Odonatologica 24(2): 187-218 *June 1, 1995*

NAVICORDULIA GEN. NOV., A NEW GENUS OF NEOTROPICAL CORDULIINAE, WITH DESCRIPTIONS OF SEVEN NEW SPECIES (ANISOPTERA: CORDULIIDAE)

A.B.M. MACHADO[1] and J.M. COSTA[2]

[1] Departamento de Zoologia, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Caixa Postal 486, BR-31270-901 Belo Horizonte - MG, Brazil

[2] Departamento de Entomologia, Museu Nacional, Universidade Federal de Rio de Janeiro, Quinta da Boa Vista, BR-20940-040 Rio de Janeiro - RJ, Brazil

Received November 20, 1994 / Reviewed and Accepted January 12, 1995

The new genus is created for the neotropical spp. until now placed in the genus *Dorocordulia*. The differences between these 2 genera are analyzed, and the characters of *Navicordulia* are described in detail. The ♀ of *N. errans* (Calvert, 1909) and the following new spp., all from Brazil, are described: *N. amazonica* sp.n., *N. atlantica* sp.n., *N. kiautai* sp.n., *N. leptostyla* sp.n., *N. longistyla* sp.n., *N. mielkei* sp.n. and *N. miersi* sp.n. A key is provided for the 10 spp. of the new genus that becomes the largest genus of neotropical Corduliidae.

INTRODUCTION

In 1909, CALVERT described *Dorocordulia errans*, based on a single male from Chapada, Mato Grosso, Brazil. However, remarking that the genus *Dorocordulia* was unknown south of the United States, he raised the possibility that the locality label in his specimen might have been erroneous.

The doubt about the existence of a *Dorocordulia* in Brazil persisted for 59 years until SANTOS (1968) reported the presence of *D. errans* in Pirassununga, São Paulo, and GEIJSKES (1970) drew attention to the fact that the wing figured by NEEDHAM (1903) as belonging to a male *Neocordulia* from Brazil was actually that of a *Dorocordulia*. Both SANTOS (1968) and GEIJSKES (1970), however, raised the possibility that *errans* might not be a true *Dorocordulia* and pointed out several differences between this species and the two nearctic species of the genus, *D. lepida* (Selys, 1871) and *D. libera* (Selys, 1871). Commenting on these differences, GEIJSKES (1970) remarked that, since for the most part they might be of specific rank, a splitting of the genus *Dorocordulia* might not yet be justified, the more so as the available material for South American species was too limited and incomplete.

Even though two new species have been recently described (DE MARMELS, 1989, 1991) our knowledge of the *Dorocordulia*-like species of South America is still based on very scanty material, only five male specimens, one of which is represented only by a wing picture, being known. As to females, in addition to the incomplete specimen figured by NEEDHAM (1903) and studied by GEIJSKES (1970), that described by RACENIS (1970) as *Paracordulia sericea* should be regarded as *Dorocordulia*, most probably *D. nitens*, according to DE MARMELS (1991).

We report now the results of a study of 85 (44 males and 41 females) specimens of Brazilian *Dorocordulia*-like species deposited in the National Museum in Rio de Janeiro and in the collection of one of the authors (ABMM). Besides describing seven new species, and the female of *D. errans*, the study resulted in the creation of the new genus *Navicordulia* for the South American species of Corduliinae so far placed in the genus *Dorocordulia*. The new genus, with 10 species, becomes the largest Corduliidae genus of the Neotropical Region and the new species described here increase the Brazilian Corduliidae fauna from 14 to 21 species.

NAVICORDULIA GEN. NOV.

Diagnosis. – Species of moderate size (abdomen 26-36 mm; hindwing 24--33 mm), brown, with green, blue or bronzy green metallic reflections; wings hyaline or partially to totally tinged with yellow or brownish yellow in females. Triangles in forewings generally free (crossed in the single female of *N. nitens* and unilaterally in the single male of *N. atlantica*), in hindwings free. Supratriangles free; subtriangle predominantly with two cells. One cubitoanal crossvein in fore and hindwings, which means the subtriangle is absent in hindwing (except in *N. miersi* which has two cubitoanal crossveins in hindwing). Not less than two, sometimes three rows of cells in the discoidal field of fore wing. R4-5 and MA not undulate. Sectors of arculus separated in fore and hindwings. Base of triangle in hindwing coinciding with the arculus or slightly proximal of it. Nodus a little distal to mid--point in forewing, and just proximal to it in hindwing. One bridge crossvein. Anal loop elongate with two cells in the proximal row and usually in the distal one. Between the distal end of the anal loop and the wing margin, 1-2 cells. Anal area with two or three rows of cells. Anal triangle in male two-celled, its anterior side usually less than half the length of the distal side. Inner wing margin posterior to the tip of anal triangle with a small excavation. Membranule ending before the tip of anal triangle. Tibial keels in males present in fore and hind legs, very small or absent in middle leg. Male superior appendages without a basal tooth. Hamulus prominent, higher than genital lobe, distally prolonged in a slender process with tips recurved externally. Penis with two cornua. Ventral part of abdominal segments 7-8 with specialized pilose areas [character not studied in *N. atlantica* sp.n., *N. nitens* (De Marmels, 1991) and *N. vagans* (De Marmels, 1989)]. Female ovipositor with an extremely elongated vulvar lamina projecting beyond the end of the abdomen and a supralaminar process.

Type species. – *Dorocordulia errans* Calvert, 1909. – Ten species known, seven described herewith.

Distribution. – South America (Brazil and Venezuela).

Etymology. – From the Latin *navis* = ship. An allusion to the fact that the vulvar lamina in the females of the genus has the shape of a small ship or boat.

THE AFFINITIES AND CHARACTERS OF *NAVICORDULIA*

The genus *Navicordulia* belongs to the subfamily Corduliinae being closely related to *Dorocordulia*. Indeed, the males of the known species of *Navicordulia* key out to *Dorocordulia* in all the existing keys (NEEDHAM, 1908; MARTIN, 1906, 1914; NEEDHAM & WESTFALL 1955; GEIJSKES, 1970; COSTA & SANTOS 1992).

The larva of only one species of *Navicordulia* is known, that of *N. nitens* described by DE MARMELS (1991). According to this author it is basically similar to the larvae of *Dorocordulia* except for the longer dorsal abdominal projections.

Table I shows the characters that distinguish *Navicordulia* from *Dorocordulia*. For analysis of the characters of *Navicordulia* we used the material from the present investigation and the descriptions of *N. nitens* and *N. vagans* made by DE MARMELS (1989, 1991), and for the characters of *Dorocordulia* we used data given by NEEDHAM & WESTFALL (1955) and GEIJSKES (1970) in addition to data obtained from the study of specimens in our collections (3 males of *D. libera*, 3 males and 1 female of *D. lepida*). Most of the characters given in Table I had already been pointed out as important to distinguish the North from South American *Dorocordulia* (SANTOS, 1968; GEIJSKES, 1970; DE MARMELS, 1991). However, some characters previously suggested as important for such distinction proved to be specific rather than generic (tibial keels, cells between the distal end of the anal loop and the wing margin, and wing colour in females). On the other hand, three new characters were discovered: the large and complex female ovipositor, the presence of pilose areas in abdomen segments 7-8 of the males and the presence of 2 cells in the distal end of the anal loop (3 in *Dorocordulia*).

The main characters of *Navicordulia* will now be considered in more detail. The venational characters of the Brazilian species are shown in Tables II and III.

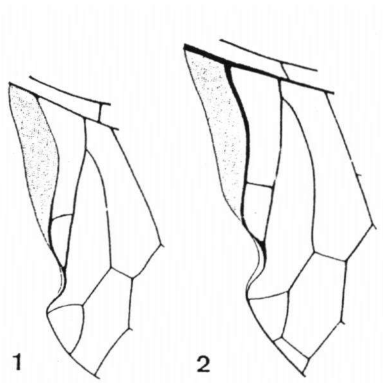
EXCAVATION IN THE INNER WING MARGIN OF THE MALE (Figs 1-2). – GEIJSKES (1970) was the first to draw attention to the presence of "a small but distinct excavation" in the wing margin distal to the anal triangle of the male of *N. errans*, and its absence in the two North American species. More recently DE MARMELS (1989, 1991) found the same excavation in *N. vagans* and *N. nitens* and regarded it as the most striking character separating the neotropical species of *Dorocordulia*

Table I
Differences between the genera *Navicordulia* and *Dorocordulia*

NAVICORDULIA	*DOROCORDULIA*
Discoidal field of forewings with two rows of cells throughout or containing a few rows of 3 cells.	Discoidal field of forewings with one row of cells in its proximal part or at least a few single cells present.
Anal loop usually (97.5%) with two cells in its distal end.	Anal loop usually (86%) with three cells in its distal end.
Membranule ceasing before the end of the anal triangle.	Membranule surpassing the end of the anal triangle.
Inner wing margin posterior to anal triangle with a small excavation.	Inner wing margin posterior to anal triangle without excavation.
Male abdominal segments 7-8 with specialized pilose areas.	Male abdominal segments 7-8 without specialized pilose areas.
Male superior appendage without basal tooth, apex rounded or at least blunt.	Male superior appendage with basal tooth, apex more or less acute.
Hamules higher than genital lobe, distally prolonged in a slender process with tips recurved externally.	Hamules lower than genital lobes, not prolonged in a slender process.
Female ovipositor with an elongated vulvar lamina projecting beyond the end of the abdomen and a supralaminar process.	Female ovipositor reduced to a vulvar lamina of normal size. No supralaminar process.
Length of anterior side of anal triangle usually (94%) less than half the distal side.	Length of anterior side of anal triangle half the distal side.

from the two North American species of the genus. This character, illustrated in Fig. 1 for *N. errans*, has now been found also in *N. kiautai* sp.n. (Fig. 2), *N. leptostyla* sp.n., *N. longistyla* sp.n., and *N. mielkei* sp.n. A preliminary search in the literature and of the neotropical species in our collections, indicates that this character is rare in the family and, among the neotropical genera, unique for *Navicordulia*.

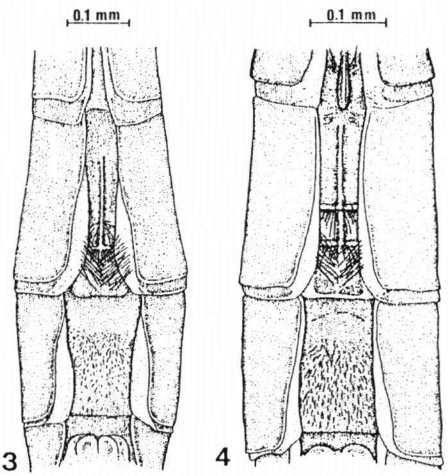
PILOSE AREAS OF MALE ABDOMINAL SEGMENTS 7-8 (Figs 3-4). – In all *Navicordulia* males in which the abdominal segment 7 was examined, it has a mid and two lateral specialized pilose areas at the ventral part of its distal third. The mid area is situated at the extremity of the longitudinal keel of sternite 7, which meets a transverse ridge out of which originates a tuft of yellow hairs directed caudally (Fig. 3). This arrangement occurs in *N. longistyla* sp.n., *N. kiautai* sp.n. and *N. mielkei* sp.n. In *N. errans* (Calvert, 1909) and *N. leptostyla* sp.n. there is an additional transverse



Figs 1-2. Base of male hindwing: (1) *N. errans* (Calvert, 1909); – (2) *N. kiautai* sp.n., paratype.

ridge with hairs, situated proximately (Fig. 4). Each lateral pilose area is a swelling of the region situated medially to the ventral carina of tergite 7 from which originates, on each side, a brush of yellow hairs directed caudally and medially. The hairs from these three pilose areas converge over a shining glabrous area situated at the hind end of sternite 7. These hairy structures and the glabrous area seem to constitute a morphological unit now named "pilose complex".

In all males examined there is also a pilose area on segment 8 (Figs 3-4), situated at the distal two thirds of sternite 8, which contains numerous short fine yellow hairs. At our request, Dr Jürg De Marmels kindly inspected the types of *N. nitens* and *N. vagans* for the presence of pilose areas on abdominal segments 7-8. *N. nitens* has a pilose complex as described above except that instead of a transverse hairy ridge, there is "a pair of prominent knob-like hairy structures", each one attached to the same point of the longitudinal keel of sternite 7. In the type of *N. vagans* the presence of a pilose complex could not be checked because the two tergal halves of segment 7 were superposed to each other completely covering sternite 7. In both species, however, sternite 8 has "scattered medium-sized hairs all over". Since the pilose complex and the specialized pilose area of segment 8 are lacking in the two species of *Dorocordulia* they can be regarded as good characters to distinguish this genus from *Navicordulia*. A survey among neotropical Corduliidae in our collections revealed that a pilose complex as now described in segment 7 of *Navicordulia* is lacking in *Gomphomacromia (paradoxa, fallax)*, *Lauromacromia (luis-moojeni)*, *Rialla (villosa)*, *Santosia (marshalli)*, *Neocordulia (androgynis, b. batesi, biancoi, carlochagasi, setifera, volxemi)* and *Aeschnosoma (forcipula, marizae)* and seems to be a unique char-



Figs 3-4. Ventral view of male abdomen showing the pilose complex of segment 7 and the pilose area of segment 8: (3) Pilose complex with a single transverse hairy ridge (*N. longistyla* sp.n., paratype); – (4) Pilose complex with two transverse hairy ridges (*N. errans*).

Table II

Venational characters of the Brazilian species of *Navicordulia* gen. nov. – males

Character	N. atlantica sp. n. (*n = 11)	N. errans (Calvert) (n = 20)	N. kiautai sp. n. (n = 2)	N. leptostyla sp. n. (n = 5)	N. longistyla sp. n. (n = 5)	N. mielkei sp. n. (n = 3)
Antenodals (FW)	8(10%)	8(70%);9(22.5%); 7(5%); 10(2.5%)	9(75%); 10(25%)	7(60%); 8(30%); 9(10%)	9(60%); 8(40%)	8(67%); 9(33%)
Antenodals (HW)	5(100%)	5(92.5%); 4(5%); 6(2.5%)	6(75%); 7(25%)	5(90%); 7(10%)	5(60%); 6(40%)	6(67%); 5(33%)
Postnodals (FW)	6(100%)	6(70%); 5(17.5%); 7(12.5%)	6(75%); 5(25%)	5(60%); 6(20%); 4(20%)	5(70%);6(20%); 4(10%)	5(50%); 6(50%)
Postnodals (HW)	7(100%)	7(77.5%); 6(12.5%); 8(10%)	7(50%); 8(50%)	6(80%); 7(10%); 5(10%)	7(60%); 6(20%); 8(20%)	6(33.3%);7(33.3%) 8(16.2%);9(16.2%)
Cells in triangle (FW)	1(50%); 2(50%)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)
Cells in triangle (HW)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)
Cells in subtriangle	2(100%)	2(100%)	2(75%); 1(25%)	2(70%); 1(30%)	2(60%); 1(40%)	2(100%)
Supratriangle (FW)	free (100%)	free (98%); crossed (2%)	free (100%)	free (100%)	free (100%)	free (100%)
Supratriangle (HW)	free (100%)	free (100%)	free(100%)	free (100%)	free (100%)	free (100%)
Arc in relation to distance between 1st. and 2nd. AX (FW)	slightly distal from middle (100%)	at distal 1/3 (87.5%); in the middle(2.5%); slightly distal from the middle (10%)	at distal 1/3 (75%); slightly distal from the middle (25%)	at distal 1/3 (100%)	in the middle (80%); slightly distal from the middle (20%)	slightly distal from the middle (100%)
Arc in relation to distance between 1st. and 2nd. AX. (HW)	slightly distal from middle (100%)	in the middle (67.5%); slightly distal from the middle (30%); at distal 1/3 (2.5%)	at distal 1/3 (75%); slightly distal from the middle (25%)	in the middle (80%) slightly distal from the middle (20%)	slightly distal from the middle (90%); in the middle (10%)	at distal 1/3 (60%); slightly distal from the middle (40%)
Base of triangle in relation to Arc (HW)	slightly proximal (100%)	slightly proximal (100%)	sightly proximal (100%)	coinciding (60%); slightly proximal (40%)	slightly proximal (100%)	slightly proximal (100%)
Cell-rows in discoidal field (FW)	two rows to the end (100%)	two rows to the end or nearly so (92.5%); two (mostly) and three rows (7.5%)	two rows to the end of nearly so (100%)	two rows to the end or nearly so (90%); two rows interrupted by one cell (10%)	two rows to the end or nearly so (80%); two (mostly) and three rows (20%)	two rows to the end or nearly so (100%)
Cell-rows in discoidal field (HW)	**2(4)+3(2-4) gradually increasing to 8-9 at margin (100%)	2(2-4)+3(2-3) gradually increasing to 8-11 at margin (100%)	2(4)+3(2) gradually increasing to 8-10 at margin (100%)	2(3-4)+3(2-5) gradually increasing to 8-10 at margin (100%)	2(2-4)+3(2-3) gradually increasing to 8-10 at margin (100%)	2(2-4)+3(2-3) gradually increasing to 8-10 at margin (100%)
MA and CuP	convergent (50%); slightly convergent (50%)	convergent (90%); slightly convergent (10%)	convergent (50%); slightly convergent (50%)	convergent (100%)	convergent (60%); slightly convergent (40%)	convergent (66.7%) slightly convergent (33.3%)
Mspl: presence; n° cells (FW)	present(100% 4(100%)	present (52.5%); 4(47.6%);5(28.5%) 6(23.8%)	present (75%); 4(66%); 5(34%)	present (55.6%); 4(60%); 5(20%); 6(20%)	present (100%); 5(60%); 4(40%)	present (66.6%); 4(75%); 3(25%)
Mspl: presence n° cells (HW)	present(100% 4(100%)	present (50%); 5(66.6%);4(33.3%)	present (66%); 4(50%); 5(50%)	present (80%); 4(37.5%);5(37.5%) 6(25%)	present (100%); 4(60%); 5(40%)	present (50%); 4(66.6%);5(33.3%)
Cells in Rspl (FW)	5(100%)	6(62.5%);5(22.5%) 7(12.5%);8(2.5%)	6(75%); 5(25%)	5(40%); 4(30%); 6(30%)	6(60%); 5(20%); 7(20%)	6(50%);5(33.3%); 7(16.7%)
Cells in Rspl (HW)	6(100%)	6(50%);7(27.5%); 5(20%); 4(2.5%)	7(66%); 5(34%)	6(60%); 5(40%)	7(40%); 6(30%); 5(30%)	5(60%); 6(40%)
Cubit-anal crossveins (FW and HW)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)

*n = number of specimens studied; the right and left wings were studied in each specimen and the percentages established with the total number of wings.

** Means two rows for a distance of 4 cells, followed by 3 rows for a distance of 2-4 cells.

Table II continued

Anal loop: cells in inner half	—	7(45%); 6(37.5%); 8(17.5%)	7(33.3%) 8(33.3); 9(33.3%)	6(70%); 7(30%)	5(50%); 7(50%)	6(16.6),7(66.6%); 8(16.6%)
Anal loop: cells in outer half	—	6(60%); 7(22.5%); 5(17.5%)	7(100%)	6(80%); 5(20%)	7(50%); 6(40%); 5(10%)	6(16.6%);7(83.4%)
Anal loop: cells in total	—	13(35%);14(25.5%) 12(22.5%);4(12%) 15(2.5%);6(2.5%)	14(50%); 15(25%); 16(25%)	12(50%); 13(30%); 11(20%)	13(75%); 12(12.5%); 11(12.5%)	14(50%); 13(33 4%) 15(16.6%)
Anal loop: cells in proximal row	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)
Anal loop: cells in distal row	—	2(95%); 3(5%)	2(100%)	2(90%); 3(10%)	2(100%)	2(100%)
Anal loop: size of distal end	—	not dilated (92.5%); dilated (5%), slightly dilated (2.5%)	not dilated (66.6%) slightly dilated(33 3%)	not dilated (90%) slightly dilated (10%)	not dilated (50%) dilated(40%) slightly dilated (10%)	not dilated (50%) dilated(16 6%) slightly dilated (33.4%)
Anal loop: shape of distal end	—	truncated (33%); sacciform (30%); intermediate (37%)	truncated (33%); slightly sacciform (67%)	sacciform (40%); truncated (20%); intermediate (40%)	truncated (75%); slightly sacciform (25%)	trunated (33.3%); sacciform(33.3%) intermediate (33.3%)
Anal loop: cells between distal end and wing margin	—	1(80%); 2(20%)	1(100%)	1(30%), 2(70%)	1(80%), 2(20%)	1(66 6); 2(33.4)
Cell-rows between anal loop and wing margin	—	two rows interrupted by 3 rows for 1 cell distance (100%)	two rows interrupted by 3 rows for 1 cell distance (100%)	two rows interrupted by 3 rows for 1 cell distance (100%)	two rows interrupted by 3 rows for 2 cells distance (100%)	two rows interrupted by 3 rows for 2 cells distance
Anal triangle: proportion between costal and distal sides	—	1 / 3 (65%); 2 / 5 (25%); 1 / 2 (10%)	1 / 3 (66.6%); 2 / 5 (33.4%)	1 / 3 (30%); 2 / 5 (40%); 3 / 7 (30%)	1 / 3 (50%); 2 / 5 (50%)	2 / 5 (100%)
Anal triangle n° of cells	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)

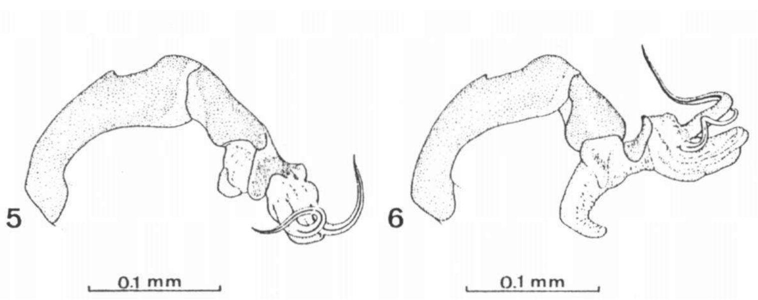
acter of *Navicordulia*. On segment 8, however, although different from those observed in *Navicordulia*, pilose structures occur on the ventral tergite of *Aeschnosoma* (*forcipula, marizae*) and on the sternite of the *Neocordulia* (except *b. batesi*). In the latter genus the hairs occur in the area distal to the biconical protuberance, either as a transverse band (*biancoi, setifera*) or two tufts of hairs, one on each side (*androgynis, carlochagasi, volxemi*). The functional significance of these interesting hairy structures of male neotropical Corduliidae is unknown and they had hardly been used in the taxonomy of the group.

MALE ANAL APPENDAGES (Figs 8-19). – The male superior appendages of *Navicordulia* are subcylindrical and have, in most species, their ventral surfaces bordered to a variable extent in its proximal part, by a ventro-medial and a ventro-lateral carina. For descriptive purposes each appendage can thus be divided into a proximal, carinated and a distal, non-carinated and smoothly rounded part. The ventro-lateral carina is always very distinct, whereas the ventro-medial one is more variable, being weak in *N. kiautai* sp.n., very weak in *N. leptostyla* and *N. nitens*, and completely absent in *N. vagans* (J. de Marmels, in litt.). These two carinae may end distally in a tubercle, respectively, the ventro-lateral and ventro-medial tubercles. In *Dorocordulia* the appendages can also be divided into a carinated and a non-carinated part, but the medial carina is absent and the lateral one very short. In *Navicordulia* the superior appendages end in a blunt or rounded tip, whereas in *Dorocordulia* they end in an acute tip.

The size and shape of the male superior anal appendages afford the most important character for distinguishing the species of *Navicordulia*. Based on its size two groups of species can be distinguished in the genus. In the *longistyla* group (*N. longistyla* sp.n., *N. kiautai* sp.n., *N. nitens*, De Marmels, 1991) the superior appendages are very long (2.5-2.9 mm), much longer than the inferior; in the *errans* group (*N. errans* [Calvert, 1909], *N. leptostyla* sp.n., *N. mielkei* sp.n., *N. atlantica* sp.n., and *N. vagans* De Marmels, 1989), they are short (1.6-2.0 mm), distinctly shorter to slightly longer than the inferior. The position in relation to these groups of *N. amazonica* sp.n. and *N. miersi* sp.n., known only from the females, is uncertain.

GENITALIA OF THE SECOND SEGMENT (Figs 5-6, 20-25). – In all species of *Navicordulia* the hamule is prominent, higher than the genital lobe, distally prolonged in a slender process with tips recurved externally (Figs 20-25). As pointed out by GEIJSKES (1970) this is in marked contrast to the hamule of *Dorocordulia*, which is lower than the genital lobe, rounded and not prolonged in a slender process. The hamule shape is rather uniform and offers no good character to separate the species. In the same species the extent of the hamule projection from the genital fossa is variable, and can be correlated with the degree of penis extrusion. For instance, in some specimens of *N. longistyla* it appears, as shown in Figure 20 or in Figure 21. In *N. errans* and *N. leptostyla* the tip of the hamule may be situated at the level of the hind border of the genital lobe, before or after it, this last condition coinciding with a somewhat extruded position of the penis. It seems, therefore, that the position of the hamular process in relation to the genital lobe and the genital fossa in dried specimens depends basically on its chance position at death, which makes this character less reliable for species identification.

The penis has been studied in seven of the eight species of *Navicordulia* in which the males are known. Two morphological types, A and B, can be distinguished, according to the size of the two cornua. In type A penis the two cornua are very large and about the same size (Fig. 5). This type occurs in *kiautai, longistyla, mielkei, nitens* and *vagans*. In type B penis one cornu is well developed whereas the other is



Figs 5-6. Penis in lateral view: (5) *N. longistyla*, holotype (penis of type A); – (6) *N. errans* (Calvert, 1909) (penis of type B).

very small (Fig. 6). This type occurred only in *errans* and *leptostyla*. The study of 8 specimens of *errans* and 2 of *leptostyla* showed that the left cornu is always the larger.

The penes of *Dorocordulia libera* and *D. lepida* have been figured by SANTOS (1968). We restudied the penis of these two *Dorocordulia* and we verified that in this genus the organ is basically similar to that of *Navicordulia* being closer to those species with type A penis as it has two large cornua of the same size.

The anterior lamina is absent in the Brazilian species in which the males are known, but it is present in the Venezuelan *N. nitens* and *N. vagans* according to J. de Marmels (in litt.). The genital lobe is always prominent in *Navicordulia*, being either triangular (Figs 22, 24) or quadrangular (Figs 20-21, 23, 25), thus offering a good character for species identification.

MALE TIBIAL KEELS. – There is always a tibial keel occupying about one third of the tibial length on the fore leg and almost the whole length on the hind leg. In some species (*errans, leptostyla, vagans, nitens*) the mid leg lacks any tibial keel; in others (*longistyla, kiautai, mielkei*) there is a small keel occupying 10-15% of the tibial length as in the two species of *Dorocordulia*. Thus, the tibial keels cannot be used as a generic character to separate the genus *Dorocordulia* from *Navicordulia*.

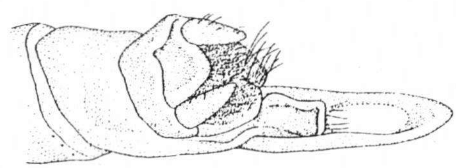


Fig. 7. Ovipositor of *N. leptostyla* in dorso-posterior view showing (dotted lines) the position occupied by an egg (accidentally removed).

OVIPOSITOR (Figs 7, 26-31). – The long ovipositor now described in females of *N. amazonica, errans, leptostyla, longistyla, mielkei* and *miersi* is one of the most important characters that distinguishes the genus *Navicordulia* from *Dorocordulia*. In 1970, RACENIS figured and referred to a similarly long ovipositor in a female thought to be *Paracordulia sericea* (Selys, 1871) and now known to be a *Navicordulia*, most probably *N. nitens*. This remains the only record of the presence of such a long ovipositor in the subfamily Corduliinae. In most Corduliidae and in Libellulidae as well as in the Gomphidae, the complete odonate type of ovipositor formed by three pairs of gonapophyses (VAN DER WEELE, 1906) has been reduced to a simple and usually small sub-genital plate or vulvar lamina. However, exceptions to this, represented by a very long vulvar lamina, occur among the Libellulidae, in the genera *Uracis, Ypirangathemis* and a few *Sympetrum* and, among the Corduliidae, in the genus *Gomphomacromia*, several species of *Synthemistinae*, some *Somatochlora* and in *Navicordulia* as described herewith. According to the classification of ovipositor types proposed by ST. QUENTIN (1962), that of *Navicordulia* may be classified as incomplete with two pairs of gonapophyses. It is made up of a dorsal and a ventral part, clearly visible on lateral view (Figs 26-31). The ventral part attached to the sternite of the 8th segment, is formed by the fusion of the two anterior gonapophyses. It represents an extremely elongated vulvar lamina which projects beyond the end of the abdomen and has the shape of a small boat. Except for small differences in size, its morphology is similar in all the six species studied herewith and it may be regarded as the ovipositor proper. The dorsal part, now named supralaminar process, on the contrary, is variable and affords good characters for species identification. It may be shaped like a spoon (*longistyla*, Fig. 28), a cup (*mielkei*, Fig. 30), a dish (*miersi*, Fig. 29) or a tongue with the apex raised (*amazonica, leptostyla* and *errans*, Figs 26-27, 31). By removing the vulvar lamina and observing the supralaminar process from below one can see that it is an extension of the sternite of the 9th segment, most probably representing the fusion of the two median gonapophyses. On each side of it and also emerging from the 9th sternite there is a small spine, which corresponds to the "Griffelchen" of RIS (1911), most probably representing a vestige of the lateral gonapophysis.

Because of the presence of a very large vulvar lamina and a supralaminar process, the ovipositor of *Navicordulia* is basically similar to those described for the Cordulegastridae and Synthemistinae as well as for *Uracis* and *Ypirangathemis* (TILLYARD, 1917; RIS, 1911; BORROR, 1947; LIEFTINCK, 1953; ST. QUENTIN, 1962).

In *Ypirangathemis*, however, there are two supralaminar processes, (described by Borror as "blade-like" structures) and in most species of *Uracis* the supralaminar process runs in a groove along the dorsal side of the elongated vulvar lamina. Interestingly, the ovipositor of the Corduliidae *Gomphomacromia*, studied by TILLYARD (1917) and RIS (1911), is quite different from that of *Navicordulia*. In *G. paradoxa* we could observe that there is no supralaminar process and the enormous vulvar lamina that springs out of the 8th sternite tapers into two elongated processes.

One specimen of *N. leptostyla* had an egg in its ovipositor (Fig. 7), the observation of which gave an idea of the possible role played by the supralaminar process in oviposition. The process was inserted inside the proximal part of the cavity of the vulvar lamina indicating that its usual position above the lamina is a resting position and that the process and the lamina move in relation to each other. Occupying the distal part of the cavity and touching the upraised part of the supralaminar process, was a single egg. It seems therefore that the process is involved in a mechanism providing for the liberation of single eggs, a situation quite different from that which occurs in the usual type of exophytic oviposition, where a mass of eggs is liberated. Presumably, individual eggs are released in the environment at each thrust of the vulvar lamina, a situation that, in this aspect, resembles endophytic oviposition.

It is reasonable to suppose that the presence of a long and complex ovipositor in *Navicordulia* might be associated with oviposition behavior quite different from that usually observed in most Corduliidae, including the related genus *Dorocordulia*. In those Cordulegastridae which also have a very long ovipositor, this organ is used to dig eggs into the bottom of shallow water or into mud (review in ST. QUENTIN,

1962) and it is possible that the females of *Navicordulia* might show similar behavior.

SPECIES KEY TO *NAVICORDULIA*

MALES

1 Superior appendages very long (2.5-2.9 mm). Inferior appendage distinctly shorter than superior. Distal half of superior appendages provided with a fringe of long hairs directed dorsally or laterally (Group *longistyla*) 2
– Superior appendages short (1.6-2.0 mm). Inferior appendages almost as long to distinctly longer than superior. Distal half of superior appendages without a fringe of long hairs directed dorsally or laterally (Group *errans*) 4
2 Superior appendages with the proximal (carinated) part distinctly longer than the distal (non carinated) one, in dorsal view with a distinct external concavity at the distal third. Genital lobe triangular .... ***nitens*** (De Marmels, 1991)
– Superior appendages with the proximal (carinated) part about as long or distinctly shorter than the distal (non-carinated) one, in dorsal view without distinct external concavity. Genital lobe quadrangular 3
3 Superior appendages with the proximal (carinated) part about as long as the distal (non-carinated) one (Fig. 15), a small ventro-lateral and ventro-medial tubercle at midlength, in dorsal view with the apex parallel or slightly divergent (Fig. 9). Maximum abdominal width 3.0 mm ..... ***kiautai*** sp.n.
– Superior appendages with the proximal (carinated) part much shorter than the distal (non-carinated) one (Fig. 14), ventro-medial-tubercle present at about 1/3 length, ventro-lateral absent (Fig. 14). In dorsal view with the apex slightly convergent (Fig. 8). Maximum abdominal width 2.3-2.4 mm .... ***longistyla*** sp.n.
4 Inferior appendages distinctly longer than the superiors (Fig. 18) .... ***mielkei*** sp.n.
– Inferior appendages about as long as superiors 5
5 Superior appendages with a ventro-lateral tubercle. Genital lobe triangular or quadrangular 6
– Superior appendages without ventral tubercles. Genital lobe triangular 7
6 Proximal (carinated) part of superior appendages four times as long as the distal one. Genital lobe triangular .... ***vagans*** (De Marmels, 1989)
– Proximal (carinated) part of superior appendages twice as long as the distal one (Fig. 17). Genital lobe quadrangular (Fig. 23) .... ***atlantica*** sp.n.
7 Superior appendages dilated distally (Fig. 16). Costa brown .... ***errans*** (Calvert, 1909)
– Superior appendages slightly narrowed distally (Fig. 19). Costa white .... ***leptostyla*** sp.n.

FEMALES

1 Pterostigma and membranule black. Tapering tergal extension of abdominal segment 9 overpassing the supralaminar process distally .... ***nitens*** (De Marmels, 1991)
– Pterostigma yellowish or brown, membranule brown or light brown. Tapering tergal extension of abdominal segment 9 not overpassing the supralaminar process distally 2
2 Two cubitoanal crossveins in hindwing. Supralaminar process shaped like a small dish (Fig. 29), in dorso-posterior view wider than the vulvar lamina .... ***miersi*** sp.n.
– One cubitoanal crossvein in hindwing. Supralaminar process of variable shapes, in dorsoposterior view narrower than the vulvar lamina 3
3 Supralaminar process shaped like a small tongue with the apex upturned (Figs 26, 27, 31) ... 4
– Supralaminar process not as above 6

4 Costa white .... *leptostyla* sp.n.
– Costa brown 5
5 Between the anal loop and the wing margin, two rows of cells throughout or interrupted by 3 rows for one cell distance .... *errans* (Calvert, 1909)
– Between the anal loop and the wing margin two rows of cells followed by 3 rows for a distance of 4-6 cells .... *amazonica* sp.n.
6 Supralaminar process spoon-shaped with the apex slightly upturned and provided with a tuft of hairs (Fig. 28) .... *longistyla* sp.n.
– Supralaminar process shaped like a small cup and not provided with a tuft of hairs (Fig. 30) ... . *mielkei* sp.n.

NAVICORDULIA LONGISTYLA SP. NOV.

Figures 3, 5, 8, 14, 20, 28

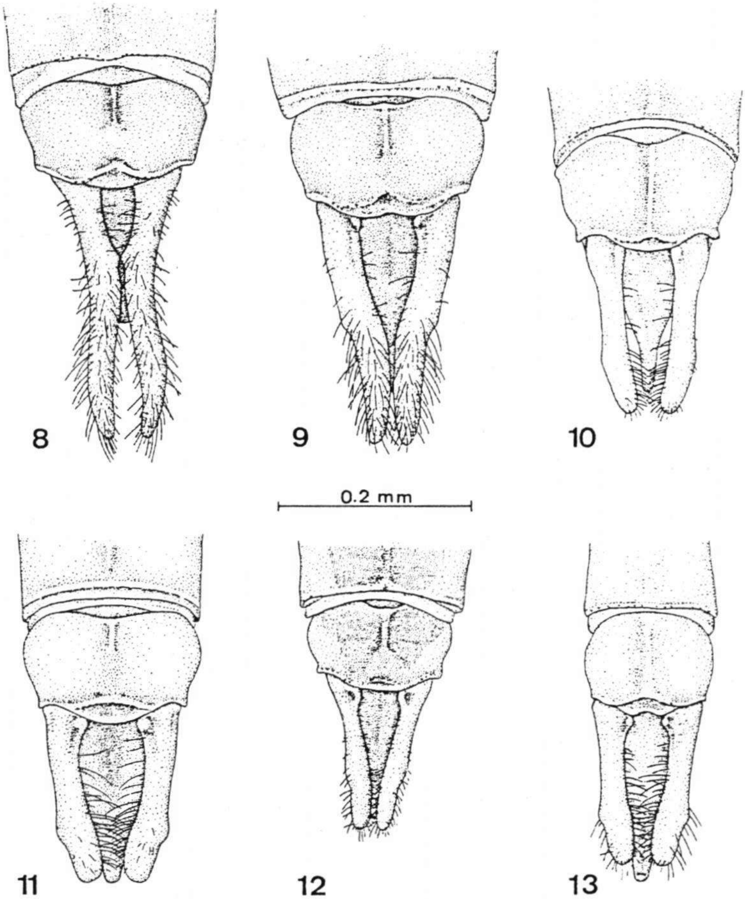
Material. – BRAZIL, Brasilia, (D.F) 1171 m, Reserva Ecológica do IBGE (BR251, km 0): **holotype ♂, and 2 ♂ paratypes**, 26/28-X-1980, (road in the cerrado, collected 6:30 a.m., 16-18:30 p.m.), N.D. Santos & H. Mesquita leg.; – **allotype ♀**, 25-X-1980 (collected at 16:30 in the cerrado of the Taguará River), N.D. Santos & H. Mesquita leg; – Chácara Ribeirão Vicente Pires; 2 ♂ paratypes, 28-X-1979 (collected at 6 a.m. near a gallery forest), Keiko leg. – Specimens (5 ♂, 1 ♀) deposited in the following collections: Museu Nacional, Rio de Janeiro (holotype, allotype and 2 paratypes); – A.B.M. Machado, Belo Horizonte (1 paratype); – Departamento de Zoologia, Universidada de Brasília (1 ♂ paratype).

Etymology. – The name is an allusion to the long superior appendages of the male, the longest so far reported for the genus.

MALE. – Head. – Labium and labrum light orange. Anteclypeus, clypeus, lateral part of frons, occiput and base of vertex brownish orange. Upper part of vertex, anterior and upper part of frons light orange the latter with a greenish violet metallic reflection and a central furrow. Antennae brown.

Thorax. – Prothorax yellowish brown. Pterothorax brown with metallic green reflections and white pilosity. Legs brown. Tibial keels occupying the following percentages of the tibial length: fore tibiae 30-33%; mid tibiae 10-15%; hind tibiae 85-90%. Wings hyaline. Venation and pterostigma brown. Membranule light brown, turning into whitish proximally, ending above the apex of the anal triangle. Wing margin at the distal end of the anal triangle with a distinct excavation. – For venation see Table II.

Abdomen. – In dorsal view slightly swollen on segments 1-2 and proximal part of 3, thence cylindrical to the proximal half of 6, swelling again to attain maximum width between segments 7-8 (2.3-2.4 mm), thence narrowing to the hind end of 10. Segment 10 with a distinct mid-dorsal carina at its proximal half. Specialized pilose areas on the ventral parts of abdominal segments 7-8 as described for the genus, the pilose complex with a single transverse hairy ridge (Fig. 3). Basic abdominal colour brown, dorsum of segments 2-9 with metallic green reflections. Ventral tergal parts of 3-9 brown with metallic green reflections laterally. Sternites dark brown. Superior anal appendages (Figs 8, 14) dark brown, longer



Figs 8-13. Male anal appendages in dorsal view: (8) *N. longistyla* sp.n., holotype; – (9) *N. kiautai* sp.n., holotype; – (10) *N. errans* (Calvert, 1909), Parque Nacional das Emas, Goiás; – (11) *N. atlantica* sp.n., holotype; – (12) *N. leptostyla* sp.n., holotype; – (13) *N. mielkei* sp.n., holotype.

than segment 9+10, in dorsal view (Fig. 8) slightly convergent on the basal half, then distinctly divergent to converge again in the apex, ending in a blunt tip. Dorsal surface in distal half bearing a fringe of long hairs directed dorsally, with basal tubercle poorly developed (Fig. 14). Proximal (carinated) part (1.0-1.2 mm) much shorter than the distal (non-carinated) one (1.5-1.9) (Fig. 14). On the ventral surface, at the limit between those two parts, a small tubercle situated at the end of the ventro-medial carina (ventro-medial tubercle), visible in dorsal view (Fig. 8). Inferior anal appendage (Fig. 14) brown, about 2/3 the length of the superiors, triangular when viewed from below, attenuated in the distal half, with the tip slightly upcurved. Hamule (Fig. 20) as described for the genus. Anterior lamina absent. Genital lobe quadrangular (Fig. 20). Penis (Fig. 5) with two very large cornua about the same size (type A penis), apical lobe of moderate size. Auricles small, rounded.

M e a s u r e m e n t s. – See Table IV.

FEMALE. – H e a d and t h o r a x, including the wings, as described for the male (except for the tibial keels). – For venation see Table III.

A b d o m e n. – Slightly swollen on segments 1-2 and proximal part of 3, thence very slightly tapering to the end. Tergum of segment 9 with a ventral tapering extension, which meets laterally the supralaminar process (Fig. 28). Segment 10 obliquely directed upwards forming an angle with segment 9. Appendages conical, black (Fig. 28). Segment 1 brown. Segments 2-3 brown with metallic coppery and green reflections dorsally. Segments 4-8 metallic copper with weak green reflections more intense on segments 7-8. Segments 9-10 brown. Ventral tergum brown. Sternites dark brown on 1-2, black on 3-8, with metallic green reflections on 3. Ovipositor as described for the genus, with a very long black vulvar lamina surpassing the apex of segment 10 (Fig. 28). Supralaminar process (Fig. 28) shaped like a small spoon with the apex slightly upturned and provided with a tuft of hairs, in dorso-posterior view slightly narrower than the vulvar lamina.

M e a s u r e m e n t s. – See Table V.

REMARKS. – *N. longistyla* can be readily separated from the other species of the genus by the characters given in the key and mainly by the long superior appendages of the male and the spoon-shaped supralaminar process of the female.

N. longistyla is a species of the cerrado (a sort of savanna). It has been collected in Brasília, a city situated in the middle of the cerrado region of Central Brazil, most specimens being actually collected in the cerrado.

NAVICORDULIA KIAUTAI SP. NOV.

Figures 2, 9, 15, 21

M a t e r i a l. – BRAZIL, Minas Gerais, Belo Horizonte, 858 m, Ursulina de Andrade Melo Municipal Park (in the border of a small secondary forest between 11:00-12.00 a.m.): **holotype ♂**, 15-XI-1979, A.B.M. & P.A.R. Machado leg.; – 1 ♂ **paratype**, 22-XII-1975, A.B.M. & P.A.R. Machado leg. – Both specimens in collection A.B.M. Machado, Belo Horizonte.

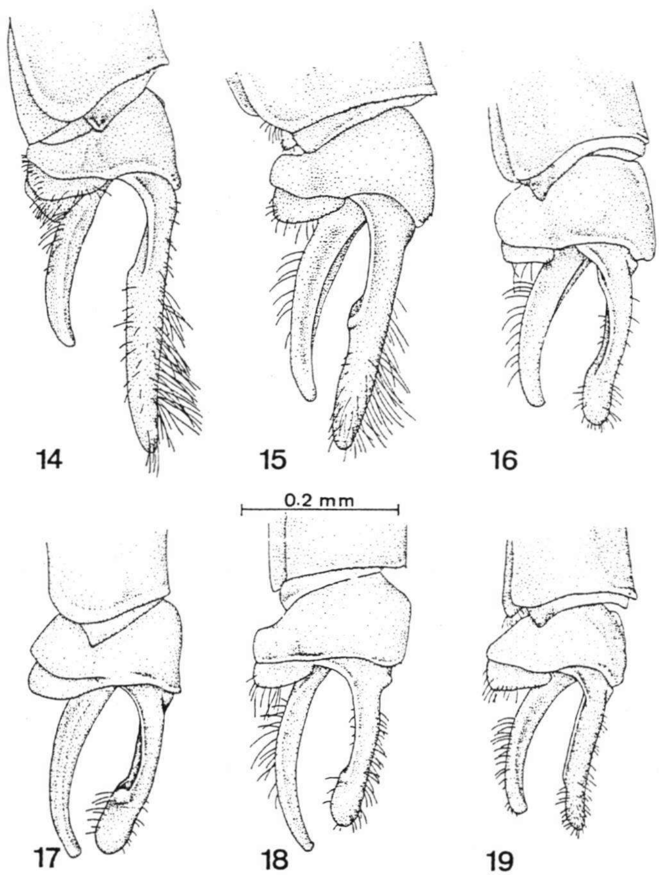
E t y m o l o g y. – We dedicate this species to Professor Dr Bastiaan K i a u t a, out of recognition for his enormous contribution towards the development of odonatology throughout the world.

MALE. – H e a d. – Labium light orange. Labrum orange. Anteclypeus, clypeus, occiput and lateral part of frons brownish orange. Remaining part of frons deep orange with metallic green reflections above and a deep central furrow. Vertex deep orange on the top, brownish orange on the base. Antennae brown.

T h o r a x. – Prothorax yellowish brown. Pterothorax brown with metallic green reflections and white pilosity. Legs brown except for the outer surface of femora, which are yellowish brown. Tibial keels occupying the following percentages of the tibial length: fore tibiae 30%; mid tibiae 15%; hind tibiae 85%. Wings hyaline.

Venation and pterostigma brown. Membranule light brown, turning into whitish proximally, ending above the apex of the anal triangle. Wing margin at the distal end of the anal triangle with a distinct excavation (Fig. 2). – For venation see Table II.

A b d o m e n. – In dorsal view slightly swollen on segments 1-2 and proximal part of 3, thence cylindrical to the proximal third of 6, swelling again to attain maximum width between segments 7-8 (3.0 mm), thence narrowing to the hind end of 10. Segment 10 with a barely visible mid-dorsal carina at its anterior half. Specialized pilose areas on the ventral parts of abdominal segments 7-8 as described for the genus, the pilose complex with a single transverse hairy ridge (Fig.



Figs 14-19. Male anal appendages in lateral view: (14) *N. longistyla* sp.n., holotype; – (15) *N. kiautai* sp.n., holotype; – (16) *N. errans* (Calvert, 1909), Parque Nacional das Emas, Goiás; – (17) *N. atlantica* sp.n., holotype; – (18) *N. mielkei* sp.n., holotype; – (19) *N. leptostyla* sp.n., holotype.

3). Basic abdominal colour brown, dorsum of segments 2-9 with metallic green or coppery reflections. Ventral tergal parts of segments 3-9 brown. Sternites dark brown. Superior anal appendages (Figs 9, 15) brown (dark brown in the paratype), as long as segments 9+10, in dorsal view (Fig. 9) slightly convergent on the basal half then very slightly divergent (or parallel in the paratype) ending in a blunt tip. Dorsal surface in the distal half bearing a fringe of long hairs directed dorsally and a small tubercle at the base (Fig. 15). Proximal (carinated) part (1.23 mm) about as long as the distal (non-carinated) one (1.33 mm) (Fig. 15). At mid-point on the ventral surface of the appendage, a small ventro-medial and ventro-lateral tubercle, situated respectively at the ends of the ventro-medial and the ventro-lateral carinae, the latter visible in dorsal view (Fig. 9). Inferior anal appendage (Fig. 15) brown, about 4/5 the length of the superiors, triangular when viewed from below, much attenuated in the distal third, with the tip slightly upcurved. Hamule (Fig. 21), as described for the genus. Anterior lamina absent. Genital lobe quadrangular (Fig. 21). Penis exactly similar to that of *N. longistyla* shown in Figure 5. Auricles small, rounded.

M e a s u r e m e n t s. – See Table IV.

FEMALE. – Unknown.

REMARKS. – By the presence of long superior appendages *N. kiautai* is very close to *N. longistyla* from which it can be easily separated by the characters given in the key.

N. kiautai was collected in the border of a small secondary forest in a park within the city of Belo Horizonte and it is probably a species of the Atlantic Forest. However, since this city is situated in the borderline between the Atlantic Forest and the cerrado regions, the possibility that it might be a species of the cerrado cannot be completely ruled out.

NAVICORDULIA ERRANS (Calvert, 1909)

Figures 1, 4, 10, 16, 22, 31

M a t e r i a l. – BRAZIL, Brasília (D.F.), 1171 m, Reserva Ecológia do IBGE (BR251, km 0): 1 ♂, 23-X-1979, 1 ♂, 9-XI-1979, 1 ♂, 15-I-1980, M. Simões leg.; – 1 ♂, 1 ♀, 25/26-X-1980 (road in cerrado, 4:45-5:30 p.m.); – **allotype** ♀, and 5 ♂, 1 ♀, 28-X-1980 (road in cerrado, 4:0-6:30 p.m.), 4 ♀, 29-X-1980 (road in cerrado, 6:15-7:00 a.m.), N.D. Santos & H. Mesquita leg.; – 2 ♂, 2 ♀, 4/16-II-1981 (road in cerrado), N.D. Santos, L.F. Netto & H. Mesquita leg.; – 2 ♂, 1 ♀, Chácara Ribeirão Vicente Pires, 28-X-1979 (6 a.m.), Keiko leg.; – Goiás: Mineiros (Parque Nacional das Emas, 650-1000 m), 2 ♂, 2 ♀ 12-X-1982 (cerrado, 6 p.m.), N.D. Santos & L.F. Netto leg.; – 2 ♂, 1 ♀, 13-X-1982 (Formoso River and Swamp), N.D. Santos, L.F. Netto & Dacio leg.; – 9 ♂, 6 ♀, 17-X-1982 (in cerrado), N.D. Santos, L.F. Netto & Dacio leg.; – São Paulo: Pirassununga, 627 m, 1 ♂, 6-X-1943, Schubart leg. – Specimens (27 ♂, 19 ♀, deposited in the following collections: Museu Nacional, Rio de Janeiro (allotype ♀ – 22 ♂, 14 ♀); – A.B.M. Machado, Belo Horizonte (5 ♂, 4 ♀).

MALE. – H e a d. – Labium, labrum and anterior part of frons orange. Anteclypeus, clypeus, occiput and lateral part of frons yellowish brown. Dorsal part of frons with a deep central furrow, brownish orange with metallic green reflections. Vertex orange on the top, brownish orange on the base. Antennae brown.

T h o r a x. – Prothorax brown. Pterothorax pale brown with large areas metallic green, in some specimens with violet or bluish reflections. Legs brown, fore femora yellowish brown. Tibial keels occupying the following percentages of the tibial length: fore tibiae 26-29%; mid tibiae 0%; hind tibiae 82-85%. Wings hyaline with a very faint yellow tinge confined to the area of the anal triangle (76%) or throughout the wings (24%). Venation brown; pterostigma yellowish brown. Membranule light brown ending above the apex of the anal triangle. Wing margin at the distal end of the anal triangle with a distinct excavation (Fig. 1). – For venation see Table II.

A b d o m e n. – In dorsal view slightly swollen in segments 1-2, thence very gradually narrowing to the base of 5, thence widening to attain maximum width between 7-8 (2.0-2.3 mm), thence narrowing to the hind end of 10. Segment 10 with a distinct mid-dorsal carina occupying its whole length. Specialized pilose areas on the ventral parts of abdominal segments 7-8 as described for the genus, the pilose complex with two transverse hairy ridges (Fig. 4). Segment 1 pale brown. Dorsum of segments 2-8 metallic green sometimes with bronzy or violet reflections. Dorsum of 9 metallic green or black. Segment 10 black or dark brown. Segments 2-9 bordered on each side with grayish orange for the entire length of each segment above the lateral carina. Ventral tergal part of 3-10 dark brown or black, except for a yellow line at the edge of the tergites. Sternites dark brown. Superior anal appendages (Figs 10, 16) dark brown, about as long as segments 9 + 10 in dorsal view, slightly convergent to the apex, ending in a rounded tip (Fig. 10). In lateral view slightly enlarged in the proximal fourth and distal third, chiefly on the ventral surface. Dorsal surface with a small basal tubercle more visible in lateral view and no fringe of long hairs (Fig. 16). Ventral tubercles absent. Proximal (carinated) part (1.25-1.40 mm) about twice as long as the distal (non-carinated) one (0.45-0.60 mm) (Fig. 16). Inferior anal appendage (Fig. 16) brown, slightly shorter than the superiors, triangular when viewed from below, much attenuated in the distal third, with the tip slightly upcurved. Hamule (Fig. 22) as described for the genus. Anterior lamina absent. Genital lobe triangular (Fig. 22). Penis (Fig. 6) with two cornua of very different sizes (type B penis), the left one very well developed, the right one very small. Apical lobe, in the fully inflated penis, sacciform and very large. Auricles small, rounded.

M e a s u r e m e n t s. – See Table IV.

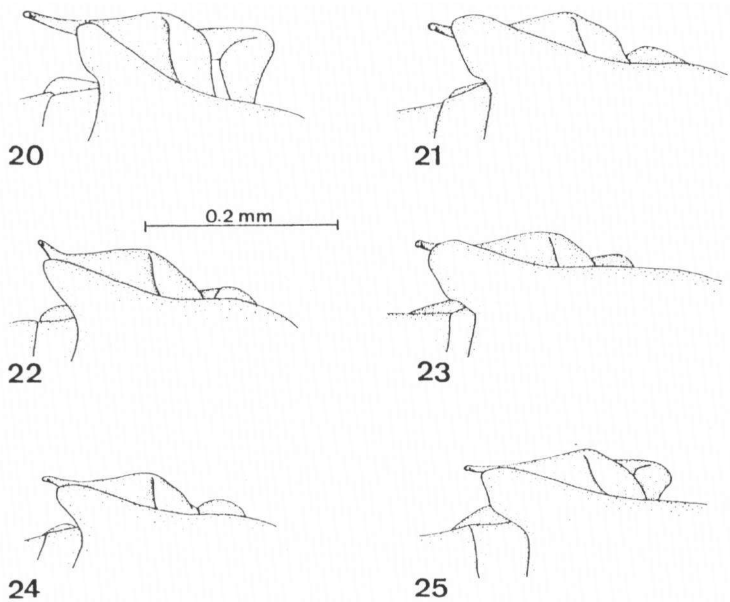
FEMALE. – H e a d. – As in the male.

T h o r a x. – Prothorax and pterothorax as in male. Legs brown, except for the fore femora, which are yellowish brown. Wings hyaline with a very faint yellow tinge on the anal area of hindwing, or in about half the specimens, also on the distal third of both wings. Venation brown, pterostigma yellowish brown. Membranule light brown. – For venation see Table III.

A b d o m e n. – In dorsal view slightly swollen on segment 2 and proximal part of 3, thence gradually tapering to the end. Tergum of segment 9 with a ventral tapering extension, which meets laterally the supralaminar process (Fig. 31). Segment 10 obliquely directed upwards at an angle with segment 9. Appendages conical, black (Fig. 31). Segment 1 pale brown, dorsum of 2-9 black with metallic green or coppery reflections, bordered on each side by grayish orange for the entire length of each segment above the lateral carina. Ventral tergum and sternites as in the males. Ovipositor as described for the genus, with a very long black vulvar lamina surpassing the apex of segment 10 (Fig. 31). Supralaminar process (Fig. 31) shaped like a small tongue with the apex upcurved forming with the shaft an angle of 90° (83%) or more in some specimens, in dorso-posterior view as wide or slightly narrower than the vulvar lamina.

M e a s u r e m e n t s. – See Table V.

REMARKS. – *Navicordulia errans* was known for certain only from two males (CALVERT, 1909; SANTOS, 1968). Our male material corresponds well to the description of the holotype made by CALVERT (1909) and is unquestionably *errans*. The redescription made herewith completes the original description in several aspects and gives an idea of the morphological variability of the species. The female had not yet been described. *N. errans* can be easily recognized by the characters given in the key and mainly by the shape of the male superior appendages.



Figs 20-25. Male genitalia of 2nd abdominal segment in lateral view: (20) *N. longistyla* sp.n., paratype; – (21) *N. kiautai* sp.n., holotype; – (22) *N. errans* (Calvert, 1909) Parque Nacional das Emas, Goiás; – (23) *N. atlantica* sp.n., holotype; – (24) *N. leptostyla* sp.n., holotype; – (25) *N. mielkei* sp.n., paratype.

Our material was collected in the Emas National Park, in Goiás, the IBGE Ecological Reserve, near Brasília and in Pirassununga, São Paulo. This indicates that *N. errans* is a species of the cerrado region. The notations made by the collectors in the envelopes of most specimens show that they were actually collected in the middle of the cerrado or "in roads within the cerrado".

NAVICORDULIA ATLANTICA SP. NOV.

Figures 11, 17, 23

Material. – BRAZIL, Santa Catarina, Joinville, 3-250 m: **holotype** ♂, XII-1957, J. Lane leg.; in collection A.B.M. Machado, Belo Horizonte.

Etymology. – The unique specimen was collected in Joinville, a region dominated by the Atlantic Forest and the name is an allusion to this fact.

MALE. – Head. – Labium missing. Labrum orange. Anteclypeus, clypeus and lateral part of frons brownish orange. Anterior part of frons orange, dorsal part deep orange with metallic green reflections and a deep central furrow. Vertex with the base brownish orange and the apex deep orange.

Thorax. – Prothorax yellowish brown. Pterothorax brown with metallic green and copper reflections and white pilosity. Fore and mid legs missing. Hind legs dark brown. Wings hyaline, slightly suffused with yellow throughout. Venation dark brown. Pterostigma brownish black. Membranule and anal area destroyed in both wings. – For venation see Table II.

Abdomen. – Slightly swollen on the segments 1-2 and proximal part of 3, thence cylindrical (segments 7-8 missing). Segment 10 with a discrete mid-dorsal carina at its anterior half. Basic colour brownish orange, with weak metallic green or coppery reflections dorsally. Superior anal appendages (Figs 11, 17) black, about as long as segments 9+10. In dorsal view (Fig. 11) slightly convergent to the apex, ending in a rounded tip. In lateral view (Fig. 17) slightly enlarged in the proximal fourth and distal third, chiefly on the ventral surface. Dorsal surface with a distinct basal tubercle. Proximal (carinated) part (1.3 mm) about twice as long as distal (non-carinated) one (0.6 mm) (Fig. 17). At the limit between these two parts a small tubercle (Fig. 17) situated at the end of the ventro-lateral carina (ventro--lateral tubercle), visible in dorsal view (Fig. 11). Inferior anal appendage (Fig. 17) dark brown, about as long as the superiors, dark brown, triangular when viewed from below, attenuated in the distal third, with the tips slightly upcurved. Hamule (Fig. 23) as described for the genus. Anterior lamina absent. Genital lobe quadrangular (Fig. 23). Penis with the medial process damaged, the apical lobe of moderate size. Auricles small, rounded.

Measurements. – See Table IV.

FEMALE. – Unknown.

REMARKS. – In addition to the characters given in the key this species can be distinguished from all other species of the genus by its brownish black pterostigma.

Table III

Venational characters of the Brazilian species of *Navicordulia* gen. nov. – females

Character	N. amazonica sp. n. *(n = 1)	N. errans (Calvert, 1909) (n = 10)	N. leptostyla sp. n. (n = 10)	N. longistyla sp. n. (n = 1)	N. mielkei sp. n. (n = 4)	N. miersi sp. n. (n = 1)
Antenodals (FW)	8(50%); 9(50%)	9(50%); 8(40.9%); 7(9.0%)	7(72.2%); 5(27.7%)	8(100%)	9(60%); 8(40%)	9(100%)
Antenodals (HW)	5(100%)	5(85%); 4(10%); 6(5%)	5(89%); 6(11%)	5(100%)	6(80%); 5(10%); 8(10%)	6(100%)
Postnodals (FW)	5(100%)	6(59.1%); 5(22.7%); 7(18.2%)	5(89%); 4(5.5%); 7(5.5%)	5(50%); 6(50%);	6(60%); 5(40%);	5(50%); 6(50%)
Postnodals (HW)	6(50%); 7(50%)	6(41%); 7(31%); 8(23%); 5(5%)	6(83%); 7(11%); 5(6%)	—	7(80%); 5(10%); 6(10%)	7(100%)
Cells in triangle (FW & HW)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)
Cells in subtriangle	2(100%)	2(95.5%); 1(4.5%)	2(66%); 1(33%)	1(100%)	2(80%); 1(20%)	1(50%); 2(50%)
Supratriangle (FW & HW)	1 (100%)	1 (100%)	1 (100%)	1 (100%)	1 (100%)	1 (100%)
Arc in relation to distance between 1st. and 2nd. AX. (FW)	at distal 1/3 (100%)	in the middle(22.7%); slightly distal from the middle (54.5%); at distal 1/3 (22.7%)	in the middle (72.2%); slightly proximal (11.1%); slightly distal (16.69%)	slightly distal from the middle (100%)	slightly distal from the middle (10%); at distal 1/3 (90%)	at distal 1/3 (100%)
Arc in relation to distance between 1st. and 2nd. AX. (HW)	slightly distal from middle (100%)	in the middle (68.2%); slightly distal from the middle (27.2%); at distal 1/3 (4.6%)	in the middle (72%); slightly distal (17%); slightly proximal (11%)	slightly distal from the middle (100%)	at distal 1/3 (70%); slightly distal from the middle (30%)	at distal 1/3 (100%)
Base of triangle in relation to Arc (HW)	slightly proximal (100%)	coinciding (63.4); slightly proximal (36.4)	sightly proximal (77.7%); coinciding (22.3%)	slightly proximal (100%)	slightly proximal (80%); coinciding (20%)	slightly proximal (100%)
Cell-rows in discoidal field (FW)	two rows to the end (100%)	two rows to the end or nearly so (60%); two (mostly) and three rows (40%)	two rows to the end of nearly so (89%); two (mostly) and three rows (11%)	two rows to nearly the end (50%); three rows followed by 2 rows to nearly to the end (50%)	two rows to the end or nearly so (100%)	two rows to nearly the end (50%); two (mostly) and three rows (50%)
Cell-rows in discoidal field (HW)	**2(3-4)+3(3-4) gradually increasing to 8-9 at margin (100%);	2(2-4) + 3(2-4) gradually increasing to 8-11 at margin (91%); 3(5)+4(4) increasing to 12 at margin (9%)	2(2-4) gradually increasing to 8-12 at margin (100%)	2(3-4)+3(3) gradually increasing to 8 at margin (100%)	2(3-4)+3(2-3) gradually increasing to 8-10 at margin (100%)	2(3)+3(3) gradually increasing to 8-9 at margin (100%)
MA and CuP (FW)	convergent (100%);	convergent (63 6%); slightly convergent (22.7%) parallel (13.6%)	convergent (100%)	parallel (100%)	slightly convergent (63%); parallel (37%)	parallel (100%)
Mspl: presence; n° cells (FW)	present(50%) 4(100%)	present (55.5%); 4(72.2%); 5(28%)	present (36.8%); 5(86%); 6(14%)	present (100%); 4(100%)	present (100%); 5(50%); 6(50%)	present (100%); 6(100%)
Mspl: presence n° cell(HW)	present(100% 4(100%)	present (61%); 5(90%); 4(10%)	present (72%); 5(54%); 6(31%); 4(15%)	present (100%); 4(100%)	present (100%); 6(50%); 5(38%); 7(21%)	present (100%); 7(100%)
Cells in Rspl (FW)	6(100%)	6(54.5%); 5(31.8%) 7(13.7%);	6(66.5%); 5(28%); 7(5.5%)	7(100%)	6(80%); 5(20%);	6(100%)
Cells in Rspl (HW)	5(50%); 6(50%)	6(50%); 7(23%); 5(18%); 8(9%)	6(39%); 5(33%); 7(28%)	6(100%)	6(40%); 7(40%); 8(20%)	7(100%)
Cubito-anal crossveins (FW)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)

*n = number of specimens studied; the right and left wings were studied in each specimen and the percentages established with the total number of wings.

** Means two rows of a distance of 3 to 4 cells, followed by 3 rows for a distance of 3 to 4 cells.

*** The cells adjacent to the membranula arranged in 3 rows for a distance of 1-2 cells in all specimens, were not recorded.

Table III continued

Cubito-anal crossveins (HW)	1(100%)	1(100%)	1(100%)	1(100%)	1(100%)	2(100%)
Anal loop: cells in inner half	7(100%)	7(63.6%); 8(31.8%); 9(54.5%)	7(61%).6(33.5%); 8(5.5%)	6(50%); 7(50%)	8(60%); 7(30%); 6(10%)	7(50%); 8(50%)
Anal loop: cells in outer half	6(50%); 7(50%)	7(50%); 6(45%); 8(5%)	6(95%); 7(5%)	6(50%); 7(50%)	7(70%); 6(20%); 8(10%)	6(100%)
Anal loop: cells in total	13(50%); 14(50%)	14(41%); 13(31.8%); 15(22.7%); 16(45%)	13(55.5%); 12(33.5%); 14(11%)	12(50%); 14(50%)	15(60%); 14(20%); 13(20%)	13(50%); 14(50%)
Anal loop: cells in proximal and distal rows	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)
Anal loop: size of distal end	not dilated (100%)	not dilated (60%); slightly dilated (40%)	not dilated (50%) slightly dilated (50%)	not dilated (100%)	not dilated (25%) slightly dilated (75%)	slightly dilated (100%)
Anal loop: shape of distal end	sacciform (50%); intermediate (50%)	truncated (40%); sacciform (40%); intermediate (20%)	sacciform (50%); truncated (33%); intermediate (17%)	truncated (100%)	truncated 25(%) sacciform 25%) intermediate (50%)	truncated (100%)
Anal loop: cells between distal end and wing margin	2(100%)	2(73.3%); 1(26.7%)	2(71.4%); 1(28.6%)	1(100%)	2(100%)	2(100%)
Cell-rows between anal loop and wing margin	***two rows followed by three rows for a distance of 4-6 cells	two rows throughout (73%) or interrupted by 3 rows for 1-cell distance (25%)	two rows throughtout (100%)	two rows throughtout (50%) or interrupted by 3 rows for 1-cell distance (50%)	two rows interrupted by 3 rows for 1-4 cells distance (100%)	two rows interrupted by 3 rows for 3-4 cells distance (100%)

The presence of a crossed triangle in one of the forewings is an unusual character for *Navicordulia* as it occurred only once in the 128 male and female forewings that have been studied in this paper (Tabs II, III). It occurred also in both wings of the single female thought to be *N. nitens* (DE MARMELS, 1991). However, only after more species are available will the taxonomical significance of this character become clear.

NAVICORDULIA LEPTOSTYLA SP. NOV.

Figures 12, 19, 24, 27

Material. – BRAZIL, Goiás: Mineiros (Parque Nacional das Emas, 650-1000 m), **holotype ♂, allotype ♀**, and 3 ♂, 7 ♀, **paratypes**, 14-X-1982 (in cerrado), N.D. Santos, L.F. Netto & Dácio leg.; – Fazenda Olho d'Água (near Parque Nacional das Emas), 1 ♂, 2 ♀ paratypes, 14-X-1982, L.F. Netto & N.D. Santos leg.; – Brasília, (D.F.), Reserva Ecológica do I.B.G.E. (BR 251, km 0): 1 ♂, 2 ♀ paratypes, 12-XI-1979 (in cerrado), M. Simões leg.; – 2 ♀ paratypes, 28-X-1980 (4:00-6:30 p.m. road in cerrado) 1 ♀, 29-X-1980 (6:15-7:00 a.m., road in cerrado), Santos & Mesquita leg. – Specimens (6 ♂, 15 ♀) deposited in the following collections: Museu Nacional, Rio de Janeiro, (holotype, allotype, 4 ♂, 10 ♀ paratypes); – A.B.M. Machado, Belo Horizonte (1 ♂, 4 ♀ paratypes).

Etymology. – The name is an allusion to the fact that unlike in the other species of *Navicordulia*, the male superior appendage is narrowed distally.

MALE. – Head. – Labium and labrum light yellow. Anteclypeus, clypeus, occiput and lateral part of frons olive yellow. Anterior part of frons olive yellow or light yellow in some paratypes. Dorsal part of frons with a deep central furrow, olive brown, with faint metallic green reflections. Vertex light yellow on the top, olive yellow on the base. Antennae brown.

T h o r a x. – Prothorax yellowish brown. Pterothorax with white pilosity, pale brown with faint metallic green and violet reflections on mesoepisternum and mesoepimeron barely noticeable on the metapleura. Legs brown, except for the outer surface of femora and tibiae, which are yellowish brown. Tibial keels yellow, occupying the following percentages of the tibial length: fore tibiae 32-40%; mid tibiae 0%; hind tibiae 78-84%. Wings hyaline, very slightly suffused with yellow, specially at the base. Venation brown, costa white, pterostigma brownish yellow. Membranule light brown ending above the apex of anal triangle. Wing margin at the distal end of the anal triangle with a distinct excavation. – For venation see Table II.

A b d o m e n. – In dorsal view very slightly swollen on segments 1-2 and proximal part of 3, thence cylindrical to the base of 5, swelling again to attain maximum width between segments 7-8 (2.1-2.4 mm), thence gradually narrowing to the hind end of 10. Segment 10 with a mid-dorsal carina at its anterior 2/3. Specialized pilose areas on the ventral parts of abdominal segments 7-8 as described for the genus, the pilose complex with two transverse hairy ridges (Fig. 4). Segment 1 pale brown. Dorsum of segments 2-8 metallic green on 2 and 4-8, bluish on 3. Dorsum of 9 metallic green or black. Segment 10 black or dark brown. Segments 2-9 bordered on each side with grayish orange for the entire length of each segment above lateral carina. Ventral tergal part of 3-10 brown. Sternites dark brown. Superior anal appendages (Figs 12, 19) brown, as long as segments 9+10, in dorsal view (Fig. 12) slightly convergent on the basal 2/3 then parallel or slightly divergent, ending in a rounded tip. Dorsal surface with small basal tubercle and no fringe of hairs. Ventral tubercles absent. Proximal (carinated) part (0.95-1.00 mm) about twice as long as the distal (non-carinated) one (0.50-0.60 mm), the latter slightly narrowed (Fig. 19). Inferior anal appendage (Fig. 19) yellowish brown, about as long as the superiors, triangular when viewed from below, very much attenuated in the distal third, with the tip slightly upcurved. Hamule (Fig. 24) as described for the genus. Anterior lamina absent. Genital lobe triangular (Fig. 24). Penis of type B, exactly similar to that of *N. errans* shown in Figure 6. Auricles small, rounded.

M e a s u r e m e n t s. – See Table IV.

FEMALE. – H e a d. – As in the male.

T h o r a x. – As in the male but metallic reflections on the pterothorax even fainter. Venation brown or yellowish brown, costa white, pterostigma yellowish brown, membranule light brown. Colour pattern of both wings variable, the following types being distinguished:

- Type I: hyaline with yellow on the basal half (3 specimens).
- Type II: hyaline with yellow on the distal third (4 specimens).
- Type III: yellow throughout, although fainter on the middle (8 specimens).

For venation see Table III.

A b d o m e n. – In dorsal view slightly swollen on segment 2 and proximal part of 3, thence gradually tapering to the end. Tergum of segment 9 with a ventral

Table IV

Mensural characters of male *Navicordulia* gen. nov.

CHARACTERS [1]	SPECIES							
	atlantica (n=1)	errans (n=10)	kiautai (n=2)	leptostyla (n=5)	longistyla (n=4)	mielkei (n=3)	nitens [2] (n=1)	vagans [3] (n=1)
Total length [4]	—	37.8 (36.0-39.0)	46.8 (46.0-47.5)	37.5 (36.5-39.0)	44.1 (43.0-45.7)	42.7 (41.3-44.0)	43.5	38.0
Abdomen length [5]	—	25.3 (24.0-26.6)	31.5 (31.3-31.7)	24.8 (24.5-25.4)	30.5 (29.6-31.4)	30.0 (29.6-31.4)	28.8	25.5
Abdomen maximum width	—	2.3 (2.1-2.7)	3.0 (3.0-3.0)	2.0 (1.8-2.3)	2.4 (2.3-2.4)	1.3 (1.2-1.4)	—	—
Forewing (F.W.) length	30.6	28.0 (27.0-29.0)	32.5 (32.0-33.0)	25.4 (25.0-25.9)	30.7 (29.8-31.4)	31.2 (30.2-31.9)	31.8	28.5
F.W. base-nodus length	16.4	15.6 (14.9-16.6)	18.0 (18.0-18.0)	13.1 (12.9-13.3)	16.2 (16.0-17.0)	16.5 (16.0-17.2)	17.9	15.9
F.W. base-nodus [6] ratio	0.54	0.56	0.55	0.52	0.52	0.53	0.56	0.55
Hindwing (H.W.) length	31.0	27.1 (26.0-28.5)	31.8 (31.5-32.0)	24.2 (23.8-24.6)	29.7 (28.9-30.4)	29.0 (29.5-30.6)	31.5	28.0
H.W. base-nodus length	14.0	12.7 (12.0-13.4)	14.7 (14.7-14.7)	10.6 (10.4-11.0)	13.6 (12.6-14.4)	13.2 (13.0-13.4)	14.6	13.7
H.W. base-nodus [6] ratio	0.45	0.47	0.46	0.45	0.46	0.44	0.46	0.48
F.W. pterostigma [7] length	2.00	1.99 (1.90-2.20)	2.05 (2.00-2.10)	2.24 (2.20-2.30)	2.00 (1.80-2.10)	2.23 (2.20-2.30)	1.90	1.70
H.W. pterostigma [7] length	2.10	1.86 (1.80-1.90)	2.00 (2.00-2.00)	2.26 (2.10-2.40)	2.00 (1.80-2.10)	2.28 (2.25-2.30)	1.80	1.70
Inferior ap. length	1.90	1.67 (1.60-1.80)	2.00 (2.00-2.00)	1.58 (1.50-1.60)	1.73 (1.70-1.80)	1.96 (1.90-2.00)	2.10	2.00
Superior ap. proximal [8] part length	1.30	1.33 (1.25-1.40)	1.23 (1.20-1.25)	0.98 (0.95-1.00)	1.05 (1.00-1.20)	1.23 (1.20-1.30)	1.60	1.60
Superior ap. distal [9] part length	0.60	0.51 (0.45-0.60)	1.33 (1.30-1.35)	0.56 (0.50-0.60)	1.70 (1.50-1.90)	0.53 (0.50-0.60)	1.10	0.40
Superior ap. total length	1.90	1.84 (1.70-1.90)	2.55 (2.50-2.60)	1.60 (1.55-1.70)	2.75 (2.70-2.90)	1.76 (1.70-1.80)	2.70	2.00
Abdomen segments 9+10 length	1.80	1.84 (1.80-2.00)	2.55 (2.50-2.60)	1.65 (1.50-1.80)	2.33 (2.30-2.40)	2.03 (2.00-2.10)	—	—
Eye seam [10] length	1.00	0.55 (0.40-0.60)	0.65 (0.60-0.70)	0.38 (0.30-0.40)	0.58 (0.50-0.70)	1.00 (1.00-1.00)	—	—

[1] Mensural characters expressed in mm as mean (range), bilaterally placed structures measured only on one side.

[2] Data from DE MARMELS (1991).

[3] Data from DE MARMELS (1989).

[4] Including anal appendages.

[5] Excluding anal appendages.

[6] Ratio length of base to nodus distance to total wing length.

[7] Measured along costal margin, including marginal vein.

[8] Carinated part.

[9] Non-carinated part.

[10] Length of middorsal contact between eyes.

tapering extension, which meets laterally the supralaminar process (Fig. 27). Segment 10 obliquely directed upwards at an angle with segment 9. Appendages conical (Fig. 27), black. Segment 1 pale brown, dorsum of segments 2-10 black, with coppery green reflections on 2-7, bordered on each side with grayish orange for the entire length of each segment above the lateral carina. Ventral tergum pale brown. Sternites dark brown. Ovipositor as described for the genus, with a very long black vulvar lamina surpassing the apex of segment 10 (Fig. 27). Supralaminar process (Fig. 27) shaped like a small tongue with the apex upcurved forming with the shaft an angle of 90° (64%) or more in some specimens, in dorso-posterior view slightly narrower than the vulvar lamina.

Measurements. – See Table V.

REMARKS. – In addition to the characters given in the key, this species may be readily identified by the presence of a white costa, a unique character for the genus.

N. leptostyla, as *N. errans* and *N. longistyla*, seems to be typical of the cerrado region of Central Brazil.

NAVICORDULIA MIELKEI SP. NOV.

Figures 13, 18, 25, 30

Material. – BRAZIL, Santa Catarina, Joinville, 3-250 m: **holotype** ♂, Serrinha, 20-200 m, 31-X-1987, O. Mielke leg.; – 2 ♂, 3 ♀ **paratypes**, 24-X-1982, 16-XII-1983, 8-X-1985 (within forest), 23-XII-1985, 2-II-1985, H. Miers leg. – Paraná, Estação Ecológica de Guaraqueçaba, 20 m: **allotype** ♀ (in forest trail at 5:00 p.m.) 13-II-1988, P.A. Machado leg. – Specimens (3 ♂, 4 ♀) deposited in the following collections: A.B.M. Machado, Belo Horizonte, (holotype, allotype, 1 ♂, 2 ♀ paratypes); – Museu Nacional, Rio de Janeiro (1 ♂, 1 ♀ paratypes).

Etymology. – We dedicate this species to our friend, Professor Dr Olaf Hermann Hendrik Mielke, who collected the holotype and whose wanderings throughout South America, in search of butterflies, have also yielded many valuable dragonfly specimens.

MALE. – Head. – Labium pale orange. Labrum orange. Anteclypeus, clypeus, occiput and frons pale brown. Vertex pale brown with faint violet lustre. Dorsal part of frons with a deep central furrow and metallic green reflections.

Thorax. – Prothorax yellowish brown. Pterothorax brown with blue and violet metallic reflections and white pilosity. Legs black, except for medial part of fore femora, mid femora and tibial keels, which are brown. Tibial keels occupying the following percentages of the tibial length: fore tibiae 33%; mid tibiae 8-9%; hind tibiae 80-90%. Wings hyaline, slightly suffused with yellow to the nodus. Venation dark brown. Pterostigma yellowish brown. Membranule light brown or whitish in the teneral paratypes, ending above the apex of the anal triangle. Wing margin at the distal end of the anal triangle with a distinct excavation. – For venation see Table II.

Abdomen. – In dorsal view slightly swollen on segments 1-2 and proximal part of 3, thence cylindrical to the end. Segment 10 without mid-dorsal carina.

Table V
Mensural characters of female *Navicordulia* gen. nov.

CHARACTERS [1]	SPECIES						
	amazonica (n=1)	errans (n=10)	leptostyla (n=10	longistyla (n=1)	mielkei (n=4)	miersi (n=1)	nitens [2] (n=1)
Total length [3]	41.5	40.1 (38.9-41.5)	37.0 (36.0-38.5)	47.0	44.4 (37.0-46.0)	45.5	—
Abdomen length [4]	29.0	28.1 (27.0-31.0)	26.2 (25.1-27.4)	33.6	34.3 (33.5-35.0)	36.0	34.0
Forewing (F.W.) length	29.7	31.0 (30.0-32.9)	26.6 (25.2-27.5)	33.4	32.8 (32.0-34.8)	33.6	34.0
F.W. base-nodus length	15.7	16.9 (15.9-18.5)	13.8 (13.3-14.5)	18.0	17.5 (16.7-18.5)	17.7	19.0
F.W. base-nodus [5] ratio	0.58	0.54	0.52	0.54	0.53	0.53	0.55
Hindwing (H.W.) length	28.8	30.0 (29.0-32.3)	25.9 (24.5-27.2)	—	31.8 (31.0-33.0)	32.7	33.0
H.W. base-nodus length	12.4	13.5 (13.0-15.0)	11.4 (10.2-11.7)	14.4	13.6 (13.2-13.8)	14.5	14.3
H.W. base-nodus [5] ratio	0.50	0.45	0.44	—	0.43	0.44	0.43
F.W. pterostigma [6] length	2.20	2.10 (2.00-2.20)	2.38 (2.20-2.60)	2.00	2.30 (2.20-2.50)	2.40	—
H.W. pterostigma [6] length	2.00	1.98 (1.90-2.00)	2.36 (2.20-2.50)	—	2.33 (2.30-2.40)	2.30	—
Anal appendage length	0.75	0.69 (0.60-0.80)	0.53 (0.50-0.60)	0.90	0.86 (0.80-0.90)	0.90	1.00
Vulvar lamina length [7]	2.90	2.68 (2.60-2.90)	2.42 (2.20-2.70)	2.90	2.50 (2.40-2.60)	2.60	—
Eye sheam [8] length	0.65	0.52 (0.50-0.60)	0.38 (0.30-0.40)	0.45	0.87 (0.80-0.90)	0.70	—

[1] Mensural characters expressed in mm as mean (range), bilaterally placed structures measured only on one side.
[2] Data from RACENIS (1970) and DE MARMELS (1983).
[3] Including ovipositor.
[4] Excluding ovipositor.
[5] Ratio length of base to nodus distance to total wing length.
[6] Measured along costal margin, including marginal vein.
[7] Measured from the hind margin of segment 8.
[8] Length of middorsal contact between eyes.

Specialized pilose areas on the ventral parts of abdominal segments 7-8 as described for the genus, the pilose complex with a single transverse hairy ridge (Fig. 3). Dorsum of segments 1-9 metallic green, bordered on each side by brownish orange. In one paratype the metallic green colour reaches the lateral carina on the distal half of segments 4-6. Segment 10 brownish orange, dorsum dark brown. Superior anal appendages (Figs 13, 18) dark brown, distinctly shorter than segment 9+10, in dorsal view very slightly convergent to the apex ending in a rounded tip (Fig. 13). In lateral view (Fig. 18) slightly enlarged in the proximal fourth and in the distal third chiefly on the lower surface. Dorsal surface, with a distinct basal tubercle and no fringe of long hairs. Proximal (carinated) part (1.2-1.3 mm) twice as long as distal (non-carinated) one (0.5-0.6 mm). At the limit between these two parts (Fig. 18), a small tubercle situated at the end of the ventro-lateral carina, (ventro-lateral tubercle) visible in dorsal view (Fig. 13). Inferior anal appendage (Figs 13, 18) distinctly longer than the superiors, dark brown, triangular when viewed from below, attenuated in the distal third, with the tip slightly upcurved. Hamule (Fig. 25) as described for the genus, the extent of hamule projection from the genital fossa variable. Anterior lamina absent. Genital lobe quadrangular (Fig. 25). Penis of type A, similar to that of *N. longistyla* shown in Figure 5, although slightly smaller. Auricles small, rounded.

M e a s u r e m e n t s. – See Table IV.

FEMALE. – Labium pale orange. Labrum orange. Anteclypeus, clypeus, occiput and lateral part of frons pale brown. Anterior and dorsal part of frons orange with a deep furrow and metallic green reflections. Vertex with the base pale brown and the apex orange with violet lustre. In the paratypes, all tenerals, the whole frons and vertex are pale brown with the violet lustre less evident.

T h o r a x. – Prothorax yellowish brown. Pterothorax brown with metallic blue and violet reflections on the mesoepisternum and metallic green on the meso- and metaepimeron. Legs black, except for medial part of fore and mid femora, which are brown. Wings in the fully adult allotype hyaline with areas of faint yellow on the basal two thirds, the distal third brownish yellow. The cells in this brownish yellow area have the centre characteristically pale. In three teneral paratypes the wings are either totally hyaline (one paratype), or hyaline with brownish yellow apical third. Venation brown. Pterostigma brown in the allotype, yellowish in the paratypes. Membranule brown in the allotype, whitish in the paratypes. – For venation see Table III.

A b d o m e n. – In dorsal view slightly swollen on segment 2 and proximal part of 3, thence cylindrical, slightly narrowed at segments 8+10. Tergum of segment 9 with a ventral tapering extension, which meets laterally the supralaminar process (Fig. 30). Segment 10 obliquely directed upward at an angle with segment 9. Appendages (Fig. 30) conical, black. Dorsum of segments 2-8 metallic coppery green, bordered on each side by brown or brownish orange. Segments 9-10 dark brown. Ovipositor as described for the genus, with a very long vulvar lamina surpassing the apex of segment 10 (Fig. 30). Supralaminar process (Fig. 30) shaped like a small cup, in dorso-posterior view as wide as the vulvar lamina.

M e a s u r e m e n t s. – See Table V.

REMARKS. – This species may be distinguished from all other species of the genus by having the inferior appendage of the male much longer than the superiors and by the cup shaped supralaminar process of the female. It seems to be a species of the Atlantic Forest of South Brazil as all specimens were collected in regions of this forest. The female allotype from Guaraqueçaba and a female paratype from Joinville were actually collected in a trail within the forest.

NAVICORDULIA AMAZONICA SP. NOV.

Figure 26

M a t e r i a l. – BRAZIL, Mato Grosso, Sinop, 378 m: holotype ♀, X-1974, M. Alvarenga leg.; in collection A.B.M. Machado, Belo Horizonte.

E t y m o l o g y. – The species is the only Brazilian *Navicordulia* so far recorded from the Amazon forest, hence its name.

MALE. – Unknown.

FEMALE. – H e a d. – Labium pale orange. Labrum, vertex and anterior part of frons orange. Anteclypeus, clypeus and lateral part of frons brownish orange. Occiput brownish orange. Upper part of frons deep orange with bluish green metallic reflections.

T h o r a x. – Prothorax yellowish brown. Pterothorax brown with metallic green reflections. Legs with femora brown, tibiae and tarsi dark brown, third tarsal segment reddish brown. Wings hyaline slightly suffused with yellow on the anal area of the hind wings, the distal third of both wings brownish yellow. Most cells in the apical brownish yellow area have the centre characteristically pale. Venation dark brown, pterostigma brown, membranule light brown. – For venation see Table III.

A b d o m e n. – In dorsal view slightly swollen on segments 2-3, thence gradually tapering to the end. Tergum of segment 9 with a ventral tapering extension, which meets laterally the base of the supralaminar process (Fig. 26). Appendages (Fig. 26) conical, dark brown. Segments 1-2 and proximal part of 3, brown. Distal part of 3 and segments 4-6, dark with faint metallic green reflections, except near the lateral carina, which is brown. Segments 7-10 laterally brown, dorsally dark with faint metallic green reflections. Ventral tergum brown on 1-3, on 4-8 dark brown laterally, brown medially. Sternites dark. Ovipositor as described for the genus with a very long vulvar lamina surpassing the apex of segment 10 (Fig. 26). Supralaminar process (Fig. 26) shaped like a small tongue, with the apex upturned forming with the shaft an angle of 90°, in dorso-posterior view slightly narrower than the vulvar lamina.

M e a s u r e m e n t s. – See Table V.

REMARKS. – *N. amazonica* differs from the other known females of *Navicordulia* by the characters given in the key. The presence of a large number of rows with 3 cells between the anal loop and the wing margin is a character that distinguishes it from all other female and male species of the genus except *N. nitens* and *miersi*. However, the supralaminar process of these two species and especially the tapering tergal extension of segment 9 of *nitens*, as figured by RACENIS (1970), are quite different. The wings of *N. amazonica* resemble almost exactly the wings of a female Corduliidae of unknown locality reproduced in a photograph (pl. 42, fig. 1) by NEEDHAM (1903). These wings do not belong to *Neocordulia androgynis* as stated by NEEDHAM (1903), nor to *N. errans* as proposed by GEIJSKES (1970), being most probably the wings of *N. amazonica*.

N. amazonica has been collected around Sinop (Mato Grosso) a village situated within the Amazon Forest, which was fairly well preserved at the time the insect was found.

NAVICORDULIA MIERSI SP. NOV.

Figure 29

M a t e r i a l. – BRAZIL, Santa Catarina, Joinville, 3-250 m: holotype ♀, 26-XI-1979, H. Miers leg.; in collection A.B.M. Machado, Belo Horizonte.

E t y m o l o g y. – We dedicate this species to Mr Herbert M i e r s, lepidopterist from Joinville, who collected the holotype and has made an important contribution to the odonatological studies of one of the authors (ABMM).

MALE. – Unknown.

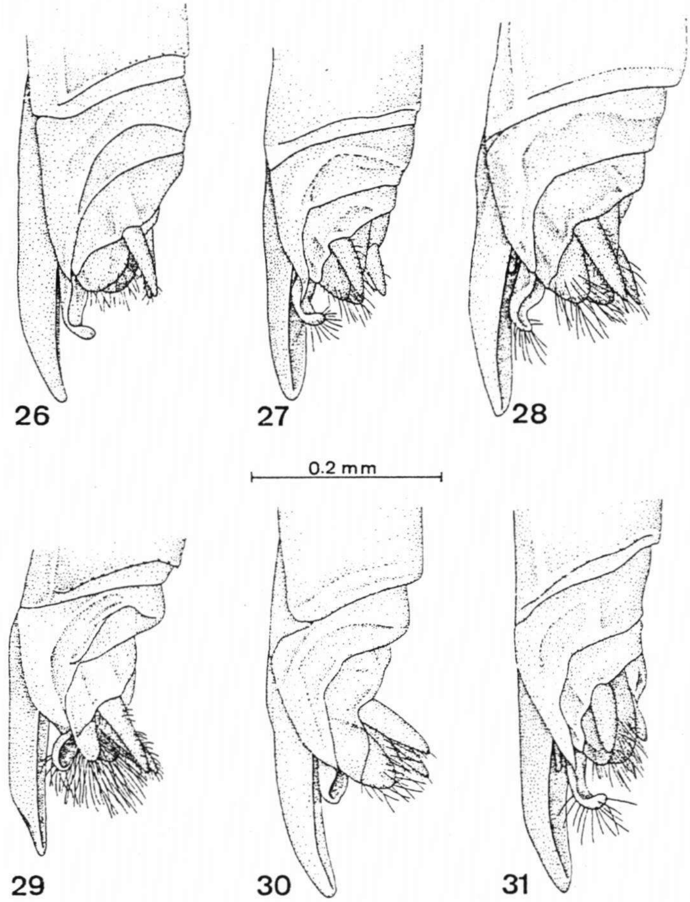
FEMALE. – H e a d. – Labium, labrum, anteclypeus, clypeus and frons pale brown. Dorsal part of frons with a deep central furrow and faint metallic green reflections. Vertex pale brown with a faint violet lustre. Occiput damaged.

T h o r a x. – Prothorax yellowish brown. Pterothorax brown with metallic green and violet reflections. Legs dark brown. Wings hyaline with the distal third grayish yellow. Venation brown. Pterostigma pale yellow. Membranule light brown. – For venation see Table III.

A b d o m e n. – Slightly swollen on segments 2-3 and proximal part of 3, thence cylindrical to segment 7, slightly narrowed at segments 8-10. Tergum of segment 9 with a ventral tapering extension, which meets laterally the base of the supralaminar process (Fig. 29). Segment 10 obliquely directed upwards forming an angle with segment 9. Appendages conical (Fig. 29). Segments 1-8 yellowish brown, the dorsum with metallic reflections, green on segments 1-3, coppery, on segments 4-8: Ovipositor as described for the genus, with a very long vulvar lamina surpassing the apex of segment 10 (Fig. 29). Supralaminar process (Fig. 29) shaped like a small dish, in dorso-posterior view wider than the vulvar lamina.

M e a s u r e m e n t s. – See Table V.

REMARKS. – By the presence of two cubitoanal crossveins in hindwing, *N. miersi* differs from all the eight known species of Brazilian *Navicordulia* as well as from



Figs 26-31. Female abdominal segments 8-10, in lateral and slightly dorsal view, showing the vulvar lamina and the supralaminar process: (26) *N. amazonica* sp.n., holotype; – (27) *N. leptostyla* sp.n., allotype; – (28) *N. longistyla* sp.n., allotype; – (29) *N. miersi* sp.n., holotype; – (30) *N. mielkei* sp.n., allotype; – (31) *N. errans* (Calvert, 1909), allotype.

the Venezuelan *N. vagans*. Indeed out of the 128 hindwings of male and female *Navicordulia* studied in the present paper, two cubitoanal crossveins occurred only in the single specimen now described as *N. miersi*. This character was, however, present on one side of the wings of the single male and the single female of *N. nitens* known so far. In the female of *N. miersi*, however, the tapering tergal extension of abdominal segment 9 stops at the base of the supralaminar process, whereas in *N. nitens* it overpasses it. In spite of the fact that the figure of the supralaminar process of *N. nitens* figured by RACENIS (1970) is somewhat schematic, it shows that, in this species, this process is quite different from the dish-like one found in *N.*

miersi, which, in its shape, is unique for the genus.

N. miersi, as *N. mielkei* and *N. atlantica*, was collected in the region of the Atlantic Forest and is most probably endemic to this forest.

ECOLOGICAL CONSIDERATIONS

From the standpoint of their biogeography, the known species of *Navicordulia* can be divided into four groups, respectively from the Amazon Forest (*amazonica, vagans*), from the Atlantic Forest (*atlantica, mielkei, miersi*), from the cerrado region (*errans, leptostyla, longistyla*) and from the tabletop mountain regions (Pantepui) of Venezuela (*nitens*). The existence of species from the forest and from the open cerrado vegetation has a morphological counterpart in the eye sheam length, which is considerably longer in the former than in the latter (Tabs IV, V). This fact possibly reflects an increase in the visual area, presumably an adaptation to the shady environment of the forest. The species from the cerrado, especially *N. errans* and *N. leptostyla*, were represented in our material by an unusually large number of specimens collected in a very short period of time, which means they were very abundant in the field. For instance, the records in the envelopes indicate that two collectors (Santos & Mesquita) were able to obtain 11 specimens of *Navicordulia* belonging to three species, namely *N. errans* (5 ♂, 2 ♀), *N. leptostyla* (2 ♀) and *N. longistyla* (2 ♂) along a road within the cerrado near Brasília between 1600-1830 h. Likewise, on the same day, October 14, 1982, 27 specimens (*N. errans*, 15; *N. leptostyla*, 12) were collected in the Emas National Park. The notation in the envelope of one *errans* specimen, collected in the cerrado at 6.00 h, stated that, at that moment, "a great number of Corduliidae was observed feeding on small insects". It seems, however, that the abundance of Corduliidae indicated by these observations was a phenomenon restricted to species of *Navicordulia*, specially *N. errans*, as the number of specimens of other genera collected on the occasion was comparatively small (1 *Neocordulia volxemi* in the cerrado road near Brasília, and 3 *N. volxemi* and 2 *Aeschnosoma marizae* in the cerrado near Emas National Park). This situation, in which a large number of cerrado *Navicordulia* were collected in a short time, is in marked contrast with that observed with the forest species, represented in our material by very few specimens, no more than a single specimen having been collected in a single day. The difference could be due to the fact that the forest *Navicordulia* could actually be less abundant than those from the cerrado, or, what seems more probable, they might be abundant in the forest canopy and therefore more difficult to collect. Indeed, according to one of the collectors, the biologist Luis Fernando Netto, most of the specimens collected in the cerrado late in the afternoon were netted when roosting in the usually low cerrado trees, a situation obviously more suitable to collecting than the forest canopy. Under any circumstances, the abundance of *Navicordulia* in the cerrado of central Brazil in October and November is an exception to the current view that neotropical Corduliidae are of rare occurrence in the field (SANTOS, 1968; GEIJSKES, 1970; COSTA & SANTOS, 1992). With regard to the altitudinal range of the Brazilian *Navicordulia*, the forest species (*amazonica, atlantica, mielkei, miersi*) were collected at low altitudes (3-378 m), and those from the cerrado (*errans, leptostyla, longistyla*) at moderate altitudes (627-1171 m) in the plains of the Central Brazilian Plateau. Thus, except for *N. nitens*, the genus does not seem to contain truly mountain species, as is usual for many neotropical Corduliidae.

The collectors' notes in the envelopes containing the 72 male and female specimens of *Navicordulia* collected in the cerrado of central Brazil reveal that, with the exception of 2 males and 1 female, collected by a river and in a swamp, all specimens were collected away from the innumerable streams and water bodies that exist in the region. This fact and the presence of a peculiarly large ovipositor, most probably associated with some unusual type of oviposition, prompt further investigation on the reproductive biology and ecology of these fascinating insects.

ACKNOWLEDGEMENTS

We would like to thank Dr JURG DE MARMELS for providing information on some morphological details of the types of *N. nitens* and *N. vagans*. We thank also the biologist MYRIAN MORATO DUARTE for the drawings illustrating this paper.

REFERENCES

BORROR, D.J., 1947. Notes on Ypirangathemis Santos (Odonata: Libellulidae) with description of the female of Y. calverti Santos. *Ann. ent. Soc. Am.* 40(2): 247-256.

CALVERT, P.P., 1909. Contributions to a knowledge of the Odonata of the neotropical region, exclusive of Mexico and Central America. *Ann. Carnegie Mus.* 6(1): 73-280, pls 1-9 excl.

COSTA, J.M. & T.C. SANTOS, 1992. Santosia marshalli gen. nov., spec. nov. A new genus and species of Corduliinae from Brazil (Anisoptera: Corduliidae). *Odonatologica* 21(2): 235-239.

DE MARMELS, J., 1983. The Odonata of the region of Mount Auyantepui and the Sierra de Lema, in Venezuelan Guyana, 3. Additions to the families Gomphidae, Aeshnidae and Corduliidae, with description of Progomphus racenisi spec. nov. *Odonatologica* 12(1): 5-13.

DE MARMELS, J., 1989. Odonata or dragonflies from Cerro de la Neblina and the adjacent lowland between the Rio Baria, the Casiquiare and the Rio Negro (Venezuela). 1. Adults. *Boln Acad. Cien. fis. mat. natur., Caracas* 25: 11-78.

DE MARMELS, J., 1991. Dorocordulia nitens sp.n., eine neue Smaragdlibelle aus Venezuela (Odonata: Corduliidae). *Mitt. ent. Ges. Basel* 41(4): 106-111.

GEIJSKES, D.C., 1970. Generic characters of the South American Corduliidae, with descriptions of the species found in the Guyanas. *Stud. Fauna Suriname* 12(44): 1-42, pls 1-2 excl.

LIEFTINCK, M.A., 1953. Revision of the Australasian species of Synthemis Selys (Odon., Corduliidae). *Idea* 9(3/4): 70-88.

MARTIN, R., 1906. Cordulines. *Collns zool. de Selys Longchamps* 17: 1-92, pl 1-3.

MARTIN, R., 1914. Odonata fam. Libellulidae, subfam. Cordulinae. *Genera Insect.* 155: 1-31, pls 1-3 excl.

NEEDHAM, J.G., 1903. A genealogic study of dragonfly wing venation. *Proc. U.S. natn. Mus.* 26: 703-764, pl. 31-54 excl.

NEEDHAM, J.G., 1908. Critical notes on the classification of the Corduliinae (Odonata). *Ann. ent. Soc. Am.* 1: 273-280.

NEEDHAM, J.G. & M.J. WESTFALL, 1955. *A manual of the dragonflies of North America (Anisoptera).* Univ. California Press, Berkeley-Los Angeles-London.

RACENIS, J., 1970. Los odonatos de la region del Auyantepui y de la Sierra de Lema, en la Guayana venezolana. 2. Las familias Gomphidae, Aeshnidae y Corduliidae. *Acta biol. venez.* 7(1): 23--39.

RIS, F., 1911. Libellulinen monographisch bearbeitet, 4. *Collns zool. de Selys Longchamps* 12: 385--700.

SANTOS, N.D., 1968. Notas sôbre "Dorocordulia errans" Calvert, 1909 (Odonata, Corduliidae). *Atas Soc. Biol. Rio de J.* 11(6): 201-202.

ST. QUENTIN, D., 1962. Der Eilegeapparat der Odonaten. *Z. Morph. Ökol. Tiere* 51: 165-189.

TILLYARD, R.J., 1917. *The biology of dragonflies (Odonata or Paraneuroptera).* Cambridge Univ. Press, Cambridge.

VAN DER WEELE, H.W., 1906. Morphologie und Entwicklung der Gonapophysen der Odonaten. *Tijdschr. Ent.* 49: 99-198.