

Two new species of *Chalybeothemis* from Malaysia, with a redefinition of the genus (Odonata: Libellulidae)

Rory A. Dow¹, Chee Y. Choong² & Albert G. Orr³

¹ 6 Bramley Avenue, Coulsdon, Surrey, CR5 2DP, UK. <rory.dow@virgin.net>

² Centre for Insect Systematics, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

³ CRC, Tropical Ecosystem Management, AES, Griffith University, Nathan, Q4111, Australia.

Key words: Odonata, dragonfly, Libellulidae, *Chalybeothemis*, *chini*, *pruinosa*, Malaysia, Sarawak, Borneo

ABSTRACT

Chalybeothemis chini sp. nov. from Pahang, Peninsular Malaysia, and *C. pruinosa* sp. nov. from Sarawak, Malaysian Borneo, are described from the male sex. The new species necessitate some redefinition of the previously monotypic genus, which is provided. The quiescent penis of *Chalybeothemis* is illustrated for the first time. Differences between *C. chini*, *C. fluviatilis* and *C. pruinosa* are discussed and tabulated. *C. fluviatilis* is reported from Sarawak for the first time. Relationships of *Chalybeothemis* within the Libellulidae are discussed.

INTRODUCTION

Lieftinck (1933a) erected the genus *Chalybeothemis* for a single species, *C. fluviatilis* Lieftinck, 1933, described from specimens collected in west Kalimantan on the island of Borneo. Subsequently the species was reported from Billiton (now Belitung) Island (Lieftinck 1936), the Sampit area in southern Kalimantan (Lieftinck 1953), Singapore and Peninsular Malaysia (Lieftinck 1954), Brunei (Orr 2001) and Thailand (Pinratana 2003).

In March 2006 CYC collected a small series of an undescribed *Chalybeothemis* species upstream on the Chini river, which connects the large lake Chini with the Pahang river in Pahang, Peninsular Malaysia. This species is described here as *C. chini* sp. nov. In April 2006 G.T. Reels and RAD collected a small series of another unnamed species of *Chalybeothemis* at the large natural lake Loagan Bunut, situated in the national park of the same name, in Bahagian Miri, Sarawak, Malaysian Borneo. This species is closely related to *C. chini*, but differs in several structural features, most notably in its build and in the accessory genitalia, and is described here as *C. pruinosa* sp. nov. It is the second species of *Chalybeothemis* to be recorded from the island of Borneo, and *C. chini* is the second to be reported from Peninsular Malaysia. The new species were compared directly with the type series of *C. fluviatilis* in the Nationaal Natuurhistorisch Museum Naturalis (RMNH), Leiden, Netherlands. Terminology for the libellulid penis follows Miller (1991), that for wing venation follows that used by Lieftinck (1933a) in his description of the genus; the reader is referred to Watson et al. (1991) for an explanation of this terminology. Penis structure was examined using a Scanning Electron Microscope (SEM).

Chalybeothemis Lieftinck, 1933

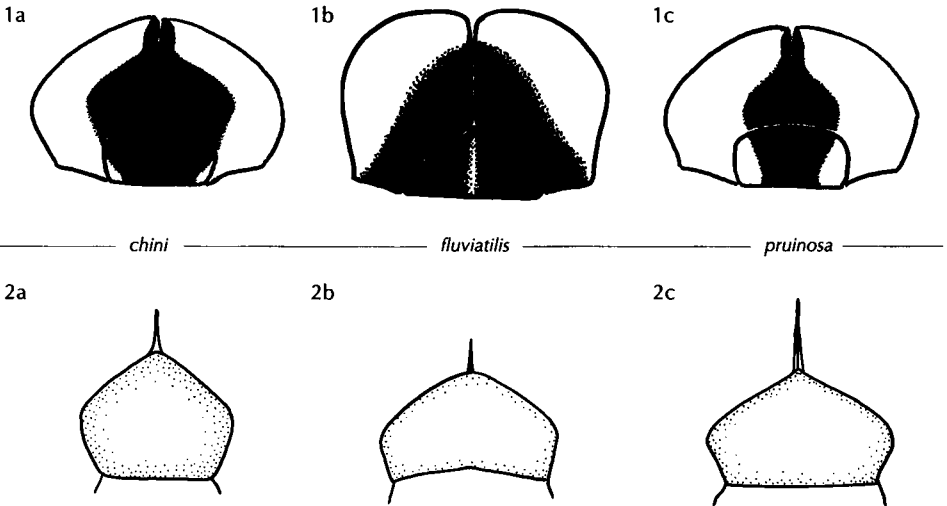
Only features that differ from the original description of the genus (Lieftinck 1933a) or that are regarded as being diagnostic for the genus are included here. The reader is directed to the original description for further details. Text in quotation marks is from the original description.

Small sized, "Stature of *Diplacodes*".

Head: Small, eyes in contact only for a short distance. Frons narrower than the transverse diameter of the compound eye (ratio ca 0.7-0.9).

Thorax: Posterior lobe of prothorax long. Synthorax "short, smaller and much narrower than in *Brachydiplax*, rather similar in form to *Tyriobapta* and *Raphismia*."

— Legs slender and very long; the posterior femora reaching at least to or beyond the posterior margin of the second abdominal segment. Poststernum (Fig. 2) approximately pentagonal. — Wings (Fig. 3) long with hypertriangles and Hw triangle uncrossed, Fw triangle crossed or uncrossed; only occasionally crossed in *C. fluviatilis*. Hw triangle midway between first and second antenodals, situated at or slightly distal to arculus. No supplementary bridge cross vein in either wing. "Last antenodal complete. M_2 and Rs faintly curved, M_2 slightly convex before the middle of its course. One row of cells between Rs-Rspl." Discoidal field in Fw with two or three cells at base, in the latter case immediately narrowing to two cells, with a kink in Cu_1 , widening to the wing margin, 6-7 marginal cells. Discoidal field in Hw with 1 cell at base, 9-13 marginal cells. Anal loop long and well-developed, extending beyond level of triangle, not meeting wing margin. 6-7 Ax in Fw, 5 in Hw, 6-7 Px in both wings.



Figures 1, 2: Two characters of *Chalybeothemis* species in comparison — (1) labium, ventral view; (2) poststernum, ventral view — (a) *C. chini*; (b) *C. fluviatilis*; (c) *C. pruinosa*.

Abdomen: Male short, S1-3 moderately to strongly dorso-ventrally expanded, narrowing in lateral view from S3. S4 without a transverse ridge, S10 with a dorsal keel (Fig. 4). Female (only *C. fluviatilis* known) “abdomen cylindrical, a little compressed laterally”. — Accessory genitalia of male (Fig. 5) prominent. Hamule of a distinctive shape (Fig. 6), with inner and outer branches well developed. Inner branch sharply curved apically and either rounded or acuminate at tip. Orientation is such that at rest the apex of the inner branch is directly anterior to the apex of the outer branch or nearly so, the two hamules lying closely appressed on either side of the sagittal plane. Anterior lamina large, with the posterior margin concave (Fig. 7). Penis as shown in Figures 8, 9, with the terminal segment longer than the second segment, and all four segments clearly distinct. — Anal appendages of male of typical libellulid form, of similar length to or greater than S9. “Female with eighth sternite simple and slightly swollen along margin. Ventral plate of ninth segment large and prominent, strongly compressed and sharply keeled below, projecting to behind”.

Diagnostic differences between the three species of *Chalybeothemis* are summarised in Table 1.

Chalybeothemis chini sp. nov.
(Figs 1a, 2a, 3a, 4a, 5a, 6a, 7a, 8a, 9a)

Etymology

A noun in apposition, *chini*; named for the type locality, the (Sungei) Chini.

Specimens examined

Holotype: ♂, 18 iii 2006, Chini river, Pahang, Peninsular Malaysia, leg. CYC. Paratypes: 4 ♂, data as for holotype. Holotype to be deposited in the Centre for Insect Systematics, Universiti Kebangsaan Malaysia, paratypes in coll. C.Y. Choong, coll. A.G. Orr, and RMNH. Female unknown.

Description of holotype male

Head: Labium (Fig. 1a) with about the central $\frac{3}{4}$ of the prementum and about the inner $\frac{1}{3}$ of the palps black, the area of this colour narrowing towards the ends, the remainder pale cream yellow. Labrum, clypeus pale cream yellow. Genae largely obscured, pale anteriorly. The lower part of the anterior surface of the frons is pale cream yellow, the remainder being dark metallic blue-green; the boundary between dark and light colouration is irregular, with the pale colour narrowest centrally. Upper surface of the frons with a moderately deep median depression. Vertex with two small anterior protuberances, on either side of the frontal concavity; vertex dark metallic green. Occiput as for genus. Antennae black, eyes green in life.

Thorax: Prothorax dull black, large posterior lobe with erect fringe of long hairs. Synthorax dull black with faint greenish metallic reflections in places. Largely covered by thin, pale-blue pruinescence; pruinescence absent on a wide band starting on the mesepimeron just above the interpleural suture and running diagonally upwards onto the mesepisternum, terminating just before the middorsal carina. Syn-

thorax ventrally dull black with a thick covering of white hairs, poststernum close to a regular pentagon (Fig. 2a), its posterior part pale. Legs black with pruinescence on coxae, trochanters and the upper parts of the flexor surfaces of the femora. Legs relatively not quite as long as in *C. fluvialis*, the anterior femora extending just to the posterior border of S2. — Wings (Fig. 3a): Subtriangle with 3 cells. Fw triangle crossed. Pterostigma dark brown, covering one underlying cell entirely and a small part of one or both of the cells on either side. Discoidal field in Fw with two cells at base, 6 marginal cells. Discoidal field in Hw with 1 cell at base, 11 marginal cells on the left, 12 on the right. Lower sector of arculus in Fw meeting the vertex of the triangle, in Hw joined to the vertex by a short stalk. Cu_1 arising at costal vertex of triangle in Fw, and slightly separated from the vertex, on the distal side, in the Hw. Anal loop 13 cells. Anal area of Hw as far as the cubito-anal cross vein with many non-elongate cells. In Fw 6 Ax, 5 in Hw, 7 Px in all wings.

Abdomen: In lateral view S1-2 expanded dorsoventrally, S4-6 dorso-ventrally flattened with the abdomen narrowing from S3 to a minimum at S5, then widening until the posterior border of S7, again narrowing thereafter. In dorsal view gradually tapering after S2 (Fig. 4a). Black, with heavy pale bluish-grey pruinescence, pale blue in life, developed dorsally on S1-7, and well developed on the underside of the abdomen. Short white hairs covering much of S1-2, the lower part of S3, sparsely present on S4-10, especially along the lateral and ventro-medial carinae. Sternum black. — Accessory genitalia (Figs 5a, 6a, 7a) with anterior lamina strongly projecting, distinctly deeper than long, with only a slight ventral notch seen in profile; ventrally broad with posterior margin deeply and smoothly concave. Base of hamule ventrally strongly convex; inner branch of hamule long, slender and evenly curved toward rounded tip; outer branch of hamule with subapical abrupt expansion, forming a heel shape, thence evenly curved to apex, which does not reach the end of the genital lobe. Genital lobe slightly spatulate, curving gently dorsad towards apex. — Anal appendages as for genus, with superior appendages substantially longer than S9, just shorter than S8.

Measurements [mm]: Hw 20.2, abdomen (excl. appendages) 15.2, superior appendages 1.3. Ratio of Hw length to length abdomen 1.3.

Penis structure

The penis of one of the paratype males was examined (Figs 8a, 9a). Terminal segment barely longer than high at highest point. The dorsal surface of the hood of terminal segment extended above the terminal opening; not truncate. Lateral lobes seen in profile large, upswept and unevenly rounded dorsally, concealing the remainder of

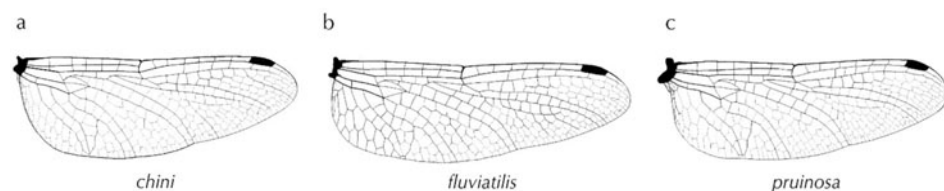


Figure 3: Hindwing of *Chalybeothemis* species — (a) *C. chini*; (b) *C. fluvialis*; (c) *C. pruinosa*.

the distal part of the penis in lateral view. In dorsal aspect the distal part of the penis is elongate, basally narrow, subquadrate in outline, with the lateral lobes obscuring most of the smaller structures.

Variation in paratype males

Discoidal field in Fw with 2 or 3 cells at base, immediately narrowing in the latter case, 6 (occasionally 7) marginal cells. Discoidal field in Hw with 10-13 marginal cells. Lower sector of arcus in both wings sometimes meeting the vertex of the triangle, sometimes joined to the vertex by a short stalk. Anal loop 13-15 cells. In Fw 6-7 Ax, 5 in Hw, 6-7 Px. Pruinescence is almost entirely lacking on the abdomen of one specimen. Hw length 20.0-20.5 mm, abdomen 15.0-15.5 mm, superior appendages 1.1-1.3 mm.

Biological notes

All specimens of this species were collected along the riverbank of the upstream part of the Chini river connecting the Chini lake to the Pahang river. The riverbank was predominantly covered by dense vegetation of *Donax arundastrum*. Males were seen frequently perching at the twigs and leaves of *D. arundastrum*. The depth of the Chini river ranged from 1.5 to 2.8 m. For most of the year, water from Chini lake flew into the Chini river and finally into the Pahang river. However, the reverse direction of water flow was observed in November-December, where water from the Pahang river flew into the Chini river and may reach the Chini lake. The condition of the Chini river was muddy throughout the year. Due to the dense vegetation along the Chini riverbank, a small boat was used to access to the water edge for specimen collection.

Chalybeothemis fluviatilis Lieftinck, 1933

(Figs 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b)

Specimens examined

Specimens from Sarawak: 2 ♂, 10 iii 2006, Binyo Penyilam, Bahagian Bintulu, Sarawak, East Malaysia, leg. RAD, in coll. R.A. Dow. — Other material: all in RMNH. Papered specimens: Kalimantan, Borneo: 3 ♂ Sampit, S Kalimantan, 11 i 1950, 20 i 1950 and 21 vii 1953; 3 ♂ Singkawang, W Kalimantan, 21 iii, 12 viii and 07 ix 1932, leg. L.C. de Ruiter; 2 ♂ Samarinda, E. Kalimantan, iii 1939, leg. M.E. Walsh; 1 ♂ Peniti River, W Kalimantan, 29 vii 1931 (paratype), leg. L.C. de Ruiter. Billiton: 1 ♂ Gantoeng, E Billiton, 07 xi 1935, 3 ♂ Seroe, xi 1936, all leg. F.J. Kuiper. Singapore: 2 ♂ Singapore, 14 ix 1950, leg. M.A. Lieftinck. Peninsular Malaysia: 2 ♂ Tasek Bera, Pahang x 1949, leg. M.W.F. Tweedie. Pinned specimens: Kalimantan, Borneo: 3 ♂, 1 ♀ (allotype), Singkawang, W Kalimantan, 22 ix and 28 xi 1931, 30 ix 1932 and 24 ii 1931 respectively, leg. L.C. de Ruiter; 1 ♂ Samarinda, E Kalimantan, iii 1939, leg. M.E. Walsh. Billiton: 2 ♂, "Tg". Pandam, 1936; 3 ♂, 2 ♀ Seru, W. Billiton, 30 iii 1936, 21 iii and 01 iv 1937 and Aer Madu, C Billiton, 20 iii 1936, all leg. F.J. Kuiper; Tasek Bera, Pahang, Peninsular Malaysia: 1 ♂, 30 vii 1961, leg. H.T. Pagden; 4 ♂, 28-31 iii 1963, leg. M.A. Lieftinck.

Descriptive notes

The specimens from Sarawak reported here are the first collected within the state, although its occurrence there could be predicted with some confidence from its known distribution in west Kalimantan and Brunei. The specimens from Sarawak agree very well with the original description of the species, except that Lieftinck (1933a) described the wings as “hyaline, with the distal two-thirds faintly suffused with greyish yellow”, one of the two specimens from Sarawak has no such colouration on the wings. The eyes are green in life. The labium is marked differently from that of either of the other species (Fig. 1b). The poststernum is a different shape from either of the other species (Fig. 2b), with the posterior margin indented so that the overall shape is hexagonal rather than pentagonal. To Lieftinck’s description of the accessory genitalia (Figs 5b, 6b, 7b) we can add that the anterior edge of the anterior lamina is deeply concave centrally, as is the case in specimens from Brunei in coll. Orr. The posterior margin in ventral view is an open ‘V’ shape (Fig. 7b). The base of the hamule is straight ventrally, the inner branch is stouter and shorter than the other two species, terminating a sharp point, the outer branch bears on its ventral margin a short subapical acuminate process, and at its apex does not quite reach the tip of the genital lobe. Genital lobe rather long, broad, subquadrate terminally.

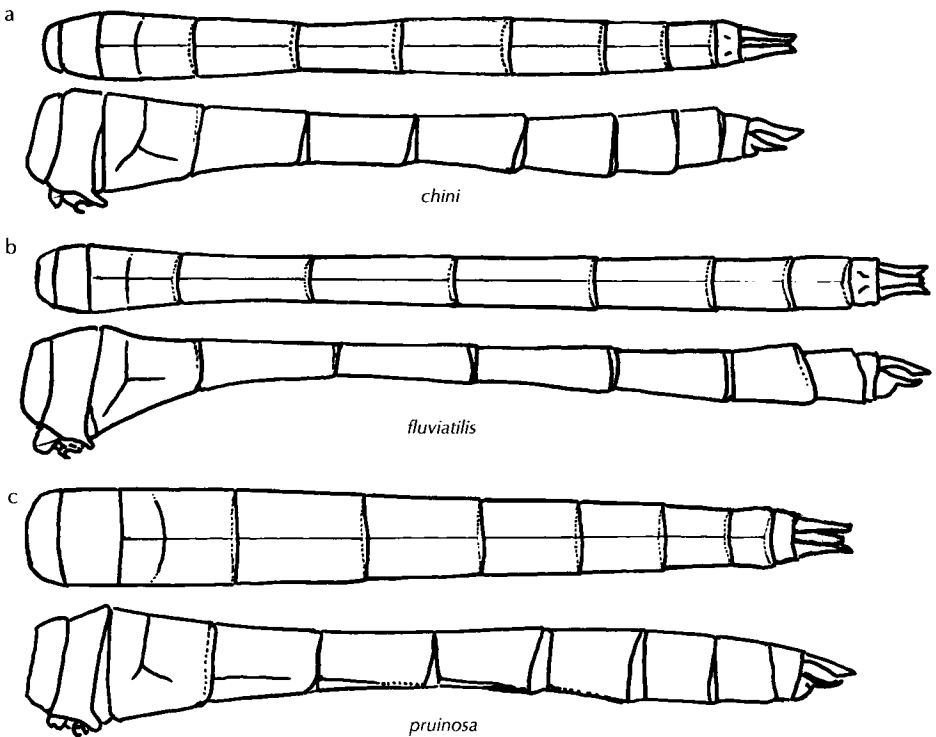


Figure 4: Abdomen of *Chalybeothemis* species, dorsal (above) and lateral (below) view — (a) *C. chini*; (b) *C. fluviatilis*; (c) *C. pruinosa*.

Penis as shown in Figures 8b, 9b. The terminal segment is ca 1.5 times as long as it is high at its highest point. The dorsal side of the hood has only a short narrow ridge, but is briefly continued roof-like over the terminal opening. The lateral lobes are less well developed than in *C. chini* or *C. pruinosa*, not concealing the rest of the distal part of the penis in lateral or dorsal view. In lateral view the presumed medial process terminates in a ventrally directed rounded hooked process. In ventral view the distal part of this is just visible as a small, broad triangular process terminating in a narrow, rounded knob.

The specimens from Sarawak were collected at the edge of a small blackwater lagoon, in an apparently natural open marsh, unusual in Sarawak, within a large secondary peat swamp forest. This was very like the usual habitat of the species in Brunei (Orr 2001).

The other specimens were examined for variation beyond that in the original description, and to check that they did in fact all represent *C. fluviatilis*. Little variation was noted.

Chalybeothemis pruinosa sp. nov.
(Figs 1c, 2c, 3c, 4c, 5c, 6c, 7c, 8c, 9c)

Etymology

Latin adjective *pruinosa*, meaning covered in frost. Named for the extensive pruinescence that develops on the male.

Specimens examined

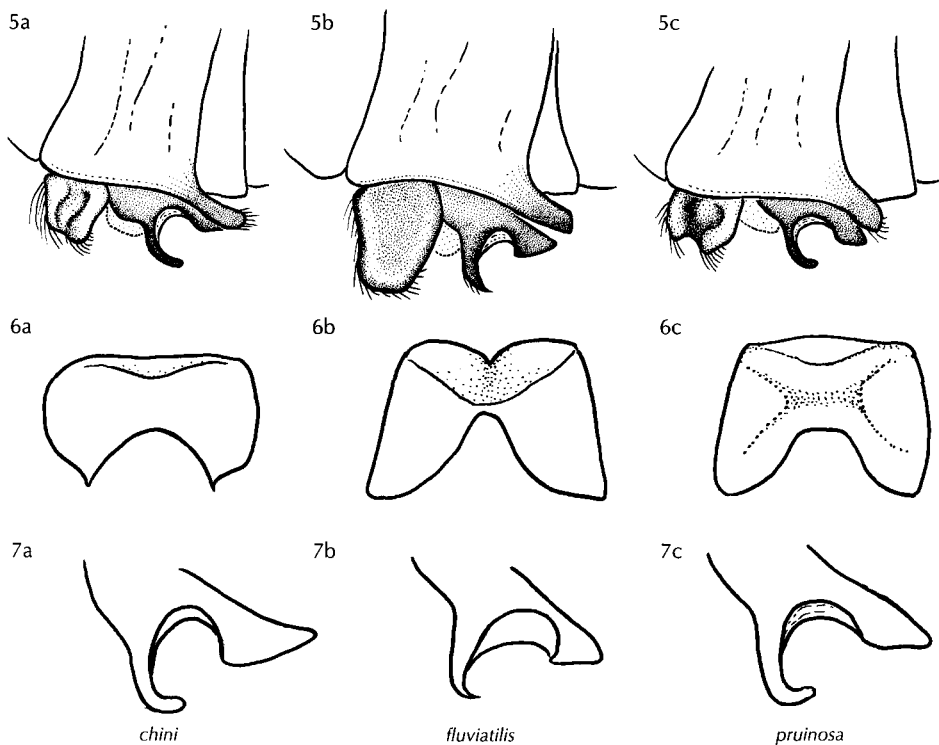
Holotype: ♂, Loagan Bunut, Loagan Bunut National Park, Bahagian Miri, Sarawak, East Malaysia, 07 iv 2006, leg. RAD. Paratypes: 1 ♂, location and date as holotype, leg. RAD; 2 ♂, location and date as holotype, leg. G.T. Reels; 1 teneral ♂, canteen lights at dusk, Loagan Bunut National Park, 03 iv 2006, leg. RAD. Holotype to be deposited in the British Museum (Natural History), paratypes in coll. R.A. Dow, coll. A.G. Orr and the RMNH. Female unknown.

Description of holotype male

Rather similar to *C. chini* sp. nov., but generally heavier in build, with further differences noted below and in Table 1.

Head: Labium (Fig. 1c) with more extensive pale colouration than in *chini*; about the central ½ of the prementum and about the inner ¼ of the palps black, the area of this colour narrowing towards the ends, remainder pale cream yellow. Labrum, clypeus pale cream yellow. Genae largely obscured, pale anteriorly. Lower part of the anterior surface of the frons pale cream yellow, remainder dark metallic blue-green; the boundary between dark and light colouration irregular, with the pale colour narrowest centrally. Upper surface of the frons with a moderately deep median depression. Vertex with two small anterior protuberances, on either side of the frontal concavity; vertex dark metallic green. Occiput as for genus. Antennae black. Eye colour in life not recorded.

Thorax: Broader than in *chini*. Prothorax dull black, large posterior lobe with erect fringe of long hairs. Synthorax dull black with faint greenish metallic reflections in places. Largely covered by thin, pale-blue pruinescence; pruinescence absent on a wide band starting on the mesepimeron just above the interpleural suture and running diagonally upwards onto the mesepisternum, terminating just before the mid-dorsal carina. Synthorax ventrally dull black with a thick covering of white hairs, poststernum pentagonal, relatively shorter than in *chini* (Fig. 2c), its posterior part pale. Legs black with pruinescence on coxae, trochanters and the upper parts of the flexor surfaces of the femora. Legs relatively not quite as long as in *C. fluviatilis*, the anterior femora extending just to the posterior border of S2. — Fw triangle crossed on the right, uncrossed on the left. Discoidal field in Fw with 3 cells at base, 6 marginal cells, in Hw with 12 marginal cells. Lower sector of arculus joined to vertex of triangle by a short stalk in all wings. Anal loop 18 cells on the right, 16 on the left. 6 Ax in Fw, 5 in Hw, 7 Px in all wings. Base of Hw relatively slightly narrower with margin of anal area more convex (Fig. 3c) than in *chini*. Marginal neuration in all fields slightly denser than in *chini*.



Figures 5-7: Male characters of *Chalybeothemis* species in comparison — (5) accessory genitalia, lateral view; — (6) hamule, lateral view; (7) anterior lamina, ventral view; — (a) *C. chini*; (b) *C. fluviatilis*; (c) *C. pruinosa*.

Abdomen: More robustly built than in *chini*, otherwise very similar than to that species in lateral view, with S1-2 expanded dorsoventrally, S4-6 dorso-ventrally flattened with the abdomen narrowing from S3 to a minimum at S5, then widening until the posterior border of S7, again narrowing thereafter. In dorsal view quite broad, of almost even width, until S8, where it narrows slightly. S9 and S10 are both slightly expanded (Fig. 4c). Pale bluish-grey pruinescence, pale blue in life, developed dorsally on S1-7, extending sparsely below the lateral carina on the middle segments; possibly more extensive in life. Short white hairs covering much of S1-2, the lower part of S3, sparsely present on S4-10, especially along the lateral and ventro-medial carinae. Sternum black, with obscure brown and brownish red markings and most ventral parts of tergum around the borders between segments, remainder of tergum black where not covered by pruinescence. — Accessory genitalia (Figs. 5c, 6c, 7c): anterior lamina somewhat projecting and hood-like, about as deep as long, with distinct median notch in lateral view, its body bilaterally pinched inward towards this notch, the contraction best seen in ventral view; posterior margin an expanded U shape (Fig. 7c). Base of hamule ventrally slightly convex; inner branch of hamule elongate, uniformly slender and curving abruptly near its apex, which is rounded; outer branch of hamule elongate, slightly acuminate and directed posteriorly, evenly curved on its lower edge with a subapical swelling (Fig. 6c); apex nearly reaching the tip of the genital lobe. Genital lobe straight, tapering and smoothly rounded terminally. — Anal appendages with superior shorter than S8, just longer than S9. **Measurements [mm]:** Hw 22.5, abdomen (excl. appendages) 16.5, superior appendages 1.3. Ratio of Hw length to length of abdomen 1.4.

Penis structure

The penis of one of the paratype males was examined (Figs 8c, 9c). Terminal segment relatively longer than in *C. chini*, ca twice as long as high at highest point. Dorsal surface of hood with a well developed median ridge sharply truncated distally. Lateral lobes in lateral view similar to *C. chini*, but more evenly rounded and narrower.

Variation in paratype males

Fw triangles crossed or uncrossed. Discoidal field in Fw with 2-3 cells at base, 6-7 marginal cells. Discoidal field in Hw with 1 cell at base, 9-13 marginal cells (10 in one wing of one specimen). Anal loop 14-18 cells, 6-7 Px. Lower sector of arculus in both wings sometimes meeting the vertex of the triangle, sometimes joined to the vertex by a short stalk. Hw 22.0-22.5 mm, abdomen 15.5-16.5 mm.

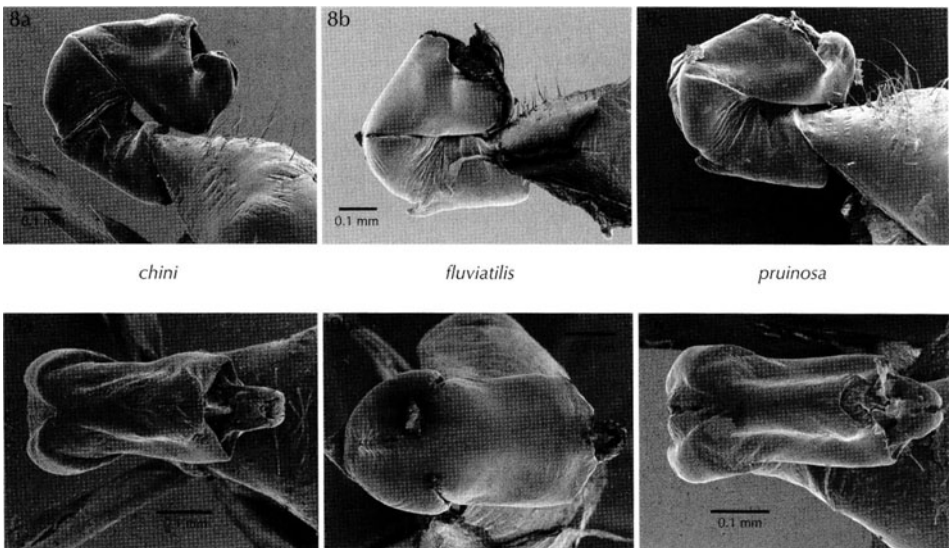
Biological notes

All the specimens of this species were collected along a broad channel on the edge of Loagan Bunut, the largest natural lake in Sarawak. The location was only accessible by boat at the time of collecting. Males were present at low densities on the semi-submerged vegetation (predominantly a species of *Donax*) lining the channel, which led to the Sg. Bunut. The water levels at Loagan Bunut fluctuated annually, they were high at the time of collection; it is likely that at times when the water levels are lower that the channel has distinct banks at the points where the species was collected. No possible females of this species were seen.

Table 1. Diagnostic differences between the three *Chalybeothemis* species, males only.

Character	<i>C. chini</i>	<i>C. fluvitailis</i>	<i>C. pruinosa</i>
Labium – extent of yellow colouration on prementum (Fig. 1)	Outer 1/7	Entirely black	Outer 1/4
Labium – extent of yellow colouration on palps	Outer 2/3	Outer 3/4 - 2/3	Outer 3/4
Colour of labrum	Yellow	Black	Yellow
Anterior surface of frons	Lower part non-metallic yellow	Entirely metallic	Lower part non-metallic yellow
Well defined anterior swellings on either side of the central concavity on vertex present or not	Present	Not present	Present
Pterostigma	Dark brown-black	Light sepia brown	Dark brown-black
Anal area of Hw proximal to cubito-anal cross vein	Many small, non-elongate cells	No more than 2-3 non-elongate cells	Many small, non-elongate cells
Hw length	Hw 20.0-20.5 mm	Hw 20.0-22.0 mm	Hw 22.0-22.5 mm
Hw length relative to abdomen (excl.) appendages	Hw markedly longer (29-33% longer)	Hw only slightly longer (nearly always < 20% longer)	Hw markedly longer (36-42% longer)
Extent of pruinescence in mature males	Extensive	Little to none	Extensive
Posterior margin of anterior lamina in ventral view (Fig. 7)	Deeply and smoothly concave	Open 'V' shape	Open 'U' shape
Inner branch of hamule (Figs 5 and 6)	Thin and evenly curved to a rounded apex	Robust and sharply acuminate	Elongate, thin and curving abruptly near its rounded apex
Outer branch of hamule (Figs 5 and 6)	Relatively long, lower edge abruptly expanded, then evenly curved, forming a distinct heel shape	Relatively short, with sharp subapical process on ventral margin	Relatively long, slightly acuminate lower edge evenly curved with a sub apical swelling
Proportions of terminal segment of penis (Fig. 8)	Barely longer than high at highest point	ca 1.5 times as long as high at highest point	ca 2 times as long as high at highest point
Dorsal surface of hood of terminal segment of penis (Fig. 9)	With a broad longitudinal ridge, and produced into a roof-like structure above the opening	Without ridge, and produced into a roof-like structure above the opening	With a broad longitudinal ridge, not produced into a roof-like structure above the opening

Character	<i>C. chini</i>	<i>C. fluvitailis</i>	<i>C. pruinosa</i>
Degree of dorso-ventral expansion of S1-3	Moderate	Strong	Moderate
Shape of abdomen	Less robust, gradually tapering	Slender from S3, not dorso-ventrally flattened	Robust from S3, of nearly even width from S3-S7, dorso-ventrally flattened at S4-S6
Length of superior appendages	Just shorter than S8, significantly longer than S9	Much shorter than S8, slightly shorter than S9	Shorter than S8, just longer than S9



Figures 8, 9: Penis characters of *Chalybeothemis* species — (8) penis, lateral view; (9) penis, ventral view of terminal segment, *fluvitailis* with segments 3 and 4 (terminal), just showing the projecting apical process; — (a) *C. chini*; (b) *C. fluvitailis*; (c) *C. pruinosa*.

DISCUSSION

When he erected *Chalybeothemis* for *C. fluviatilis*, Lieftinck (1933a) expressed some uncertainty about the placement of the genus, noting that it appeared closely related to *Brachydiplax*, *Raphismia* and *Tyriobapta* but that “the shape of the abdomen and the very characteristic distal course of the veins M_2 , Rs and the evenly curved Rspl in both pairs of wings point to real affinities with the Sympetrini, more especially with the genus *Acisoma* which is less specialised than *Diplacodes* and its immediate allies” and “It is characterised by ... some striking Sympetrine characters, among which the insect’s outward appearance and the genital apparatus of the male are the most obvious facts.”

The new species described here, and the SEM images of the penes of all known species of *Chalybeothemis*, do not immediately shed much new light on the relationships of the genus. The venational features used by Lieftinck are of doubtful value by themselves in placing the genus, as is “the insect’s outward appearance”. There is little difference in the shape of Rspl in the wings of *Chalybeothemis* species from that of the three *Tyriobapta* species, or from that of *Brachydiplax*. The course of veins M_2 and Rs is only slightly different from that in *Brachydiplax*; these veins are more strongly curved than in *Brachydiplax*, but less so than in *Acisoma*.

With regard to the supposedly sympetrine nature of the males’ genital apparatus, we note the great similarity of the external parts of the accessory genitalia of *Chalybeothemis* to, for instance, that of *Diplacina paula* Ris, 1919, as illustrated by Lieftinck (1933b: 44, fig. 26); by similar reasoning to Lieftinck’s we could just as well argue that the males accessory genitalia of *Chalybeothemis* are libelluline in nature.

RAD has examined the penes of the following species under a stereomicroscope: *Acisoma panorpoides* Rambur, 1842, *Brachydiplax chalybea* Brauer, 1868, *B. farinosa* Krüger, 1902, *Diplacodes trivialis* (Rambur, 1842), *Tyriobapta kuekenthali* (Karsch, 1900), *T. laidlawi* Ris, 1919 and *T. torrida* Kirby, 1889. The penis of *Chalybeothemis* is at least superficially similar in its coarse structure and proportions to that of *Acisoma*, *Diplacodes* and *Tyriobapta*, but differs markedly from *Brachydiplax*, where the terminal segment of the penis is shorter than the second segment (shaft), whereas in *Chalybeothemis* and species of the other mentioned genera examined the terminal segment is longer than the second segment. The second and third segments of the penis of *Tyriobapta* species appear to be fused or nearly so, in contrast with *Chalybeothemis* where the two segments are clearly distinct. Miller (1991) concluded that the structure of libellulid genitalia provides a poor guide to phylogenetic relationships, a conclusion that seems to hold true in the present case.

It appears difficult to come to a firm conclusion as to the placement of *Chalybeothemis* within the Libellulidae in the context of the current subfamily classification, but on balance it appears best to retain it for the time being in the Brachydiplacinae, between *Brachydiplax* and *Tyriobapta*, as Lieftinck did. There is little support for the Brachydiplacinae and a number of other libellulid subfamilies; our placement of *Chalybeothemis* here is to be regarded as a temporary measure until a wide ranging revision of the libellulid subfamilies is carried out. *Chalybeothemis* is clearly separated from *Tyriobapta* on features of wing venation, in particular the closed anal loop, lower numbers antenodal and postnodal crossveins and the lack of supplementary crossveins basal to the bridge, as well as having segments two and three of the penis clearly unfused. It differs from *Brachydiplax* in penis structure and in having only five antenodal crossveins in the hindwing.

The two newly described species appear to be more closely related to each other than to *C. fluviatilis*, sharing far more characters with each other than they do with *C. fluviatilis* (see Table 1). In particular the colouration of the head, anal area of the hindwing, extensive pruinescence, shape of the abdomen, shape and length of the outer branch of the hamule, structure of the penis and the length of the hindwing relative to the abdomen all point to a closer relationship between *C. chini* and *C. pruinosa* than between either one of them and *C. fluviatilis*. However the penis of *C. chini* is rather intermediate between *C. fluviatilis* and *C. pruinosa* in its proportions, and the dorsal surface of the hood above the terminal opening is similar to that of *C. fluviatilis*, but is otherwise more similar to *C. pruinosa*. The males of *C. chini* and *C. pruinosa* are easily separated from that of *C. fluviatilis* by their general appearance, yellow labrum and penis structure. Separation of males of *C. chini* and *C. pruinosa* is more difficult but *C. pruinosa* is altogether a more robust insect. Otherwise, the best distinguishing characters appear to be penis structure and length of the superior appendages relative to S9. However the extent of the yellow on the labium may also prove to be a useful character, once sufficient material becomes known to determine the extent of its variability.

It is slightly surprising that the species described here have remained undetected until now, but they are clearly very local in occurrence; the fact that both known sites are only accessible by boat may also account for their elusiveness. The known habitat of *C. pruinosa* is scarce in Sarawak. Loagan Bunut is largely surrounded by peatswamp and alluvial forest, a factor that might be important for this species. The habitat of *C. chini* in Pahang appears to be very similar, even in terms of the genus of the dominant plant species, *Donax*. Both *C. chini* and *C. pruinosa* appear to be specialist species of lake margins and relatively deep water channels, and should be sought for in such habitats in Borneo, west Malaysia and adjacent areas. Orr (2001) recorded *C. fluviatilis* in similar habitat at Luagan Lalak in Brunei. In Sarawak there are ox-bow lakes in the vicinity of Marudi north-west of Loagan Bunut, and lakes (as yet inaccessible) within peatswamp forest at Binyo Penyilam in Bintulu Division; *C. pruinosa* should be sought for at these and other similar locations in the state. The identity of *Chalybeothemis* specimens from Thailand should be checked to determine whether they are in fact *C. fluviatilis*, or are one of the species described here, or even a fourth species.

ACKNOWLEDGEMENTS

RAD would like to thank Graham Reels for much assistance in the field; the staff of Loagan Bunut National Park for assistance in the field, with accommodation and transport; the Sarawak Forestry Corporation and Sarawak Forestry Department for granting permission to collect in Sarawak; and Vincent Kalkman, Jan van Tol and Caroline Pepermans for assistance at the RMNH. He would also like to thank Luke Southwell and John Barraha for assistance with transport to Loagan Bunut. His part in the writing of this paper was partially supported by the European Commission's SYNTHESYS Program (reference NL-TAF-3498). CYC would like to thank Mohamed Effendi Hj Taip, the supporting staff of School of Environmental and Natural Resource Sciences, who assisted in collecting specimens. We all owe a debt of gratitude to Dirk Gassmann, for making the SEM images, and to the RMNH for allowing the use of their SEM for this purpose.

REFERENCES

- Lieftinck, M.A., 1933a. A new genus and species of Libellulinae from western Borneo (Odonata). *Sarawak Museum Journal* 4: 131-137, pls 13-15.
- Lieftinck, M.A., 1933b. The dragonflies (Odonata) of New Guinea and neighbouring islands. Part II. Descriptions of a new genus and species of Platycneminae (Agrionidae) and of new Libellulidae. *Nova Guinea* 17 (1): 1-66, figs 1-35.
- Lieftinck, M.A., 1936. Zeldzame Libellulidae van het eiland Billiton. *Entomologische Mededeelingen van Nederlandsch-Indië* 2: 4.
- Lieftinck, M.A., 1953. New dragonflies (Odonata) from Borneo, with notes on their habits and larvae. *Treubia* 22: 381-406.
- Lieftinck, M.A., 1954. Handlist of Malaysian Odonata. A catalogue of the dragonflies of the Malay Peninsula, Sumatra, Java and Borneo, including the adjacent small islands. *Treubia (Suppl.)* 22: i-xiii, 1-202.
- Miller, P.L., 1991. The structure and function of the genitalia in the Libellulidae (Odonata). *Zoological Journal of the Linnaean Society* 102: 43-73.
- Orr, A.G., 2001. An annotated checklist of the Odonata of Brunei with ecological notes and descriptions of hitherto unknown males and larvae. *International Journal of Odonatology* 4: 167-220.
- Watson, J.A.L. & A.F. O'Farrell, 1991. Odonata (dragonflies and damselflies). In: Naumann, I.D., P.B. Carne, J.F. Lawrence, E.S. Nielsen, J.P. Spradbery, R.W. Taylor, M.J. Whitten & M.J. Littlejohn (eds) "The insects of Australia", 2nd edition, Melbourne University Press, Melbourne, pp. 294-310.
- Pinratana, A., 2003. Editorial. *Malangpo* 20: 195.