ON THE TRUE POSITION OF THE GENUS *OROLESTES* McLACH., with notes on *O. wallacei* (Kirby), its habits and life-history (Odon., Lestid.).

By

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The main purpose of this paper is to give a description of the hitherto unknown larva of *Orolestes*, and to prove that the genus should be considered a true member of the family *Lestidae*, a conclusion arrived at from a study of the larva, or nymph. This paper embodies also the results of some observations on the synonymy and geographical distribution of *Orolestes wallacei* in Malaysia, preceded by a description of the living insect and followed by notes on its habits and dwelling-places.

So far as the habits and life-history of *Orolestes wallacei* are concerned, my observations were carried out only during a few morning-hours of two successive days. Hence many points of dispute, more specifically those relative to the development and hatching of the egg, and the duration of larval life, are still unknown and can only be cleared up by spending a great deal of time in careful observation. I have therefore merely attempted to put down accurately the few observations I made, and to draw the correct conclusions from them.

Orolestes wallacei (Kirby).

1889. Kirby, P. Z. S. London, p. 302 - 303. — ♀ Borneo, Sarawak (*Lestes*).
1890. Kirby, Cat. Odon. p. 162 (*Lestes*).
1898. Krüger, Stett. Ent. Ztg. 59, p. 127 - 130. — ♂ N. E. Sumatra (*O. udeana*).
1902. Laidlaw, P. Z. S. London, p. 92. — ♂ def. Malaya (*Lestes ridleyi*).
1920. Laidlaw, P. Z. S. London, p. 341. — ♂ def. Borneo, Sarawak (*Lestes* spec.).
1920. Laidlaw, Rec. Ind. Mus. 19, p. 149 fig. 1 (♂ wings). — ♂ Borneo, Sarawak (*Lestes* spec.).
1927. Ris. Zoöl. Meded. Leiden, 10, p. 11 - 15, comp. notes, fig. 4 (♀ wings), 5 (♂ apps.), 6 (♀ valves). — ♂♀ C. Sumatra (*O. udeana*).
1928. Laidlaw, P. Z. S. London, p. 134 - 135 (incl. key), 138 (note). — ♂ Malaya and Borneo, notes.
1931. Laidlaw, J. Fed. Mal. States Mus. 16, p. 184 (♀), 246 (♂). — ♀ Pahang, Malaya, ♂ N. Borneo.
1933. Fraser, Rec. Ind. Mus. 35, p. 176 (key, *wallacei* + *udeana*), 177 - 178 fig. 1D (penis), 2 (♂ apps.), pl. 4 fig. 1 (♂ wings ? Borneo). — Sumatra (non vidi), Sarawak and Brit. N. Borneo (*O. wallacei* + *udeana*).
1935. Lieftinck, Misc. Zool. Sum. 92 - 93, p. 5 - 6 (note on synonymy). — Perak, Malaya, and S. Sumatra.

Material studied: 49 ♂, 12 ♀. — MALAY PENINSULA. 1 ♂ (semiad.), Perak, Kwala Kangsar, ROLLE vdt., "*Lestes magnus* Foerster, *Udeanus* Krüger Rasse *magnus* ♂ Type" (in FÖRSTER's hand), Mus. Ann. Arbor. — 3 ♂, 2 ♀ (ad.), Perak, Kwala Kangsar, B. JACHAN vend., Mus. Hamburg and author's collection.

BILLITON I. 13 ♂, 4 ♀ (ad.), Tandjong Pandan, 1.IX - 6.X.1936, 18.I.1937; 1 ♂, Banten, 21.VIII.1936; all F. J. KUIPER, Mus. Buitenzorg.

SUMATRA. Eastcoast Gvt.: 1 ♂ (ad.), Serdang, Tandjong Morawa, Dr. B. HAGEN, Mus. Leiden; 1 ♂ (ad.), id., Deli, Saentis Estate, 10.X.1936, L. J. TOXOPEUS, Mus. Buitenzorg. — Lampoeng Res.: 2 ♂ (ad.), Mt. Tanggamoes, Gisting, 500 m, 26.IX.1933 and 28.XII.1934, L. J. TOXOPEUS & AUTHOR, Mus. Buitenzorg.

JAVA (West). Buitenzorg Res.: 9 ♂, 5 ♀ (ad.), Oedjoeng Genteng (south-coast), 27 - 29.III.1937, AUTHOR, Mus. Buitenzorg. — Priangan Res.: 14 ♂, 1 ♀ (ad.), Tjidamar (south-coast), Tjisindang and Tjidaoen near Sempoertjondong, 23.X and 5 - 8.XI.1935, M. BARTELS, Mus. Buitenzorg.

BORNEO. 1 ♂ (ad.), Sarawak, Mt. Mulud, coll. SHARPE, acq. 1903, Mus. Leiden. — 3 ♂ (ad.), E. Borneo, Sangkoelirang, Kariorang, V-VI.1937, M. E. WALSH, Mus. Buitenzorg.

All specimens of *Orolestes wallacei* in Museum-collections are entirely discoloured; and since the available colour-descriptions in the literature have been made from slightly immature specimens or from those in which the dark colouring of the body is doubtless due to the effects of decomposition, it seems worth while to give a description of the living insect.

Additional description of the full-coloured imago.

Male (ad., Java, Sumatra, Billiton). — Labium yellow, rear of the head pale yellowish-green. Genae, mandible-bases, anteclypeus and labrum throughout bright greenish-blue, the labrum usually clear blue. Remaining parts of the head dull bronzy blackish-brown with metallic-green reflections on the vertex. A light brown spot in the depression just anterior to the median ocellus and two similar spots, one on each side of the lateral ocelli. Postoccipital lobes mottled with brown and yellow, fading to yellow rearwards. Antennae dark brown. Eyes olive-green intermingled with blue dorsally, shading to pale yellowish-green ventrally.

Prothorax greenish-yellow with bronzy-brown dorsal marks.

Synthorax with the dark areas dull bronzy-brown (adulti), or metallic-green with bronzy reflections (semiadulti). A narrow, dull olive-green stripe over the mid-dorsal carina and complete juxta-humeral stripes of the same colour. These shoulder-stripes are twice broader than the mid-dorsal stripe and are widest ventrally. Metepisternum and lower portion of mesinfraepisternites vivid bluish-green; most of the metepimerum and metinfraepisternites light green turning to greenish-yellow ventrally; beneath yellow.

Coxae greenish-yellow. Legs pale brown, flexor surfaces and apices of all femora ill-defined blackish-brown.

Abdomen dark blackish-brown or black with slight bronzy reflections. Segm. 2 - 4 and occasionally 5 with a fine mid-dorsal longitudinal yellow line (incomplete on both ends of the segment). Sides of 1 - 2, narrow basal rings of 3 - 7 (usually incomplete above on 5 - 7), and lower tergal margins of 3 - 7 bright bluish-green. Segm. 8, 9 and 10, with the exception of a very narrow line bordering the posterior margin of 8 - 10 and the lower margin of 9, throughout bright azure blue.

Anal appendages black. Superior pair shaped as described and figured by KRÜGER and RIS. Inferior appendages distinctly shorter than half the length of the superiors, either closely apposed or well-separated (*cf.* RIS, loc. cit. fig. 5; in the topotypical example from N.E. Sumatra of *"udeana"*, the inferior appendages are apposed!).

Wings either entirely hyaline, or with the apices, from the middle of the pterostigma outwards, very palely enfumed (semiadulti and part of the adulti); in old males the entire wing-membrane has a yellowish- or rather more greyish-brown tinge, very similar in appearance to the wings of old females of *Gynacantha*. Pterostigma dark reddish-brown, covering 3 to 5½ cells, braced. Number of postnodal cross-veins very variable: $\frac{18-24}{16-24}$ (Java), $\frac{16-19}{14-18}$ (Billiton), $\frac{17-20}{13-17}$ (Sumatra), $\frac{18-21}{16-20}$ (Borneo). A very excellent photograph of the wings of *O. wallacei* has been published by FRASER (*loc. cit.*).

F e m a l e (ad., Java, Billiton). — Under surfaces of head as in the male. Mouth-parts green instead of blue. Remaining parts of the head reddish- to dark-brown with a metallic-green trapezoidal spot on the vertex, sometimes obliterated so as to form three more or less separate spots, and with a dark metallic-green area on each side of the antennae bordering the eye-margin. Antennae with the two basal joints light brown, apex of second joint and flagellum blackish.

Prothorax yellowish, dorsum indistinctly spotted with brown.

Synthorax as in the male but all blue colours replaced by a soft light green, sometimes with very slight bluish intermingling on the metepisternites. Legs and wings as in the opposite sex.

Abdomen short and robust, apical segments considerably widened in both dimensions. Dorsum warm reddish-brown, progressively darker from before backwards and each segment growing darker from base to apex, with blackish-brown intersegmental rings. Pale median longitudinal line distinct on segm. 2 - 4. Basal rings light green dorsally, prolonged laterad into greenish-yellow stripes, which are much broader than in the male, occupying most of the sides of segm. 3 - 6 or 7. Segm. 8 and 9 each with a very large, bright blue-green side-spot, rounded dorsally; 8 in addition with a narrow, azure-blue mid-dorsal line, and 9 with a similar though much wider longitudinal oval azure-blue spot, pointed on both ends. Segm. 10 blackish-brown with a squarish side-spot of blue.

Anal appendages brown, very slender and pointed, apices with 2 or 3 fine dorsal denticles. Valves black save for a large bluish-green basal spot; armature

of lower margin as described by RIS (*loc. cit.* fig. 6); number of spines variable, usually 3 strong, slightly recurved spines in addition to the apical hook but occasionally there are only 2 of such spines, and in a few females there are, in addition, 2 - 4 much smaller spinules, decreasing in size and placed more basad.

Measurements.

The measurements given in the literature are as follows:

♂ abd. + app. 47, hw. 30, pt. 2.5 mm. (RIS, C. Sumatra).
— — — 48, — 28, — — — (FRASER, Borneo).
— — — 42, — 28, — 2.25 - 2.50 mm. (KRÜGER, N.E. Sumatra).
— — (excl. app.) 48, hw. 31, pt. 2.75 - 3 mm. (LAIDLAW, Malaya).
♀ long. corp. 46, exp. al. 55, pt. 2.5 mm. (KIRBY, holotype Borneo).
— abd. (incl. apps?) 43, hw. 32, pt. 2.5 mm. (RIS, C. Sumatra).

In our material the measurements are as follows:

Length: ♂ abd. + app. 50, hw. 30.5, pt. fw. 2.8 mm. (Malaya).
— — — — 45.5 - 51, hw. 31.5 - 32, pt. fw. 3 mm. (Sumatra).
— — — — 47 - 51, — 30 - 31, — — 2.9 - 3.0 mm. (Borneo).
— — — — 43 - 52, — 29 - 32, — — 2.6 - 3.1 — (Billiton).
— — — — 46 - 54, — 31.5 - 34.5, — — 3.0 - 3.4 — (Java).

Long-bodied males with relatively long wings occur together with short-bodied specimens in which the wings are comparatively less shortened, *e.g.* 54, 34, 3.3 mm, and 49.5, 33, 3.5 mm (S. Javan examples).

Length: ♀ abd. + app. 38 - 42, hw. 27 - 30, pt. fw. 2.6 - 2.8 mm. (Billiton).
— — — — 43 - 45, — 31 - 34, — — 3.0 - 3.2 — (Java).

As has been emphasized by me on a previous occasion (LIEFTINCK, *loc. cit.* 1935), and as may appear more obviously from the above descriptions, there remains but little doubt that the examples of *Orolestes* from Sumatra, and of the Malay Peninsula and Billiton as well, are all conspecific with *O. wallacei*. This species was described as a *Lestes* in the first instance. The original description of KIRBY is very poor and by the absence of a male KRÜGER was well justified to describe the specimens from Sumatra as a new species, *viz. Lestes udeana*, KRÜGER.

An examination of the wing-venation of a great number of individuals from various islands makes it evident that *O. udeana* is not a distinct species and can be referred without any difficulties to *wallacei*. The points of distinction between the wing-venation of Sumatran *udeana* and that of an example from Borneo, of which LAIDLAW has published a photograph, are of no specific value since there is a great deal of variability in the neural characters of this species (*cf.* RIS, *loc. cit.*). The number of postnodal cross-nerves for instance, varies considerably, and it has been found that small winged specimens do not necessarily have few cross-nerves, and *vice versa*. Even the ratios between the length and breadth of the wing, the antenodal and postnodal parts of the wing, the

size of the pterostigma and the wing-length, and the length of the costal side of the quadrangle are by no means the same in a series of specimens from one locality [1]).

Geographical distribution.

This species was known only from the Malay Peninsula, Sumatra and Borneo. Its recorded range now includes also the islands of Billiton and Java.

In Mr. J. COWLEY's collection are a few specimens of an *Orolestes* from Formosa, of which I have been able to examine one male. It is possible that this species may ultimately require a distinct specific name to hold it, for although it is very similar to *wallacei*, it differs in a few respects.

Notes on the life-history of *Orolestes wallacei*.

Orolestes wallacei was first discovered in Java in October and November, 1935, by Dr. MAX BARTELS, who sent me a small series collected by him on a forest-pool near Tjidaoen, in the wooded coastal district of Tjidamar, South-Java.

I had of course kept a sharp look-out for this species in all our ephemeral collecting-expeditions round Buitenzorg; but it was not until March 26, 1937, that we left Buitenzorg for a three days' Easter-holiday trip to the coastal forests round the Oedjoeng Genteng Bay, situated some 100 kilometres (about 62 miles) as the crow flies south of Buitenzorg and 120 km (74 miles) to the west of the original locality near Tjidaoen, where *O. wallacei* was first discovered.

The weather-conditions were excellent; there had been no rain for about ten days and every morning we enjoyed bright sunshine and a fresh sea-breeze. We were staying at the government rest-house Oedjoeng Genteng, lying immediately behind the beach on a small peninsula, just on the east side of the picturesque landing-stage or pier which is conspicuous in the miniature harbour. Close to the rest-house a deep clearing has been made in the scrub-jungle that extends westwards as a fringe along the coast; from near the harbour directly to the extensive coco-nut plantation about 6 km away from Genteng. During the greater part of the year the narrow gauge lorry-track, for which this clearing has been originally made, is in use for the transport of copra to the harbour. Following this track further inland, one finally reaches the factory-site of Tjitespong Estate.

The first morning of our stay, on March 27, we took a short drive following this clearing in search of good collecting-places. After about 2 miles we discovered and explored thoroughly a number of open sunny pools, some of these boggy, and all fringed with low bushes, reeds and cat's tails. All around the largest of these pools was a dense mass of ferns and shrubbery growing on hard coral-

[1]) A similar considerable variation in size and neuration has been observed by CALVERT and GARMAN in the allied nearctic genus *Archilestes* (Cf. GARMAN, Ent. News, Philad., 43, 1932, p. 85 - 92, figs.).

rock. Although dragonfly-life was abundant and of considerable interest here [1]), after some very hot and trying hours, we stopped collecting, and went home, intending to explore the forest another day. Shortly before leaving, however, I lingered for a while round a boggy pool under the bushes and quite suddenly there flew out from the tangled mass of twigs a large zygopteron; this was secured and proved to be a fine male of *Orolestes wallacei*. No other specimens were seen.

The next morning we set about finding the breeding-places of *Orolestes* and of other species of interest. At about 10 *a.m.*, we penetrated the wood in a place along the path some hundred yards or more back, and entering by a narrow pathway used by native woodsmen, we were soon in the twilight of the scrub.

Owing to the hard calcareous substance of the ground, the coastal stretch of forest which we were about to investigate was devoid of the enormous trees and the rich undergrowth usually found in the jungle. Many huge *Pandanus*-rozettes sent their ribbon-like and prickly leaves in all directions to the ground; but otherwise there were mainly tall trees, thorny palms and lianas, entangled together here and there above one's head in thick masses so as to produce deeply shadowed areas in the thin forest. The soil-surface was flat and consisted of black muddy earth through which a tiny trickling brook found its way to a shallow, leaf-bottomed pool. Ranging further afield we discovered several other pools similar to the last, but with clear stagnant water, often well concealed by overhanging bushes. Some of them were little better than dried up puddles, and the largest was about 6 metres long with a maximum depth of about 2 feet.

All these pools were simply alive with tadpoles of perhaps two species of *Rhacophorus* whose frothy egg-balls, or properly the remnants of these, were noticed several times among the green foliage overshadowing a pool. As regards the tadpoles I wondered how so many had survived; for all the pools were teeming with Dytiscid beetles of which 20 to 30 individuals could be dredged up with a single stroke of my net [2]). Of the zygopterid *Odonata* occurring in these surroundings, two species were particularly abundant among the shady undergrowth near the first pool and its outfall; these were the purplish *Archibasis ?melanocyana* (SELYS), and the slender *Teinobasis euglena* LIEFT. Both species oviposit in the matted tangle of fine submerged rootlets that fringe the steeper sides of the pool through which the brook flowed. Many pairs were taken *in coitu*, and although tenerals of neither were seen more than once or twice, I managed to secure the exuviae of both. An undescribed species of *Copera* was likewise very common here while *Argiocnemis rubescens* SELYS, and the

[1]) This pool is artificial, caused by excavations made when laying the railway. Besides a new species of *Lestes* (*L. praecellens* LIEFT.), we found on this pond-like pool a number of rare species and interesting new larval forms, among others *Lestes praemorsus*, *Ceriagrion erubescens*, *Camacinia gigantea* and *Rhyothemis triangularis*. (See: Treubia, 16, 1937, p. 59 - 62).

[2]) These beetles belonged to two large species, *viz*; *Hydaticus pacificus* AUBÉ, and *Sandracottus maculatus* (WEHNCKE), *Sandracottus* being far outnumbered by *Hydaticus*. We did not find a single larva of these species.

small *Mortonagrion amoenum* (RIS) completed the Agrionid fauna of the marshy part of the forest. The two last mentioned species were very inconspicuous and only found over still water.

The anisopterid fauna was composed mainly of some typically forest-loving *Libellulidae* of the *Agrionoptera*-group, *viz. Agrionoptera insignis* (RAMB.), *Lathrecista asiatica* (F.) and *Potamarcha obscura* (RAMB.), especially the two former being quite common, settling on the tips of dead twigs and branches or hovering in the sunlit-openings over the water. Later on the morning I took two teneral females of a fourth red-bodied member of the same group, *viz. Nesoxenia lineata* (SELYS) [1]). The discovery of this delicate and rare dragonfly was quite a surprise for it is the first locality in Java where this species has been recorded. In habits it resembles *Agrionoptera* closely; both are pre-eminent shade-lovers and very inconspicuous when on the wing. My specimens were persistent as to keeping to their secure positions on a leaf or twig high overhead. Other dragonflies noted here were *Tetrathemis irregularis hyalina* KIRBY, a common though strictly arboreal insect; *Brachydiplax chalybea* BRAUER, and a few species of more universal distribution.

After some hours' work, in a circumscribed area of not over 2 acres in extent (width approximately 50 yd), we got more used to the habits of the species referred to above, and at about 12 *a.m.* we set about investigating a pool for the larvae of *Aeshnidae* and *Mortonagrion.* It was one of the few pools in which a low semi-aquatic plant with small roundish leaves was growing; and very soon my attention was attracted to a number of blackish exuviae upon the leaves and stems jutting out an inch or so above the water's surface. Judging from their slender form and size these empty skins were pretty sure to belong to *Orolestes,* a presumption that was almost instantly corroborated by the fact that suddenly there rose up from near the pool a pale, long-tailed dragonfly with glittering wings that flew almost straight up right in front of us and settled on the hanging festoon of a liana, under the shelter of a broad leaf of a palm-tree. On looking at it more closely, it proved at once to be a newly-emerged male of *O. wallacei* that hung motionless and vertically on the bough, its long transparent wings outspread. In the course of half an hour it became evident that most of the insects had been out for some time, for several mature specimens were flushed among the tangled bushes within striking distance of the pool.

The flight of this insect is distinctly Lestine but with some 'archaic' peculiarities. It is very easily disturbed from a twig or bush where it is resting and will make off speedily for one or two yards, and re-settle in any suitable dark place, usually not far above one's head. It has a great fondness for shady places where it may take long rests, adopting invariably the 'hanging' position so advantageous for concealment. I took a small series of both sexes and had several opportunities of observing the efficiency of the colour-scheme of blue, moss green and metallic-green or -brown, which serves to render them almost

[1]) The next day at about 4 *p.m.* the first males and some more females of this species could be secured on exactly the same spot. These were the only individuals seen.

invisible when at rest. The brilliant azure blue segments 8 to 10 of the male, however, are very conspicuous as soon as the insect comes out in the sunshine. Can it be that these sky-blue spots possibly serve as 'recognition-marks' to

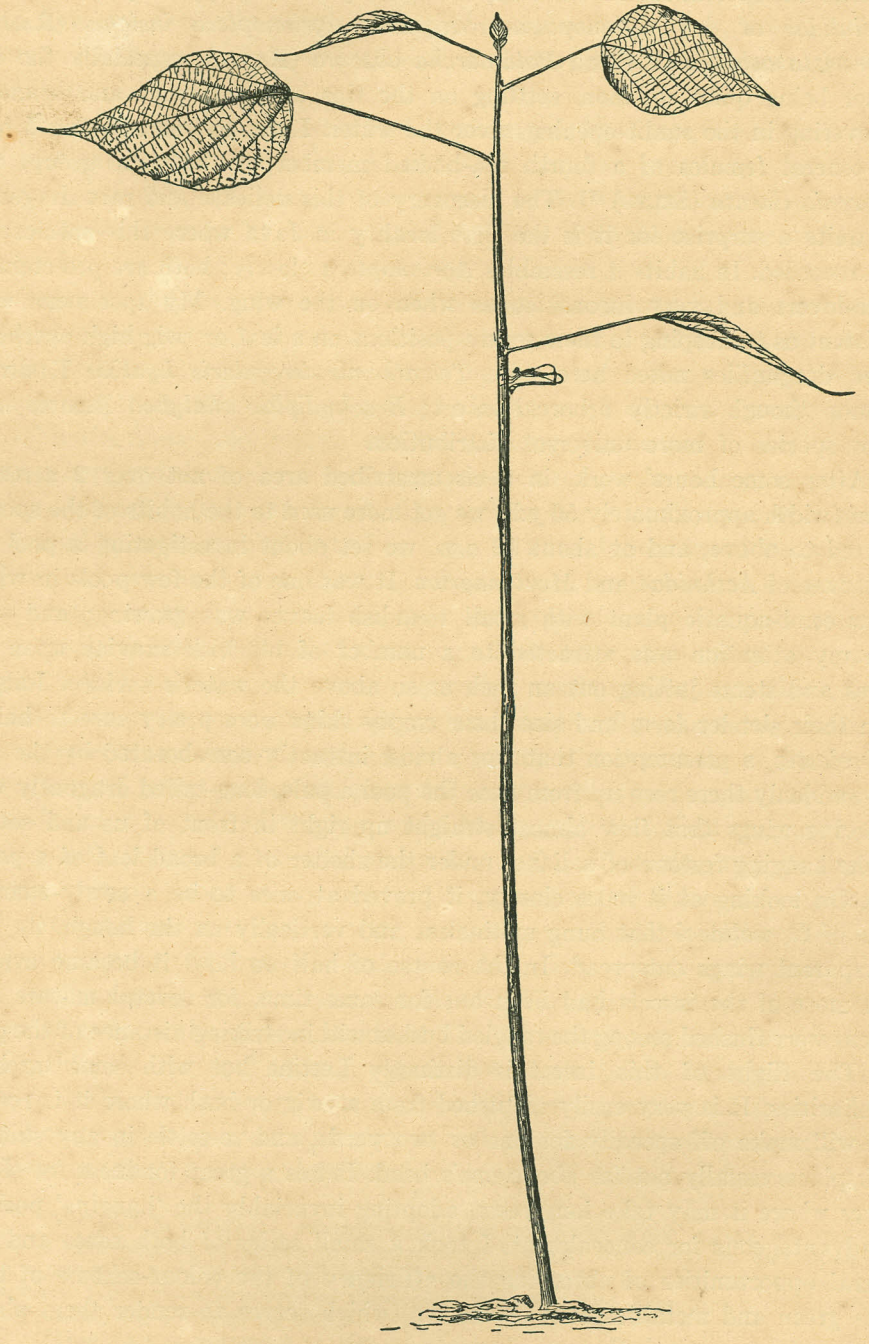

Fig. 1. *Orolestes wallacei* (KIRBY), ♀ ovipositing in the stem of a sapling, growing in dry soil. Drawn to scale on ¼ natural size.

the female during courtship? Although I earnestly looked about in the hope of dislodging a copulating pair, I failed to see any.

Turning back to the pool from which the specimens had emerged, I found several other exuviae on twigs of dead branches fallen into the water, and I picked up two nymphal skins from a tree growing about 3 yards away from the pool. One of these was fastened with outspread legs close to the trunk of the tree, but the other had crawled up the stem to a height of over 5 feet! In using the water-net I found that dragging among the semi-aquatic plants yielded me two full-grown larvae. One of these had its wing-sheaths swollen and it was evident on this warm sunny day that it ascended with the definite purpose of emerging.

The larva is a clean-living creature that avoids the mud at the bottom of the pool, spending most of its time among the dead leaves and submerged twigs; it is almost black in colour with only a slight trace of any markings. In propelling itself it travels in the same manner as larvae of *Lestes*, by a series of graceful half-twists (fig. 4).

Later in the day, at about 2.30 *p.m.*, being on the very verge of leaving the forest for my car to go home, I remember myself glancing cursorily at a male *Agrionoptera* hovering above the black soil in front of me, when, purely by chance, I caught sight of some sort of insect adhering to the smooth stem of a treelet. Creeping cautiously forward, until I was able to sit down within 3 feet of the object, I observed an egg-laying female of *Orolestes wallacei*, hanging motionless and horizontally on the stem of a tiny sapling. This was a mere seedling, rising straight up from the black soil; it was only about 2 feet 3 inches (68 cm) high, and judging from the absence of side-branches and the poor development of leaves it could have been scarcely older than about 6 - 8 months (fig. 1).

The position of the female was most extraordinary (fig. 2). The wings were held horizontally at right angles to the body and she had drawn the tip of her abdomen up until her body had formed a double right-angled bend at the 4th segment, holding the ovipositor between her legs. Evidently I had surprised this female in the middle of the tedious process of oviposition, which was performed very deliberately and slowly. By observing the process of oviposition close at hand I was enabled to note exactly how it went on.

The method of our dragonfly was to select some soft point, guided probably by the styli; she then would saw slowly and longitudinally across the bark with its sharply toothed valves until she could evert the terebra that would make the hole large enough; finally she would slip a single egg into the hole, whereupon the ovipositor is withdrawn. Almost immediately after one egg had been laid the female would start to make a new thrust under the foregoing and repeat the process.

During the oviposition, which was a very lengthy process, the insect remained almost motionless and I was struck by the great muscular strength and hardness of the legs which kept her for a long time in the same position.

She was remarkably indifferent to what happened around her, as I could watch her on every side and easily pick her up by the hand. As time went on the dragonfly at one moment was full in the sun's rays, at another in the dim light of the shady forest.

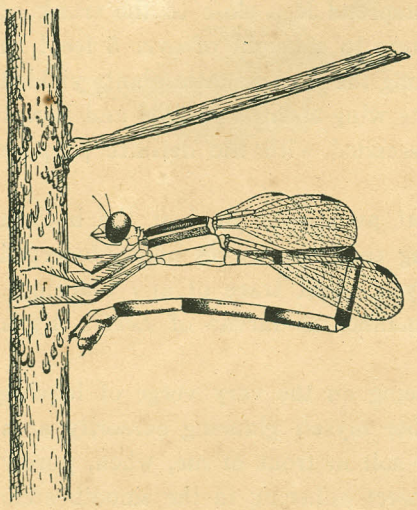

Fig. 2. *Orolestes wallacei* (KIRBY), the same ♀ ovipositing, showing ovipositor and punctures (× 1½).

On my arrival the position of the female was immediately below the stalk of the lowest leaf of the sapling. She was captured at last, after I had watched it ovipositing for one hour and ten minutes, at the end of which time she had backed down the stem imperceptibly about one fourth of an inch, and I am pretty sure that no more than 6 - 8 eggs had been inserted during that period!

Although the genital valves of the female abdomen are armed with a series of enormous teeth, which would seemingly facilitate the operation considerably, I have watched this dragonfly remaining in the same position for many minutes, evidently experiencing much difficulty in scratching open the somewhat hard tissue of the sapling in which the eggs were placed. The movements of the terebra could not clearly be followed but it seems reasonable to conclude that this species has thrown over the laborious usage of some of its relatives (*e.g. Archilestes grandis & californica* [1]); *Lestes viridis* [2]), whose eggs are neatly and regularly arranged in groups or rows, and who measure off with their styli equal distances between the successive incisions. For, turning my attention to the sapling of our ovipositing dragonfly, I noticed several irregular clusters of elongate punctures, placed where the female ovipositor had made a downward thrust. On examining this sapling more closely later, it was found that every thrust contained a single egg and that the eggs had been laid with their narrowest point directed upward. In spite of much careful waiting and watching this was the only time that I saw this species ovipositing.

Before leaving for home I satisfied myself of the fact that the tiny sapling emerged from perfectly dry soil, and that there were no pools within a distance of about 15 yards. Judging from the flat surroundings and the nature of the soil-vegetation we may safely assume that this part of the forest — and the drier zones as well — would be flooded more than once before the wet monsoon set in for good; at which time the whole country must doubtless remain inundated for at least 3 months in succession.

[1]) C. H. KENNEDY, Proc. U. S. Nat. Mus. 49, 1915, p. 259 - 269, figs.
[2]) D. C. GEIJSKES, De Levende Natuur, 33, 1928, p. 17 - 24, 48 - 52, 85 - 90, figs.

If this were not the case the hatching nymphs of our *Orolestes* could not find their way into the water before October; that means six months after oviposition took place, or, in other words after the period that would, under the conditions we are considering, necessarily elapse between the time of oviposition (*viz.* the end of March) and the beginning of the rainy season! This is, of course, impossible. In spite of the drought setting in so early at the time of my observation on the ovipositing female, I believe that, owing to the impermeability of the old coral-bottom, temporary rain-showers would rapidly drench the soil, bringing into existence a number of pools and so would prevent an untimely death of the hatching larvae. For all that it is hardly beyond doubt that at times a pool will dry up too early so that all aquatic animals that can not fly away (except Dytiscid beetles!) or resist prolonged drought, would be doomed to perish. Lack of water is fatal to Lestid larvae and if the final drying up of the pool takes place before the larvae have reached maturity, then they will soon die. From which it will be realized without further explanation that in a fortnight or less, had there been no rain during that period, the young brood of our dragonfly would have died at once.

At last, I pulled out the sapling, wrapped it up in a wet handkerchief and so it was taken along with me to the rest-house. The next day we drove home but unfortunately the sapling died during the journey. As soon as was possible I cut out the particular portion of the stem which contained the eggs, placing it in a petri-dish filled with water, but the eggs soon died and further observations were impossible.

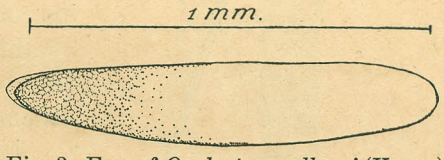

Fig. 3. Egg of *Orolestes wallacei* (KIRBY).

The egg.

From the shoot I extracted a fair number of eggs, which I found to be of the typical Lestine form (fig. 3).

Elongate, cylindrical, very slightly curved; anterior pole obtusely pointed, posterior pole well-rounded. Colour pale wax-yellow.

Length 1.08 - 1.12, greatest diameter 0.22 mm.

Description of the full-grown larva (fig. 4).

Total length of body without caudal gills 21 - 22; median gill 8.5, lateral gill 8.8; length of head 2.12, width of same across the eyes 4.38; length of antenna (one specimen) 6.42, of separate joints 1 - 7: 0.80, 0.90, 1.67, 1.40, 0.90, 0.40, 0.25 mm. Length of hind wing rudiment 6.7; of posterior femur (excl. troch.) 6.16 mm.

Body elongate, cylindrical. General appearance very similar to species of *Lestes* though less slenderly built. Head distinctly wider than the thorax, more than twice as wide as long, with large, well-rounded, laterally prominent eyes. Occipital lobes strongly convex, rounded posteriorly and covered with a number of fine spinulose setae. Antennae very long and slender beyond the two basal segments. Labium long and very slender, adpressed to the body; hinge reaching

back between the legs to the middle or almost to the end of the posterior pair of coxae. Mentum at first rather broad, thence tapering and after a slight constriction suddenly triangularly widened in its distal third. Median lobe with 5 very short spinulose setae along each lateral margin; anterior border straight (or very slightly undulated), with the median cleft distinct though closed, 0.16 mm long. Mental setae 5 each side, placed rather close together. Anterior margin of median lobe with a row of very fine denticles. Lateral lobe trifid at its distal portion, consisting of two divisions. The inner division forms a long hook whose inner border is microscopically serrulate; apical tooth of same simple, slenderly incurved. Outer division deeply excised, consisting of two almost equally long, simple, arcuate prongs. Lateral setae 3 in number of which but one is on the body of the lateral lobe, the others being upon the very long and curved movable end-hook. Latero-basal corner of lateral lobe with a conspicuous, crescent-shaped ridge, and latero-apical edge with a single short seta (fig. 5).

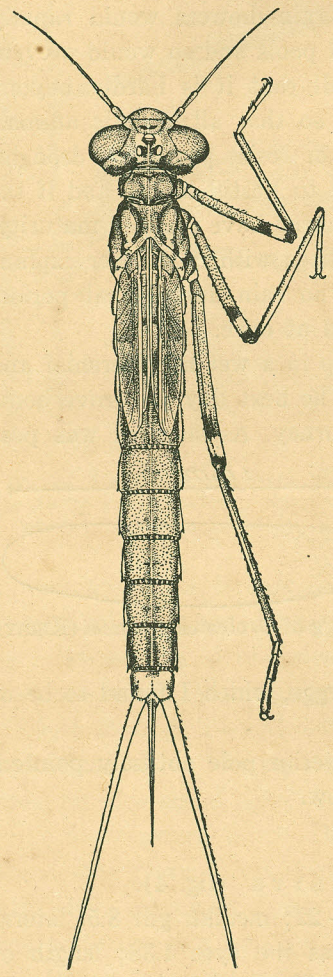

Fig. 4. Ultimate larval instar of *Orolestes wallacei* (KIRBY).

Prothorax wider than long; notum trapezoidal, obtuse-angulate without lateral projections. Synthorax rather robust. Wing-cases parallel, reaching back almost to the end of the fourth abdominal segment.

Legs long and very slender; longitudinal ridges finely denticulate.

Abdomen with cylindrical segments, very slightly tapering towards the apex; sternites and tergites of all segments finely granulate. Lateral ridges smooth, sharply acute, with stout lateral spines on segment 4 - 9 increasing gradually in length, that on 4 vestigial; lateral margins of all segments except 10 microscopically serrulate. Segm. 10 with a sharply compressed dorsal ridge, which ends in a high triangular fold whose posterior margins are strongly spinose.

Caudal gills relatively short and broad, almost parallel-sided with a slight but distinct sub-basal expansion, ventral on the median gill, dorsal on the lateral gill. Apices obtusely truncated. Tracheation distinct, typically Lestine, as is shown in fig. 5.

Coloration. — Generally dark brown. Labium pale with brown lateral stripes to the stalk of the median lobe and an indistinct brown spot on each side of the middle and on the lateral angles. Head mottled with paler brown round the ocelli and on the occipital lobes. Eyes dark olive-brown above,

bluish-grey underneath. Antennae very pale brown, first joint a little darkened on middle.

Pronotum brown, sides almost black; meso-metathorax with alternating dark brown and black vertical bands.

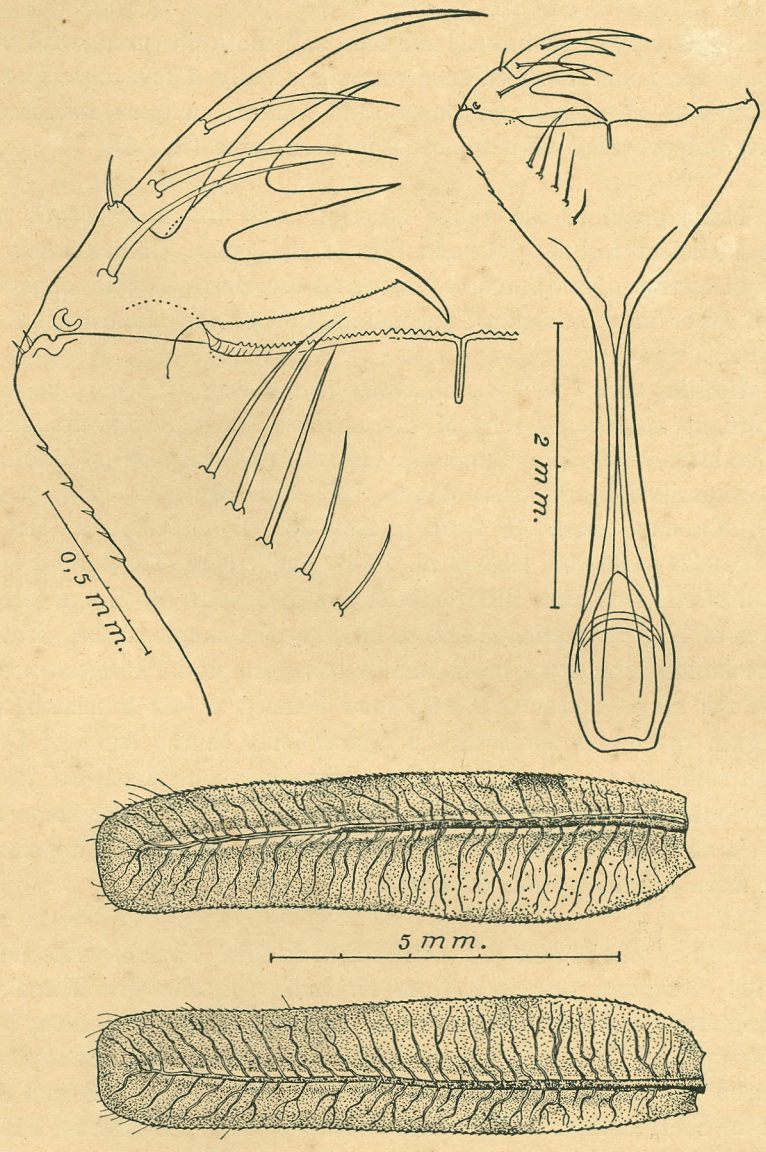

Fig. 5. Larval structures of *Orolestes wallacei* (KIRBY). Interior view of labium, distal portion of same more highly magnified, median and right lateral caudal gill (bottom).

Wing-sheaths dark brown with paler brown areas near the base and apex.

Legs light brown with distinct dark brown sub-apical rings and with the apices also darkened; tibiae with brown longitudinal ridges, and tarsal joints with the two ridges also finely black.

Abdomen, segm. 1 - 9 dark brown, a little paler dorsally on each side of the middle; the lateral keels are smooth and definitely pale brown in colour, forming an interrupted pale stripe alongside the abdominal segments 1 - 9; apical spines darkened. Segm. 10 pale brown, base and sides diffusely mottled with dark brown.

Caudal gills very dark brown, mid-ribs still more obscured, with very indefinite pale basal and sub-median areas and usually a few dark spots along margin. Mid-ribs laterally, and dorsal and ventral margins microscopically denticulate and provided with minute spinulose setae (fig. 5).

The details given in the above description of the larva of *O. wallacei* should be sufficient for the determination of the genus. Unfortunately, owing to a fatal distortion of the fore-gut (including the gizzard) while engaged with a study of other internal organs, an examination of the gizzard could not be carried out.

The affinities with the larva of *Lestes* [1]) are very evident; but so far as I am aware, it approaches that of the nearctic genus *Archilestes* still more closely. The larva of *Archilestes grandis* (RAMB.) and *californica* (MACLACHLAN) have been described by NEEDHAM (Proc. U.S. Nat. Mus. 27, 1904, p. 712, pl. 42 fig. 3), KENNEDY (Ibid. 49, 1915, p. 259 - 269, figs.), GARMAN (Ent. News, Philad. 43, 1932, p. 85 - 92, tfig. & pl. 2 - 4), and others. The larvae of *Lestes* and *Archilestes* have been differentiated by NEEDHAM (A Handbook of the Dragonflies of North America, 1929, p. 268) by the shape of the trifid lateral lobe of the labium, the upper notch of this being simple in *Archilestes*, whereas most — if not all — larvae of *Lestes* show a more or less truncated, serrated border within the upper notch of the lateral lobe. In the larva of *Orolestes*, the structure of the lateral lobe of the labium is almost identical to that of *Archilestes* but the shape of the mentum is quite different, the setae are less numerous, and there are several other differences. *Archilestes* appears to be decidedly more primitive than *Orolestes*.

The true position of *Orolestes* in the family *Lestidae*.

In 1911, NEEDHAM described from N. India (possibly the Himalayas) a large zygopterous larva which was left unidentified by him though it was presumably placed in the "legion *Podagrion* s.lat." Venationally, it was characterized by the two interpolated sectors between veins M_3 and Rs with a number of short oblique ones behind the tip of M_3. (Ent. News, Philad. 22, 1911, p. 342 - 344, pl. 11 fig. 1 - 4).

[1]) *Lestes* LEACH, in its widest sense, includes a number of other genera, whose generic value must be called in question until a thorough revision of the family *Lestidae* has been given. These genera are: *Africalestes* KENNEDY, *Austrolestes* TILLYARD *Ceylonolestes* KENNEDY, *Chalcolestes* KENNEDY, *Indolestes* FRASER, and *Sympecma* SELYS. Besides these, only *Archilestes* SELYS, *Cyptolestes* WILLIAMSON, *Orolestes* MACLACHLAN, *Platylestes* SELYS, *Superlestes* WILLIAMSON, and probably *Ortholestes* CALVERT appear to belong to the family *Lestidae* in its restricted sense here adopted.

In 1920, LAIDLAW described the supposed larva of *Megalestes major* SELYS after examples from Pashok, Darjeeling. (Rec. Ind. Mus. 19, 1920, p. 185 - 187, figs. 1 - 3).

Although NEEDHAM's larva was considerably larger than the one described by LAIDLAW, both insects resembled each other closely, showing also a close approach to the larva of the Australian genus *Synlestes*. This very close similarity in structure between the larva of *Megalestes* and that of *Synlestes* was first demonstrated by TILLYARD; and on this evidence it was found necessary by LAIDLAW to remove the genus *Megalestes* from the neighbourhood of *Lestes* and refer it to the subfamily *Synlestinae* [1]).

This performance has been followed by all subsequent writers. However, in respect of its superior size, NEEDHAM's unknown larva, which had been found also in the high mountainous regions of northern India, was ascribed by LAIDLAW in the same paper to *Orolestes*, "the only (other) known Indian genus to which this larva can be assigned with any degree of probability" (LAIDLAW, *loc. cit.*). This ascription was considered reasonable on account of the assumption (LAIDLAW *seq.* TILLYARD, *loc. cit.*) that *Orolestes selysi* MACLACHLAN, another Lestid dragonfly of great size inhabiting the northern parts of India (Darjeeling), would be a true Synlestine. As will be soon evident, however, this statement is wrong. From the larval characters as given by NEEDHAM, the genus would be undoubtedly a Synlestine and this was admitted also by FRASER.

In his "Revision of the genus *Orolestes*" (Rec. Ind. Mus. 35, 1933, p. 175 - 182), this author, on the other hand, gave a description and some drawings of the penile organs of five species of *Orolestes* (including *O. wallacei*). From an examination of these, FRASER found that they are closely similar to the same organ in *Austrolestes* (*Lestes* of the present writer), which fact led him to consider *Orolestes* on this evidence as a modern product of that genus. He adds: "NEEDHAM's larva is more probably a *Megalestes*, which genus is closely related to the *Synlestinae* and probably a genus of that subfamily" (*loc. cit.*, p. 176).

This statement is fully corroborated by the discovery of the true larva of *Orolestes wallacei*, and a study of this has proved up to the hilt that NEEDHAM's larva is not an *Orolestes* at all, and that TILLYARD's supposition of *Orolestes selysi* being a Synlestid, is wrong. As has been pointed out by FRASER, the large Indian species *O. selysi* MACLACHLAN is doubtless congeneric with *wallacei;* and regarding the former we may expect a type of larva which — though larger than that of *wallacei* — shows the same obviously Lestid characters as that species.

Recently, NEEDHAM has expressed doubt as to the correctness of LAIDLAW's identification of his larva as that of *Megalestes major* (Zool. Sinica, A, 11, 1930, p. 229). Nevertheless, in the writer's opinion, the two kinds of Himalayan

[1]) As will appear later, I have followed TILLYARD (1936), who first gave the *Synlestinae* family-rank. This can scarcely be questioned, especially when the larvae of each of the two subfamilies *Lestinae* and *Synlestinae* are compared together.

larvae, described subsequently by NEEDHAM and LAIDLAW, are so similar to each other and so obviously Synlestid in appearance, that both of them can be ascribed conveniently to *Megalestes*, which genus then would remain in the *Synlestidae* [1]).

The larval characters of the families *Lestidae* and *Synlestidae*.

Although the larval characters of the three known genera of *Synlestidae* do not, so far as my knowledge goes, support the view that *Chlorolestes*, *Megalestes* and *Synlestes* are closely related *inter se*, these genera on the other hand may remain in this family on account of their larvae, which are fundamentally different in a number of important characters from those of the *Lestidae*.

The larval characters may be tabulated as follows:—

1. Mid-lobe of labium with the median cleft only incompletely developed, very narrowly incised or closed. Side-lobes greatly expanded, usually distinctly concave, mesial margin very irregularly and deeply cleft. Mental and lateral setae present. Antennae long and slender, basal joints of the usual size and appearance, pedicel elongate, not conspicuously longer than the distalia. Gizzard with 4 major and 4 minor folds. Caudal gills very long, sub-parallel, apices ellipsoidal, rounded or bluntly pointed; secondary tracheae approximately at right angles to the main axis. Pedicel of caudal gills unapparent, annular, no "breaking-joint". Gills caducous. Cercoids inconspicuous.

   Fam. *Lestidae*.

   [Genera: *Archilestes* SELYS (Nearctic); *Cyptolestes* WILLIAMSON (Neotropical); *Lestes* LEACH (*s. lat.*) (Cosmopolitan); *Orolestes* MACLACHLAN (Oriental); ? *Ortholestes* CALVERT (West Indies); *Platylestes* SELYS (Oriental); *Superlestes* WILLIAMSON (Neotropical)].

1'. Mid-lobe of labium with the median cleft well-developed, deeply and narrowly incised. Side-lobes narrow and straight, cleft into two simple, unequal teeth; movable hook long and slender. No mental or lateral

[1]) It may be noted here that NEEDHAM, in his 'Manual of the Dragonflies of China' (*loc. cit.*) does not mention the subfamily *Synlestinae* at all. He places four genera, *viz. Toalestes*, *Pseudolestes*, *Megalestes*, and *Lestes* in the subfamily *Lestinae*. Of these, *Taolestes* is undoubtedly synonymous with *Rhipidolestes* RIS, which belongs to the *Megapodagrionidae*; *Pseudolestes* KIRBY belongs to the same family; *Megalestes* belongs to the *Synlestidae*; lastly, *Lestes* is the only genus that should remain in the family *Lestidae*! The supposed larva of *Taolestes*, described also by NEEDHAM, has certainly nothing to do with *Taolestes nectans*, and it should in all probability be referred to some genus of the *Euphaeidae*. NEEDHAM further places *Mesopodagrion*, *Philosina* and *Rhipidolestes* (all true *Megapodagrionidae* in the opinion of modern odonatologists) along with *Sinolestes* (which is a true Synlestid) in the subfamily *Coenagrioninae*. Lastly, in his "Additions and Corrections" to the Manual (Peking Nat. Hist. Soc. 5, 1931, p. 8), NEEDHAM removes the genus *Pseudolestes* (a Megapodagrionid) from the *Lestinae* (sensu NEEDHAM) and places it in the key to the genera of *Coenagrioninae*!

setae. Antennae variable, usually with the first and second segments stouter than the remaining (except *Megalestes*). First joint long and slender but not as long as second; third segment is the longest (*Chlorolestes*); first joint short and broad, second joint (pedicel) stout and very long, remaining joints much shorter than second joint (*Synlestes*); or antennae rather short, segments subequal in length, third joint longest (*Megalestes*). Gizzard with 8 major folds, no minor folds (*Chlorolestes*), or with 4 major and 4 minor folds (*Synlestes* and ?*Megalestes*). Caudal gills short or moderately long, elongate-oval, narrowed somewhat at their bases; apices broadly rounded (*Megalestes, Chlorolestes*), or bluntly pointed (*Synlestes*); secondary tracheae oblique to the main axis. Pedicel of caudal gills distinct, flattened, forming part of the gill lamella and separated from this by a "breaking-joint". Gills not caducous. Cercoids acute, conspicuous. ..... Fam. *Synlestidae.*

[Genera: *Chlorolestes* SELYS (Ethiopian); *Megalestes* SELYS (Oriental); *Sinolestes* NEEDHAM (Oriental); *Synlestes* SELYS (Australian)].