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Notes on the postembryonic development of two species of *Isometrus* Ehrenberg (Scorpiones, Buthidae) from Sri Lanka

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Abstract

The results of the study on the postembryonic development of two buthid scorpions of the genus *Isometrus* are presented. The species, *Isometrus* (*Isometrus*) *maculatus* (De Geer, 1778) and *Isometrus* (*Reddyanus*) *besucheti* Vachon, 1982, have been collected in Sri Lanka. The results are analysed in term of the life history strategies of both species. The remarkable reproductive potential of *I.* (*I.*) *maculatus*, is a possible explanation of the enormous ecological plasticity and dispersion capacity of this species.

Introduction

Studies on the scorpions of Sri Lanka, formerly Ceylon, began in the second half of the 19th century but, in most cases, these were isolated descriptions (see Lourenço & Huber 2002). The first comprehensive study of the scorpions of India and Ceylon, which also included Burma, was published by Pocock (1900). Vachon (1982) made a specific study on the scorpions of Sri Lanka, however, both contributions were limited to taxonomy and faunistics.

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The species of the genus *Isometrus* have been the subject of very few biological studies. One exception being the studies of Probst (1967, 1972) on *Isometrus* (*I.*) *maculatus* (De Geer, 1778), based on specimens collected in Tanzania.

During a field trip to Sri Lanka by the senior author at the beginning of 2000, among other scorpions, females belonging to the species *I.* (*I.*) *maculatus* and *Isometrus* (*Reddyanus*) *besucheti* Vachon, 1982 were collected alive in the regions of Monaragala District, Province of Uva for the former, and Anuradhapura District, NW Coast of Nuwara Wewa and Polonnaruwa District, Minneriya Giritale Sanctuary for the later species.

No data are available for the biology or development of *I.* (*R.*) *besucheti,* which was described from Sri Lanka, and which is undoubtedly an endemic element to this island. As for *I.* (*I.*) *maculatus*, the biological studies of Probst (1967, 1972) are quite exhaustive, but based on specimens from Tanzania. It is most certain that this region in Africa does not correspond to the natural population of this species.

In fact, *I.* (*I.*) *maculatus* is the most widely distributed scorpion in the world. Its distribution has anthropogenical background, probably going back to the great naval voyages of the 16th century. *I.* (*I.*) *maculatus* is found in most tropical and subtropical coastal regions of the world, and the question concerning its original area of distribution has been often addressed. In the recent paper by Lourenço and Huber (2002), it was suggested that the original area of distribution of *I.* (*I.*) *maculatus* could be in Sri Lanka. This is the only region in the world where *I.* (*I.*) maculatus is found in really wild conditions inland.

Material and methods

Scorpions were reared according to standard methods using plastic terraria of different sizes. These contained a layer of soil, 2-3 cm in depth, as well as a few pieces of bark and a small Petri dish containing water. Food, consisting of crickets, spiders and *Tenebrio* larvae was provided once every week to 10 days. Temperature ranged from 24 to 27° C and humidity was maintained at saturation level. After each molt, the exuvia were removed from the terraria and stored in boxes - one for each individual scorpion. Morphometric growth values were measured both on dead specimens and on the exuvia. Three parameters were recorded: carapace length, metasomal segment V length and movable finger length (Lourenço 1979a, b, in press). The growth factor (the Dyar's constant) between succeeding instars was determined for each structure on each individual by dividing the dimension at one instar by the dimension at the previous instar. The average growth factor per molt for each structure was then calculated from the pooled data.

The scorpions have been collected from the following localities:

I. (*I.*) *maculatus*: Sri Lanka: Monaragala District, Province of Uva, 10 km N of Wellawaya (under bark of rotten tree, dry vegetation), 24 February 2000, coll. D. Huber.

I. (R.) besucheti: Sri Lanka: (Site 1), Anuradhapura District, NW Coast of Nuwara Wewa (under a stack of bricks in a dry area), 15 February 2000, coll. D. Huber. (Site 2), Polonnaruwa District, Minneriya to Habarana, Minneriya Giritale Sanctuary (under bark of rotten tree, dry jungle vegetation), 18 Feburary 2000, coll. D. Huber.

The voucher material is deposited in the Zoologisches Museum, Hamburg.

Results and discussion

Embryonic development

The duration of embryonic development ranged from 2.2 to 3.2 months for *I.* (*I.*) *maculatus* and from 2.2 to 3.9 months for *I.* (*R.*) *besucheti*. The lower values of these developmental periods are shorter than those found in species of other genera of Buthidae.

Postnatal development

Young scorpions remain with their mother until their first molt after which they disperse (Figs. 1-3). The first molt took place about 5 days after birth on average in *I.* (*I.*) *maculatus* and 6 days on average in *I.* (*R.*) *besucheti*. During this period, a certain amount of basic maternal behavior was observed.

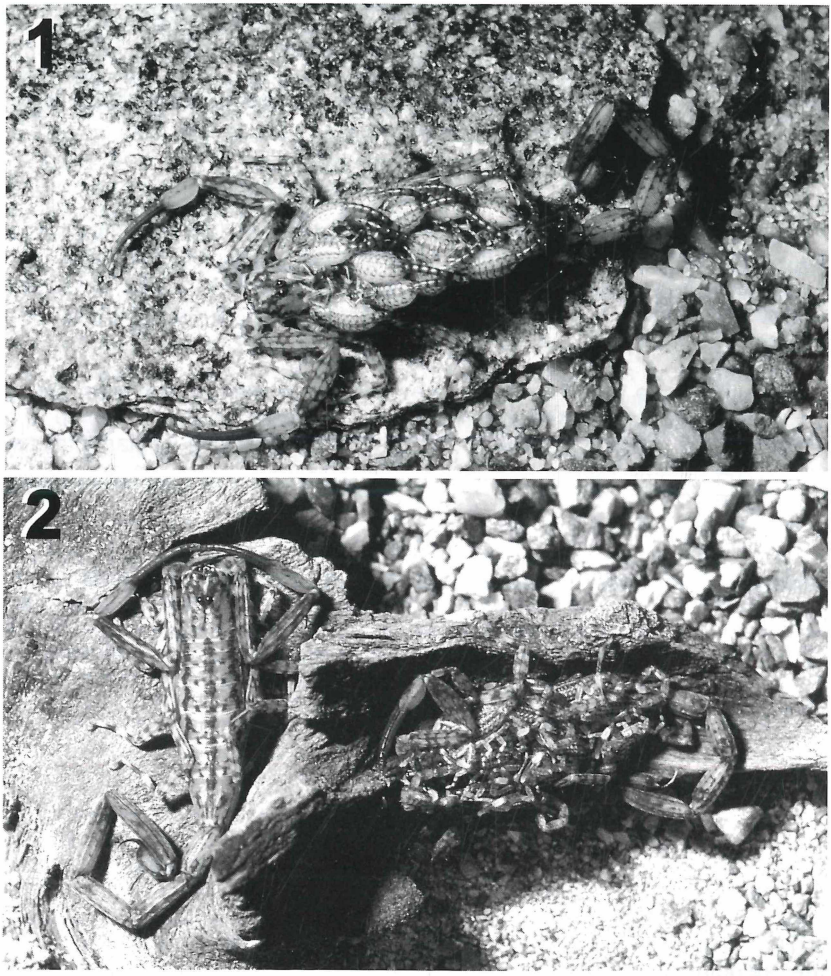
More than one brood was produced, without a new insemination taking place between broods. Kovoor *et al.* (1987) demonstrate the existence of a novel process for the storage of spermatozoa embedded in glandular tissue in the genital tract of the female. This has been shown to occur in at least three genera of Buthidae: *Centruroides* Marx, 1890, *Tityus* C. L. Koch, 1836 and *Isometrus* Ehrenberg, 1828. After a single insemination, females of these genera can give birth to from three to five broods when isolated in laboratory conditions. Probst (1972) reported up to 4-5 broods for *I.* (*I.*) *maculatus*. In this study we observed up to 6 broods, and possibly 7 for one female which was already collected in the field with juveniles. For *I.* (*R.*) *besucheti* a total of three multiple broods was observed in all females. These observations can be analysed in the light of the reproductive strategies of the two species.

Litter size

The observations made on *I.* (*I.*) *maculatus* and *I.* (*R.*) *besucheti* show that for the first species the 21 broods obtained were composed of 14 to 21 juvenile individuals. In one case, female "E" produced only 5 juveniles; this kind of situation can be observed for females which arrive to the end of their life cycle, when follicles start to be reduced in number (Lourenço 1979b). The observations for *I. (R.) besucheti* show that the females from the "population 1", collected at Anuradhapura District, produced broods composed of 10 juveniles, whereas those from the "population 2", collected at Polonnaruwa District, produced broods composed of 17 juveniles.

Most of these numbers represent the average of the values observed in most Buthidae species, and only the lower values observed for *I.* (*R.*) *besucheti* approximate those observed for some small species of the family. The first instar pro-juveniles are randomly positioned on the mother's back (Williams, 1969).

Subsequent molts took place at different ages, on average 46, 78, 111 and 155 days for *I.* (*I.*) *maculatus*, and 59, 112, 168 and 235 days for *I.* (*R.*) *besucheti*. The duration of postembryonic development ranged from 4.5 to 5.6 months for *I.* (*I.*) *maculatus* and from 6.6 to 10.5 months for *I.* (*R.*)



Figs 1-2. *Isometrus (I.) maculatus* (De Geer): **1** – female with first instar brood; **2** – male and female with second instar brood.

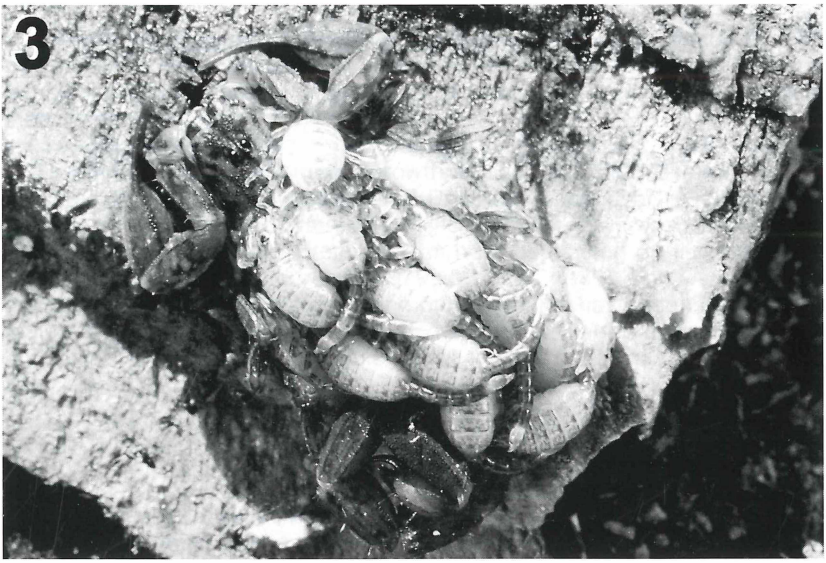


Fig. 3. *Isometrus* (*R.*) *besucheti* Vachon: female with first instar brood.

besucheti. These developmental periods are shorter than those found in species of other genera of Buthidae. Growth rates in the different instars are similar to those observed for other Buthidae that have been studied (Polis & Sissom 1990; Lourenço 2002). Growth parameters of both *Isometrus* species, based on morphometric values, measured both on dead individuals and on exuvia, are shown in Figs 4-5.

The adult lifespan of both *Isometrus* species probably reaches only 24 to 35 months (Probst 1972), being shorter than that observed in several other species of the Buthidae (Lourenço, in press).

These developmental periods differ greatly from those observed in most other species of scorpion. They represent very short life cycles, and are only somewhat similar to those observed in some species of the genus *Centruroides*. Little variability was observed in the developmental periods of different individuals. Both males and females passed through six instars to reach adulthood (= instar 6).

Secondary sexual characteristics and growth characteristics

Male and female of *I.* (*I.*) *maculatus* and *I.* (*R.*) *besucheti* can be easily recognised after the last molt, when sexual dimorphism becomes visible. Recognition of immature males and females may be difficult. The sexes of juveniles can tentatively be distinguished by careful observation of the pectines. These are longer and larger in males than in females. Male pectines have also more teeth than female pectines.

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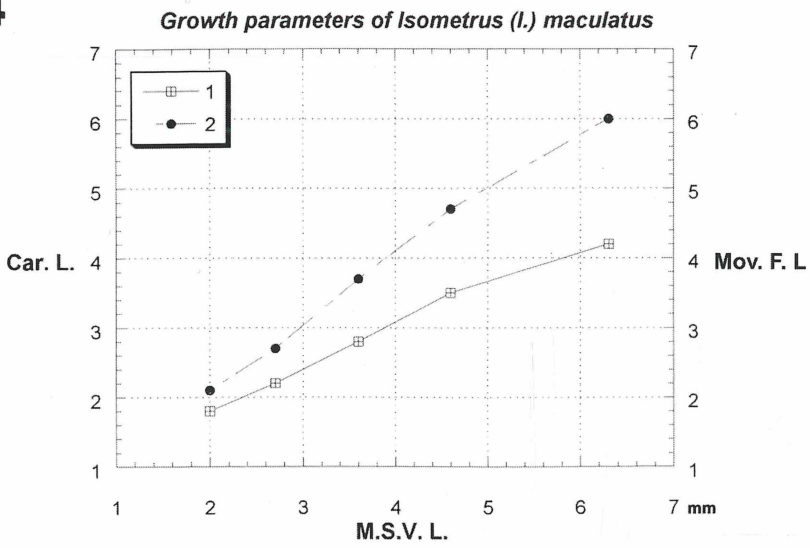

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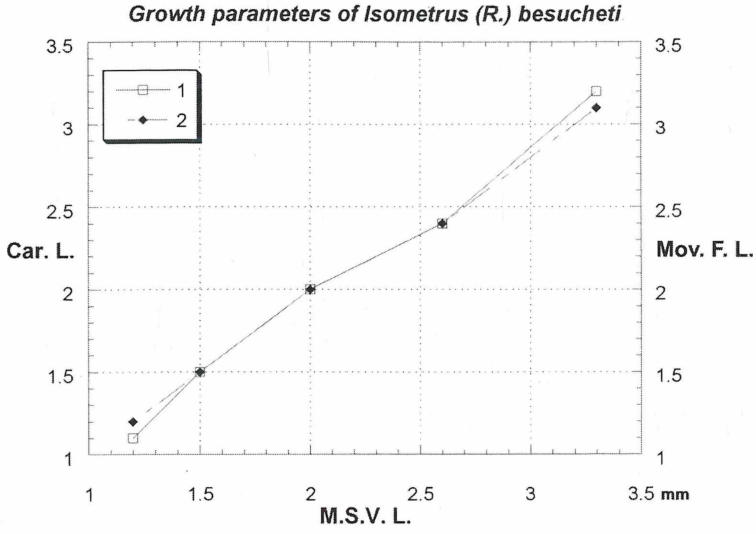

Fig. 4-5. The distribution of morphometric values, for juvenile and adult instars of *Isometrus* (*I.*) *maculatus* (De Geer) (**4**) and *Isometrus* (*R.*) *besucheti* Vachon (**5**) (Car. L. = carapace length, Mov. F. L. = movable finger length, M.S.V.L. = metasomal segment V length. 1 = Car. L. vs. M.S.V.L. 2 = Mov. F.L. vs. M.S.V.L.).

Sexual dimorphism is different for the two species. Adult males of *I.* (*I.*) *maculatus* develop pedipalps that are longer and slender than those of females, whereas, in adult males of *I.* (*R.*) *besucheti* pedipalps are bulkier than those of females.

The theoretical morphometric growth values for the development of arthropods defined by Dyar (1890) and Przibram & Megusar (1912) is 1:26. The values observed for different species of *Tityus*, *Centruroides* and *Rhopalurus* Thorell, 1876 vary from 1:22 to 1:33, depending on the parameter (segment) considered (Lourenço 1979a,b, 1988, 1989). For *I.* (*I.*) *maculatus* and *I.* (*R.*) *besucheti* the following growth values have been observed in males and females: carapace length, 1:24 and 1:30; metasomal segment V length, 1:33 and 1:29; movable finger length, 1:30 and 1:27 (see also Figs 4-5).

Analysis of the reproductive traits of *I.* (*I.*) *maculatus* in the context of its evolutionary ecology

Contributions to the ecology of scorpions contain very few references to life history strategies. In a recent publication, Polis (1990) proposed a synthesis of the ecology of scorpions. He defined two general patterns. Non-buthid scorpions are regarded as equilibrium species (type "K"), whereas buthid are opportunistic species (type "r"). This dichotomy, however, is not satisfactory, in the light of additional data that has become available in recent years. Rather than dividing scorpions into two categories: opportunistic species (= Buthidae); equilibrium species (= non-Buthidae), it appears more reasonable to accept the existence of different evolutionary gradients inside both Buthidae and non-Buthidae. Even if some scorpions are opportunistic species, the majority of species are equilibrium species.

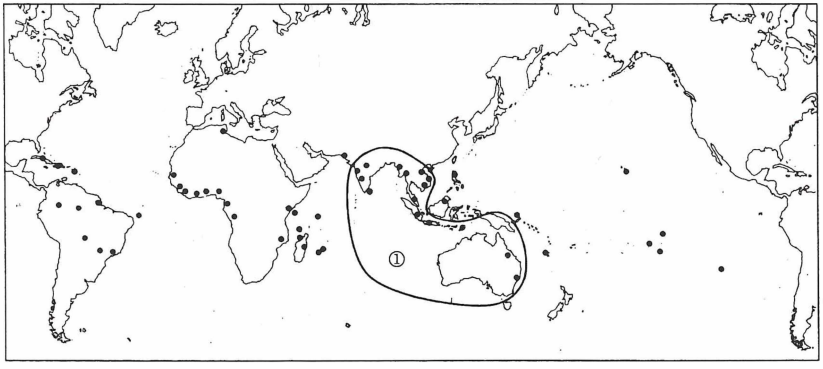

Fig. 6. Natural area of distribution of the genus *Isometrus* (1) and the present distribution of *Isometrus* (*I.*) *maculatus* (De Geer) (black circles).

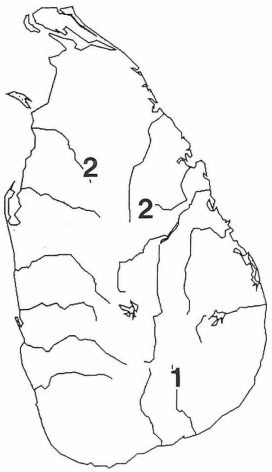

Fig. 7. Discussed localities of *Isometrus* (*I.*) *maculatus* (De Geer) (1) and *Isometrus* (*R.*) *besucheti* Vachon (2) in Sri Lanka.

The present comparative study of two species of the same genus (*Isometrus*) inhabiting the same island (Sri Lanka), shows that individually each species has a marked different behaviour in relation to human agency and secondary succession. As said before, *I.* (*I.*) *maculatus* is found today in most tropical and subtropical coastal regions of the world, even if its original distribution probably was limited to Sri Lanka. Its present distribution has anthropogenical background, probably going back to the great naval voyages of the 16th century.

The remarkable reproductive potential of *I.* (*I.*) *maculatus* appears like a possible explanation to the enormous ecological plasticity and dispersion capacity of this species. The duration of embryonic development ranged from 2.2 to 3.2 months. These values of developmental periods are shorter than those found in other species of Buthidae. Up to 6-7 multiple broods composed of 14 to 21 individuals have been observed without new fecundation. The duration of postembryonic development ranged from 4.5 to 5.6 months. These developmental periods are also shorter than those found in other species of Buthidae, having therefore as consequence, very short life cycles.

The adult lifespan of *I. I. maculatus* probably reaches only 24-25 months (Probst 1972), being shorter than those observed in other species of Buthidae (Lourenço in press). All these parameters can readily classify *I.* (*I.*) *maculatus* as a typical opportunistic species.

References

Dyar, H., 1890: The number of molts in Lepidopterous larvae. – Psyche, **5**: 420-422. Cambridge.

Kovoor, J., Lourenço W. R. & Muñoz-Cuevas, A., 1987: Conservation des spermatozoïdes dans les voies génitales des femelles et biologie de la reproduction des Scorpions (Chélicérates). – C. R. Acad. Sci., 304, sér. III, **10**: 259-264. Paris.

Lourenço, W. R., 1979a: Le Scorpion Buthidae: *Tityus mattogrossensis* Borelli, 1901 (Morphologie, écologie, biologie et développement postembryonnaire). – Bull. Mus. natn. Hist. nat., 4e sér., **1** (A1): 95-117. Paris.

Lourenço, W. R., 1979b: La biologie sexuelle et le développement postembryonnaire du Scorpion Buthidae: *Tityus trivittatus fasciolatus* Pessôa, 1935. – Rev. Nordestina Biol., **2** (1-2): 49-96. João Pessoa.

Lourenço, W. R., 1988: Le développement postembryonnaire de *Centruroides pococki* Sissom et Francke, 1983 (Buthidae) et de *Didymocentrus lesueurii* (Gervais, 1844) (Diplocentridae) (Arachnida, Scorpiones). – Rev. Arachnol., **7** (5): 213-222. Aramon.

Lourenço, W. R., 1989: Le développement postembryonnaire de *Rhopalurus princeps* (Karsch, 1879) (Scorpiones, Buthidae). – Rev. Brasileira Biol., **49** (3): 743-747. Rio de Janeiro.

Lourenço, W. R., in press: Reproduction in scorpions, with special reference to parthenogenesis. – Proc. European Congr. Arachnol., Aarhus 2000. Aarhus.

Lourenço, W. R. & Huber, D., 2002: New addition to the scorpiofauna of Sri Lanka. – Rev. suisse Zool., **109** (2) : 265-275. Geneva.

Pocock, R. I. 1900: Arachnida. – In: Blandford, W. T. (Ed.). The Fauna of British India, including Ceylon and Burma, xii, 279 pp. London.

Polis G. A., 1990: Ecology. – In: G. A. Polis (Ed.), The Biology of Scorpions Stanford Univ. Press, pp. 247-293. Stanford.

Polis, G. A. & Sissom, W. D. 1990: Life History. – In: G. A. Polis (Ed.), The Biology of scorpions. Stanford Univ. Press, pp. 161-223. Stanford.

Probst, P., 1967: Der Geburtsvorgang beim Skorpion *Isometrus maculatus* De Geer (Buthidae). Rev. suisse Zool., **74** (3): 616-619. Geneva.

Probst, P. J., 1972: Zur Fortpflanzungsbiologie und zur Entwicklung der Giftdrüsen beim Skorpion *Isometrus maculatus* (De Geer, 1778) (Scorpiones: Buthidae). – Acta Tropica, **29** (1): 1-87. Basel.

Przibram, H. & Megusar, F. 1912: Wachstummessungen an *Sphodromantis bioculata* Burm. 1. Länge und Masse. – Arch. Entwicklungsmech. Organism., **34**: 680-741. Berlin.

Vachon, M. 1982: Les scorpions de Sri Lanka (Recherches sur les scorpions appartenant ou déposés au Muséum d'Histoire naturelle de Genève III). – Rev. suisse Zool., **89** (1): 77-114. Geneva.

Williams, S. C., 1969. Birth activities of some North American scorpions. – Proc. Califor. Acad. Nat. Sci., 4th ser., **37** (1): 1-24. San Francisco.

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