'Ivoire are still wanting. Gambles (1980) listed *consueta* for Nigeria, remarking "= *luminosa* of authors, not of Karsch 1893", which seems to preclude the presence of *luminosa* in that country, and no specimens by that name were found in the BMNH where Gambles' collection is housed. The species has a typical Upper Guinean distribution. It inhabits large streams and small rivers in Ghana, but was reported from larger rivers in Liberia (Lempert 1988).

*Chlorocypha jejuna* (Baumann, 1898)

(Figs 1N, 3f)

*Libellago jejuna* Baumann, 1898: 345 [type: Misahöhe, Togo; ZMB].*Chlorocypha jejuna* (Baumann). — Longfield (1936: 494).*Libellago luminosa* Karsch. — Fraser (1949: 20, 37); suggested synonymy.

## Specimens studied

Holotype ♂ *jejuna* — with labels: blue, printed "Togo, Misahöhe, 1895, E. Baumann S.", white, hand-written "Misahöhe, 11.V.95, Baumann"; red, printed "Typus"; white, hand-written "Libellago jejuna\*" (1898), E. Baumann" (in ZMB).

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(Figs 1N, 3I)

*Libellago jejuna* Baumann, 1898: 345 [type: Misahöhe, Togo; ZMB].

*Chlorocypha jejuna* (Baumann). — Longfield (1936: 494).

*Libellago luminosa* Karsch. — Fraser (1949: 20, 37); suggested synonymy.

#### Specimens studied

Holotype ♂ *jejuna* — with labels: blue, printed "Togo, Misahöhe, 1895, E. Baumann S."; white, hand-written "Misahöhe, 11.V.95, Baumann"; red, printed "Typus"; white, hand-written "Libellago jejuna\*" (1898), E. Baumann" (in ZMB).

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#### *Chlorocypha pyriformosa* Fraser, 1947 stat. nov.

(Figs 1O-P, 2, 3G)

*Chlorocypha dispar pyriformosa* Fraser, 1947: 23 [type: Ivory Coast; BMNH].

*Chlorocypha dispar ovulosa* Fraser, 1947: 23 [type: Old Calabar; BMNH]; simultaneously introduced; relative precedence of *pyriformosa* defined by present act as first revisor.

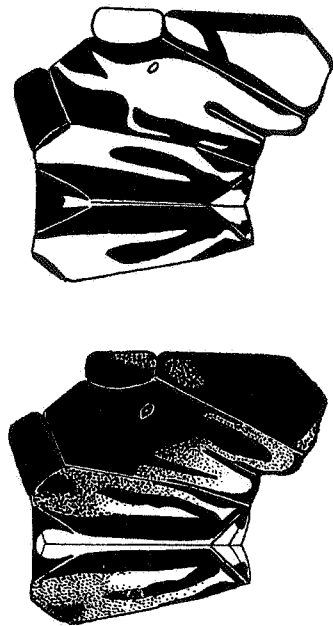


Figure 2. Synthoraces of *Chlorocypha* taxa drawn by Schmidt (1951) and their presumed identity: *C. pyriformosa* subadult (left), *C. dispar* juvenile (right).

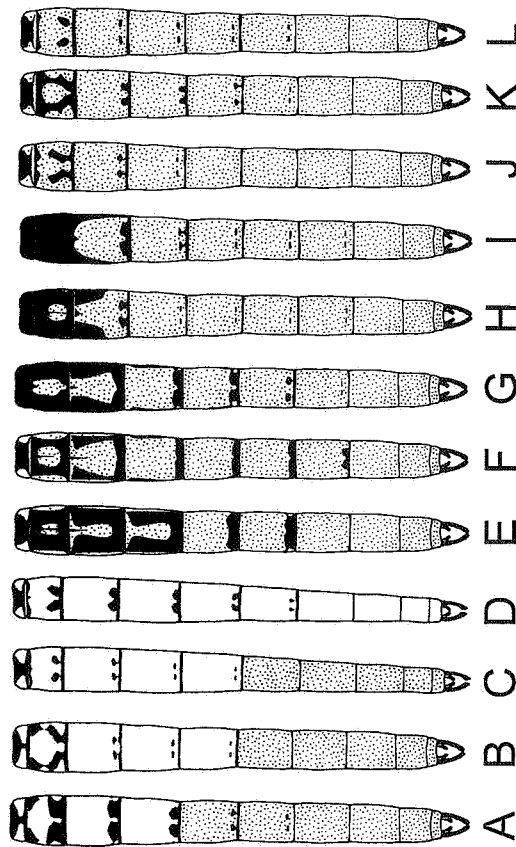


Figure 3. Dorsal views of abdomens of discussed *Chlorocypha* species and their relatives — *C. radix* (A), *C. glauca* (B), *C. seydeli* (C), *C. aphroditae* (D), *C. neptunus* (E), *C. luminosa* (F), *C. pyriformosa* (G), *C. dispar* (H), *C. schmidti* (I), *C. jejuana* (J), *C. consuetata* (K) and *C. wittei* (L). Dotted areas are red or orange, undotted blue.

*Libellago dispar fraseri* Schmidt, 1951: 161 [syntypes: Boé, Portuguese Guinea; ♂ fig. 19c (p. 164) is designated here as lectotype]; new synonymy.

*Libellago mutans* Martin, label name. — Legrand & Couturier (1985: 144); nomen nudum.

*Chlorocypha mutans* Legrand & Couturier, 1985: 144 [type: Côte d'Ivoire; MNHN]; new synonymy.

#### Specimens studied

Lectotype ♂ *pyriformosa* — with labels: white, hand-written “*C. dispar* Ivory Coast 22.vii.44 R. Paulian”; white, printed “F.C. Fraser Bequest Brit. Mus. 1963-243”; white, hand-written “Lectotype *Chlorocypha dispar pyriformosa* Fraser, 1947, K.-D.B. Dijkstra December 2002” (in BMNH; missing head). Lectotype ♂ *ovulosa* — with labels: white, hand-written “Old Calabar R.94”; blue, printed “McLachlan” Coll. B.M. 1938-674; white, hand-written “Lectotype *Chlorocypha dispar ovulosa* Fraser, 1945, K.-D.B. Dijkstra December 2002” (in BMNH).

Numerous males from Benin, Ghana, Liberia, Nigeria and Sierra Leone (in BMNH, RMNH, coll. J. Lempert and coll. H.A. Olsvik). Holotype ♂ *mutans* not seen.

#### Discussion

Legrand & Couturier (1985) described *C. mutans* as a doppelganger of *C. dispar* that differs ecologically, *mutans* being found on rivers and *dispar* on streams. *Mutans* is smaller and differs in the distribution of white markings on the legs and more extensive and differently shaped black markings on the abdomen. Furthermore, in *mutans* the white line of the middorsal carina is much broader than in *dispar*. Before the description of *mutans*, five names have been linked as subspecies to *dispar*. Because of the similarity between the aforementioned species, it seems sensible to examine their identity. In a brief and rather messy discussion of variation in *dispar*, Fraser (1947) introduces four of these combinations. The history of *luminosa* is discussed above. Of three new names introduced by Fraser, a type was only designated for *C. cordosa* Fraser, 1947. This was found to be synonymous with *C. cyanifrons* (Selys, 1873) by Pinhey (1962, 1967).

*Pyriformosa* was based on a series of seven males and 11 females collected in the ‘Réserve forestière du Banco’ near Abidjan, South-eastern Côte d’Ivoire, by R. Paulian between 1941 and 1946. A male and a female were found under *C. dispar* in the BMNH, both labelled “Ivory Coast 22.vii.44 R. Paulian”, as well as four males of unspecified origin that may also have belonged to the series. Paulian was associated with the MNHN, but no material of the collection treated by Fraser (1947) has been found there (J. Legrand pers. comm.). As described by Fraser (1947), in *dispar* “the red dorsal spot on segment 2 occupies the middle two-fourths of the segment and is oval in shape” whereas in *pyriformosa* “this spot is much larger, extending the whole length of the segment and [is] bilobate in shape, one lobe occupying the basal three-fourths of the segment, the other, very much smaller and narrower, is a mere stalk connecting the larger lobe to the apical border of the segment.” Furthermore he states that “segments 4 and 5 have a pair of black apical spots confluent to the apical black ring, whilst segment 6 has a vestige

of this marking". The single Paulian male demonstrates these distinctions, and was therefore selected as the lectotype of *pyriformosa*. Fraser's description and illustration conform with the abdominal differences between *dispar* and *mutans* described by Legrand & Couturier (1985). Moreover, the *pyriformosa* lectotype agrees with *mutans* in its relatively small size, leg coloration and broad white lining of the middorsal carina. As *pyriformosa* and *mutans* are identical in all characters, they are regarded synonymous.

Fraser (1947) adds that "in the McLachlan collection, a male from Old Calabar [south-eastern Nigeria] is closely similar to these Ivory Coast specimens [*pyriformosa*] in possessing a red oval dorsal spot on segment 2, but it is unilobate and regularly oval in shape." He names this taxon *ovulosa*. In the BMNH I found two males from Old Calabar originating from the McLachlan collection, which agree in all aspects with the *pyriformosa* lectotype. The most complete specimen is designated as the lectotype of *ovulosa*. Both names are introduced on the same page, but because the *pyriformosa* description is more extensive and *ovulosa* is only characterized in comparison with *pyriformosa*, I give *pyriformosa* priority and regard *ovulosa* as a synonym of it.

Schmidt (1951) recognizes four so-called "geographisch geschiedene Formen" of *C. dispar*, but ignores *pyriformosa* and *ovulosa*. Two of the four 'forms' were later regarded distinct species (Figs 3F-I): *C. luminosa* (see above) under that name, and the subspecies *cordosa* (sensu Schmidt 1951, nec Fraser 1947) as *C. schmidtii* Pinhey, 1967. The other two are nominotypic *dispar* and Schmidt's subspecies *fraseri*. The latter was based on a series of 25 males and 10 females from Boé in present-day Guinea-Bissau. *Fraseri* differs from *dispar* in details of the black markings on the abdomen, and in its smaller size. S2-3 of *fraseri* are similar to the condition of *pyriformosa*, but S4-6 are not so extensively black. Schmidt did not mention that the middorsal carina was broadly white-lined, although this is apparent in his figure 19c (Fig. 2). He describes the distribution of white on the legs as follows: "Die adulten Männchen haben die Beine schwarz. Vorderschienen basales Drittel innen gelblichweiss, Mittelschienen basale Hälfte und Hinterschienen innen ganz weiss." Whereas the other character states given for *fraseri* suggest *pyriformosa*, this is the character state of *dispar*. The origin of this conflicting information may be sought in Schmidt's remark: "In der Serie sind neben den meisten Adulten einige nicht völlig ausgefärbte Stücke, ... Bei den adulten Männchen der Boé-Serie ist die Zeichnung der Abdomenbasis auffallend konstant, auch bei den anderen Unterarten nach unserem Material, sodass diese als gut begründet angesehen werden: Variationen der Boé-Serie Männchen führen wir, wie oben erwähnt, auf Ausfärbung zurück." Schmidt depicts an abdomen (fig. 18F) and two synthoraces (figs 19a-b) of such 'not fully coloured' specimens. The abdomen may have belonged either to *dispar* or *pyriformosa*, as the markings are not yet fully developed in teneral. One of the synthoraces shows only narrow white lining of the middorsal carina (Fig. 2), suggesting the series contained immature specimens of *dispar*. From Schmidt's remarks and illustrations it seems that his series included both *dispar* and *pyriformosa*. Schmidt did not designate a holotype and unfortunately his entire series appears to be lost. It has not been found in the museum in La Chaux-de-Fonds, where Schmidt indicates it was. Possibly the material was lost when the collection was attacked by pests in the 1960s (M. Jacquat pers. comm.). Pinhey (1962) states (probably by default) the holotype

is in the Schmidt collection, but no specimens of the series could be found there (M. Tomokuni pers. comm.). It seems best to designate the specimen in figure 19c of Schmidt (1951: 164) as the lectotype of *fraseri*, because this clearly depicts a reliable feature, and to place it into synonymy with *pyriformosa*.

As is obvious from the obscurity of the names *pyriformosa*, *ovulosa* and *fraseri*, as well as the late description of *mutans*, this species has been much confused with *dispar* (see also next paragraph). Legrand & Couturier (1985) give a good summary of the distinguishing characters. Having seen many males from across West Africa, I can add the following about their reliability: specimens of *pyriformosa* among those of *dispar* can be picked out by their smaller size (Hw 18-19 mm in *pyriformosa*; 20-21 mm in *dispar*), the relatively short abdomen of *pyriformosa* reinforces this distinction. The extent of black markings on the abdomen is very variable in both species, though greater on average in *pyriformosa*. The shape of the red mark on S2 seems to be the most reliable difference. The mark is long and entire in *pyriformosa* ("fête de loup" of Legrand & Couturier), short and normally severed longitudinally by a black line in *dispar* ("grain de café"). The red marking on S3 is, on the other hand, normally more extensive in *dispar*, usually expanded across the full breadth of the segment, a condition I have only seen in one very pale male of *pyriformosa*. Mature males, with an all black synthorax, of *pyriformosa* always retain some white along the middorsal carina, although this can be extremely thin. The most reliable character is the leg markings: in *pyriformosa* the fore tibiae are all black, while the anterior side of the mid and hind tibiae are entirely white, whereas in *dispar* the anterior sides are respectively about one-, two- and three-thirds white.

Besides South-eastern Côte d'Ivoire, South-eastern Nigeria and Guinea-Bissau, *C. pyriformosa* has been reported (as *mutans*) from Guinea, Liberia and South-western Côte d'Ivoire where it inhabits larger rivers (Legrand & Couturier 1985; Lempert 1988). K.-D.B. Dijkstra & H. Olsvik (unpubl.) report the species from two Ghanaian rivers, near the Ivorian and Togolese borders. A specimen published as *C. neptunus* (Sjöstedt, 1899) from Sierra Leone by Carfi & D'Andrea (1994) was re-examined and found to be *pyriformosa*. The locality there, a river, conforms with its known habitat. Among material placed under *C. dispar* (some labelled "very dark" by R.M. Gambles) in the BMNH were further one male from Sierra Leone and seven more from Nigeria (from Sapoba Forest Reserve, Soba Plain and Port Harcourt). S. Tchibozo sent me a single male from Lokoli Forest in South Benin (in RMNH).

### General discussion

Fraser (1949) already complained that "whilst the comparatively simple colouring and markings of the body and the unvarying nature of the colouring and markings of the wings in most genera of the family Chlorocyphidae render the task of identification of the species a matter of simplicity, it is far otherwise in the case of the genus *Chlorocypha*." The four cases discussed above illustrate these problems. They came to light while investigating the species of a rather small part of West Africa. It may therefore be expected that many more problems remain, especially in Central Africa where the ranges of many



(so-called) species may be expected to meet and where the available material is fragmentary. In particular the Rubida-group of Pinhey (1967) is potentially problematic. This group is rich in species that differ principally in details of black abdominal markings and colour-patterns on the face. The latter factor at least is partially age-dependent. The overall complexity of African chlorocyphid taxonomy can be brought back to two factors:

1. General absence of structural characters.
2. Great age- and environment-related variation, especially in melanization and size. The first factor is typical of taxa that use visual, instead of tactile, cues as the principal means to recognise conspecifics. The second factor plagues all odonate taxonomy, and is discussed in more detail below.

#### *Change of colours and markings with age and temperature*

Fraser (1949) continues that "quite often the teneral or subadult state is entirely different from the adult ..., a number of teneral forms have been described as new species and thus synonymy has grown which is extremely difficult to check without the availability of long series of each of the species involved." In many *Chlorocypha* species, but not all, the pale markings on the head and synthorax become obliterated by black with increasing age. *C. dispar* and *C. luminosa*, for instance, have a virtually identical sharply-marked black and yellow synthorax when teneral. That of *dispar* becomes entirely black with age, while *luminosa* does not blacken at all. Degrees of blackening may also vary between parts of the body. Some species of *Chlorocypha* retain brightly coloured markings in the face, apparently with a signalling function, while other markings darken. Abdominal melanization may also be less extensive in tenerals.

Teneral specimens lack the bright colours of adults, their abdomens tending to be yellowish and often partially darkened. The darkened areas can be of a colour completely unlike that of the adult (e.g. blue-grey in red species) and contrast with paler parts, creating patterns not seen in mature specimens. This phenomenon is probably physiologically similar to so-called Reversible Temperature-Induced Colour Change (RTCC). Such colour-changes have been observed in numerous odonate species (Corbet 1999: 280, 638), and is described for *C. trifaria* (Karsch, 1899) by Miller (1993). He observed that bright red turns to dark grey when specimens are cooled below 25°C. Possibly the darkening of tenerals results from them exposing themselves less to sun, or having recently emerged from relatively cool water. The most dramatic colour changes occur in *Africocypha lacuselephantum* (Karsch, 1899) and are still not fully understood (Pinhey 1971). Teneral females are almost entirely orange, and become black with blue dorsal abdominal spots. Males also start off largely orange, blacken and develop various combinations of orange, red and blue dorsal spots. As has been suggested by Corbet (1999: 280) these changes may partly reflect RTCC, though increasing melanization is interwoven into the complexity.

As is apparent from the above, extreme caution must be taken when identifying immature specimens, especially as RTCC-related darkening is retained by preserved specimens (Miller 1993; K.-D.B. Dijkstra pers. obs.). It must be noted that if adults collected are allowed to cool before they die, they will be preserved with a darkened abdomen, especially on the central segments.

#### *Melanization variation: intensity versus configuration*

In Odonata the most obvious manifestation of melanization, the presence of melanin, is black markings. Blacker specimens also tend to have more deeply and extensively coloured wings. Melanization intensity can be defined as the extent of black markings, and is often under the influence of age (see above) and environment. Black pigment appears to become more extensive with increasing humidity and shading (e.g. savannah vs forest), at least in these tropical zygopterans. Intensity variation in chlorocyphids can be most easily recognised by the extent of the paired (sub)apical markings on the segments, the so-called "hyphens" (small markings not touching the posterior border of the segment) and "bollards" (large markings fused with the border) of Pinhey (1967).

Due to the problems of intensity variation of black markings, it is only their configuration that is taxonomically informative. Configuration can be defined as variation in markings between species that is not positively correlated with overall variation of their intensity, i.e. variation trends that are inverse to or independent of intensity trends. Such trends result in the unexpected expression (presence, shape) of black markings if intensity was the only predictor. An example of an inverse trend between species is the reduced extent of black bollards on S3-5 of *C. glauca* compared with *C. radix*, while the synthorax is relatively dark. Similarly, *C. dispar* has more black than *C. pyrriformosa* on the synthorax, mid tibiae and S2, with the reverse on the fore tibiae and S3-6.

Odonate taxonomy counts numerous examples of taxa, especially subspecies, based solely on intensity of melanization (e.g. Dijkstra & Dingemans 2000). Such taxa are superfluous, as purely phenotypic factors can not be ruled out as the only cause of their distinctiveness. Moreover this distinctiveness can often be questioned, considering the fragmentary nature of material available for descriptions. An example of such a subspecies in Chlorocyphidae is *C. selysi nigeriensis* Gambles, 1975. This name was given to Nigerian specimens that were much paler than those of the nominotypic subspecies in adjoining Cameroon. In the same paper Gambles described *Pseudagrion sjoestedti nigeriense*, a member of the notoriously variable 'group B' (Pinhey 1964) of the genus. Again the Nigerian taxon is much paler than the nominotypic subspecies from Cameroon. Specimens of both species from Ghana are intermediate between the examples from Nigeria and Cameroon, and this pattern appears to be simply environmentally induced.

The 'intensity vs configuration' guideline can be difficult and subjective in its use, but it does offer a degree of objectivity in evaluating taxa where more qualitative characters, such as morphological differences in the genitalia, are lacking. This rule has here been applied to regard one taxon as specifically distinct from its closest relatives, and to render several others synonyms. It must be noted that this account, and chlorocyphid classification in general, is based entirely on characters of the males. Females lack the bright colour patterns of the males (with the mentioned exception of *A. lacuselephantum*), being brown with extensive black markings. These patterns are susceptible to strong variation too, but may differ in configuration as well.



### Reds and blues: a quick switch?

Another trend is found in those *Chlorocypha* species with a bicoloured abdomen (Figs 3A-C, 4). Here the basal four to six segments are of a different colour from the remaining segments, the two opposing colours being shades of blue and red respectively. In some species there is polymorphism regarding the point of this colour-switch, and in preserved specimens the transition can be vague. This variation is summarized in Table 2. The partly sympatric *C. cancellata* (Selys, 1879) and *C. hintzi* (Grünberg, 1914) are listed as one species, as they only differ in the colour of S6 and Pinhey (1967) remarks that "it is probable that the two species... are colour variants of the same species (vide *C. glauca* and *C. curta*)." It can be noted from the Table that the switch takes place on S5 in blue-based species, and S6 in red-based ones. Furthermore, the form in which the 'switch-segment' takes the colour of the basal segments seems to be the commoner one.

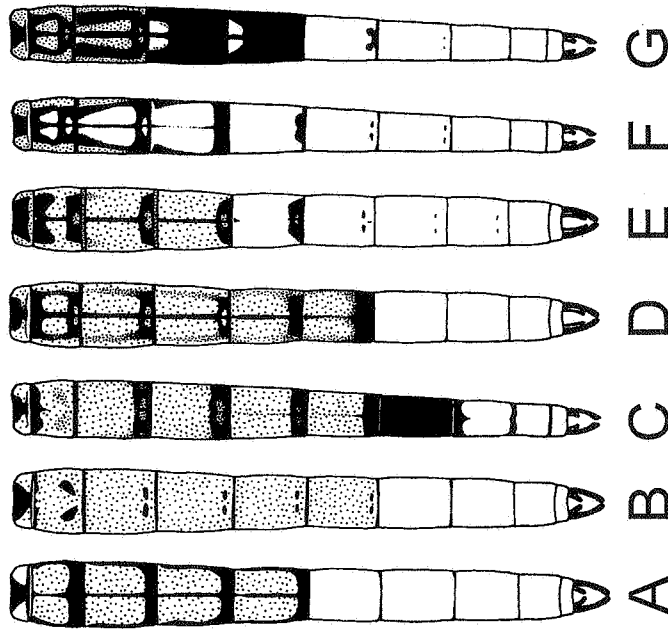


Figure 4. Dorsal views of abdomens of bicoloured *Chlorocypha* and *Platycypha* species — *C. hintzi* (A), common variety of *C. curta* (B), *P. ruftibia lucalaensis* Pinhey (C), *P. pinheyi* Fraser (D), *P. amboniensis* (E), pale (F) and very dark (G) examples of *P. caligata* f. *lacus*. Dotted areas are reddish, undotted blue.

Table 2. The distribution of colour on abdominal segments of bicoloured *Chlorocypha* species, following Legrand (1984) and Pinhey (1967). In polymorphic species the variety that appears to be rarer is bracketed. Species are sorted according to colour pattern.

	S1-4	S5	S6	S7-10
<i>seydéli</i>	blue	blue	red	red
<i>glauca</i>	blue	blue (red)	red	red
<i>radix</i>	blue	red	red	red
<i>curta</i>	red	red	red (blue)	blue
<i>helenae</i>	red	red	blue	blue
<i>cancellata</i> ( <i>hintzi</i> )	reddish	reddish	reddish (dark blue)	dark blue

This two-tone variation also occurs in the related genus *Platycypha*, in which several red-based, blue-tipped species are known (Figs 4C-G). Here variation between species is much greater, there being species with as few as four — *P. amboniensis* (Martin, 1915) — and as many as seven basal segments reddish — *P. ruftibia* (Pinhey, 1961) —, while the variation appears to be absent within species. Bicoloured species may be very closely related to all-blue or all-red species. *Platycypha* includes all-red — *P. auripes* (Förster, 1906) — and all-blue species — *P. caligata* (Selys, 1853) —. The all-blue *C. aphrodite* has already been placed close to three red-tipped species, especially *C. seydeli*. *C. wittei* Fraser, 1955, from Shaba and adjacent Angola and Zambia, appears rather like an all-red form of the widespread *C. curta* (Figs 3L, 4B). The BMNH houses a Nigerian series under the name *wittei* and these seemingly disjoint representatives do not differ from sympatric *curta* other than having the terminal segments red instead of blue.

The above suggests that the red and blue colour have a physiologically similar origin. According to Longfield (1959) the "blue on some [*Chlorocypha*] will begin as light red", and I have observed the reverse in *P. caligata* f. *lacus* Pinhey, 1982. In the aforementioned example of *A. lacuselephantum* a complex colour change involving shades of red and blue occurs. It is conceivable that the colour-switch is influenced by just a single gene, or is even merely a phenotypic expression. Pinhey (1967) observed regional variation in the frequency of the forms of *curta* and *cancellata* + *hintzi*, while genetic drift may have led to conformity in the species without this variation (e.g. *C. radix* and *Platycypha* species). At present we see that there is some taxonomic information in this two-tone variation, and it is clearly a factor to consider when dealing with the specific status of taxa like *cancellata*, *hintzi*, *curta* and *wittei*, although here too caution is required.

### Other clues: ecology and behaviour

As noted above, an important difference in the sympatric species pair *C. dispar* and *C. pyriformosa*, besides the configuration of markings, is that the two occur in different habitats. Such differences may prove useful to assess species limits in African chlorocyphids in the future: In West Africa the species occur on different sections of running

waters, with seldom more than two species occurring together (Dijkstra & Lempert 2003). Nonetheless there is some danger of interpretation here too. Pinhey (1982) describes a lacustrine form of the normally riverine *P. caligata* from Lake Malawi. This form is smaller, as Pinhey describes, but also has a different age-related melanization pattern (K.-D.B. Dijkstra pers. obs., Figs 4F-G). Obviously careful study is needed here to determine whether they are two different species, or distinct phenotypes of only one.

In species where visual signals appear to be the main cue for specific recognition, differences in reproductive behaviour and agonistic interaction may also prove to be of taxonomic value. Robertson (1982) describes different mating behaviour in three chlorocyphids (two of them African). Lempert (1988) and Dijkstra & Olsvik (2004) describe differing male-male and male-female interactions in several West African *Chlorocyphina* species.

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### References

- Baumann, E., 1898. Odonaten von Misahöhe (Landschaft Agome im Togohinterlande) gesammelt von Ernst Baumann. [Finished by F. Karsch]. Entomologische Nachrichten 24: 342-347.
- Bridges, C.A., 1994. Catalogue of the family-group, genus-group and species-group names of the Odonata of the World. 3rd edition. Privately published, Urbana.
- Cammaerts, R., 1978. Mission entomologique du Musée Royal de l'Afrique Centrale aux Monts Uluguru, Tanzanie. Revue de Zoologie et de Botanique Africaines 92: 7-36.
- Carfi, S. & M. D'Andrea, 1994. Contribution to the knowledge of odonatological fauna in Sierra Leone, West Africa. Problemi Attuali di Scienza e di Cultura 267: 111-119.
- Corbet, P.S., 1999. Dragonflies: behaviour and ecology of Odonata. Harley Books, Colchester.
- Dijkstra, K.-D.B. & N.J. Dingemans, 2000. New records of *Crocothemis sanguinolenta* (Burmeister, 1839) from Israel, with a critical note on the subspecies *arabica* Schneider, 1982. International Journal of Odonatology 3: 169-171.
- Dijkstra, K.-D.B. & J. Lempert, 2003. Odonate assemblages of running waters in the Upper Guinean forest. Archiv für Hydrobiologie 157: 397-412.
- Fraser, F.C., 1947. The Odonata of the Ivory Coast based on the mission of Dr. R. Paulian and P. Lepsme. Transactions of the Royal Entomological Society of London 98: 19-39.
- Fraser, F.C., 1949. A revision of the Chlorocyphidae with notes on the differentiation of the Selysian species *ribida*, *glauca*, *cyanifrons* and *curta*. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique 25: 1-50.

- Fraser, F.C., 1958. *Chlorocyphina Seydéli*, a new species of dragonfly from the Belgian Congo. Revue de Zoologie et de Botanique Africaines 57: 109-112.
- Gambles, R.M., 1975. A new species of *Chlorocyphina* Fraser, 1928 (Odonata: Chlorocyphidae) from Nigeria, and some new or little-known Nigerian subspecies of forms better known from the Cameroons. Entomologist's Monthly Magazine 111: 105-121.
- Gambles, R.M., 1980. Odonata. In: Medler, J.T. (ed.) "Insects of Nigeria, checklist and bibliography", Mémoires of the American Entomological Institute 30: 24-28.
- Karsch, F., 1891. Uebersicht der von Herrn Dr. Paul Preuss in Deutsch-Westafrika 1890 gesammelten Odonaten. Entomologische Nachrichten 17: 65-81, pl. II.
- Karsch, F., 1893. Die Insecten der Berglandschaft Adeli im Hinterlande von Togo (Westafrika). Libellen - Odonata - von Adeli. Berliner Entomologische Zeitschrift 38: 17-48.
- Karsch, F., 1899. Odonaten von Johann-Albrecht-Höhe (Nord-Kamerun), gesammelt von Herrn Leopold Conradt. Entomologische Nachrichten 25: 161-176.
- Legrand, J., 1984. Trois nouveaux zygoptères forestiers du Gabon oriental et une synonymie nouvelle (Chlorocyphidae, Protoneuridae, Coenagrionidae). Odonatologica 13: 237-244.
- Legrand, J., 1985. Additions à la faune des odonates des Monts Nimba (Afrique Occidentale). Revue Française d'Entomologie (N.S.) 7: 37-38.
- Legrand, J. & G. Couturier, 1985. Les Odonates de la forêt de Tai (Côte d'Ivoire). Premières approches: faunistique, répartition écologique et association d'espèces. Revue d'Hydrobiologie Tropicale 18: 133-158.
- Legrand, J. & C. Girard, 1992. Biodiversité des odonates du Simandou, recensement des espèces de Guinée, Afrique Occidentale (Odonata). Opuscula Zoologica Fluminensia 92: 1-23.
- Lempert, J., 1988. Untersuchungen zur Fauna, Ökologie und zum Fortpflanzungsverhalten von Libellen (Odonata) an Gewässern des tropischen Regenwaldes in Liberia, Westafrika. Diplomarbeit, Friedrich-Wilhelms Universität, Bonn.
- Liefertinck, M.A., 1973. *Chlorocyphina pavonis* spec. nov., a new chlorocyphid dragonfly from West Africa (Odonata). Entomologische Berichten, Amsterdam 33: 32-37.
- Longfield, C., 1959. The Odonata of N. Angola. Part II. Publicacoes Culturais Companhia de Diamantes de Angola 45: 13-42.
- Miller, P.L., 1993. Fast, temperature-controlled colour changes in *Chlorocyphina straeleni* Fraser (Zygoptera: Chlorocyphidae). Notulae Odonatologicae 4: 6-8.
- Pinhey, E., 1962. A descriptive catalogue of the Odonata of the African continent. Publicacoes Culturais Companhia de Diamantes de Angola 59: 11-322.
- Pinhey, E., 1964. A revision of the African members of the genus *Pseudagrion* Selys (Odonata). Revista de Entomologia de Moçambique 7: 5-196.
- Pinhey, E., 1967. African Chlorocyphidae (Odonata). Journal of the Entomological Society of South Africa 29: 161-197.
- Pinhey, E., 1971. Odonata of Fernando Po Island and of neighbouring Cameroons territory. Journal of the Entomological Society of South Africa 34: 215-230.
- Pinhey, E., 1972. A new species of Chlorocyphidae (Odonata) from Liberia. Arnoldia Rhodesia 5(28): 1-3.
- Pinhey, E., 1982. *Platycypha caligata* (Selys) and a new lacustrine morph (Odonata: Chlorocyphidae). Advances in Odonatology 1: 213-225.
- Robertson, H.M., 1982. Courtships displays and mating behaviour of three species of Chlorocyphidae (Zygoptera). Odonatologica 11: 53-58.
- Schmidt, E., 1951. Libellen aus Portugiesisch Guinea, mit Bemerkungen über andere aethiopische Odonaten. Arquivos do Museu Bocage 20: 125-200.