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The embryonic and postembryonic developments of *Chiromachus ochropus* (C. L. Koch, 1837) (Scorpiones, Liochelidae) from Fregate Island, Seychelles

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(with 7 figures)

Abstract

Observations have been made since the end of the 1990s on living scorpions of the species *Chiromachus ochropus* (C. L. Koch, 1837). These were collected by British biologists, on a field trip to Fregate Island, Seychelles. The total duration of embryonic development averaged 25 months. The moults necessary to reach the various juvenile instars and adulthood took place at average ages of 10, 242, 596, 925, 1763, 2310, 2661, 2957, 3313 and 3773 days. These developmental periods are remarkable longer than those previously observed in any other species of scorpions. Eleven instars were observed among the specimens that had been reared in captivity. This is unique among scorpions. Morphometric growth values of the different instars are significantly inferior to those in other species studied. A significantly larger size was observed in some of the females collected in the field, suggesting the occasional existence of at least one extra instar.

K e y w o r d s: Scorpiones, *Chiromachus ochropus,* life history, Fregate Island, Seychelles.

Introduction

Since the middle 1970s, numerous observations have been made on the biology of several species of scorpions (Lourenço 2002). Nevertheless, observations on the entire life cycles of most scorpions species and, in particular, on species belonging to the family Liochelidae, are extremely scarce. The taxonomic status and pattern of distribution of *Chiromachus ochropus (*C. L. Koch, 1837*)*, have, however, been well defined in recent years (Lourenço 1983, 1989).

Early embryological studies on scorpions carried out by Laurie (1896) included *C. ochropus* (as *Ischnurus ochropus*). Subsequently, these embryological studies were extended by Vachon (1950). Although Vachon's re-

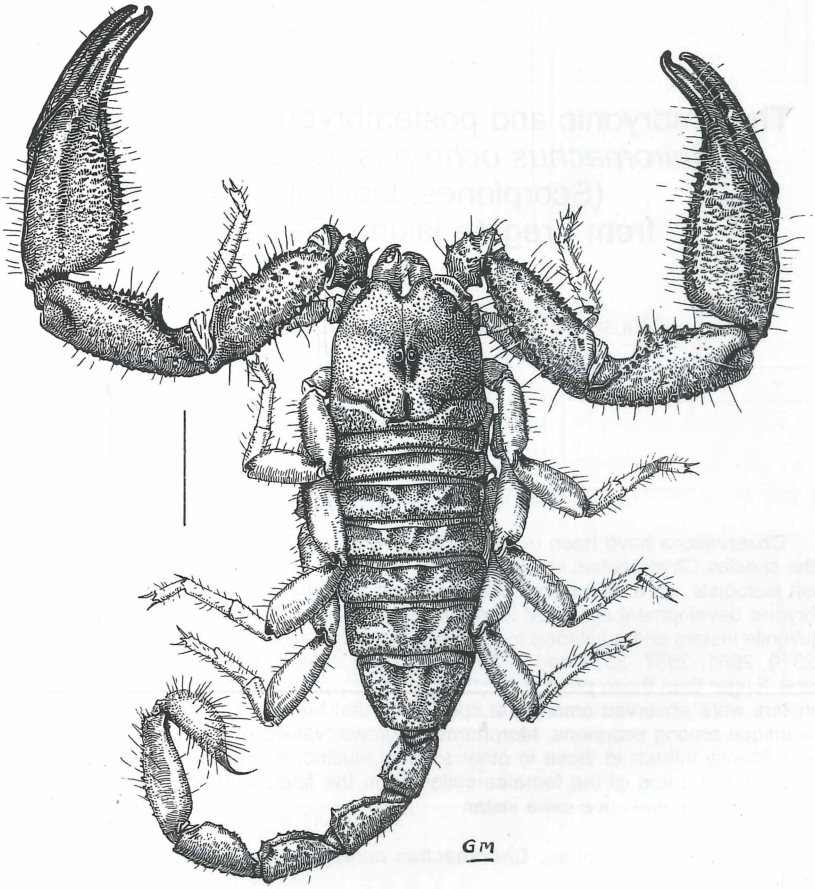


Fig. 1. *Chiromachus ochropus* (C. L. Koch), adult ♂, habitus (scale bar = 1 cm).

search was carried out only on preserved specimens, it brought out new and interesting information about the embryological development of this species, and also about the katoikogenic model proposed by Laurie (1896).

During a field trip to Fregate Island in 1999, British biologists of the Zoological Society of London collected, with the help of local research people, several living specimens of *C. ochropus*. This was part of the 'Fregate Island Invertebrate Programme of the Zoological Society of London'. The specimens collected have been maintained alive under laboratory conditions for several years, and some are still alive. Specimens have been shared with other scientific institutions and, the senior author (WRL) received 11 specimens in 2005, some of which died during the transfer. The specimens yet living, have been the subject of intense biological observations. Some couples mated and bred in captivity, and several instars of their development were observed. At least two specimens born at the Zoological Society of London in 2000 and 2001 concluded their biological cycles in Paris, between 2005 and 2010. We therefore decided to summarize here the available data on the development and growth factors of this species.

Material and methods

The scorpions were reared by standard methods in plastic terraria of different sizes. These contained layers 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 *Tenebrio molitor* L. larvae, was provided once every 7 to 10 days. Temperatures ranged from 25 to 27 °C and the humidity was around at 70-80 % (R.H.). After each moult, the exuvia were removed from the terrarium. Morphometric growth values of these exuvia, and of the individuals that died in captivity, were measured. Three parameters were recorded: carapace length, the length of metasomal segment V, and of the movable finger (Lourenço 1979, 2002). The growth factor (Dyar's constant) between succeeding instars was determined for every individual from each of these three structures (by dividing the dimension at one instar stage by the dimension of the previous instar). The average growth factor per moult for each structure was then calculated from the pooled data. The available voucher material from the laboratory-reared specimens is now deposited in the Zoologisches Museum Hamburg.

Characteristics of *Chiromachus ochropus*

C. ochropus is a large species when compared with most other species of the family Liochelidae. Males and females measure up to 105-120 mm in total length (Figs 1, 2). C o l o r a t i o n: basically reddish-brown to dark brown. Metasomal segments reddish-brown; vesicle reddish-yellow; aculeus reddish-yellow with the tip reddish. Chelicerae yellowish; base of fingers dark reddish. Pedipalps reddish-brown. Venter and sternites dark yellow; pectines and genital operculum yellowish; legs yellowish. M o r p h o l o g y: body and appendages moderately to weakly granulated. Anterior margin of carapace strongly emarginated. Sternum wider than long. Genital operculum formed by two semi-triangular plates in males, and a single triangular plate in females. Pectinal tooth count 9 to 11 in males and 7 to 10 in females; mean 10 in males, 8 in females. Trichobothriotaxy type *C*; orthobothriotaxic (Vachon, 1974). Legs: tarsi with 2 rows of long setae. Hemispermatophore with the distal lamina long and moderately complex (Lourenço 1983).

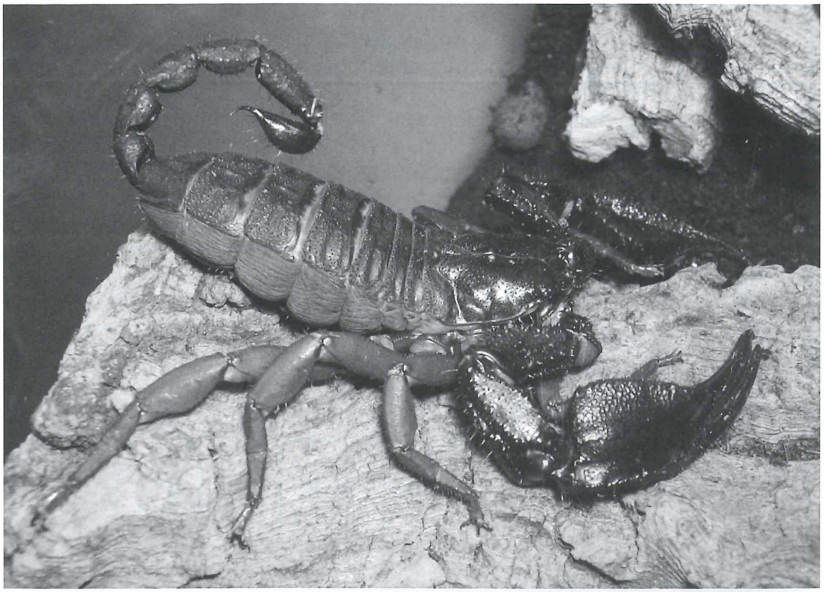


Fig. 2. Adult ♀ of *Chiromachus ochropus* (C. L. Koch) in terrarium (photo E. Ythier).

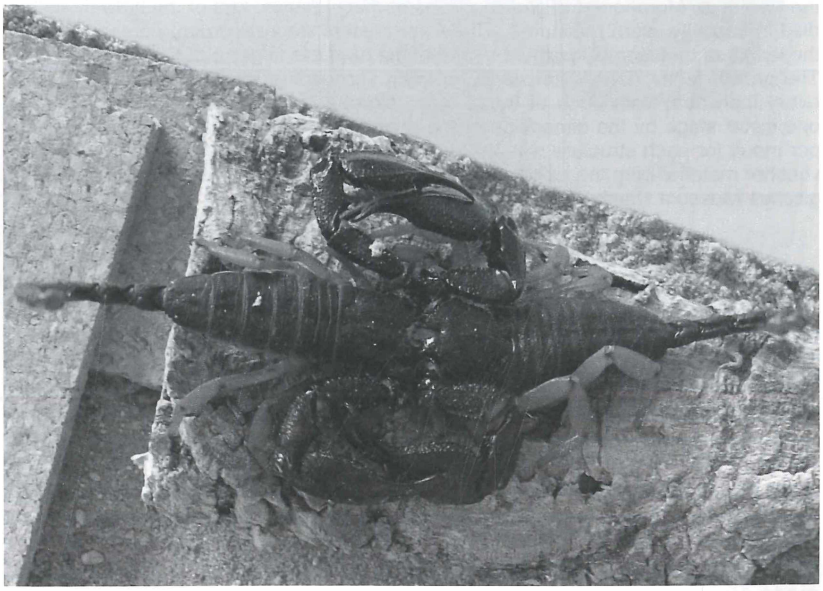
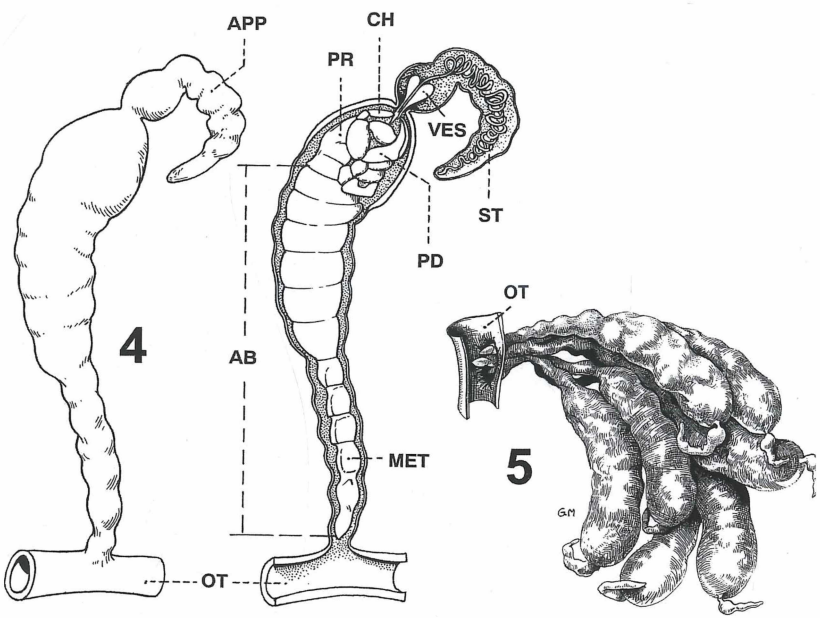


Fig. 3. Mating behaviour of of *Chiromachus ochropus* (C. L. Koch). ♂ on the left, ♀ on the right (photo W. R. Lourenço).

Population densities appear to be high on several of the Seychelles islands where *C. ochropus* is distributed. We cannot, however, estimate the relative position of *C. ochropus* within the guild, because very little is known about *Lychas braueri* (Kraepelin, 1896), the only other scorpion species native to the Seychelles (Lourenço 1996). Not much is known about the diel behaviour of *C. ochropus* in the field (Cloudsley-Thompson 1981). Under laboratory conditions, however, the scorpions move slowly and only leave their retreats at night. Their predatory technique is of the 'sit-and-wait' type. They remain motionless with the pedipalp fingers opened. Cannibalism is probably uncommon in the natural habitat, since under laboratory conditions, it was observed only among individuals in their second instar. Individuals of the subsequent instars were maintained together in numbers varying from 4 to 6, but no cannibalism was observed in these cases.



Figs 4-5. *Chiromachus ochropus* (C. L. Koch). **4** - Morphology of the katoikogenic diverticulum: on the left the external structure; on the right diverticulum with an embryo: APP, appendix; CH, chelicerae; VES, vesicular organ of chelicerae; ST, spiral tubule; PR, prosoma; AB, opisthosoma; MET, metasoma, OT, ovariuterine tubule, PD, pedipalp (modified from Vachon 1950); **5** - a group of seven diverticula.

Fig. 6. *Chiromachus ochropus* (C. L. Koch), ♀, with first instar brood (photo E. Ythier).

Laboratory observations - Developmental periods

COURTSHIP AND MATING

Courtship and sperm transfer in *C. ochropus* were observed in some couples and proved to be rather simple. The male approached the female and grasped her pedipalpal chelae with his own chelae fingers. No real form of dance took place. Only very short forward and backward movements were observed. This process lasted for several minutes until ejection of the spermatophore took place. The male then lead the female to position her genital aperture over the spermatophore, and the female takes up the sperm (Fig. 3). Once sperm transfer had been completed, the partners usually separated.

EMBRYONIC AND POSTEMBRYONIC DEVELOPMENTS

The family Liochelidae exhibits complex gradients of embryonic development, with well-developed diverticula (Figs 4, 5) corresponding to the katoikogenic model proposed by Laurie (1896). After mating, females of *C. ochropus* gave birth to broods composed of 60 to 110 neonates (Fig. 6). The total duration of embryonic development ranged from 22 to 28 months,

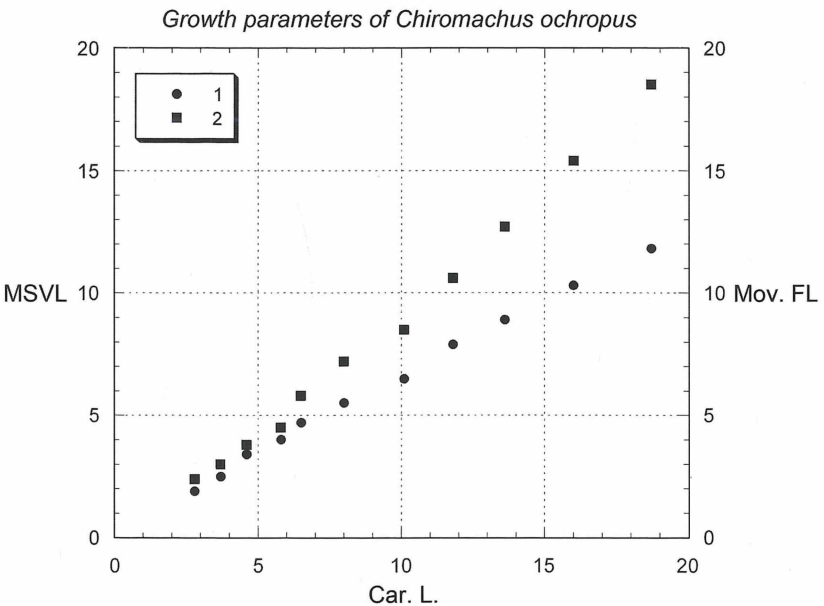


Fig. 7. The distribution of morphometric values (in mm) in juvenile and adult instars of *Chiromachus ochropus* (C. L. Koch). Car. L. = carapace length. M.S.V.L. = metasomal segment V length. Mov. F.L. = movable finger length. **1** = Car. L. vs. M.S.V.L.; **2** = Car. L. vs. Mov. F.L.

averaging 25 months and appears to be longer than that observed for other species of the family Liochelidae (Lourenço 2002). After being carried on their mother's back for 8 to 16 days, the first moults of the young scorpions were observed. Juveniles began to disperse from their mother's back at the age of 20 to 40 days.

Subsequent moults took place at different ages. The average number of days occupied by the development of each of these were as follows: - second moult (242 days), third (596), fourth (925), fifth (1763), sixth (2310), seventh (2661), eighth (2957), nineth (3313) and tenth moult (3773 days). Males may become adult from the nineth moult. Females become adult from the tenth moult; some very large females observed in the field suggests, however, that an extra moult may have occurred in these individuals (Lourenço et al. 2010). The duration of different instars observed in laboratory conditions can vary greatly, even among members of the same brood. These developmental periods are remarkably longer than those observed in any other species of scorpion. Eleven instars were observed among the specimens reared in captivity - a unique number among scorpion species.

Table 1. Average morphometric values (in mm) for juvenile and adult instars of male and female *Chiromachus ochropus*.

	Car. L.	**M.S.V.L.**	**Mov. F.L.**	**G.V.**	**No**
Instar I				-	
Instar II	2.8	1.9	2.4	*	56
Instar III	3.7	2.5	3.0	1.32/1.32/1.25	45
Instar IV	4.6	3.4	3.8	1.24/1.18/1.27	36
Instar V	5.8	4.0	4.5	1.26/1.18/1.18	22
Instar VI	6.5	4.7	5.8	1.12/1.23/1.29	20
Instar VII	8.0	5.5	7.2	1.23/1.17/1.24	18
Instar VIII	10.1	6.5	8.5	1.26/1.18/1.18	14
Instar IX	11.8	7.9	10.6	1.17/1.21/1.25	06
Instar X	13.6	8.9	12.7	1.15/1.13/1.20	06
Instar XI(L & F-adult)	16.0	10.3	15.4	1.18/1.16/1.21	05
Instar XII(F-adult)	18.7	11.8	18.5	1.17/1.15/1.20	04
			AGV	1.21/1.19/1.23	

Car. L. = carapace length. M.S.V.L. = metasomal segment V length. Mov. F.L. = movable finger length. G.V. = growth values. AGV = average growth values. N° =number of individuals measured, including exuvia. L = Laboratory adult. F = Field adult.

* Growth values between instars I and II can be considered as atypical due to very strong morphological differences between the juveniles of these instars. For this reason these values were not considered in the final calculations.

GROWTH FACTORS

The theoretical morphometric growth factor for arthropods, as defined by Dyar (1890) and Przibram & Megusar (1912) is 1.26. Growth parameters

of *C. ochropus*, based on morphometric values (measured on both dead individuals and on exuvia), are shown in Figure 7. Three parameters were considered: the length of the carapace, that of the movable finger, and of metasomal segment five. The results obtained from morphometric growth values in the different instars of *C. ochropus* are less marked than those observed among other species of the family Liochelidae in captivity (Lourenço 2002, Lourenço et al. 2010).

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