REVUE SUISSE DE ZOOLOGIE 112 (4): 869-941; décembre 2005

Hemiscorpiidae (Scorpiones) from Iran, with descriptions of two new species and notes on biogeography and phylogenetic relationships

Lionel MONOD[1] & Wilson R. LOURENÇO[2]

[1] Muséum d'histoire naturelle, route de Malagnou 1, case postale 6434, CH-1211 Genève 6, Switzerland. E-mail: liocheles@gmail.com

[2] Département de Systématique et Evolution, USM 0602 – CP 53, Section Arthropodes (Arachnologie), Muséum National d'Histoire Naturelle, 61 rue de Buffon, F-75005 Paris, France. E-mail: arachne@mnhn.fr

Hemiscorpiidae (Scorpiones) from Iran, with descriptions of two new species and notes on biogeography and phylogenetic relationships. - The family Hemiscorpiidae is closely related to the Liochelidae. Within the Hemiscorpiidae, the Oriental species are particularly interesting. Most of them exhibit highly derived characters in comparison to their African relatives. Males possess a strongly elongated metasoma and a similarly elongated telson bearing a pair of tuberculiform processes at the base of the aculeus. Furthermore, *Hemiscorpius lepturus* Peters, 1861, which occurs in Iraq and Iran, is known to have an extremely virulent venom with cytotoxic and haemolytic components. It is responsible for severe dermonecrotic scorpionism in southern Iran. This is the only non-buthid scorpion that is potentially lethal. In this paper an overview of the species of *Hemiscorpius* in Iran is presented with revised diagnoses and descriptions. Two new species from western Iran, *H. enischnochela* sp. n. and *H. acanthocercus* sp. n., are described. The genus *Habibiella* Vachon, 1974 is synonymised with *Hemiscorpius* Peters, 1861. A thorough analysis of hemispermatophores shows close phylogenetic relationships with several genera of the family Liochelidae. A hypothesis on the geological events that probably triggered the present distribution of *Hemiscorpius* is finally proposed.

Keywords: Scorpiones - Hemiscorpiidae - *Hemiscorpius* - new species - new synonymy - Iran - hemispermatophore - Liochelidae.

INTRODUCTION

The family Hemiscorpiidae Pocock, 1893 was formerly considered as a subfamily (Hemiscorpiinae) of the Scorpionidae Latreille, 1802 (Fet, 2000). Sissom (1990) criticised the placement of the Hemiscorpiinae in the Scorpionidae, but did not suggest an alternative. Stockwell (1989) first suggested the transfer of Hemiscorpiinae directly from the Scorpionidae to the Ischnuridae, where they retained their subfamily rank. Recently Lourenço (2000) and Prendini (2000) simultaneously elevated the

Manuscript accepted 11.08.2005

Hemiscorpiinae to family level. While Lourenço did not give any justification, Prendini provided a detailed phylogenetic analysis where he demonstrated that Hemiscorpiidae is the sister group of Ischnuridae Simon, 1879, now Liochelidae Fet & Bechly, 2001. Solegad & Fet (2003) confirmed the phylogeny of Scorpionoidea established by Prendini (2000), but downgraded the Hemiscorpiidae from family to subfamily rank under Liochelidae. Until the discussion is settled, we decided to follow Lourenço's and Prendini's view and consider the hemiscorpiids as a family.

Two genera were traditionally listed in the family Hemiscorpiidae (see Fet, 2000), *Habibiella* Vachon, 1974 and *Hemiscorpius* Peters, 1861a. *Habibiella* is a monotypic genus, the type species, *H. gaillardi*, was described by Vachon (1974) from a single female collected in eastern Iran. This genus is here placed in the synonymy of *Hemiscorpius*. The genus *Hemiscorpius* in the traditional sense includes six species which occur from Somalia to Pakistan, most of them in the Middle East (Fet, 2000). These are: *H. arabicus* (Pocock, 1899a), *H. lepturus* Peters, 1861a, *H. maindroni* (Kraepelin, 1900), *H. persicus* Birula, 1903, *H. socotranus* Pocock, 1899b and *H. tellinii* Borelli, 1904. Species of *Hemiscorpius* and *Habibiella gaillardi* (now under *Hemiscorpius*) are morphologically very similar and were distinguished only by their trichobothriotaxy. *Habibiella* is neobothriotaxic major, with 10-12 trichobothria on the ventral side of the pedipalp patella instead of 3 as in the species previously comprising *Hemiscorpius*, and 15 trichobothria on the external side of the pedipalp patella instead of 13.

Three species belonging to the family Hemiscorpiidae are known to occur in Iran: *H. gaillardi*, *H. lepturus* and *H. persicus*. *H. lepturus* is of particular medical interest. This species is the only dangerous and potentially lethal scorpion that does not belong to the family Buthidae. It is responsible for significant scorpionism problems in the southern provinces of Iran. The venom of *H. lepturus* is highly cytotoxic and haemolytic and can cause serious wounds and skin inflammations whereas other scorpions have a neurotoxic venom. The deep dermonecrotic ulcers and blisters caused by such a sting are slow and difficult to heal and therefore usually result in very unpleasant scars. Severe complications such as serious haemolysis, internal haemorrhages, secondary renal failure and death were also reported (Radmanesh, 1990, 1998). Venoms with such cytotoxic and hemolytic effects are also quite uncommon in spiders and only known in three genera, i. e. *Cheiracanthium* C.L. Koch, 1839 (Miturgidae), *Loxosceles* Heineken & Lowe, 1832 (Sicariidae) and *Sicarius* Walckenaer, 1847 (Sicariidae), (Filmer, 1999). While severe envenomations in humans by *Cheiracanthium* and *Sicarius* are not known, the virulent poison of the Brown Recluse Spider, *Loxosceles reclusa* Gertsch & Mulaik, 1940, and its enzymatic activities have been extensively studied (Anderson, 1998; Butz *et al.*, 1971; Dillaha *et al.*, 1964; Foil *et al.*, 1979; Patek *et al.*, 1994). Among the 13 species of *Loxosceles* present in the United States (at least 5 of them are associated with necrotic arachnidism), *L. reclusa* is most commonly responsible for dermonecrotic arachnidism in North America. Brown spiders are also of significant clinical concern in South America, with *L. laeta* (Nicolet, 1849) being responsible for several deaths each year. In Iran cases of scorpion envenomation with cutaneous and viscerocutaneous reactions are usually attributed to the species *H. lepturus*. Species of *Hemiscorpius* are morphologically very close to each other and difficult to distinguish for a non-specialist, therefore we assume that *H. lepturus* is probably not the only species responsible for all envenomations in that country. Other *Hemiscorpius* species probably possess venoms with similar necrotic effects.

As stated by Fet (2000), there is no recent revision and no dichotomic key for *Hemiscorpius*. In the past 40 years several checklists of scorpions from Iran, which also include *Hemiscorpius* species, have been published (Vachon, 1966; Habibi, 1971; Farzanpay & Pretzmann, 1974; Pérez-Minnocci, 1974; Farzanpay, 1988; Kinzelbach, 1985; Kovařík, 1997). However, neither precise descriptions, nor specific diagnoses were included in these publications. The extensive cladistic analysis of Scorpionoidea by Prendini (2000) gives a precise diagnosis and description for the family, but not for the two species used in that study, i. e. *H. lepturus* and *H. maindroni*. Early descriptions are very short and not accurate enough, and therefore do not allow species identification. The present paper gives an overview of the hemiscorpiids of Iran, with revised diagnoses and redescriptions of *H. gaillardi*, *H. lepturus* and *H. persicus*. *H. enischnochela* sp. n. and *H. acanthocercus* sp. n. are described from the region of Bandar Abbas, Hormozgan Province, south-eastern Iran. This study also allowed to clarify the taxonomic position of the enigmatic genus *Habibiella*, which is here synonymised with the genus *Hemiscorpius*. Strong evidence of a close phylogenetic relationship with the liochelids *Iomachus politus* Pocock, 1896, *Hadogenes* Kraepelin, 1894 and *Opisthacanthus* (*Opisthacanthus*) Peters, 1861b is pointed out by the examination of hemispermatophore morphology. Finally a hypothesis on the geological events that presumably triggered the evolution and present distribution of the family is proposed.

MATERIAL AND METHODS

Illustrations were produce by using a Wild M5 stereo-microscope with a drawing tube. Trichobothrial notations and terminology of metasomal carination follow Vachon (1974), measurements follow Stahnke (1970) and are given in mm. Additional morphological terminology mostly follows Hjelle (1990) and Sissom (1990), terminology of carination of pedipalpal chela follows Prendini (2000). Hemispermatophore terminology is modified from the terminology applied by Lamoral (1979) and was used by Monod & Volschenk (2004). The distribution map was generated with ArcView® GIS 3.1, maps and drawings were subsequently edited in Adobe Illustrator® 8.0 and Adobe Photoshop® 6.0.

List of acronyms

BPBM Bernice P. Bishop Museum, Honolulu, Hawaii.
CAS Californian Academy of Sciences, San Fransisco, USA.
MHNG Muséum d'histoire naturelle, Genève, Switzerland.
MNHN Muséum National d'Histoire Naturelle, Paris, France.
NHMW Naturhistorisches Museum Wien, Austria.
ZISP Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.
ZMB Zoologisches Museum, Humboldt Universität, Berlin, Germany.

SYSTEMATICS

Hemiscorpiidae Pocock, 1893

Hemiscorpinii Pocock, 1893: 306, 308. Type genus *Hemiscorpius* Peters, 1861a.

Diagnosis (modified from Prendini, 2000). The Hemiscorpiidae can be distinguished from all other scorpionoid taxa by their trichobothriotaxy: trichobothria *ib* and *it* of the pedipalp chela are situated midway on the finger, whereas both are at the base of the fixed finger in all other scorpionoid taxa except Nebinae and *ib* is situated basally and *it* distally on the fixed finger in Nebinae, Diplocentridae. Hemiscorpiids also differ from other scorpionoid taxa, except for Heteroscorpionidae and Urodacidae, by their metasomal segments I-IV, which bear a single ventromedian carina equally developed on all segments. Hemiscorpiidae can be distinguished from the Heteroscorpionidae and Urodacidae by the following characters: (1) 3 pairs of lateral ocelli present; (2) median ocular tubercle shallow; (3) movable cheliceral finger with distal external and distal internal teeth approximately equal in size and closely opposed; (4) pedipalp chela fingers with 2 primary rows of denticles often fused at the base; (5) trichobothrium *db* located on internal surface of fixed finger; (6) trichobothrium *Db* located basally on dorsal surface of manus; (7) trichobothrium *Dt* located at proximal end of fixed finger; (8) no accessory trichobothria in *v* series of chela; (9) telson vesicle of male elongated and laterally compressed; (10) hemispermatophores with a double lamellar hook and a complex median capsular structure.

Remarks. Telson vesicles of mature *Hemiscorpius leturus* males are unusually elongated, laterally compressed, and bear a pair of distal lobes at the base of aculeus (Fig. 1A-B), whereas females possess bulky telsons, which are laterally not compressed and have no distal lobes. Subadult males do not have an extremely elongated metasoma and a modified telson like mature males have, their metasoma and telson are just slightly more elongated than in females. These secondary sexual characters appear only in the last developmental instar. In Prendini's (2000) cladistic interpretation of relationships within the superfamily Scorpionoidea this very unusual feature is considered as a valid character for the whole family Hemiscorpiidae and is mentionned in the diagnosis: telsons of *H. lepturus* and *H. maindroni* males are described as possessing an extreme elongation and paired distal lobes. Our examination of syntypes of *Hemiscorpius maindroni* from Mascate also revealed a pronounced sexual dimorphism but not as extreme as in *H. lepturus*. Indeed *H. maindroni* males possess telsons (Fig. 1G-H) without any distal lobes or elongation as in *H. lepturus*. Therefore the species identified as *H. maindroni* in Prendini's cladistic revision of the superfamily Scorpionoidea (2000) undoubtedly belongs to another species. All the other non-Iranian hemiscorpiids examined, i. e. *H. socotranus*, *Hemiscorpius* spp. from Somalia, Eritrea and Djibouti possess a simple telson and a less elongated metasoma than in *H. maindroni* (Fig. 27A-B). The Iranian hemiscorpiids *H. acanthocercus* sp. n., *H. enischnochela* sp. n., *H. lepturus* and probably also *H. gaillardi* can therefore be placed together in the *H. lepturus* species complex. However, the Iranian *H. persicus* does not belong to this group. The mature male holotype studied does not have modified metasoma and telson.

Prendini (2000) described the hemispermatophores of hemiscorpiids as possessing a single lamellar hook. In his data matrix (Table 3, p. 6), the character 90 (hemispermatophore, lamellar hook) is coded 0 (single hook) for both *H. lepturus* and *H. maindroni*. Mature males in the material examined have been systematically dissected in order to remove and study their hemispermatophores. Several hemispermatophores in excellent shape of *H. lepturus*, *H. acanthocercus* and *H. maindroni* have been obtained. All of them bear a double lamellar hook, a very unusual feature that was so far only recorded for the liochelid genus *Hadogenes*. Unfortunately this character cannot be assessed for *H. enischnochela* sp. n., *H. persicus* and *H. socotranus*. The only available mature male of *H. enischnochela* had been dissected before but the hemispermatophore was not found inside the vial and is probably lost. We were not allowed to dissect the type of *H. persicus* and no other specimens of this species were available to us. The only available mature male of *H. socotranus* had poorly preserved paraxial organs from which it was impossible to extract hemispermatophores. Nevertheless the character "double lamellar hook" is used in our diagnosis of the family. In liochelids morphometric proportions of hemispermatophores and shape of the capsular median structure are usually the only features that vary between genera. The single lamellar hook is a constant character within the family, except for *Hadogenes*, species of which possess hemispermatophores with a double lamellar hook. According to Prendini (2000) *Hadogenes* and *Cheloctonus* are the more basal liochelid genera and Hemiscorpiidae is the basal sister-group of Liochelidae. The double lamellar hook can therefore be considered as a plesiomorphy for Hemiscorpiidae and Liochelidae, and the single lamellar hook is synapomorphic for Liochelidae except *Hadogenes*. Therefore the probability that the double lamellar hook is present in the whole Hemiscorpiidae is strong. Furthermore a double lamellar hook was assessed for hemiscorpiids from Oman by Dr. Graeme Lowe (pers. comm.) who is currently carrying out a revision of the scorpion fauna of Oman (Lowe, in prep.). This is another argument for including the double lamellar hook into the family diagnosis.

Hemiscorpius **Peters, 1861**

Hemiscorpius Peters, 1861a: 426. Type species by monotypy *Hemiscorpius lepturus* Peters, 1861a.

Habibiella Vachon, 1974: 952, **syn. n.** Type species *Habibiella gaillardi* Vachon, 1974.

Remarks. Prendini (2000) suggested in his revision of the superfamily Scorpionoidea that *Habibiella* should be considered as a synonym of *Hemiscorpius*, because the monophyly of *Hemiscorpius* was not supported in any of his cladistic analyses. However, he did not formally propose this taxonomic change and listed both *Habibiella* and *Hemiscorpius* in the family Hemiscorpiidae. The genus *Habibiella* is monotypic and only known from a single female. It can be distinguished from *Hemiscorpius* only on the basis of its trichobotriotaxy, 15 external trichobothria on the pedipal patella instead of 13, and 10-12 ventral trichobothria on the pedipalp patella instead of 3. The study of a mature male from the Natural History Museum of Vienna that belongs to this genus and that is described here under *Hemiscorpius enischnochela* sp. n. allowed to re-evaluate the taxonomic status of *Habibiella*. Metasoma and telson of this specimen possess exactly the same morphology encountered in *Hemiscorpius lepturus*, i. e. extremely elongated metasoma, vesicle strongly elongated and bearing a pair of blunt tuberculiform projections at the base of the short and strongly curved aculeus. The African and Arabian hemiscorpiids examined, i. e. *H. maindroni* and *H. socotranus*, do not have such features. Species of "*Habibiella*" are therefore more closely related to *Hemiscorpius lepturus*, the type species of *Hemiscorpius*, than *H. lepturus* is to the other *Hemiscorpius* species. *Habibiella* is therefore considered as a junior synonym of *Hemiscorpius*.

Diagnosis. With *Habibiella* now in synonymy with *Hemiscorpius*, the family Hemiscorpiidae becomes monotypic and its diagnosis is also applicable to the genus.

Hemiscorpius acanthocercus sp. n. Figs 1C-D, 2-7, 36

Material examined. Holotype: ♂, IRAN (Hormozgan), Abad-Geno, 38 km N Bandar Abbas, 3.IV.1972, K. Bilek, *NHMW 4718 (39)*. Paratypes: 1 ♂, 1 ♀, no locality specified, H. Löffler, Austrian Iran Expedition 1949-1950, *MHNG*. 2 ♂ juv., 2 ♀ juv., no locality specified, H. Löffler, Austrian Iran Expedition 1949-1950, *NHMW*. 1 ♂ juv., IRAN (Hormozgan), ca. 50 km N Bandar Abbas, 4.IV.1970, F. Ressl, *NHMW 3393*. 1 ♂ juv., 1 ♀ juv., IRAN (Hormozgan), ca. 41 km N Bandar Abbas, 7.IV.1972, G. Pretzman & A. Konetschnig, *NHMW 3394*. 1 ♂ subadult, 2 ♂ juv., 2 ♀, 1 ♀ juv., IRAN (Hormozgan), 115 km E Bandar Abbas, 27.III.1972, K. Bilek, *NHMW 4716*. 1 ♂ juv., 1 ♀, IRAN (Hormozgan), 22 km N Bandar Abbas, 4.IV.1972, K. Bilek, *NHMW 4717*. 2 ♀ juv., same data as for holotype, *NHMW 4718*. 1 ♂ juv., 1 ♀, 1 ♀ juv., IRAN (Hormozgan), 40 km N Bandar Abbas, 7.IV.1972, K. Bilek, *NHMW 4719*. 1 ♂ subadult, IRAN (Hormozgan), 41 km N Bandar Abbas, 20.IV.1974, G. Pretzman, *NHMW 4720*. 1 ♂ subadult, 2 ♀, IRAN (Hormozgan), 65 km N Bandar Abbas, 30.III.1972, K. Bilek, *NHMW 4721*. 1 ♀ juv., IRAN (Hormozgan), 22 km N Bandar Abbas, 1974, G. Pretzman, *NHMW 21142*. 1 ♂ imm., 1 ♀, 1 ♀ juv., IRAN (Hormozgan), 38 km N Bandar Abbas, 28.III.1972, K. Bilek, *NHMW 21143*. 2 ♀, IRAN (Hormozgan), 65 km N Bandar Abbas, 4.IV.1972, K. Bilek, *NHMW 21144*.

Distribution. Known from the surroundings of Bandar Abbas, Hormozgan Province, eastern Iran (Fig. 36).

Etymology. The name *acanthocercus* is a construct from the Greek words *akantha* [thorn, prickle] and *kerkos* [tail]. The name is an invariable noun in apposition and refers to the metasomal dorsal carinae of males, which have numerous strong spiniform granules, and to the telson of males which also bears numerous small spiniform granules, especially at the posterior extremity, on the blunt tuberculiform processes at the base of the aculeus.

Diagnosis. (1) Carapace longer than wide, shagreened and finely granular, with small smooth patches; lateral margins with small spiniform granules below lateral ocular tubercles; superciliary carinae finely granular; (2) pedipalps stout and bulky, chela fingers slightly shorter than or equal in length to chela manus; (3) internal protuberance of pedipalpal patella with internodorsal carina bearing 1-2 strong spiniform granules; (4) pedipalp patella orthobothriotaxic, external side with 13 trichobotria (1 *est* and 2 *esb*), ventral side with 3 trichobothria; (5) metasoma of males elongated and slender, with dorsal carinae bearing numerous strong spiniform granules, and ventral and ventrolateral carinae of segments IV-V bearing spiniform granules; (7) telson of males strongly elongated, bearing a pair of blunt tuberculiform processes with small spiniform granules at base of aculeus; (8) metasoma of females with dorsal carinae of segments I-IV and ventral and ventrolateral carinae of segment V bearing strong spiniform granules; (9) hemispermatophore with strong double lamellar hook located above distal transverse ridge, very close to it, and pointing anteriad.

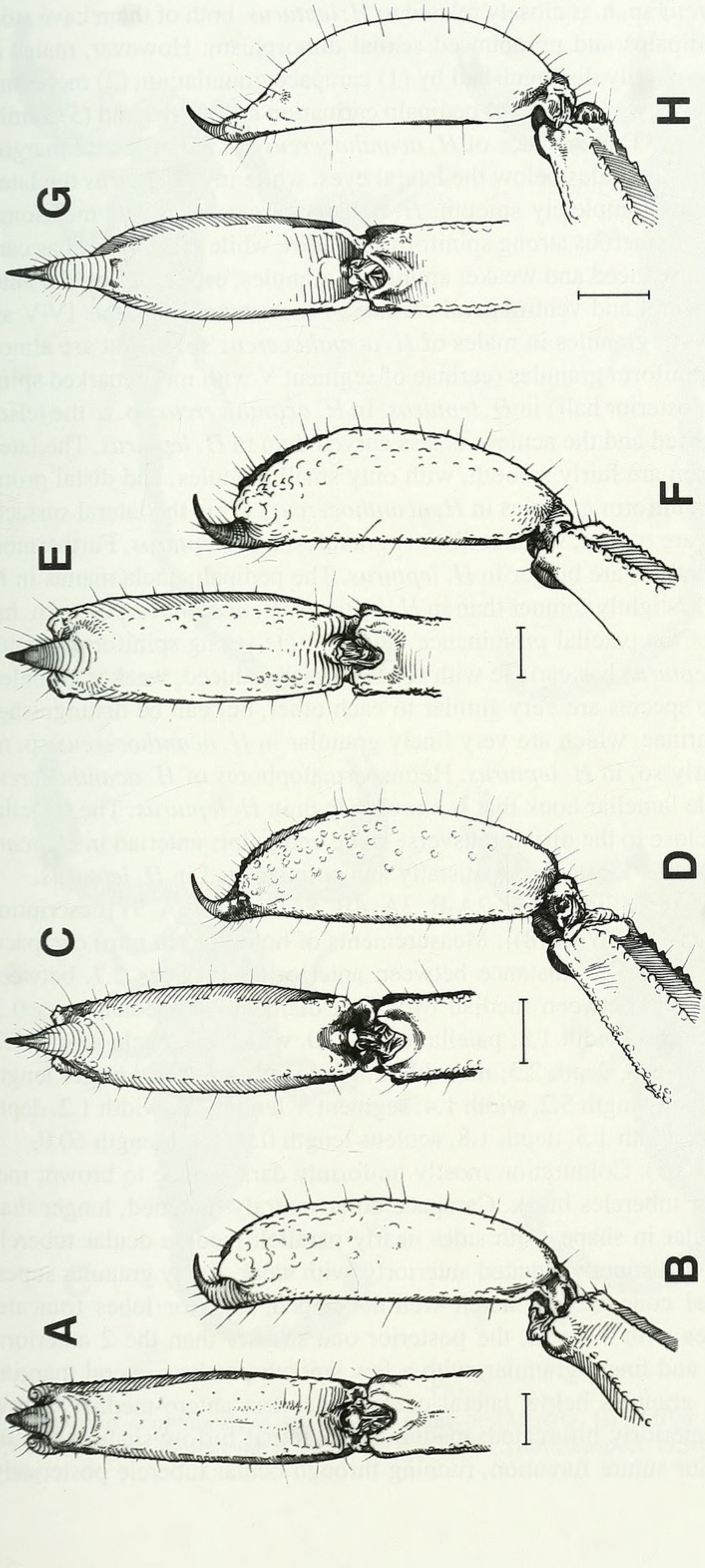

FIG. 1

Hemiscorpius spp., males: telsons, ventral face (A, C, E, G), lateral face (B, D, F, H). A-B, *Hemiscorpius lepturus* (*MNHN-RS* 5232); C-D, *Hemiscorpius acanthocercus* sp. n. (paratype, *MHNG*, H. Löffler coll.); E-F, *Hemiscorpius enischnochela* sp. n. (holotype); G-H, *Hemiscorpius maindroni*, (syntype, *MNHN-RS* 4328). Scale lines, 1 mm.

H. acanthocercus sp. n. is closely related to *H. lepturus*, both of them have stout orthobothriotaxic pedipalps and pronounced sexual dimorphism. However, males of these 2 species can be readily distinguished by (1) carapace granulation, (2) metasoma carination, (3) morphology of telson, (4) pedipalp carination and shape, and (5) hemispermatophore morphogy. The carapace of *H. acanthocercus* sp. n. has lateral margins bearing small spiniform granules below the lateral eyes, while in *H. lepturus* the lateral carapace margins are completely smooth. *H. acanthocercus* sp. n. has metasomal dorsal carinae bearing numerous strong spiniform granules, while *H. lepturus* has carinae with sparse, much reduced and weaker spiniform granules, especially on the anterior segments. The ventral and ventrolateral carinae of metasomal segments IV-V are furnished with spiniform granules in males of *H. acanthocercus* sp. n., but are almost smooth, with weak spiniform granules (carinae of segment V with more marked spiniform granules in the posterior half) in *H. lepturus*. In *H. acanthicercus* sp. n. the telson of males is less elongated and the aculeus is less curved than in *H. lepturus*. The lateral surfaces of the telson are fairly smooth, with only small granules, and distal protuberances bear small spiniform granules in *H. acanthocercus*, while the lateral surfaces and distal projections are rugose, without distinct granules, in *H. lepturus*. Furthermore the distal telson projections are bigger in *H. lepturus*. The pedipalp chela manus in *H. acanthocercus* sp. n. is slightly thinner than in *H. lepturus*. *H. acanthocercus* sp. n. has intero-dorsal carina of the patellal prominence with a single strong spiniform granule (rarely 2), while *H. lepturus* has carinae with several much reduced, weaker granules. Females of these two species are very similar to each other, but can be distinguished by the superciliary carinae, which are very finely granular in *H. acanthocercus* sp. n., while smooth, or nearly so, in *H. lepturus*. Hemispermatophores of *H. acanthocercus* sp. n. possess a double lamellar hook that is stronger than in *H. lepturus*. The lamellar hook is located very close to the distal transverse ridge and points anteriad in *H. acanthocercus* sp. n., while it is located more distally and points distad in *H. lepturus*.

Description. MALE (Figs 1C-D, 2A-B, 3A, 4B, 5A-C, E-F, 6A, 7) [description based on the holotype (NHMW 4718)]. Measurements of holotype (in mm) carapace, length 5.2; posterior width 4.9; distance between anterior lateral eyes 2.7, between posterior lateral eyes 3.2, between median eyes 0.2; diameter of median eyes 0.3. Pedipalp, femur length 5.0, width 1.8; patella length 5.0, width 1.7, chela length 9.7; manus length 5.0, width 3.8, depth 2.3; movable finger length 4.6; fixed finger length 3.6. Metasoma, segment I length 5.2, width 1.4; segment V length 7.4, width 1.2, depth 1.4; vesicle length 4.6, width 1.5, depth 1.8, aculeus length 0.9. Total length 60.0.

Carapace (Fig. 3A). Colouration mostly uniformly dark orange to brown; median and lateral ocular tubercles black. Carapace dorsoventraly flattened, longer than wide, almost rectangular in shape, with sides nearly parallel; median ocular tubercle weakly developed, low, distinctly situated anteriorly, with weak, finely granular superciliary carinae; frontal concavity or notch well-developed; anterior lobes truncate; lateral ocular tubercles with 3 ocelli, the posterior one smaller than the 2 anteriors. Carapace shagreened and finely granular, with a few smooth patches; lateral margins with small spiniform granules below lateral ocular tubercles; antero-median furrow narrow, suturiform, anteriorly bifurcated; median longitudinal furrow shallow, continuous from the anterior suture furcation, running through ocular tubercle posteriorly

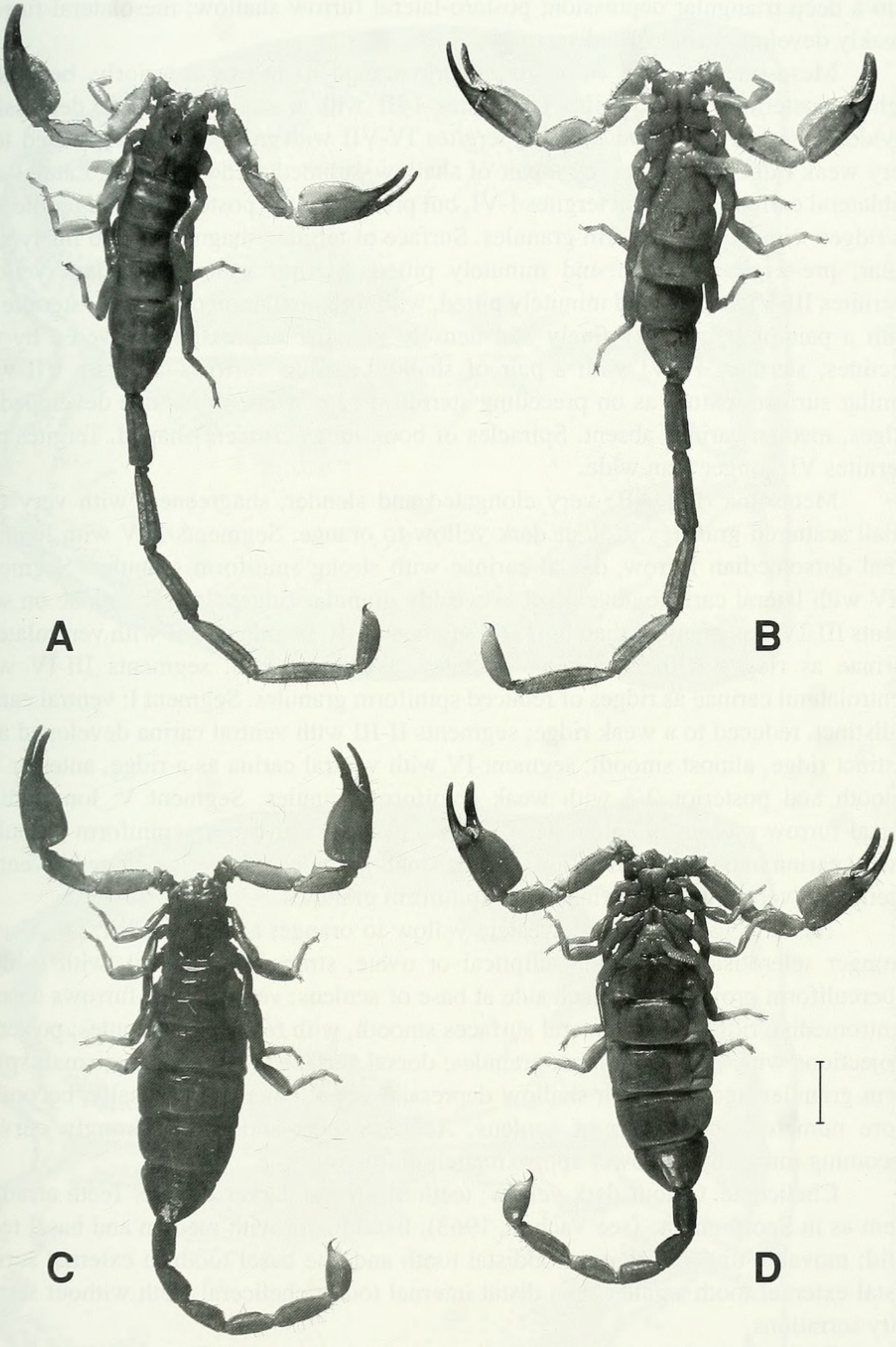

FIG. 2
Hemiscorpius acanthocercus sp. n. Male paratype (*MHNG*, H. Löffler coll.): A, dorsal aspect; B, ventral aspect. Female paratype (*NHMW 4719*): C, dorsal aspect; D, ventral aspect. Scale line, 5 mm.

into a deep triangular depression; postero-lateral furrow shallow; mesolateral furrow weakly developed, almost indiscernible.

Mesosoma. Tergite colouration dark orange to brown anteriorly, becoming lighter posteriorly (dark yellow). Tergites I-III with a shallow median depression divided anteriorly by a weak ridge; tergites IV-VII with median carina reduced to a very weak ridge surrounded by a pair of shallow, submedian depressions. Lateral and sublateral carinae absent on tergites I-VI, but present on the posterior 2/3 of tergite VII as ridges with weak spiniform granules. Surface of tergites shagreened and finely granular; pre-tergites smooth and minutely pitted. Sternite colouration dark yellow. Sternites III-VI smooth and minutely pitted, without granulation or carinae; sternite III with a pair of large, very finely and densely granular depressions, covered by the pectines; sternites IV-VI with a pair of shallow median furrows. Sternite VII with similar surface texture as on preceding sternites; pair of lateral carinae developed as ridges; median carinae absent. Spiracles of book lungs crescent-shaped. Tergites and sternites VII longer than wide.

Metasoma (Fig. 4B) very elongated and slender, shagreened, with very few small scattered granules. Colour dark yellow to orange. Segments I-IV with longitudinal dorsomedian furrow, dorsal carinae with strong spiniform granules. Segments I-IV with lateral carinae developed as weakly granular ridges, lateral carinae on segments III-IV less granular than those on segments I-II. Segments I-II with ventrolateral carinae as ridges with few weak granules, almost smooth; segments III-IV with ventrolateral carinae as ridges of reduced spiniform granules. Segment I: ventral carina indistinct, reduced to a weak ridge; segments II-III with ventral carina developed as a distinct ridge, almost smooth; segment IV with ventral carina as a ridge, anterior 1/3 smooth and posterior 2/3 with weak spiniform granules. Segment V: longitudinal dorsal furrow present in anterior half, dorsal carinae with strong spiniform granules; lateral carina indistinct, visible as a row of small granules in anterior 2/3 only; ventrolateral and ventromedian carinae with spiniform granules.

Telson (Figs 1C-D, 4B). Vesicle yellow to orange; aculeus darker, tan, due to stronger sclerotisation; vesicle elliptical or ovate, strongly elongated, with a blunt tuberculiform projection on each side at base of aculeus; ventrolateral furrows absent; ventromedian ridge absent; lateral surfaces smooth, with few weak granules; posterior projections with small spiniform granules; dorsal surface with numerous small spiniform granules and a median shallow depression. Few macrosetae basally, becoming more numerous near base of aculeus. Aculeus short and stout, strongly curved, becoming markedly narrower approximately midway.

Chelicerae. Colour dark yellow; teeth of fingers darker orange. Teeth arrangement as in Scorpionidae (see Vachon, 1963); fixed finger with median and basal teeth bifid; movable finger with one subdistal tooth and one basal tooth in external series; distal external tooth smaller than distal internal tooth; cheliceral teeth without secondary serrations.

Pedipalp stout and bulky. Pedipalp coxa and femur (Fig. 5A, E-F). Internoventral margin of coxa with strong spiniform granules. Dorsal surface of femur predominantly dark yellow-orange, carinae darker, orange. Femur stout (length less than 2.5 times its width), pentacarinate, with 4 distinct carinae; internodorsal carina

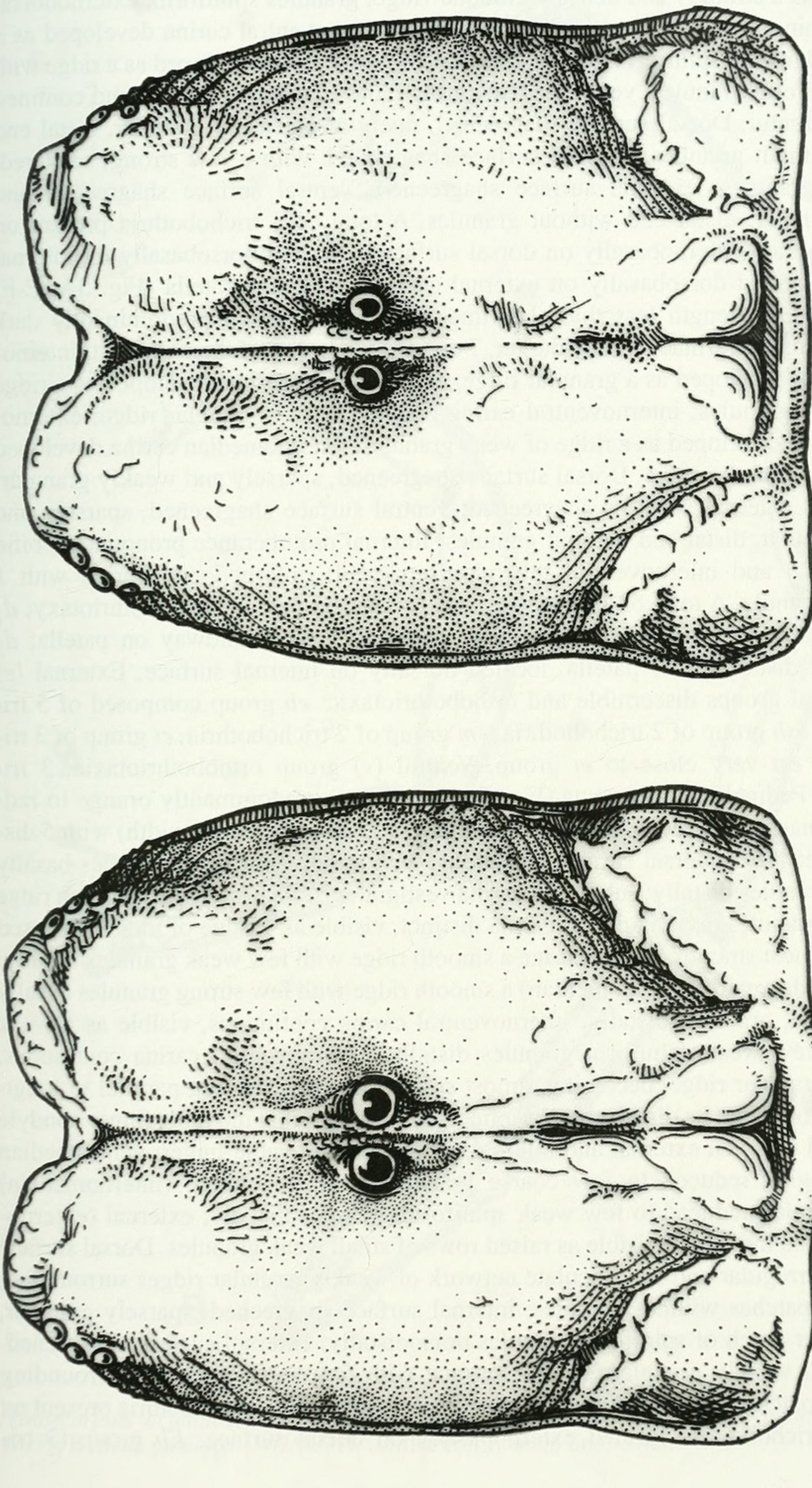

FIG. 3

Hemiscorpius acanthocercus sp. n., carapace, dorsal aspect: A, male holotype (*NHMW 4718*); B, female paratype (*NHMW 4719*). Scale line, 1 mm.

developed as a strongly and densely granular ridge, granules spiniform; externodorsal carina forming a ridge with spiniform granules; internoventral carina developed as a granular ridge with spiniform granules; externoventral carina developed as a ridge with strong spiniform granules; ventromedian carina reduced to few granules and confined to base of femur. Dorsal surface shagreened, finely and densely granular, distal end smooth, without granules; internal surface shagreened, with a few strong, scattered, spiniform granules; external surface shagreened; ventral surface shagreened and weakly granular, distal end without granules. A total of 3 trichobothria present on femur; *d* located externobasally on dorsal surface; *i* located dorsobasally on internal surface; *e* located dorsobasally on external surface. Pedipalp patella (Fig. 5A, E-F) stout and bulky (length less than 2.5 times its width). Colour predominantly dark yellow to orange; carinae slightly darker. 7 carinae present, 6 of them distinct; internodorsal carina developed as a granular ridge; externodorsal carina developed as a ridge of indistinct granules; internoventral carina developed as a granular ridge; externoventral carina developed as a ridge of weak granules; externomedian carina developed as a weakly granular ridge. Dorsal surface shagreened, sparsely and weakly granular; internal and external surfaces shagreened; ventral surface shagreened, sparsely and weakly granular, distal end without granules. Internal protuberance pronounced, bifid (internodorsal and internoventral tubercles separated), internodorsal carina with 1 spiniform granule. A total of 19 trichobothria present on patella, orthobothriotaxy; d_1 located basally, external to internodorsal carina; d_2 located midway on patella; d_3 absent; *i* in distal half of patella, located dorsally on internal surface. External (*e*) trichobothrial groups discernible and orthobothriotaxic: *eb* group composed of 5 trichobothria, *esb* group of 2 trichobothria, *em* group of 2 trichobothria, *et* group of 3 trichobothria; *est* very close to *et* group. Ventral (*v*) group orthobothriotaxic, 3 trichobothria. Pedipalp chela manus (Fig. 5A-C). Colour predominantly orange to red-brown; carinae darker red. Chela stout (length less than 2.5 times its width) with 5 distinct carinae; internodorsal carina continuous, with strong spiniform granules basally and weak granules distally; subdigital carina vestigial, visible basally as a smooth ridge with weak granules; externodorsal carina distinct, visible as a ridge of indistinct fused granules, almost smooth; digital carina a smooth ridge with few weak granules basally; dorsal secondary carina (dorsomedian) a smooth ridge with few strong granules basally and few weak granules distally; internoventral carina continuous, visible as a weak ridge with few weak spiniform granules distally; externoventral carina continuous, forming a granular ridge, becoming almost smooth distally, running parallel to longitudinal axis of chela, its distal edge disconnected from external movable finger condyle and directed between external and internal condyles of movable finger; ventromedian carina vestigial, reduced to few coarse granules basally; internal (internomedian) carina vestigial, reduced to few weak spiniform granules distally; external (externomedian) carina indistinct, visible as raised rows of small weak granules. Dorsal surface forming an irregular and subreticulate network of weakly granular ridges surrounding shagreened patches without granules; internal surface shagreened, sparsely granular, with a denser patch of spiniform granules dorsodistally; external surface shagreened, sparsely and weakly granular; ventral surface with few weak granules surrounding shagreened patches, distal end smooth and pitted. A total of 15 trichobothria present on chela; *Db* trichobothria located externobasally on dorsal surface; *Eb* group (3 tri-

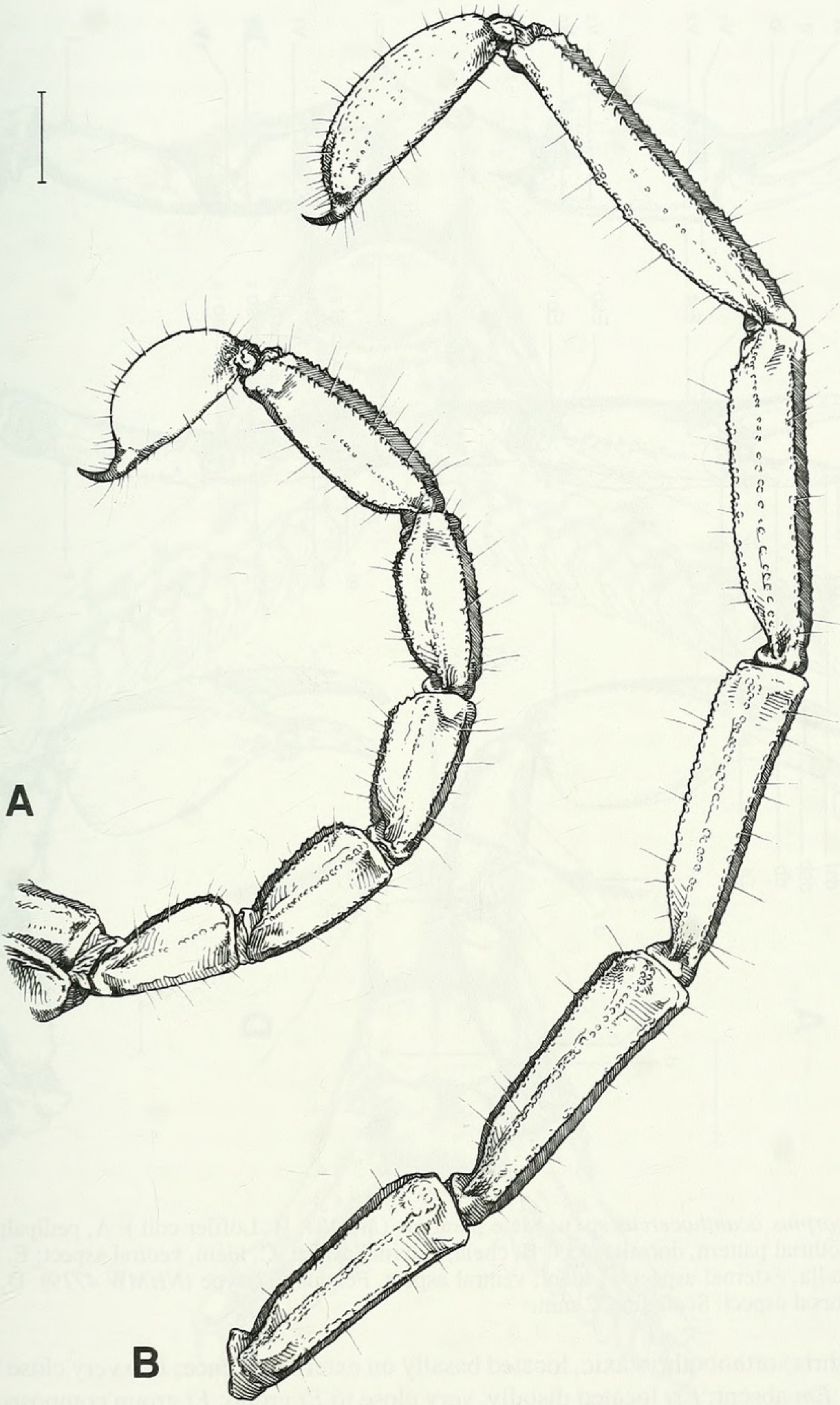

FIG. 4
Hemiscorpius acanthocercus sp. n., metasoma, lateral aspect: A, female paratype (*NHMW 4717*); B, male paratype (*MHNG*, H. Löffler coll.). Scale line, 2 mm.

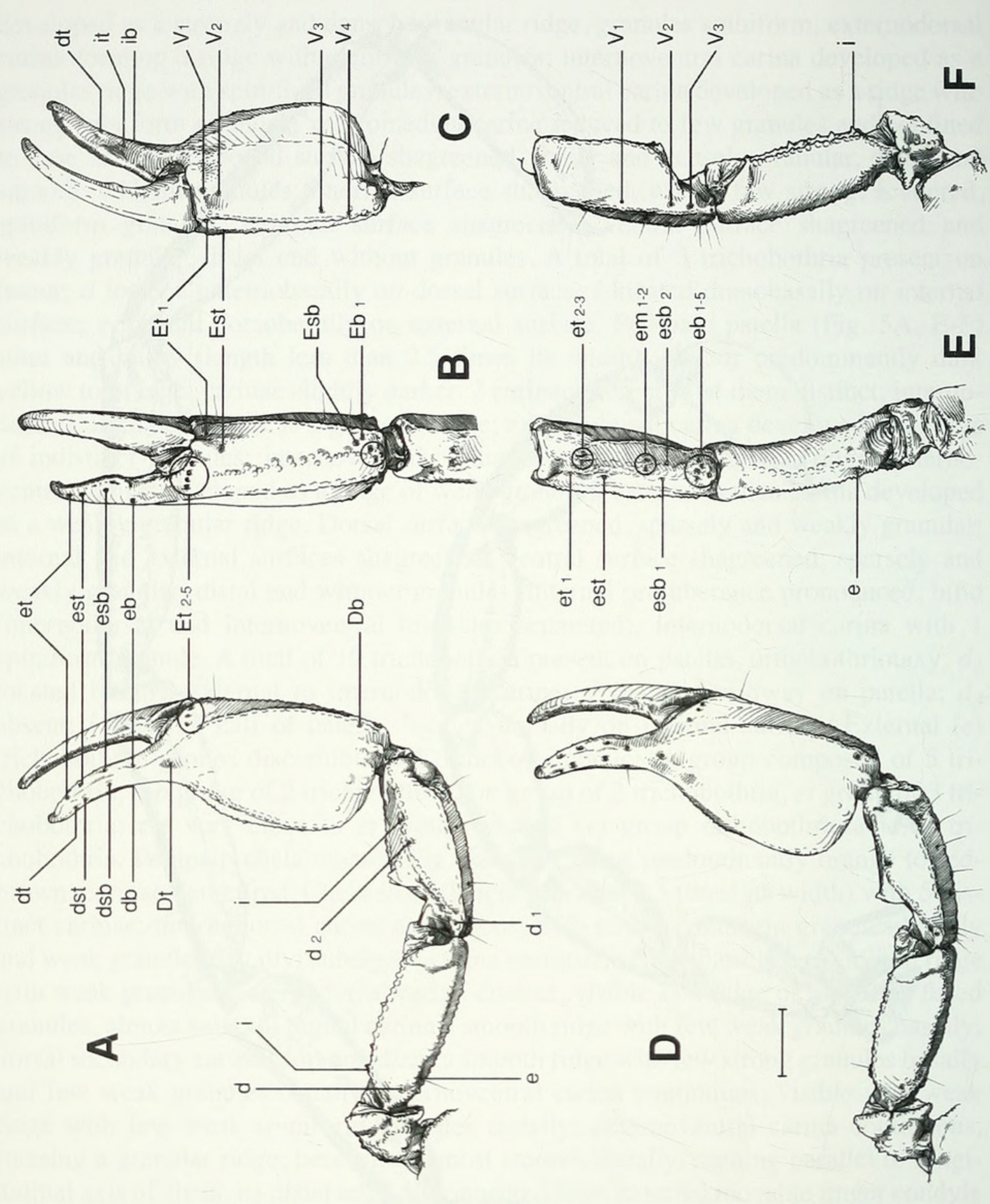

FIG. 5

Hemiscorpius acanthocercus sp. n. Male paratype (*MHNG*, H. Löffler coll.): A, pedipalp with trichobothrial pattern, dorsal aspect; B, chela, external aspect; C, idem, ventral aspect; E, femur and patella, external aspect; F, idem, ventral aspect. Female paratype (*NHMW 4719*): D, pedipalp, dorsal aspect. Scale line, 2 mm.

chobothria) orthobothriotaxic, located basally on external surface; *Esb* very close to *Eb* group; *Em* absent; *Est* located distally, very close to *Et* group; *Et* group composed of 5 trichobothria, Et_1 located ventrally; *V* group comprising 4 trichobothria, *V3* and *V4* located in basal half of manus, *V1* and *V2* located very distally. Fingers of pedipalpal chela (Fig. 5A-C). Basally reddish tan, becoming gradually lighter distally, tips of fin-

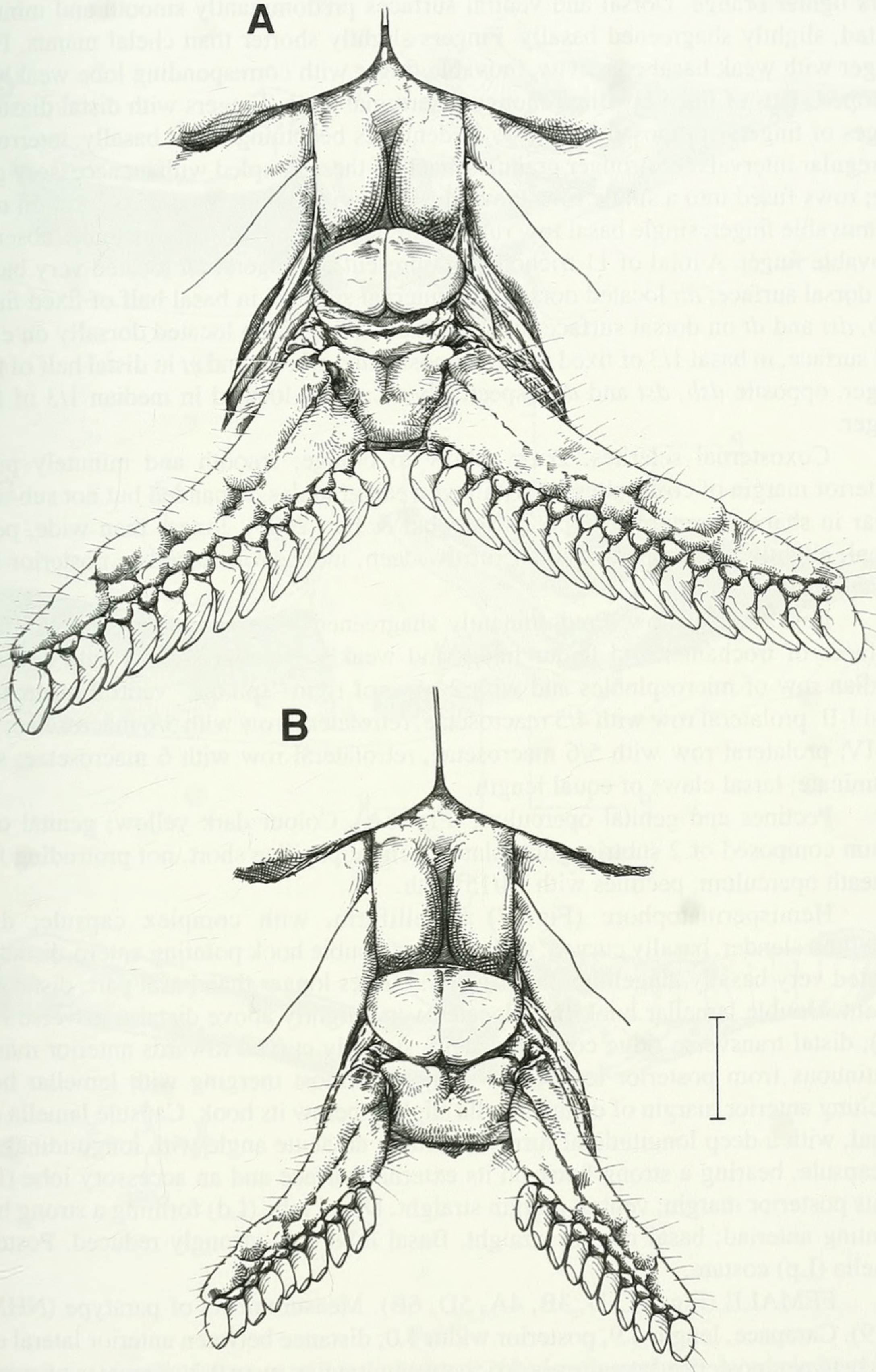

FIG. 6

Hemiscorpius acanthocercus sp. n., pectines and genital opercula, ventral aspect: A, male holotype; B, female paratype (*NHMW 21143*). Scale line, 1 mm.

gers lighter orange. Dorsal and ventral surfaces predominantly smooth and minutely pitted, slightly shagreened basally. Fingers slightly shorter than chelal manus. Fixed finger with weak basal concavity, movable finger with corresponding lobe weakly developed. Tips of fingers with pronounced terminal hook. Fingers with distal diastema; edges of fingers composed of 2 rows of denticles becoming fused basally, interrupted at regular intervals by stronger granules, each of these coupled with an accessory granule; rows fused into a single row above the concavity on the fixed finger and on notch of movable finger, single basal row running to base of fingers, in some males absent on movable finger. A total of 11 trichobothria present on fingers; *Dt* located very basally on dorsal surface; *db* located dorsally on internal surface, in basal half of fixed finger; *dsb*, *dst* and *dt* on dorsal surface, in distal half of finger; *eb* located dorsally on external surface, in basal 1/3 of fixed finger, opposite *db*; *esb*, *est* and *et* in distal half of fixed finger, opposite *dsb*, *dst* and *dt* respectively; *it* and *ib* located in median 1/3 of fixed finger.

Coxosternal sclerites. Dark yellow to orange; smooth and minutely pitted. Anterior margin of coxapohysis I with few weak granules, expanded but not sub-triangular in shape. Sternum of type 2 (Soleglad & Fet, 2003), longer than wide, pentagonal, slightly shagreened; median furrow deep, more pronounced in posterior half; posterior pit absent.

Legs. Pale yellow. Predominantly shagreened; ventral surface smooth; dorsal surfaces of trochanter and femur finely and weakly granular. Tarsus with a ventromedian row of microspinules and with 2 rows of rigid "spinoid" ventral macrosetae, tarsi I-II: prolateral row with 4/5 macrosetae, retrolateral row with 5/6 macrosetae; tarsi III-IV: prolateral row with 5/6 macrosetae, retrolateral row with 6 macrosetae; setae acuminate; tarsal claws of equal length.

Pectines and genital operculum (Fig. 6A). Colour dark yellow; genital operculum composed of 2 subtriangular plates; genital papillae short, not protruding from beneath operculum; pectines with 14/15 teeth.

Hemispermatophore (Fig. 7) lamelliform, with complex capsule; distal lamellum slender, basally curved, with a strong double hook pointing antero-distad and located very basally, flagellum more than 1.5 times longer than basal part; distal crest absent. Double lamellar hook (Dh) located very slightly above distal transverse ridge (Tr); distal transverse ridge costate, distally strongly curved towards anterior margin, continuous from posterior to anterior margins, almost merging with lamellar hook, reaching anterior margin of distal lamella slightly below its hook. Capsule lamella (La) broad, with a deep longitudinal furrow, forming an acute angle with longitudinal axis of capsule, bearing a strong hook on its external surface and an accessory lobe (Lac) on its posterior margin; ventral margin straight. Distal lobe (Ld) forming a strong hook pointing anteriad; basal margin straight. Basal lobe (Lb) strongly reduced. Posterior lamella (Lp) costate.

FEMALE (Figs 2C-D, 3B, 4A, 5D, 6B). Measurements of paratype (NHMW 4719). Carapace, length 5.9, posterior width 5.0; distance between anterior lateral eyes 3.1, between posterior lateral eyes 3.6, between median eyes 0.2; diameter of median eyes 0.2. Pedipalp, femur length 5.0, width 1.9; patella length 5.2, width 1.8, chela length 10.1; manus length 5.2, width 4.0, depth 2.7; movable finger length 5.2; fixed finger length 3.9. Metasoma, segment I length 3.3, width 1.9; segment V length 5.1,

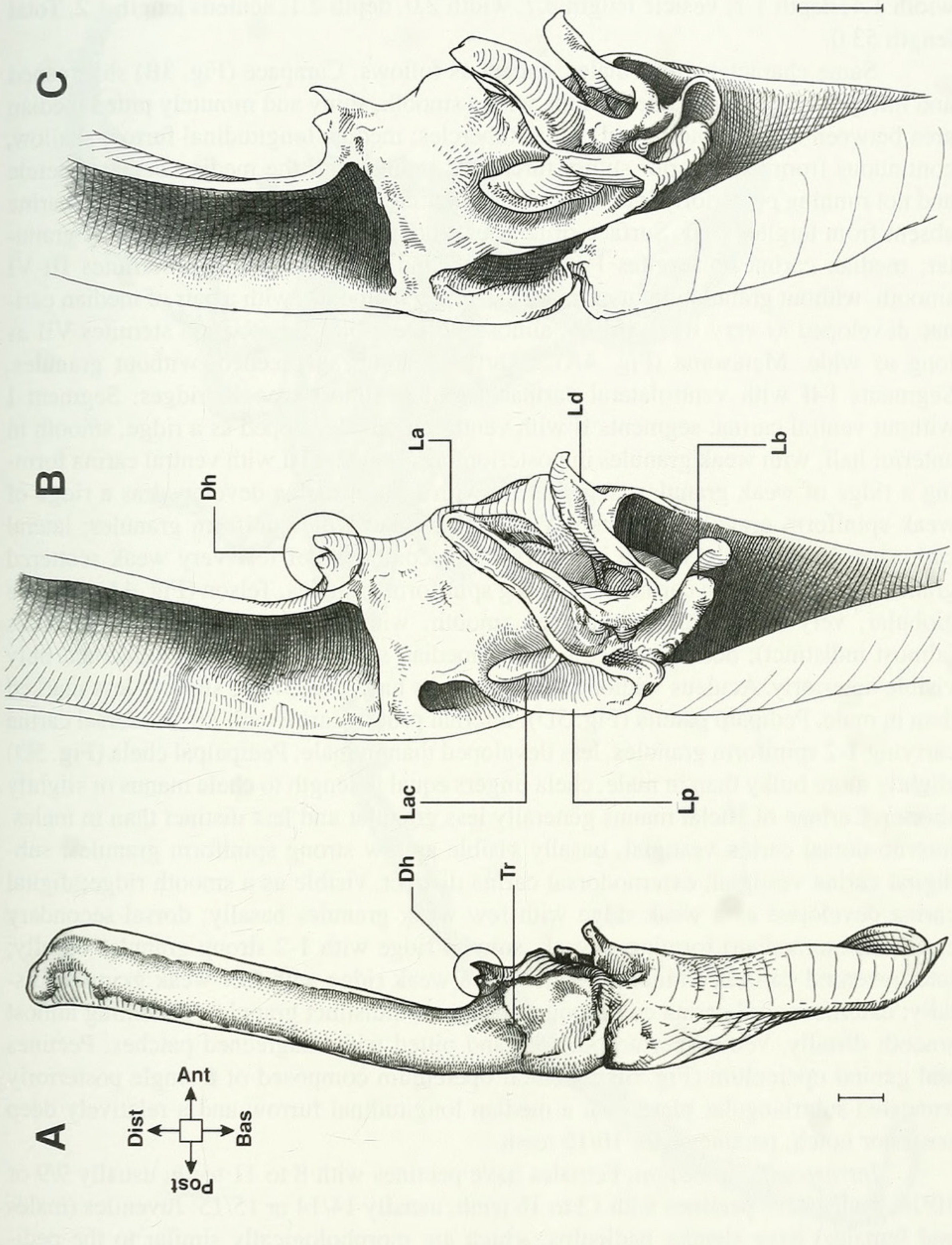

FIG. 7

Hemiscorpius acanthocercus sp. n., male holotype, hemispermatophore: A, whole hemispermatophore, arrows indicating its post-extrusion orientation, Ant (anterior), Bas (basal), Dist (distal), Post (posterior), Tr (transverse ridge); B-C, detail of the capsular region, internal aspect, Dh (double hook), La (lamella), Lac (accessory lobe), Lb (basal lobe), Ld (distal lobe), Lp (posterior lobe). Scale lines, 0.25 mm.

width 1.4, depth 1.7; vesicle length 3.7, width 2.0, depth 2.1, aculeus length 1.2. Total length 53.0.

Same characters as in males, except as follows. Carapace (Fig. 3B) shagreened and finely granular, each anterior lobe with a smooth, shiny and minutely pitted median area between median and lateral ocular tubercles; median longitudinal furrow shallow, continuous from the anterior suture furcation, ending after the median ocular tubercle and not running posteriorly into a deep triangular depression. Mesosoma. Median carina absent from tergites I-III. Surface of tergites smooth, shiny; median area finely granular; median carina on tergites IV-IV smooth and pitted posteriorly. Sternites III-VI smooth, without granulation or carinae. Sternite VII smooth, with a pair of median carinae developed as very weak ridges, almost indiscernible. Tergites and sternites VII as long as wide. Metasoma (Fig. 4A). Short and stout, shagreened, without granules. Segments I-II with ventrolateral carinae forming almost smooth ridges. Segment I without ventral carina; segments II with ventral carina developed as a ridge, smooth in anterior half, with weak granules in posterior half; segment III with ventral carina forming a ridge of weak granules; segment IV with ventral carina developed as a ridge of weak spiniform granules. Segment V: dorsal carinae with spiniform granules; lateral carina vestigial, barely visible in anterior 2/3, composed of few very weak scattered granules; ventromedian carina with strong spiniform granules. Telson (Fig. 4A). Vesicle globular, very bulky; lateral surfaces smooth, with few extremely weak granules (almost indistinct); dorsal surface smooth, median shallow depression indistinct, only visible anteriorly. Aculeus without tubercles at its base, narrowing slightly less marked than in male. Pedipalp patella (Fig. 5D). Internal protuberance with internodorsal carina carrying 1-2 spiniform granules, less developed than in male. Pedipalpal chela (Fig. 5D) slightly more bulky than in male, chela fingers equal in length to chela manus or slightly shorter. Carinae of chelal manus generally less granular and less distinct than in males. Interno-dorsal carina vestigial, basally visible as few strong spiniform granules; subdigital carina vestigial; externodorsal carina distinct, visible as a smooth ridge; digital carina developed as a weak ridge with few weak granules basally; dorsal secondary carina (dorsomedian) forming a weak, smooth ridge with 1-2 strong granules basally; internoventral carina continuous, visible as a weak ridge with few weak granules distally; externoventral carina continuous, a ridge of indistinct granules, becoming almost smooth distally. Ventral surface smooth and pitted with shagreened patches. Pectines and genital operculum (Fig. 6B). Genital operculum composed of a single posteriorly truncated subtriangular plate with a median longitudinal furrow and a relatively deep posterior notch; pectines with 10/10 teeth.

Intraspecific variation. Females have pectines with 8 to 11 teeth, usually 9/9 or 10/10, males have pectines with 13 to 16 teeth, usually 14/14 or 15/15. Juveniles (males and females) have slender pedipalps, which are morphologically similar to the pedipalps of mature males. Juveniles and subadult males do not possess an extremely elongated metasoma, they apparently acquire this feature only in the last developmental stage.

Hemiscorpius enischnochela **sp. n.** Figs 1E-F, 8-12, 26A-B, 27 C-D, 36

Material examined. Holotype: ♂, IRAN (Hormozgan), ca. 115 km E Bandar Abbas, VII.1974, G. Pretzman, *NHMW (52)*. Paratypes: 2 ♀, IRAN (Khuzestan), S of Masdjed-e-

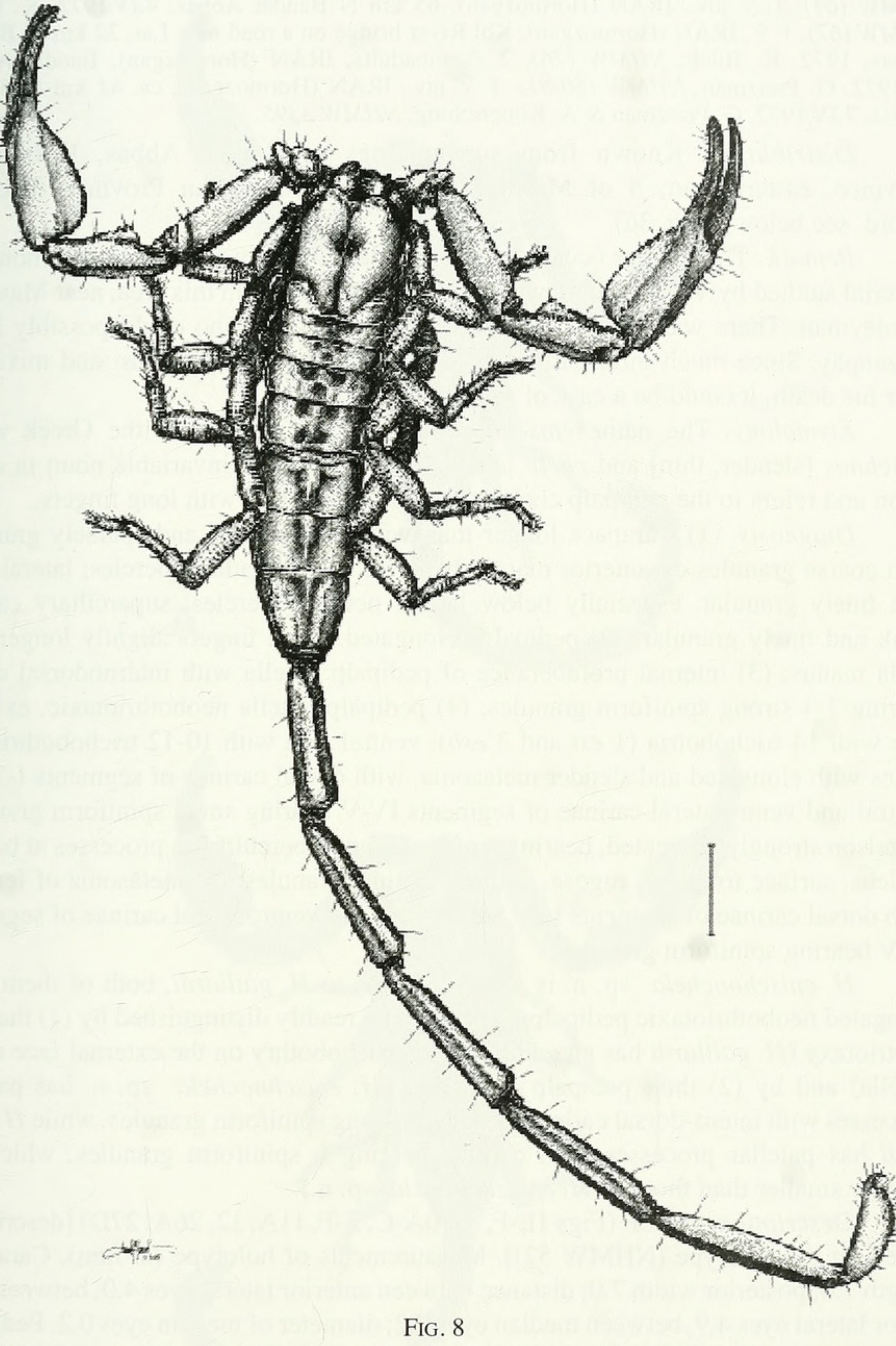

FIG. 8
Hemiscorpius enischnochela sp. n. Male holotype: dorsal aspect. Scale line, 5 mm.

Soleyman, I.1970, R. Farzanpay ?, *MHNG (SF 0057-1/2)*. 1 ♀ juv., same data as for holotype, *NHMW (53)*. 1 ♀ subadult, IRAN (Hormozgan), 38 km N Bandar Abbas, 28.III.1972, K. Bilek, *NHMW (54)*. 1 ♀ juv., IRAN (Hormozgan), 38 km N Bandar Abbas, 28.III.1972, K. Bilek, *NHMW (58)*. 1 ♀ juv., IRAN (Hormozgan), 22 km N Bandar Abbas, VII.1974, G. Pretzman ?, *NHMW (60)*. 1 ♀ juv., IRAN (Hormozgan), 65 km N Bandar Abbas, 4.IV.1972, K. Bilek, *NHMW (64)*. 1 ♂ juv., IRAN (Hormozgan), 65 km N Bandar Abbas, 4.IV.1972, K. Bilek, *NHMW (67)*. 1 ♀, IRAN (Hormozgan), Kol River bridge on a road near Lar, 32 km W Bandar Abbas, 1972, K. Bilek, *NHMW (76)*. 2 ♂ subadults, IRAN (Hormozgan), Bandar Abbas, VI.1972, G. Pretzman, *NHMW (80-81)*. 1 ♀ juv., IRAN (Hormozgan), ca. 41 km N Bandar Abbas, 7.IV.1972, G. Pretzman & A. Konetschnig, *NHMW 3395*.

Distribution. Known from surroundings of Bandar Abbas, Hormozgan Province, eastern Iran; S of Masdjed-e-Soleyman, Khuzestan Province (doubtful record, see below) (Fig. 36).

Remark. The species occurs around Bandar-Abbas in Eastern Iran. Among the material studied by Vachon, there was a female found far from this area, near Masdjed-e-Soleyman. There was no indication about the collector, who could possibly be R. Farzanpay. Since much information about Vachon's material was lost and mixed up after his death, it could be a case of mislabelling.

Etymology. The name *enischnochela* is a construct from the Greek words *enischnos* [slender, thin] and *chele* [claw]. The name is an invariable noun in apposition and refers to the pedipalp chela, which is slender and with long fingers.

Diagnosis. (1) Carapace longer than wide, shagreened and sparsely granular, with coarse granules on anterior margin between lateral ocular tubercles; lateral margins finely granular, especially below lateral ocular tubercles; superciliary carinae weak and finely granular; (2) pedipalps elongated, chela fingers slightly longer than chela manus; (3) internal protuberance of pedipalp patella with internodorsal carina bearing 3-4 strong spiniform granules; (4) pedipalp patella neobothriotaxic, external side with 14 trichobotria (1 *est* and 3 *esb*), ventral side with 10-12 trichobothria; (5) males with elongated and slender metasoma, with dorsal carinae of segments I-V and ventral and ventrolateral carinae of segments IV-V bearing small spiniform granules; (7) telson strongly elongated, bearing a pair of blunt tuberculiform processes at base of aculeus, surface irregular, rugose, without distinct granules; (8) metasoma of females with dorsal carinae of segments I-IV and ventral and ventrolateral carinae of segments IV-V bearing spiniform granules.

H. enischnochela sp. n. is closely related to *H. gaillardi*, both of them have elongated neobothriotaxic pedipalps. They can be readily distinguished by (1) their trichotriotaxy (*H. gaillardi* has an additional *est* trichobothry on the external face of the patella) and by (2) their pedipalp carination (*H. enischnochela* sp. n. has patellar processes with intero-dorsal carinae bearing 3 strong spiniform granules, while *H. gaillardi* has patellar processes with carinae bearing 6 spiniform granules, which are slightly smaller than those in *H. enischnochela* sp. n.).

Description. MALE (Figs 1E-F, 8, 10A-C, E-F, 11A, 12, 26A, 27D) [description based on the holotype (NHMW 52)]. Measurements of holotype (in mm). Carapace, length 7.6; posterior width 7.0; distance between anterior lateral eyes 4.0, between posterior lateral eyes 4.9, between median eyes 0.2; diameter of median eyes 0.2. Pedipalp, femur length 8.8, width 2.7; patella length 8.6, width 2.6, chela length 15,2; manus length 7.4, width 4.6, depth 3.2; movable finger length 8.2; fixed finger length 7.2. Metasoma, segment I length 9.6, width 2.5; segment V length 12.3, width 1.6, depth 2.0; vesicle length 7.4, width 2.3, depth 1.9, aculeus length 1.0. Total length 93.0.

Carapace (Fig. 26A). Colouration mostly uniformly dark yellow to orange; median and lateral ocular tubercle black. Carapace dorsoventraly flattened, longer than

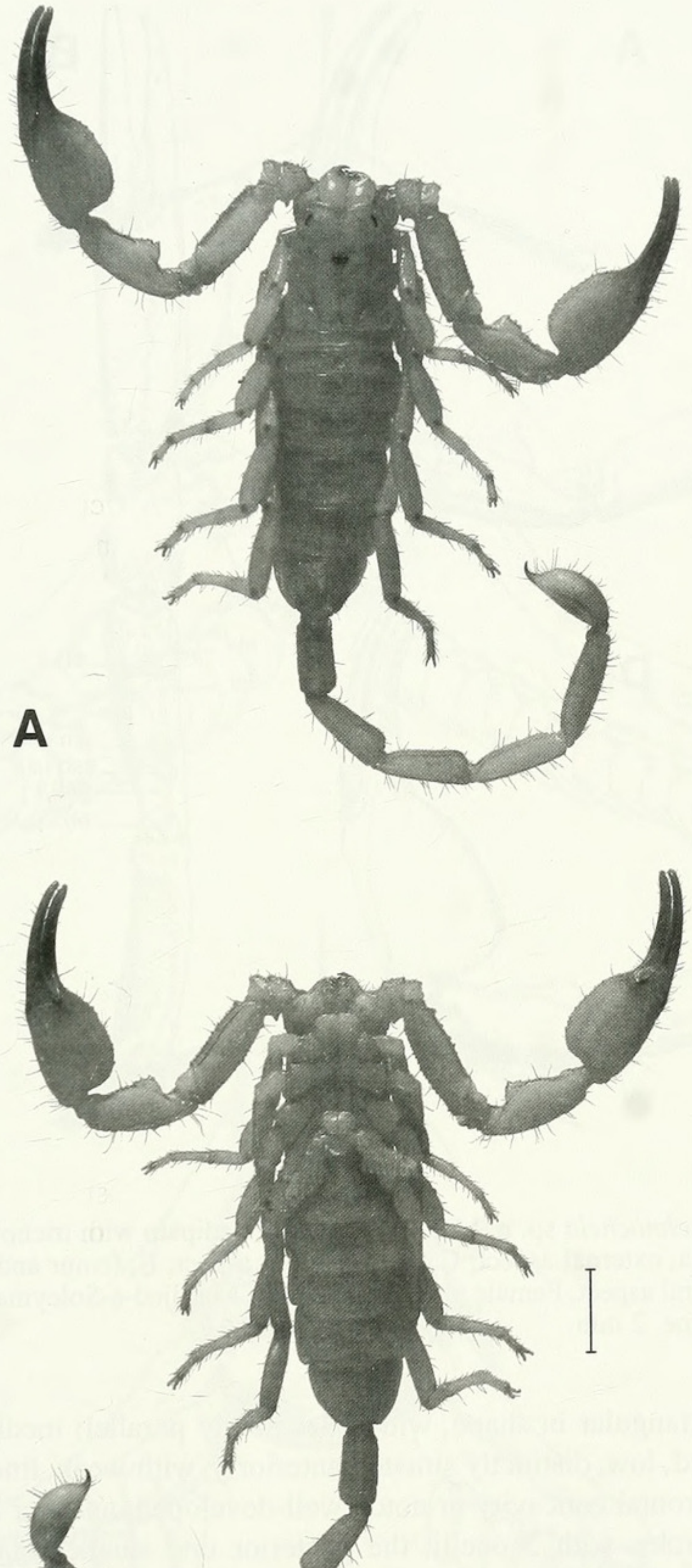

FIG. 9
Hemiscorpius enischnochela sp. n. Female paratype (*NHMW 76*, Kol River): A, dorsal aspect; B, ventral aspect. Scale line, 5 mm.

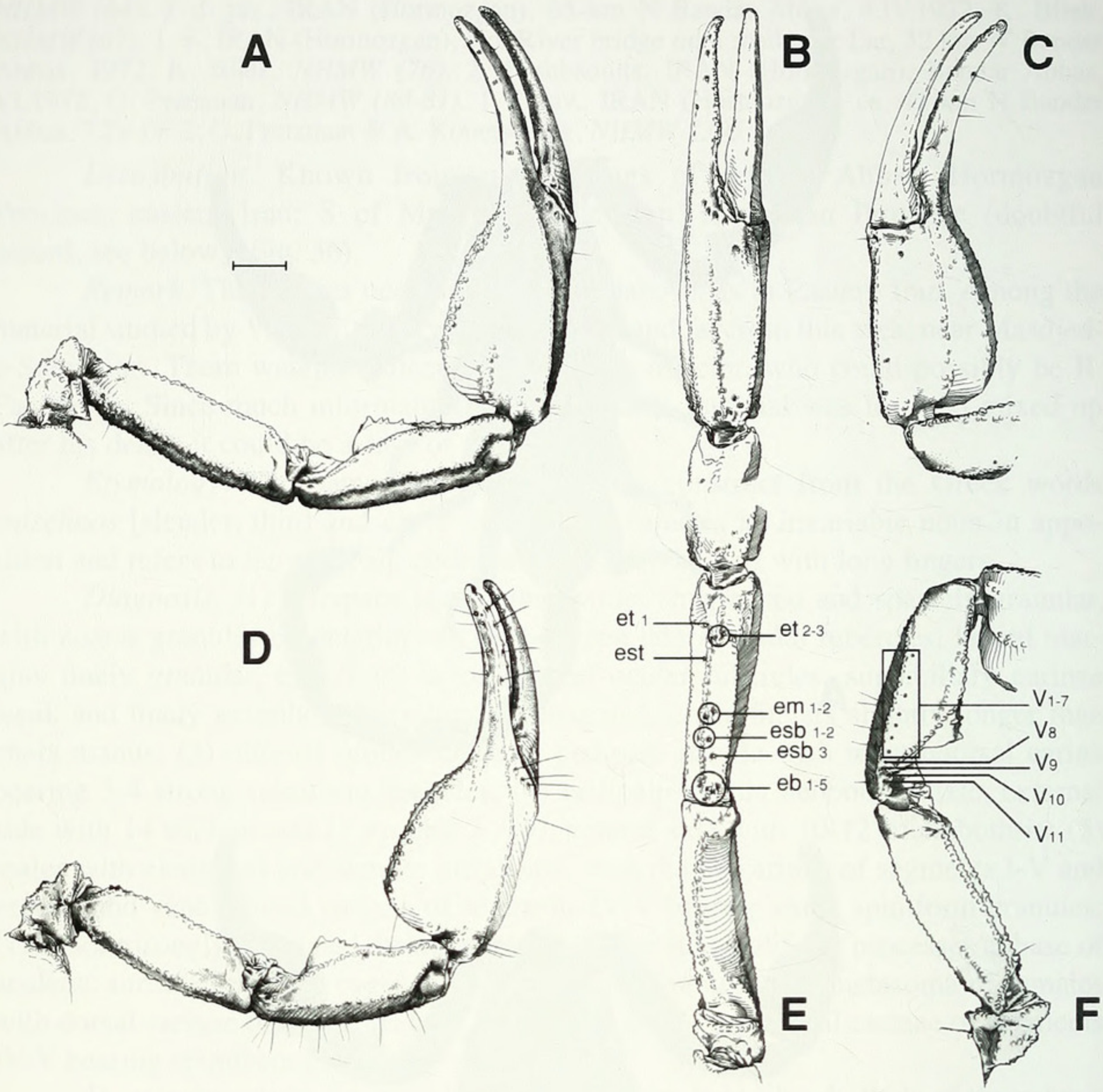

FIG. 10

Hemiscorpius enischnochela sp. n. Male holotype: A, pedipalp with trichobothrial pattern, dorsal aspect; B, chela, external aspect; C, idem, ventral aspect; E, femur and patella, external aspect; F, idem, ventral aspect. Female paratype (*MHNG*, Masdjed-e-Soleyman): D, pedipalp, dorsal aspect. Scale line, 2 mm.

wide, almost rectangular in shape, with sides nearly parallel; median ocular tubercle weakly developed, low, distinctly situated anteriorly, with weak, finely granular superciliary carinae; frontal concavity or notch well-developed; anterior lobes truncate; lateral ocular tubercles with 3 ocelli, the posterior one smaller than the 2 anteriors. Carapace shagreened, with sparse granules; stronger granules on the anterior margin between lateral ocular tubercles; edges granular, with stronger spiniform granules below lateral ocular tubercles; anteromedian furrow narrow, suturiform, anteriorly bifurcated; median longitudinal furrow shallow, continuous from the anterior suture furcation, running through ocular tubercle posteriorly into a deep triangular depression; posterolateral furrow shallow; mesolateral furrow weakly developed, almost indiscernible.

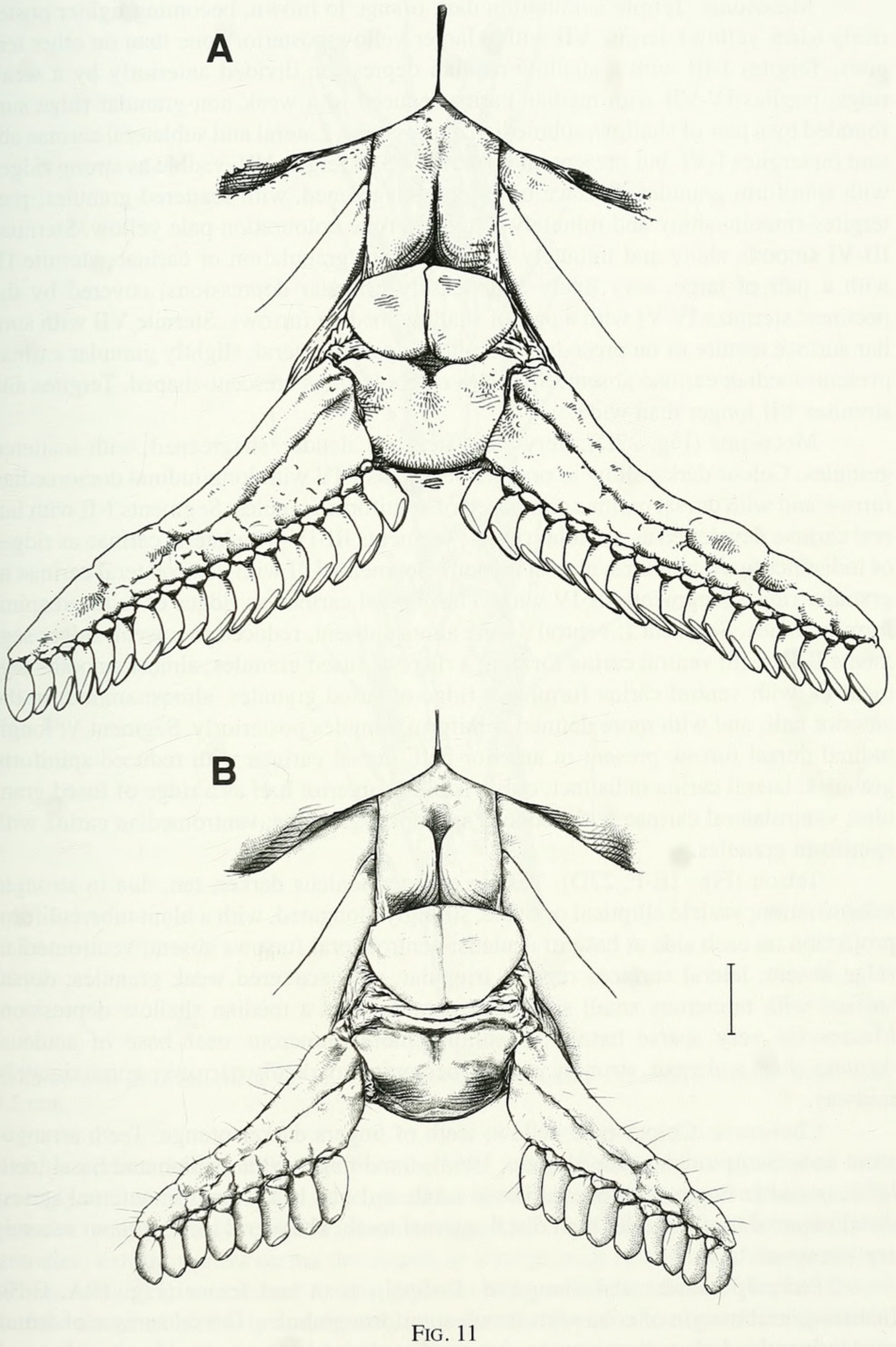

FIG. 11

Hemiscorpius enischnochela sp. n., pectines and genital opercula, ventral aspect: A, male holotype; B, female paratype (*MHNG*, Masdjed-e-Soleyman). Scale line, 1 mm.

Mesosoma. Tergite colouration dark orange to brown, becoming lighter posteriorly (dark yellow), tergite VII with a larger yellow posterior zone than on other tergites. Tergites I-III with a shallow median depression divided anteriorly by a weak ridge, tergites IV-VII with median carina reduced to a weak non-granular ridge surrounded by a pair of shallow, submedian depressions. Lateral and sublateral carinae absent on tergites I-VI, but present on posterior 2/3 of tergite VII, visible as strong ridges with spiniform granules. Surface of tergites shagreened, with scattered granules; pretergites smooth, shiny and minutely pitted. Sternite colouration pale yellow. Sternites III-VI smooth, shiny and minutely pitted, without granulation or carinae; sternite III with a pair of large, very finely and densely granular depressions, covered by the pectines; sternites IV-VI with a pair of shallow median furrows. Sternite VII with similar surface texture as on preceding sternites; a pair of lateral, slightly granular carinae present; median carinae absent. Spiracles of book lungs crescent-shaped. Tergites and sternites VII longer than wide.

Metasoma (Fig. 27D). Very elongated and slender, shagreened, with scattered granules. Colour dark yellow to orange. Segments I-IV with longitudinal dorsomedian furrow and with dorsal carinae composed of spiniform granules. Segments I-II with lateral carinae developed as granular ridges; segments III-IV with lateral carinae as ridges of indistinct fused granules, almost smooth. Segments I-II with ventrolateral carinae as granular ridges; segments III-IV with ventrolateral carinae as ridges of reduced spiniform granules. Segment I: ventral carina almost absent, reduced to a weak ridge; segments II-III with ventral carina forming a ridge of fused granules, almost smooth; segment IV with ventral carina forming a ridge of fused granules, almost smooth in the anterior half, and with more defined spiniform granules posteriorly. Segment V: longitudinal dorsal furrow present in anterior half, dorsal carinae with reduced spiniform granules; lateral carina indistinct, only visible in anterior half as a ridge of fused granules; ventrolateral carinae with reduced spiniform granules; ventromedian carina with spiniform granules.

Telson (Fig. 1E-F, 27D). Vesicle orange; aculeus darker, tan, due to stronger sclerotisation; vesicle elliptical or ovate, strongly elongated, with a blunt tuberculiform projection on each side at base of aculeus; ventrolateral furrows absent; ventromedian ridge absent; lateral surfaces rugose, irregular, with scattered weak granules; dorsal surface with numerous small spiniform granules and a median shallow depression. Macrosetae very sparse basally, becoming more numerous near base of aculeus. Aculeus short and stout, strongly curved, becoming markedly narrower approximately midway.

Chelicerae. Colour pale yellow; teeth of fingers darker orange. Teeth arrangement as in Scorpionidae (see Vachon, 1963); fixed finger with median and basal teeth bifid; movable finger with one subdistal tooth and one basal tooth in external series; distal external tooth smaller than distal internal tooth; cheliceral teeth without secondary serrations.

Pedipalp slender and elongated. Pedipalp coxa and femur (Fig. 10A, E-F). Internoventral margin of coxa with strong spiniform granules. Dorsal surface of femur predominantly dark yellow-orange, internodorsal, internoventral and externoventral carinae darker orange. Femur slender, elongate (equal to or longer than 3 times its

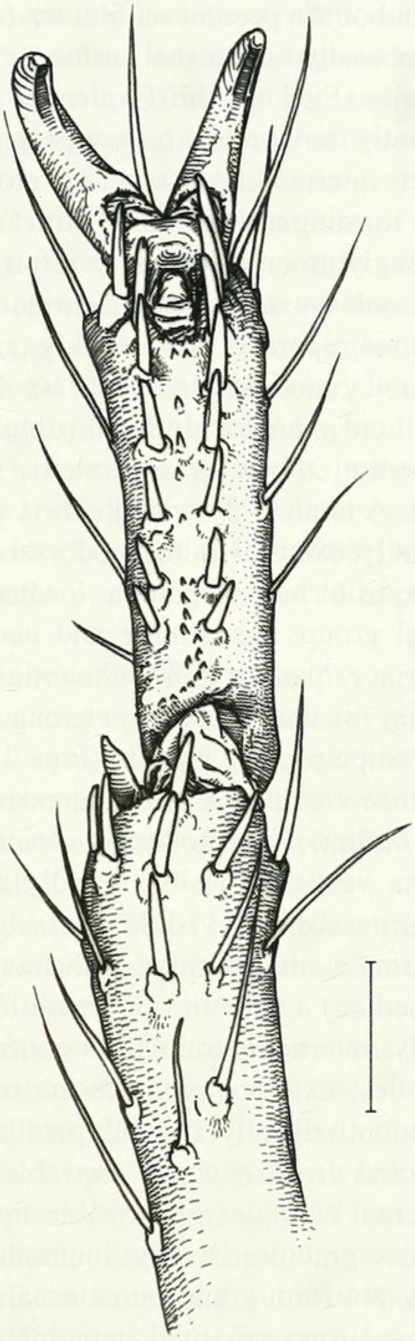

FIG. 12

Hemiscorpius enischnochela sp. n., male holotype: left tarsus IV, ventral aspect. Scale line, 0.5 mm.

width), pentacarinate, with 4 distinct carinae; internodorsal carina developed as a strongly and densely granular ridge, granules spiniform; externodorsal carina a strong granular ridge; internoventral carina developed as a granular ridge with spiniform granules; externoventral carina developed as a ridge with strong spiniform granules; ventromedian carina reduced to few granules and confined to base of femur. Dorsal surface shagreened, finely and densely granular, distal end smooth, without granules; internal surface shagreened, with few strong scattered spiniform granules; external surface shagreened; ventral surface shagreened and sparsely granular, distal end without granules. A total of 3 trichobothria present on femur; *d* located externobasally on dorsal surface; *i* located dorsobasally on internal surface; *e* located dorsobasally on external surface. Pedipalp patella (Figs 10A, E-F) slender (length less than 2.5 times its width). Colour predominantly dark yellow to orange; carinae slightly darker. 7 carinae present, 6 of them distinct; internodorsal carina developed as a ridge of coarse granules; externodorsal carina forming a ridge of indistinct coarse granules; internoventral carina developed as a strongly granular ridge (spiniform granules); externoventral carina as a ridge of weak granules; externomedian carina as a granular ridge. Dorsal and internal surfaces shagreened, sparsely and weakly granular; external surface shagreened, with a few scattered granules; ventral surface shagreened, sparsely and weakly granular, distal end without granules. Internal protuberance pronounced, bifid (internodorsal and internoventral tubercles separated), internodorsal carina with 3-4 strong spiniform granules. A total of 28 trichobothria present on patella, neobothriotaxy major; d_1 located basally, external to internodorsal carina; d_2 situated in distal half of patella; d_3 absent; *i* in distal half of patella, located dorsally on internal surface. External (*e*) trichobothrial groups discernible and neobothriotaxic major: *eb* group composed of 5 trichobothria, *esb* group of 3 trichobothria, *em* group of 2 trichobothria, *et* group of 3 trichobothria; *est* very close to *et* group. Ventral (*v*) group neobothriotaxic, 11 trichobothria. Pedipalp chela manus (Figs 10A-C). Colour predominantly orange to red-brown; carinae darker red. Chela slender (length more than 3 times its width), with 5 distinct carinae; internodorsal carina continuous, with spiniform granules; subdigital carina vestigial, visible basally as a smooth ridge with weak granules; externodorsal carina distinct, visible as a ridge of indistinct fused granules, almost smooth; digital carina a smooth ridge with few weak granules basally; dorsal secondary carina (dorsomedian) a smooth ridge with few strong granules basally and few weak granules distally; internoventral carina continuous, visible as a weak ridge with few spiniform granules; externoventral carina continuous, forming a granular ridge, becoming almost smooth distally, running parallel to longitudinal axis of chela, its distal edge disconnected from external movable finger condyle and directed between external and internal condyles of movable finger; ventromedian carina vestigial, reduced to few coarse granules basally; internal (internomedian) carina visible as a weak ridge with few spiniform granules; external (externomedian) carina hardly discernible, visible as raised rows of small indistinct granules. Dorsal surface shagreened, sparsely and weakly granular; internal surface shagreened, sparsely granular, with a denser patch of spiniform granules dorsodistally; external surface shagreened, sparsely and weakly granular; ventral surface shagreened, sparsely and weakly granular, distal end without granules. A total of 15 trichobothria present on chelal manus; *Db* trichobothria situated externobasally on dorsal surface; *Eb* group (3 trichobothria) orthobothriotaxic, located basally on external surface; *Esb* very close to *Eb* group; *Em* absent; *Est* located distally, very close to *Et* group; *Et* group composed of 5 trichobothria, Et_1 located ventrally; *V* group comprising 4 trichobothria, *V3* and *V4* situated in basal third of manus, *V1* and *V2* located in distal quarter. Pedipalp chela fingers (Figs 10A-C). Basally reddish tan, becoming gradually lighter distally, tips of fingers yellow. Dorsal and ventral surfaces predominantly smooth, slightly shagreened basally. Fingers longer than chela manus. Fixed finger with a weak basal concavity, movable finger with corresponding lobe weakly developed. Tips of fingers with pronounced distal hook. Fingers with distal diastema; edges of fingers composed of 2 rows of denticles becoming fused basally, interrupted at regular intervals by stronger granules, each of them coupled with an accessory granule; rows fused into a single row above concavity on fixed finger and on notch of movable finger, single basal row running towards base of fingers. A total of 11 trichobothria present on fingers; *Dt* located on dorsal surface, in basal third of fixed finger; *db* located dorsally on internal surface, approximately midway on fixed finger; *dsb*, *dst* and *dt* on dorsal surface, in distal half of finger; *eb* located dorsally on external surface, approximately midway on fixed finger, opposite *db*; *esb*, *est* and *et* in distal half of fixed finger; *esb* and *et* opposite *dsb* and *dt*, respectively; *it* and *ib* located in distal half of fixed finger.

Coxosternal sclerites. Dark yellow to orange, smooth and minutely pitted. Anterior margin of coxapohysis I with few weak granules, expanded but not sub-triangular in shape. Sternum of type 2 (Soleglad & Fet, 2003), longer than wide, pentagonal, shagreened; median furrow deep, more pronounced in posterior half; posterior pit absent.

Legs. Pale yellow. Predominantly shagreened; ventral surface smooth; dorsal surfaces of trochanter and femur finely granular. Tarsus (Fig. 12) with a ventromedian row of microspinules and with 2 rows of rigid "spinoid" ventral macrosetae; tarsi I-II: prolateral row with 5 or 6 macrosetae, retrolateral row with 7 macrosetae; tarsi III-IV: prolateral row with 7 macrosetae, retrolateral row with 7/8 macrosetae; setae acuminate; tarsal claws of equal length.

Pectines and genital operculum (Fig. 11A). Colour pale yellow; genital operculum composed of 2 ovoid plates; genital papillae short, not protruding from beneath operculum; pectines with 17/17 teeth.

Hemispermatophore. Unknown. The specimen was already dissected and the hemispermatophores were probably lost.

FEMALE (Figs 9, 10D, 11B, 26B, 27C). Measurements of paratype (MNHN Masdjed-e Soleyman). Carapace, length 7.4, posterior width 7.0; distance between anterior lateral eyes 4.0, between posterior lateral eyes 4.7, between median eyes 0.2; diameter of median eyes 0.2. Pedipalp, femur length 7.5, width 2.4; patella length 7.2, width 2.6, chela length 13.6; manus length 6.8, width 4.6, depth 3.3; movable finger length 6.9; fixed finger length 6.2. Metasoma, segment I length 4.8, width 2.2; segment V length 6.9, width 1.6, depth 2.0; vesicle length 5.2, width 2.8, depth 2.7, aculeus length 1.3. Total length 64.0.

Same characters as in males, except as follows. Carapace (Fig. 26B) shagreened and sparsely granular, each anterior lobe with a reduced central smooth area between median and lateral ocular tubercles. Mesosoma. Surface of tergites shagreened, with few smooth and pitted patches and scattered granules. Tergites and sternites VII almost as long as wide. Metasoma (Fig. 27C). Short and stout. Segments I-II with ventral carina developed as a smooth ridge; segments III with ventral carina as a ridge of weak spiniform granules; segment IV with ventral carina as a ridge of spiniform granules. Segment V: lateral carina indistinct; ventromedian carina with spiniform granules. Telson (Fig. 27C). Vesicle elliptical or ovate, short and bulky; lateral surfaces smooth and irregular; dorsal surface smooth and irregular, with a shallow median depression posteriorly. Aculeus without tubercles at its base, narrowing slightly less marked than in male. Pedipalp coxa and femur (Fig. 10D). Pedipalp slightly less slender and elongated than in males. Femur: externoventral carina developed as a ridge with spiniform granules, these weaker, more scattered and less numerous than in male. Pedipalp patella (Fig. 10D). Less elongated than in males. Externodorsal carina developed as a ridge of weak granules, almost smooth. Internal and external surface shagreened, not granular. Pedipalp chela manus (Fig. 10D). Chela more bulky than in males. Pectines and genital operculum (Fig. 11B). Genital operculum composed of a hexagonal ovoid plate divided by a moderately deep longitudinal furrow; posterior notch weakly pronounced; pectines with 8-10 teeth.

Intraspecific variation. The specimens examined possess 10 to 12 trichobothria on the ventral side of the patella. Females have pectines with 8 to 10 teeth, usually 8-8, males have pectines with 14 to 17 teeth. The same remark about pedipalps and metasoma of males can be given as for *H. acanthocercus*.

Hemiscorpius gaillardi (Vachon, 1974) comb. n. Figs 13-15, 26C

Habibiella gaillardi Vachon, 1974: 952, fig. 105.

Material examined. Holotype: 1 ♀, IRAN, East, no locatity specified, *MNHN-RS 4328*.

Distribution. Known from eastern Iran, no locatity specified.

Diagnosis. (1) Carapace almost as wide as long, shagreened and sparsely granular, with few smooth patches and with coarse granules on anterior margin between lateral ocular tubercles; lateral margins with small spiniform granules below lateral ocular tubercles; superciliary carinae weak, finely granular; (2) pedipalps very elongated, chela fingers longer than chela manus; (3) internal protuberance of patella with internodorsal carina bearing 6 strong spiniform granules; (4) pedipalp patella neothobothriotaxic, external side with 15 trichobotria (2 *est* and 3 *esb*), ventral side with 10-12 trichobothria; (5) metasoma of females with dorsal carinae of segments I-IV and ventral and ventrolateral carinae of segments V bearing weak small spiniform granules.

The male of *H. gaillardi* remains unknown. For more details see also diagnosis of *H. enischnochela* sp. n., to which *H. gaillardi* is closely related.

Description. FEMALE. Measurements of holotype (MNHN-RS 4328). Carapace, length 6.6, posterior width 6.7; distance between anterior lateral eyes 3.6, between posterior lateral eyes 4.4, between median eyes 0.2; diameter of median eyes 0.3. Pedipalp, femur length 7.7, width 2.3; patella length 7.5, width 2.4, chela length 14.2; manus length 6.2, width 3.8, depth 2.7; movable finger length 7.7; fixed finger length 6.7. Metasoma, segment I length 4.5, width 2.2; segment V length 6.5, width 1.7, depth 1.9; vesicle length 4.2, width 2.3, depth 2.3, aculeus length 1.5. Total length 58.0.

Carapace (Fig. 26C). Colouration mostly uniformly pale yellow to orange; median and lateral ocular tubercle black. Carapace dorsoventraly flattened, almost as wide as long, with sides nearly parallel, slightly convergent; median ocular tubercle weakly developed, low, distinctly situated anteriorly, with superciliary carinae weak but finely granular. Frontal concavity or notch well-developed; anterior lobes truncate;

FIG. 13
Hemiscorpius gaillardi, female holotype: A, dorsal aspect; B, ventral aspect. Scale line, 5 mm.

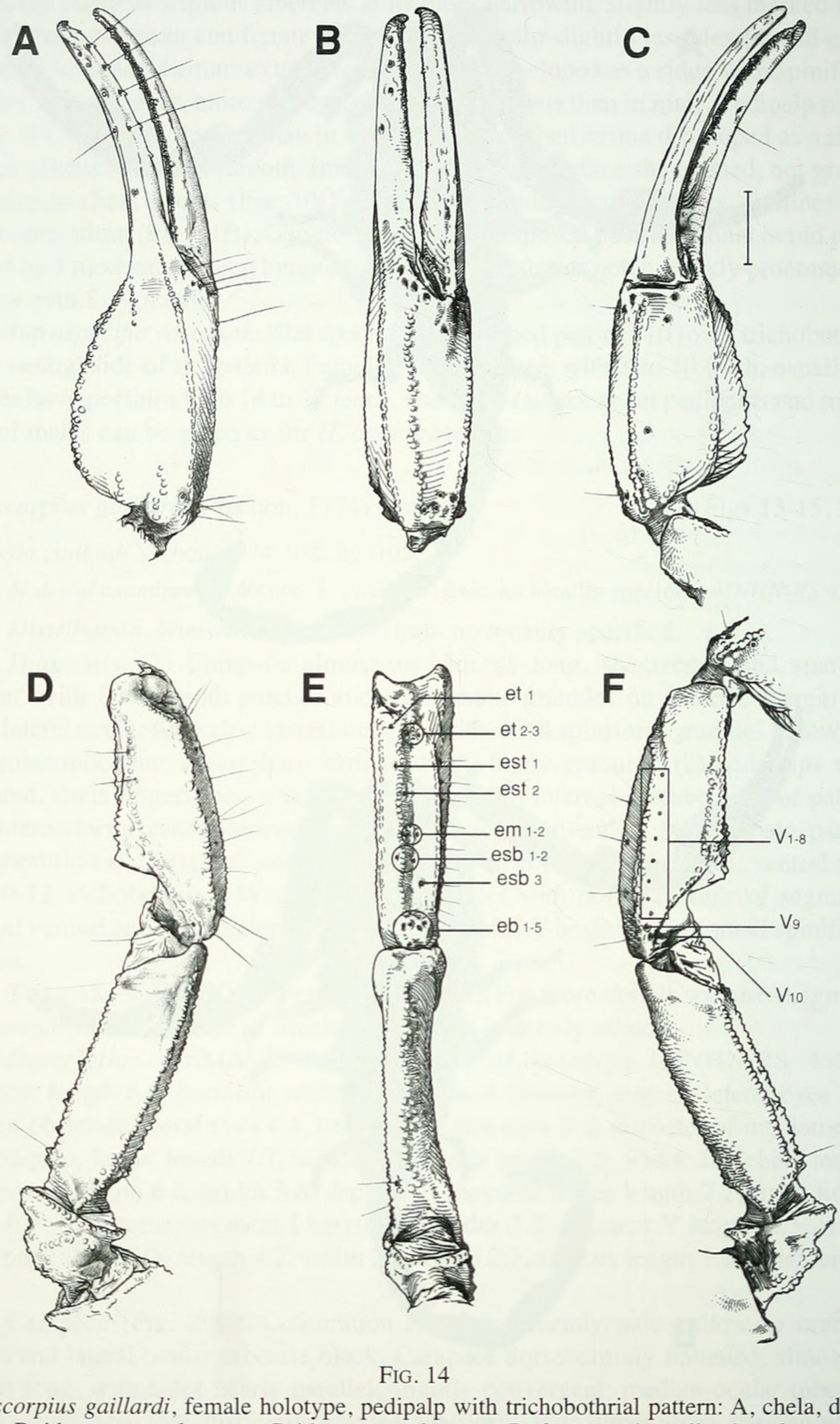

FIG. 14

Hemiscorpius gaillardi, female holotype, pedipalp with trichobothrial pattern: A, chela, dorsal aspect; B, idem, external aspect; C, idem, ventral aspect; D, femur and patella, dorsal aspect; E, idem, external aspect; F, idem, ventral aspect. Scale line, 2 mm.

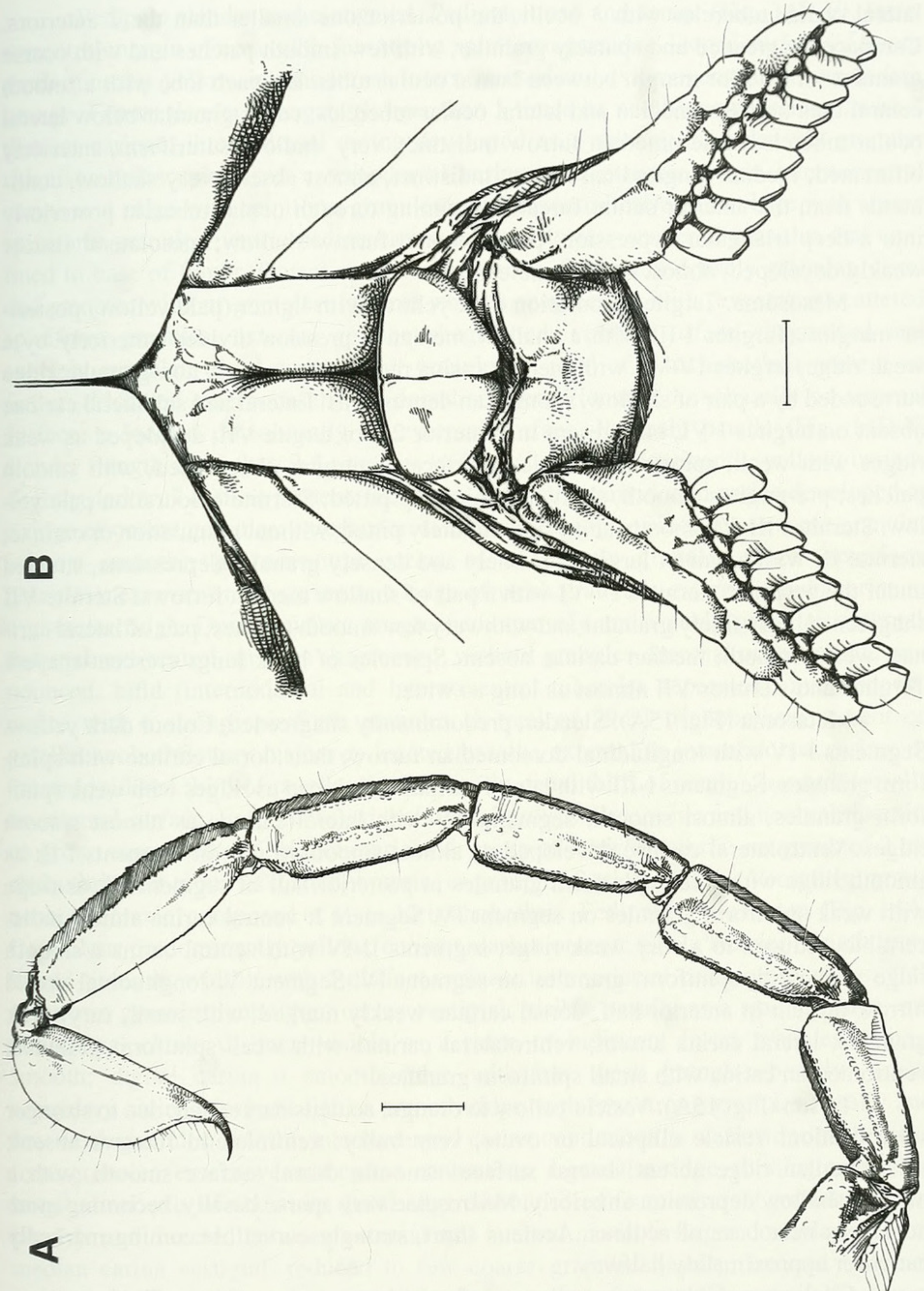

FIG. 15

Hemiscorpius gaillardi, female holotype: A, metasoma, lateral aspect (scale line, 2 mm); B, pectines and genital opercula, ventral aspect (scale line, 1 mm).

lateral ocular tubercles with 3 ocelli, the posterior one smaller than the 2 anteriors. Carapace shagreened and sparsely granular, with few smooth patches and with coarse granules on anterior margin between lateral ocular tubercles, each lobe with a smooth central area between median and lateral ocular tubercles; edges granular below lateral ocular tubercles; anteromedian furrow indistinct, very shallow, suturiform, anteriorly bifurcated; median longitudinal furrow indistinct, almost absent, very shallow, continuous from the anterior suture furcation, running through ocular tubercle posteriorly into a deep triangular depression; posterolateral furrow shallow; mesolateral furrow weakly developed, almost indiscernible.

Mesosoma. Tergite colouration dark yellow, with lighter (pale yellow) posterior margins. Tergites I-III with a shallow median depression divided anteriorly by a weak ridge, tergites IV-VII with median carina reduced to a weak, non-granular ridge surrounded by a pair of shallow, submedian depressions. Lateral and sublateral carinae absent on tergites I-VI, but present in posterior 2/3 of tergite VII, developed as weak ridges with weak, spiniform granules. Surface of tergites shagreened, with smooth patches; pre-tergites smooth, shiny and minutely pitted. Sternite colouration pale yellow. Sternites III-VI smooth, shiny and minutely pitted, without granulation or carinae; sternite III with a pair of large, very finely and densely granular depressions, situated under the pectines; sternites IV-VI with a pair of shallow median furrows. Sternite VII shagreened, very finely granular and with very few smooth patches; pair of lateral carinae, weak, smooth; median carinae absent. Spiracles of book lungs crescent-shaped. Tergites and sternites VII almost as long as wide.

Metasoma (Fig. 15A). Slender, predominantly shagreened. Colour dark yellow. Segments I-IV with longitudinal dorsomedian furrow, their dorsal carinae with spiniform granules. Segments I-III with lateral carinae developed as ridges with weak spiniform granules, almost smooth; segments IV with lateral carinae as almost smooth ridges. Ventrolateral carinae developed as almost smooth ridges on segments I-II; as smooth ridge with weak spiniform granules in posterior half of segment III; as ridge with weak spiniform granules on segment IV. Segment I: ventral carina almost indiscernible, reduced to a very weak ridge; segments II-IV with ventral carina a smooth ridge with weak spiniform granules on segment IV. Segment V: longitudinal dorsal furrow present in anterior half, dorsal carinae weakly marked, with small, very weak granules; lateral carina absent; ventrolateral carinae with weak spiniform granules; ventromedian carina with small spiniform granules.

Telson (Fig. 15A). Vesicle yellow to orange; aculeus darker, tan, due to stronger sclerotisation; vesicle elliptical or ovate, very bulky; ventrolateral furrows absent; ventromedian ridge absent; lateral surfaces smooth; dorsal surface smooth, with a median shallow depression anteriorly. Macrosetae very sparse basally, becoming more numerous near base of aculeus. Aculeus short, strongly curved, becoming markedly narrower approximately halfway.

Chelicerae. Colour pale yellow; teeth of fingers darker, orange. Teeth arrangement as in Scorpionidae (see Vachon, 1963); fixed finger with median and basal teeth bifid; movable finger with one subdistal tooth and one basal tooth in external series; distal external tooth smaller than distal internal tooth; cheliceral teeth without secondary serrations.

Pedipalp slender and elongated. Pedipalp coxa and femur (Fig. 14D-F). Internoventral margin of coxa with few strong spiniform granules. Dorsal surface of femur predominantly yellow, internodorsal, internoventral and externoventral carinae darker, orange. Femur slender, elongate (longer than 3 times its width), pentacarinate, with 4 distinct carinae; internodorsal carina developed as a strongly and densely granular ridge, granules spiniform; externodorsal carina as a granular ridge; internoventral carina as a ridge with spiniform granules; externoventral carina as a ridge with strong spiniform granules; ventromedian carina reduced to few scattered granules and confined to base of femur. Dorsal surface shagreened, finely and densely granular, distal end smooth, without granules; internal surface shagreened, with few strong scattered spiniform granules; external surface shagreened; ventral surface shagreened and sparsely granular, distal end without granules. A total of 3 trichobothria present on femur; *d* located externobasally on dorsal surface; *i* located dorsobasally on internal surface; *e* located dorsobasally on external surface. Pedipalp patella (Fig. 14D-F) slender (length more than 2.5 times its width). Colour predominantly yellow; carinae slightly darker. 7 carinae present, 6 of them distinct; internodorsal carina developed as a ridge of coarse granules; externodorsal carina as a ridge of indistinct coarse granules (almost smooth); internoventral carina as a strongly granular ridge (spiniform granules); externoventral carina as a ridge of weak granules; externomedian carina as a granular ridge. Dorsal surface shagreened, sparsely and weakly granular; internal, external and ventral surfaces shagreened, without granules. Internal protuberance pronounced, bifid (internodorsal and internoventral tubercles separated), internodorsal carina with 6 strong spiniform granules. A total of 29-31 trichobothria present on patella, neobothriotaxy major; d_1 located basally, external to internodorsal carina; d_2 located in distal third of patella; d_3 absent; *i* in distal third of patella, located dorsally on internal surface. External (*e*) trichobothrial groups discernible and neobothriotaxic: *eb* group composed of 5 trichobothria, *esb* group of 3 trichobothria, *em* group of 2 trichobothria, *est* group of 2 trichobothria, *et* group of 3 trichobothria. Ventral (*v*) group neobothriotaxic, composed of 10 to 12 trichobothria. Pedipalp chela manus (Fig. 14A-C). Colour predominantly yellow; carinae, darker orange. Chela slender (length more than 3 times its width), with 5 distinct carinae; internodorsal carina continuous, with spiniform granules; subdigital carina vestigial, visible basally as a smooth ridge; externodorsal carina distinct, visible as a ridge of indistinct fused granules, almost smooth; digital carina a smooth ridge with few weak granules basally; dorsal secondary carina (dorsomedian) a smooth ridge with few strong granules basally and few weak granules distally; internoventral carina continuous, a weak ridge with spiniform granules; externoventral carina continuous, a granular ridge, running parallel to longitudinal axis of chela, its distal edge disconnected from external movable finger condyle and directed between external and internal movable finger condyles; ventromedian carina vestigial, reduced to few coarse granules basally; internal (internomedian) carina visible as a weak ridge with few spiniform granules; external (externomedian) carina weakly pronounced, visible as raised rows of small weak granules. Dorsal surface of chela shagreened, sparsely and weakly granular; internal surface shagreened, sparsely granular, with a denser patch of spiniform granules dorsodistally; external surface shagreened, sparsely and weakly granular; ventral surface shagreened, sparsely and weakly granular, distal end without granules. A total of 15 trichobothria present on chelal manus; *Db* trichobothria located externo-basally on dorsal surface; *Eb* group (3 trichobothria) orthobothriotaxic, located basally on external surface; *Esb* very close to *Eb* group; *Em* absent; *Est* located distally, very close to *Et* group; *Et* group composed of 5 trichobothria, Et_1 located ventrally; *V* group comprising 4 trichobothria, *V3* and *V4* located in the basal half of manus, *V1* and *V2* situated very distally. Pedipalp chela fingers (Fig. 14A-C). Dark reddish tan, with tips yellow-orange. Dorsal and ventral surfaces predominantly smooth, slightly shagreened and minutely pitted basally. Fingers longer than chela manus. Fixed finger with a very weak basal concavity, movable finger with corresponding lobe very weakly developed. Tips of fingers with pronounced distal hook. Fingers with distal diastema; edges of fingers composed of 2 rows of denticles becoming fused basally, interrupted at regular intervals by stronger granules, each of them coupled with an accessory granule; rows fused into a single row above concavity on fixed finger and on notch of movable finger, single basal row running towards base of fingers. A total of 11 trichobothria present on fingers; *Dt* located basally on dorsal surface of fixed finger; *db* located dorsally on internal surface, approximately midway on the fixed finger; *dsb*, *dst* and *dt* on dorsal surface, in distal third of finger; *eb* located dorsally on external surface, midway on fixed finger, opposite *db*; *esb*, *est* and *et* in distal third of fixed finger; *esb*, *est* and *et*, opposite *dsb*, *dst* and *dt*, respectively; *it* and *ib* located in distal half of fixed finger.

Coxosternal sclerites. Dark yellow to orange; smooth. Anterior margin of coxapohysis I smooth, with few weak granules, expanded but not sub-triangular in shape. Sternum of type 2 (Soleglad & Fet, 2003), longer than wide, pentagonal, shagreened; median furrow deep, more pronounced in posterior half; posterior pit absent.

Legs. Pale yellow. Predominantly smooth, dorsal surfaces of trochanter and femur finely and weakly granular. Tarsus with a ventromedian row of microspinules and with 2 rows of rigid "spinoid" ventral macrosetae; tarsi I-II: prolateral row with 5-6 macrosetae, retrolateral row with 7 macrosetae; tarsi III-IV: prolateral row with 6 macrosetae, retrolateral row with 7 macrosetae; setae acuminate; tarsal claws of equal length.

Pectines and genital operculum (Fig. 15B). Colour pale yellow; genital operculum composed of a single subtriangular plate, posterior extremity truncate, longitudinal median furrow relatively deep, posterior notch pronounced; pectines with 9/9 teeth.

Hemiscorpius lepturus Peters, 1861 Figs 1A-B, 16-21, 27E-F, 36

Hemiscorpius lepturus Peters, 1861a: 426-427, 8 figs.

Syntypes (not examined). 1 ♂ (*ZMB 43a*), 1 ♀ (*ZMB 43b*), IRAQ, Baghdad; 2 specimens (*ZMB 43*), IRAQ, Mendeli; YEMEN, Aden.

Material examined. 1 ♀ (7408), IRAN (Kohkiluyeh), Charam road, 22.V.1974, A. Senglet, *MHNG*. 1 ♀ juv. (7412b), IRAN (Kohkīluyeh), Yasudj road, 25.V.1974, A. Senglet, *MHNG*. 1 ♂ (2002/27), IRAN (Ghilan), 2 km W Cham-Khaled (Sea Star, Hotel Resort), nsl, 37°14.922'N, 50°15.037'E, 10.V.2002, B. Schätti, *MHNG*. 2 ♂, 2 ♀, IRAN (Khuzestan), Ahwaz region, 21.XI.1995, B. Masihpour, *MHNG*. 1 ♂, IRAN, ? Lali, VI.1961, M. Vasserot, *MNHN-RS 4332*. 1 ♀ juv., IRAN, 28.III.1961, M. Vasserot, *MNHN-RS 4333*. 1 ♂, 1 ♀, without locality, *MNHN-RS 5232 (122-123)*. 2 ♂, 2 ♀, 4 ♂ subadult, IRAN (Khuzestan), Masched-Soleyman, R. Farzanpay ?, *MHNG (SF 0006/13-20)*. 1 ♂ juv., 1 ♀, 2 ♀ juv., IRAN (Fars), ca. 90 km W Shiraz,

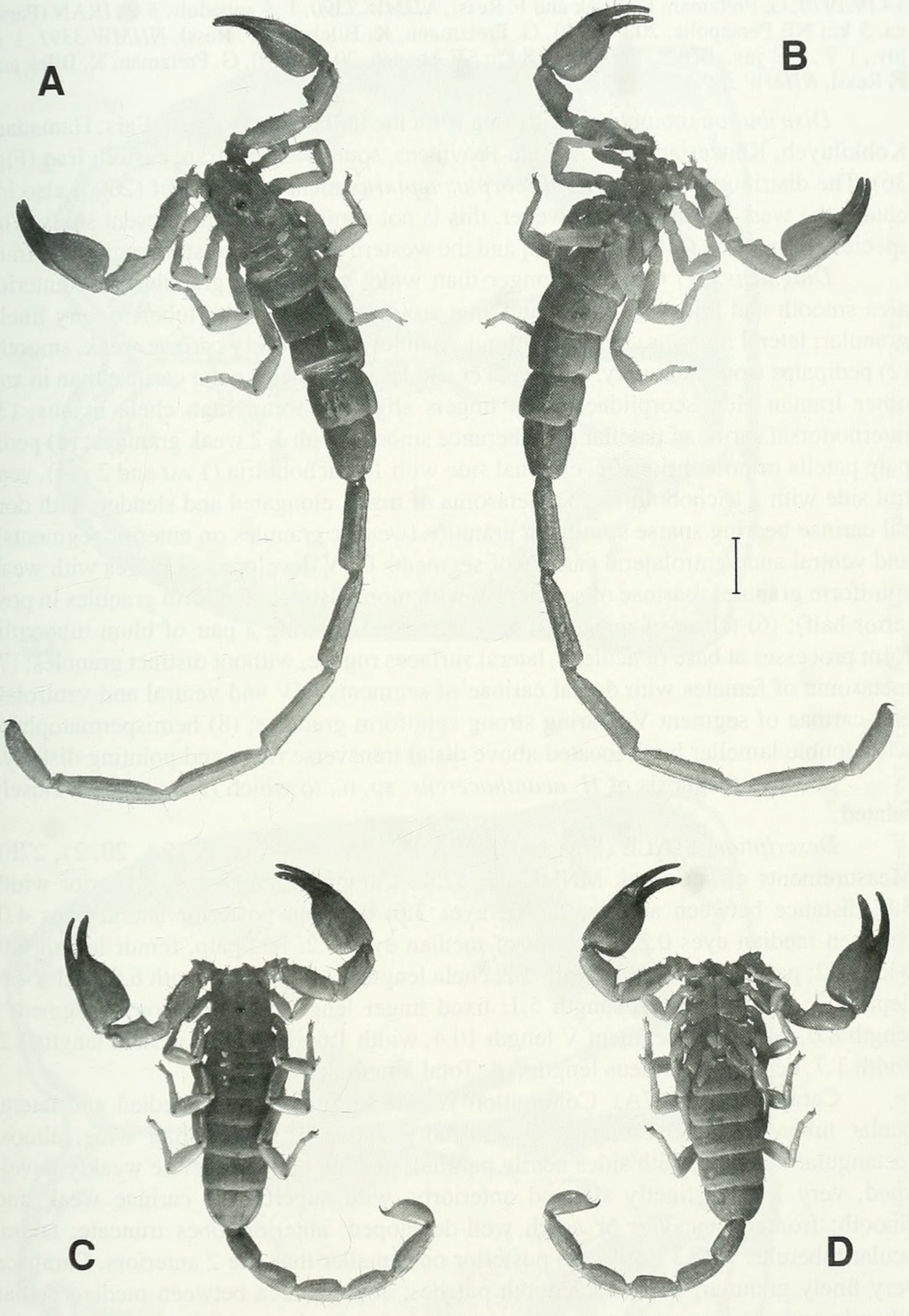

FIG. 16
Hemiscorpius lepturus. Male (*MNHN-RS 5232*): A, dorsal aspect; B, ventral aspect. Female paratype (*MNHN, SF0006/17*): C, dorsal aspect; D, ventral aspect. Scale line, 5 mm.

14.IV.1970, G. Pretzman, K. Bilek and F. Ressl, *NHMW 3390*. 1 ♂ subadult, 3 ♀, IRAN (Fars), ca. 5 km NE Persepolis, 20.IV.1970, G. Pretzmann, K. Bilek and F. Ressl, *NHMW 3391*. 1 ♂ juv., 1 ♀, 1 ♀ juv., IRAN (Fårs), ca. 18 km SE Abadeh, 20.IV.1970, G. Pretzman, K. Bilek and F. Ressl, *NHMW 3392*.

Distribution (completed with data from the literature). Esfahan, Fars, Hamadan, Kohkiluyeh, Khuzestan and Lorestan Provinces, south western Iran, eastern Iraq (Fig. 36). The distribution area of *Hemiscorpius lepturus* mentioned by Fet (2000) also includes the west of Pakistan. However, this is not confirmed by the present study. The species seems to be restricted to Iraq and the western and south western regions of Iran.

Diagnosis. (1) Carapace longer than wide, very finely granular with anterior area smooth and minutely pitted, and area around median ocular tubercle very finely granular; lateral margins smooth, without granules; superciliary carinae weak, smooth; (2) pedipalps stout and bulky, with weaker and less distinct granular carinae than in any other Iranian Hemiscorpiidae, chela fingers slightly shorter than chela manus; (3) internodorsal carina of patellar protuberance smooth, with 1-2 weak granules; (4) pedipalp patella orthobothriotaxic, external side with 13 trichobotria (1 *est* and 2 *esb*), ventral side with 3 trichobothria; (5) metasoma of males elongated and slender, with dorsal carinae bearing sparse spiniform granules (weaker granules on anterior segments), and ventral and ventrolateral carinae of segments IV-V developed as ridges with weak spiniform granules (carinae of segment V with more distinct spiniform granules in posterior half); (6) telson of males strongly elongated, bearing a pair of blunt tuberculiform processes at base of aculeus, lateral surfaces rugose, without distinct granules; (7) metasoma of females with dorsal carinae of segments I-IV and ventral and ventrolateral carinae of segment V bearing strong spiniform granules; (8) hemispermatophore with double lamellar hook located above distal transverse ridge and pointing distally.

See also diagnosis of *H. acanthocercus* sp. n., to which *H. lepturus* is closely related.

Description. MALE (Figs 1A-B, 16A-B, 17A, 18A-C, E-F, 19A, 20, 21, 27F). Measurements of specimen MNHN-RS 5232. Carapace, length 6.4, posterior width 5.8; distance between anterior lateral eyes 3.6, between posterior lateral eyes 4.0, between median eyes 0.2; diameter of median eyes 0.2. Pedipalp, femur length 6.0, width 2.2; patella length 5.8, width 2.2, chela length 10.8; manus length 6.0, width 4.4, depth 2.7; movable finger length 5.1; fixed finger length 3.8. Metasoma, segment I length 8.0, width 2.2; segment V length 10.4, width 1.6, depth 1.9; vesicle length 7.2, width 1.7, depth 2.0, aculeus length 0.8. Total length 85.0.

Carapace (Fig. 17A). Colouration yellow to light orange; median and lateral ocular tubercle black. Carapace dorsodistally flattened, longer than wide, almost rectangular in shape, with sides nearly parallel; median ocular tubercle weakly developed, very low, distinctly situated anteriorly, with superciliary carinae weak and smooth; frontal concavity or notch well-developed; anterior lobes truncate; lateral ocular tubercles with 3 ocelli, the posterior one smaller than the 2 anteriors. Carapace very finely granular, with few smooth patches; anterior area between median ocular tubercle and anterior margin smooth and minutely pitted, area around median ocular tubercle very finely granular; edges usually smooth, sometimes with very few weak granules below lateral ocular tubercles; anteromedian furrow narrow, suturiform, anteriorly bifurcated; median longitudinal furrow shallow, continuous from anterior suture

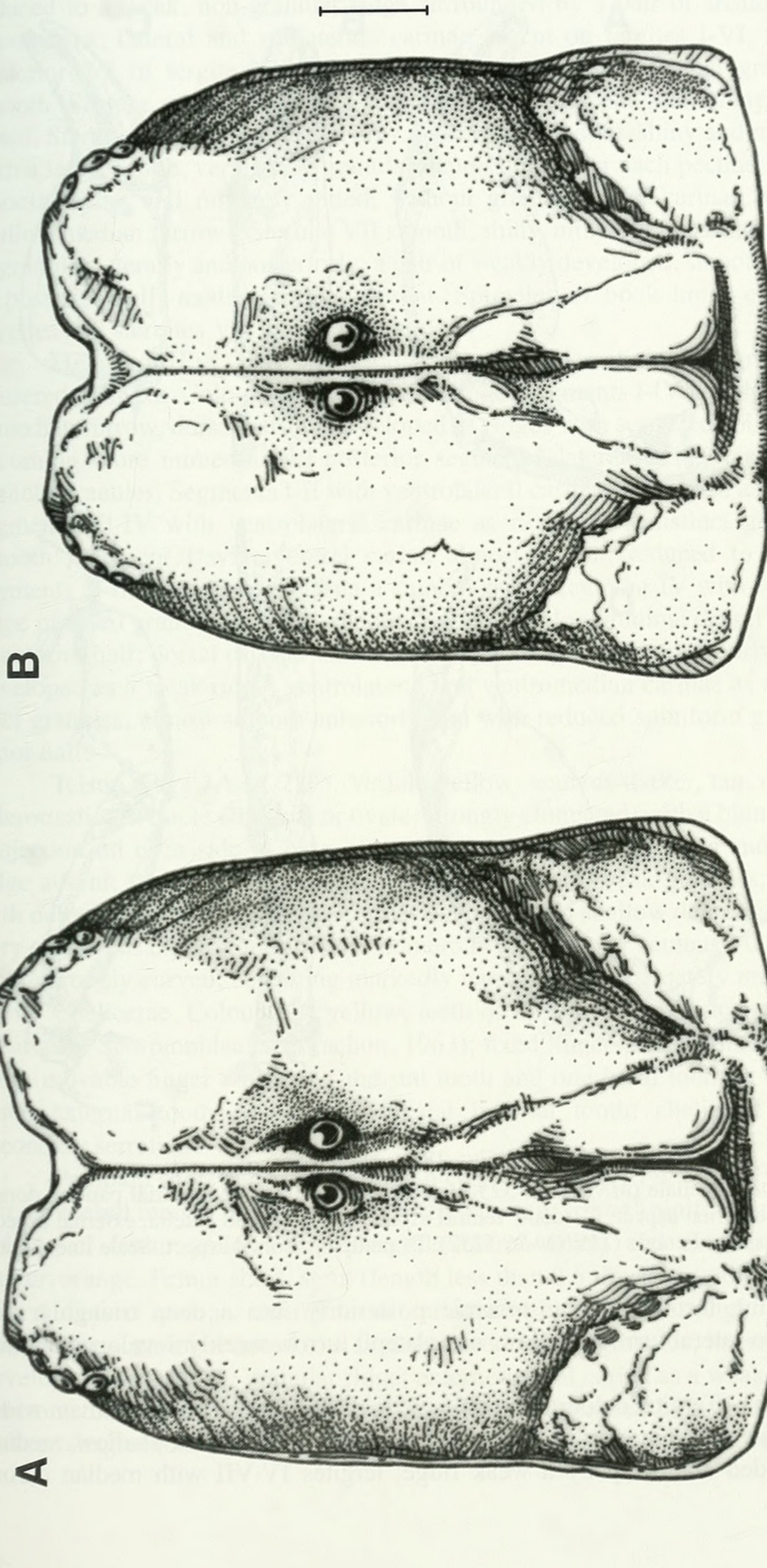

FIG. 17
Hemiscorpius lepturus, carapace, dorsal aspect (*MNHN-RS 5232*): A, male; B, female. Scale line, 1mm.

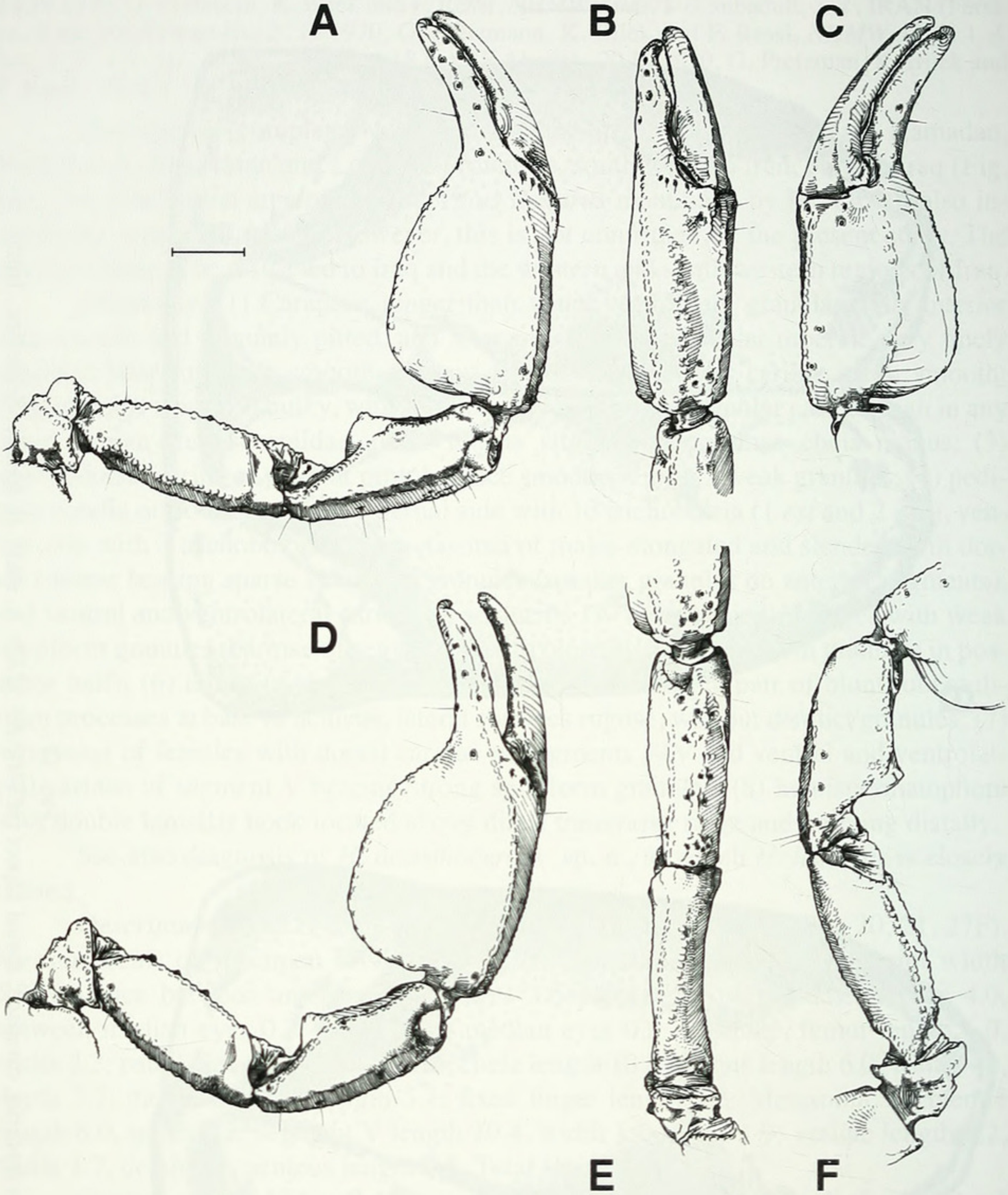

FIG. 18

Hemiscorpius lepturus, male (*MNHN-RS 5232*): A, pedipalp with trichobothrial pattern, dorsal aspect; B, chela, external aspect; C, idem, ventral aspect; E, femur and patella, external aspect; F, idem, ventral aspect. Female (*MNHN-RS 5232*): D, pedipalp, dorsal aspect. Scale line, 2 mm.

furcation, running through ocular tubercle posteriorly into a deep triangular depression; postero-lateral furrow shallow; mesolateral furrow weekly developed, almost indiscernible.

Mesosoma. Tergite colouration pale yellow. Tergite VII longer than wide. Tergite I without any depressions or carinae, tergites II-III with a shallow median depression divided anteriorly by a weak ridge, tergites IV-VII with median carina reduced to a weak, non-granular ridge surrounded by a pair of shallow, submedian depressions. Lateral and sublateral carinae absent on tergites I-VI, but present in posterior 2/3 of tergite VII, developed as ridges with indistinct granules, almost smooth. Surface of tergites finely granular; pre-tergites smooth, shiny and minutely pitted. Sternite colouration pale yellow. Sternite III smooth, shiny and minutely pitted, with a large, rough, very finely granular depression under each pectine; sternite IV-VI smooth, shiny and minutely pitted, without granulation or carinae, with a pair of shallow median furrows. Sternite VII smooth, shiny, minutely pitted medially and finely granular laterally and posteriorly; a pair of weakly developed, smooth lateral carinae in posterior half; median carinae absent. Spiracles of book lungs crescent-shaped. Tergites and sternites VII longer than wide.

Metasoma (Fig. 27F). Very elongated and slender, slightly shagreened, with fine scattered granules. Colour yellow to light orange. Segments I-IV with longitudinal dorsomedian furrow, dorsal carinae developed as ridges with scattered spiniform granules becoming more numerous on posterior segments, lateral carinae as smooth ridges without granules. Segments I-II with ventrolateral carinae developed as smooth ridges; segments III-IV with ventrolateral carinae as ridges of indistinct granules, almost smooth. Segment I with ventral carina almost absent, reduced to a weak ridge; segments II-III with ventral carina a smooth ridge; segment IV with ventral carina a ridge of fused granules, almost smooth. Segment V: longitudinal dorsal furrow present in anterior half; dorsal carinae with small spiniform granules posteriorly; lateral carina developed as a weak ridge; ventrolateral and ventromedian carinae as ridges of indistinct granules, almost smooth anteriorly and with reduced spiniform granules in posterior half.

Telson (Figs 1A-B, 27F). Vesicle yellow; aculeus darker, tan, due to stronger sclerotisation; vesicle elliptical or ovate, strongly elongated, with a blunt tuberculiform projection on each side at base of aculeus; ventrolateral furrows and ventromedian ridge absent; lateral surfaces irregular, with numerous weak granules; dorsal surface with numerous small spiniform granules and a median shallow depression. Macrosetae very sparse basally, becoming more numerous near base of aculeus. Aculeus short and stout, strongly curved, becoming markedly narrower approximately midway.

Chelicerae. Colour pale yellow; teeth of fingers darker, orange. Teeth arrangement as in Scorpionidae (see Vachon, 1963); fixed finger with median and basal teeth bifid; movable finger with one subdistal tooth and one basal tooth in external series; distal external tooth smaller than distal internal tooth; cheliceral teeth without secondary serrations.

Pedipalp short and stout. Pedipalp coxa and femur (Fig. 18A, E-F). Coxa with internoventral margin mostly smooth, with only few strong spiniform granules. Dorsal surface of femur yellow, internodorsal, internoventral and externoventral carinae darker, orange. Femur short, stout (length less than 2.5 times its width), pentacarinate, with 4 distinct carinae; internodorsal carina developed as a strongly granular ridge; externodorsal carina reduced to a slightly raised row of granules; internoventral carina developed as a strongly granular ridge; externoventral carina as a weak granular ridge; ventromedian carina reduced to few granules and confined to base of femur. Dorsal surface shagreened, finely and densely granular, distal end smooth, without granules;

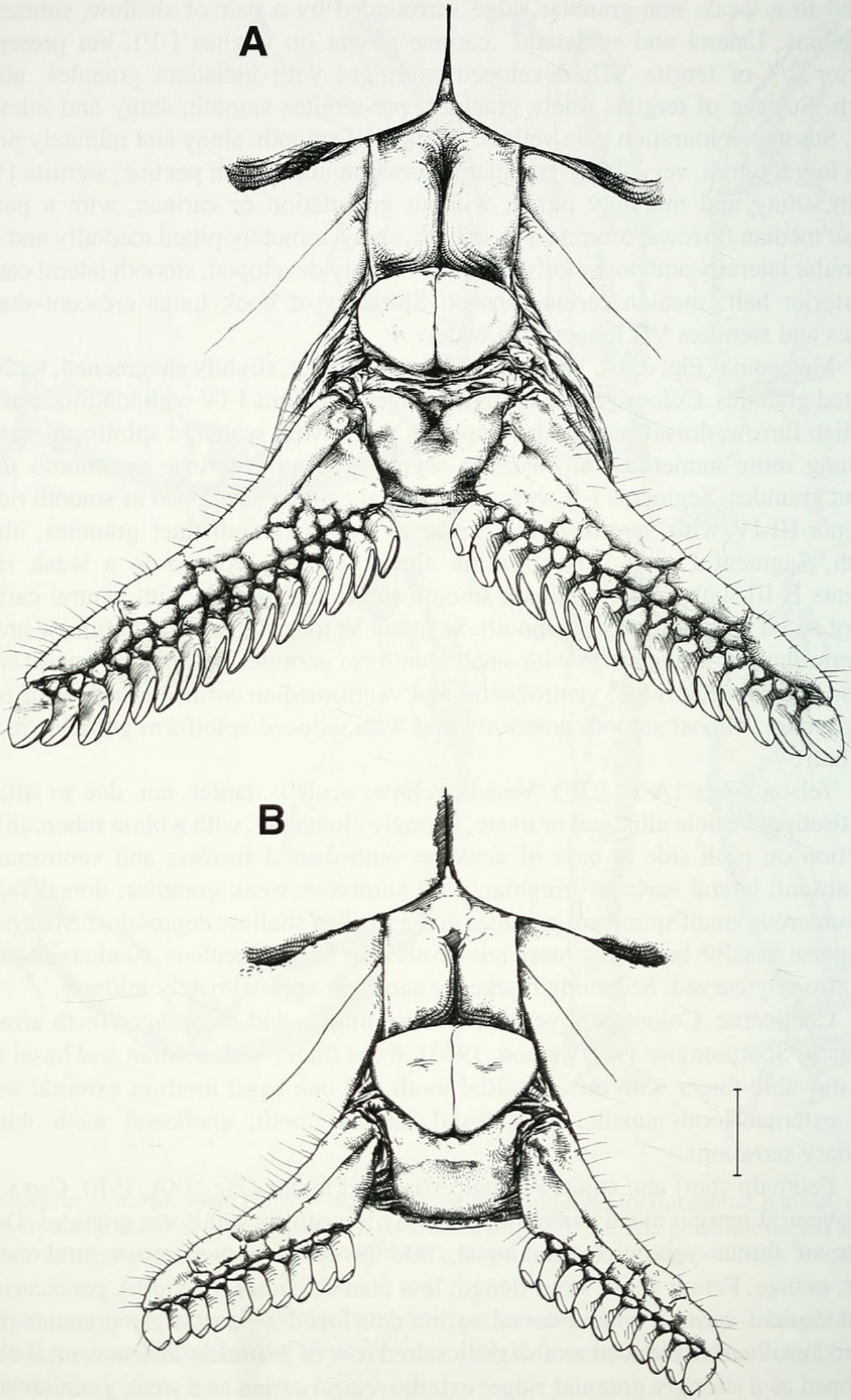

FIG. 19

Hemiscorpius lepturus, pectines and genital opercula, ventral aspect: A, male (*MNHN-RS5232*); B, female (*MHNG*, *SF 0006*). Scale line, 1 mm.

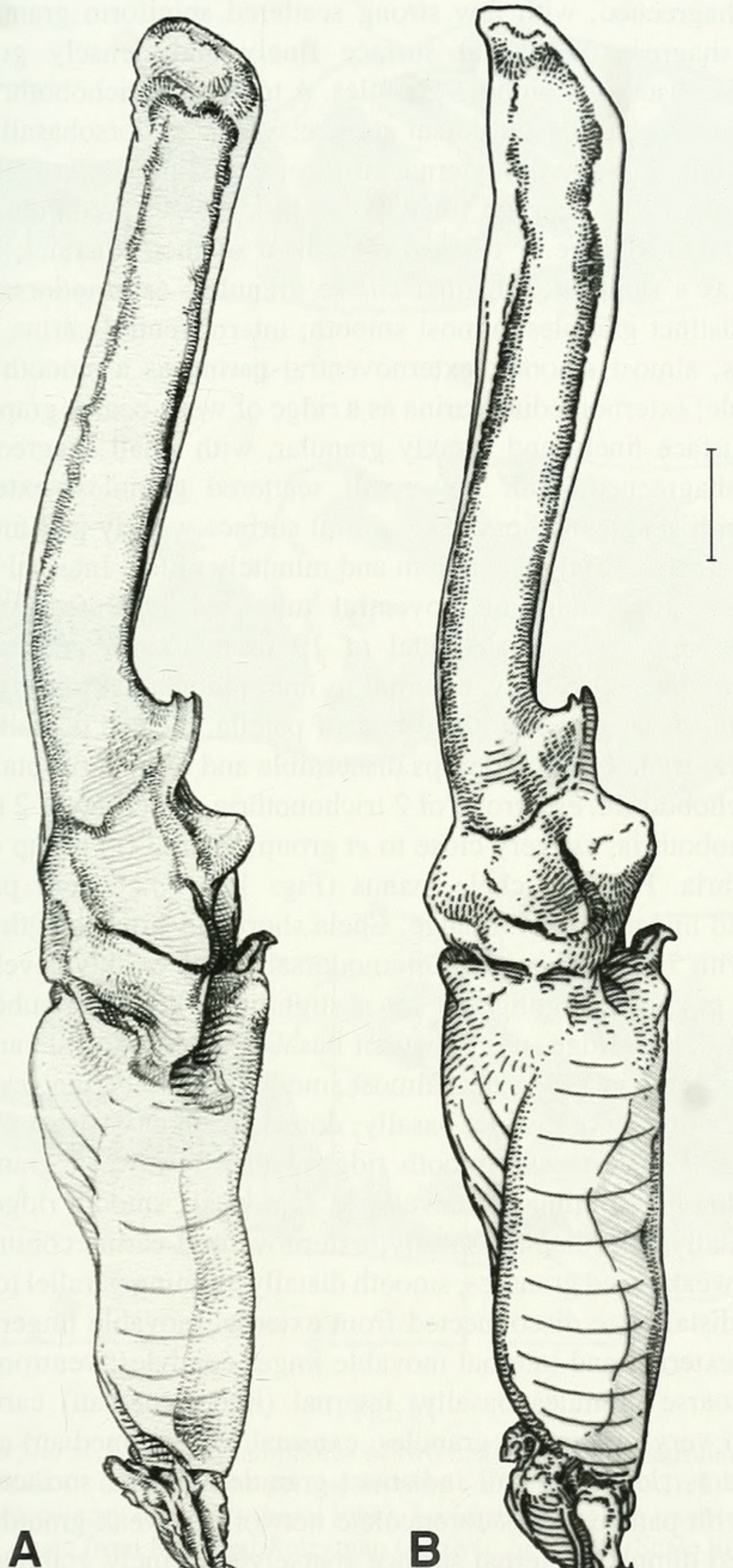

FIG. 20

Hemiscorpius lepturus, hemispermatophores of two males, external aspect: A, male from Masched-Soleyman (*MHNG, SF 0006*); B, male from Iran, without precise locality (*MNHN-RS 4332*). Scale line, 0.5 mm.

internal surface shagreened, with few strong scattered spiniform granules; external surface slightly shagreened; ventral surface finely and densely granular, with shagreened patches, distal end without granules. A total of 3 trichobothria present on femur; *d* located externobasally on dorsal surface; *i* located dorsobasally on internal surface; *e* located dorsobasally on external surface. Pedipalp patella (Figs 18A, E-F) short and stout (length less than 2.5 times its width). Colour predominantly yellow; carinae slightly darker, orange. 7 carinae present, 6 of them distinct; internodorsal carina developed as a ridge of indistinct coarse granules; externodorsal carina as a weak ridge of indistinct granules, almost smooth; internoventral carina as a ridge of indistinct granules, almost smooth; externoventral carina as a smooth weak ridge, almost indiscernible; externomedian carina as a ridge of weak coarse granulaes, almost smooth. Dorsal surface finely and weakly granular, with small shagreened patches; internal surface shagreened, with few small scattered granules; external surface minutely pitted, with shagreened patches; ventral surface weakly and finely granular, with shagreened patches, distal end smooth and minutely pitted. Internal protuberance weak, bifid (internodorsal and internoventral tubercles separated), dorsal carina smooth, with 1-3 weak granules. A total of 19 trichobothria present on patella, orthobothriotaxy; d_1 located basally, external to internodorsal carina; d_2 located submedially on patella; d_3 absent; *i* in distal half of patella, located dorsally on internal surface. External (*e*) trichobothrial groups discernible and orthobothriotaxic: *eb* group composed of 5 trichobothria, *esb* group of 2 trichobothria, *em* group of 2 trichobothria, *et* group of 3 trichobothria; *est* very close to *et* group. Ventral (*v*) group orthobothriotaxic, 3 trichobothria. Pedipalp chela manus (Figs 18A-C). Colour predominantly yellow; carinae and fingers darker, orange. Chela short and stout (length less than 2.5 times its width), with 5 distinct carinae; internodorsal carina weakly developed, visible as a row of few granules, highlighted by a slightly darker line; subdigital carina vestigial, a smooth, weak ridge, more distinct basally; externodorsal carina vestigial, visible as a ridge of indistinct granules, almost smooth; digital carina vestigial, visible as a smooth, weak ridge more distinct basally; dorsal secondary carina (dorsomedian) vestigial, visible as a very weak, smooth ridge with a few weak granules basally; internoventral carina not continuous, developed as a weak, smooth ridge, with a few weak granules distally, less distinct basally; externoventral carina continuous, developed as a ridge of weak fused granules, smooth distally, running parallel to longitudinal axis of chela, its distal edge disconnected from external movable finger condyle and directed between external and internal movable finger condyles; ventromedian carina reduced to 1-2 coarse granules basally; internal (internomedian) carina vestigial, visible as a row of very few sparse granules; external (externomedian) carina weakly developed, visible as ridge of small indistinct granules. Dorsal surface smooth and minutely pitted, with patches of a subreticulate network of weak granular ridges and shallow shagreened dimples; internal surface sparsely and finely granular, with small shagreened patches, with a patch of stronger spiniform granules dorsodistally; external surface minutely pitted, forming an irregular and subreticulate network of weakly and finely granular ridges and shallow shagreened dimples; ventral surface smooth and minutely pitted, with few small shagreened patches. A total of 15 trichobothria present on chela manus; *Db* trichobothria located externobasally on dorsal surface; *Eb* group

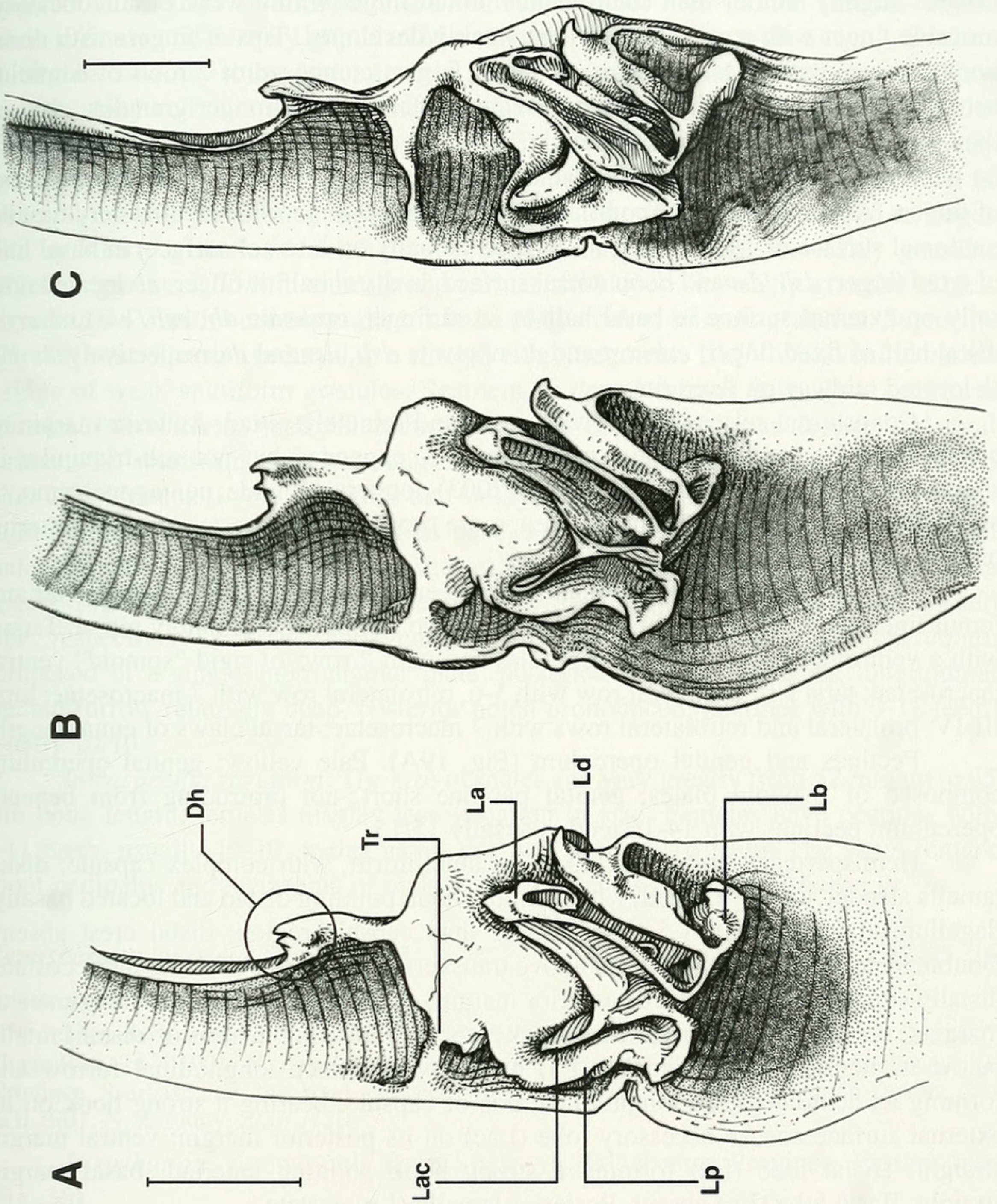

FIG. 21

Hemiscorpius lepturus, hemispermatophores of two males, detail of capsular region, internal aspect: A-B, male from Iran, without precise locality (*MNHN-RS 4332*), Dh (double hook), La (lamella), Lac (accessory lobe), Lb (basal lobe), Ld (distal lobe), Lp (posterior lobe), Tr (transverse ridge); C, male from Masched-Soleyman (*MHNG, SF 0006*). Scale lines, 0.5 mm.

(3 trichobothria) orthobothriotaxic, located basally on external surface; *Esb* very close to *Eb* group; *Em* absent; *Est* located distally, very close to *Et* group; *Et* group composed of 5 trichobothria, Et_1 located ventrally; *V* group comprising 4 trichobothria, *V3* and *V4* located in the basal half of manus, *V1* and *V2* located very distally. Pedipalp chela fingers (Figs 18A-C). Dark orange to reddish tan, smooth, minutely pitted basally.

Fingers slightly shorter than chela manus. Fixed finger with a weak basal concavity, movable finger with corresponding lobe weakly developed. Tips of fingers with distal hook. Fingers with distal diastema; edges of fingers composed of 2 rows of denticles becoming fused basally, interrupted at regular intervals by stronger granules, each of these coupled with an accessory granule; rows fused into a single row above concavity on fixed finger and on notch of movable finger, single basal row running towards base of fingers. A total of 11 trichobothria present on chelal fingers; *Dt* located very basally on dorsal surface of fixed finger; *db* located dorsally on internal surface, in basal half of fixed finger; *dsb*, *dst* and *dt* on dorsal surface, in distal half of finger; *eb* located dorsally on external surface in basal half of fixed finger, opposite *db*; *esb*, *est* and *et* in distal half of fixed finger; *esb*, *est* and *et*, opposite *dsb*, *dst* and *dt*, respectively; *it* and *ib* located midway on fixed finger.

Coxosternal sclerites. Yellow; smooth and minutely pitted. Anterior margin of coxapohysis I smooth, with few weak granules, expanded but not sub-triangular in shape. Sternum of type 2 (Soleglad & Fet, 2003), longer than wide, pentagonal, smooth and minutely pitted; median furrow deep, more pronounced in posterior half; posterior pit absent.

Legs. Pale yellow. Predominantly shagreened; dorsal surfaces of trochanter and femur finely and densely granular; ventral surface smooth and minutely pitted. Tarsus with a ventromedian row of microspinules and with 2 rows of rigid "spinoid" ventral macrosetae; tarsi I-II: prolateral row with 5-6, retrolateral row with 7 macrosetae; tarsi III-IV: prolateral and retrolateral rows with 7 macrosetae; tarsal claws of equal length.

Pectines and genital operculum (Fig. 19A). Pale yellow; genital operculum composed of 2 ovoid plates; genital papillae short, not protruding from beneath operculum; pectines with 14-16 teeth, ususally 15/15.

Hemispermatophore (Figs 20-21). Lamelliform, with complex capsule; distal lamella slender, basally curved, with a double hook pointing distad and located basally, flagellum approximately 1.5 times longer than capsule region; distal crest absent. Double lamellar hook (Dh) located above transverse distal ridge (Tr), the latter costate, distally strongly curved towards anterior margin, continuous from posterior to anterior margins, not merging with lamellar hook, reaching anterior margin of distal lamella below its hook. Capsule lamella (La) broad, with a deep longitudinal furrow and forming an acute angle to longitudinal axis of capsule, bearing a strong hook on its external surface and an accessory lobe (Lac) on its posterior margin; ventral margin straight. Distal lobe (Ld) forming a strong hook pointing anteriad; basal margin straight. Basal lobe (Lb) absent. Posterior lamella (Lp) costate.

FEMALE (Figs 16C-D, 17B, 18D, 19B, 27E). Measurements of specimen MNHN-SF0006/18. Carapace, length 6.0, posterior width 5.6; distance between anterior lateral eyes 3.4, between posterior lateral eyes 3.8, between median eyes 0.2; diameter of median eyes 0.2. Pedipalp, femur length 5.7, width 2.1; patella length 5.6; width 2.1, chela length 10.7; manus length 6.0, width 4.5, depth 2.5; movable finger length 4.9; fixed finger length 3.6. Metasoma, segment I length 3.9, width 2.3; segment V length 5.7, width 1.6, depth 2.0; vesicle length 3.9, width 2.3, depth 2.3, aculeus length 1.1. Total length 56.0.

Same characters as in males, except as follows. Carapace (Fig. 17B) less elongated than in male, almost as wide as long. Carapace finely granular, with larger longitudinal median area smooth and minutely pitted; area around median ocular tubercle finely and densely granular. Mesosoma. Tergite VII as wide as long. Surface of tergites smooth, shiny and minutely pitted, finely granular laterally; pre-tergites smooth, shiny and minutely pitted, tergites VI-VII more granular than others. Sternite VII as wide as long. Metasoma (Fig. 27E). Short and relatively stout, slightly shagreened, with fine scattered granules. Carinae generally more granular than in males, spiniform granules stronger. Segments I-IV, dorsal carinae developed as ridges with spiniform granules (denser than in males), lateral carinae as weakly granular ridges. Segments I-II with ventrolateral carinae developed as weakly granular ridges, segment III-IV with ventrolateral carinae bearing weak spiniform granules. Segments I-II with ventral carina reduced to a smooth ridge; segments III-IV with ventral carina a ridge of weak spiniform granules. Segment V: dorsal carinae with weak spiniform granules; lateral carina vestigial, reduced to a row of scattered granules, ventrolateral carinae with spiniform granules; ventromedian carina with spiniform granules. Telson (Fig. 27E). Vesicle ovoid, globular and bulky; lateral surfaces smooth, slightly irregular. Aculeus without tubercles at its base, narrowing slightly less marked than in male. Pedipalp (Figs 18D). Slightly shorter and stouter than in males. Pedipalp chela fingers (Figs 18D). Fixed and movable fingers with slightly weaker basal concavity and lobe, respectively. Pectines and genital operculum (Fig. 19B). Genital operculum composed of a single subtriangular plate, posterior extremity truncate, longitudinal median furrow relatively deep, posterior notch pronounced; pectines with 9-11 teeth, usually 10/10.

Intraspecific variation. The size of males can vary greatly from 52 mm up to 85 mm body length, females display less variation in size. Females have pectines with 8-11 teeth, usually 10-10, males haves pectines with 14-16 teeth. The same remark about pedipalps and metasoma of males can be given as for *H. acanthocercus*.

Hemiscorpius persicus Birula, 1903 Figs 22-25, 36

Hemiscorpion persicum Birula, 1903: 77-80.

Material examined. Syntypes: 1 ♂, IRAN (Sīstān va Balūchestan), "Province Ssarbas", village Riss, 24.II.1901, N. Zarudny, *ZISP 1120*; 1 ♂ subadult, IRAN (Sīstān va Balūchestan), "Province Ssarbas", on the road between village Riss and locality Kaptegin-Dukan, 24-26.II.1901, N. Zarudny, *ZISP 1120*.

Distribution. Known only from Sīstān va Balūchestan Province, Eastern Iran (Fig. 36).

Diagnosis. (1) Carapace longer than wide, shagreened and finely granular, with small smooth patches; lateral margins with small spiniform granules below lateral ocular tubercles; superciliary carinae finely granular; (2) pedipalps relatively stout and bulky, chela fingers slightly shorter or equal in size to chela manus; (3) internal protuberance of pedipalpal patella with internodorsal carina bearing 1-2 strong spiniform granules, usually 2; (4) pedipalp patella orthobothriotaxic, external side with 13 trichobotria (1 *est* and 2 *esb*), ventral side with 3 trichobothria; (5) metasoma of males relatively elongated and slender, with dorsal carinae of segments I-V and ventral and ventrolateral carinae of segments IV-V bearing spiniform granules; (7) telson of males not strongly elongated, without blunt tuberculiform processes at base of aculeus.

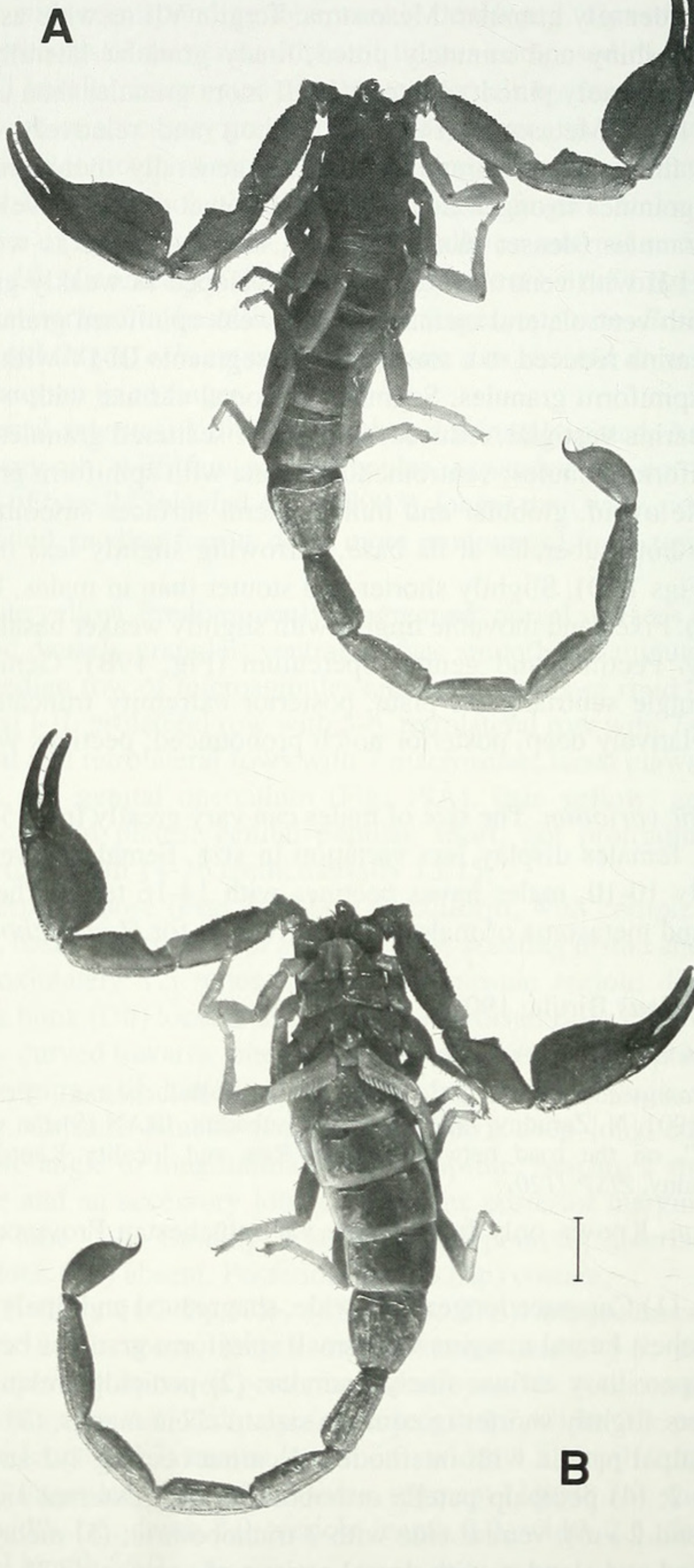

FIG. 22
Hemiscorpius persicus, male syntype (*ZISP 1120*): A, dorsal aspect; B, ventral aspect. Scale line, 2.5 mm.

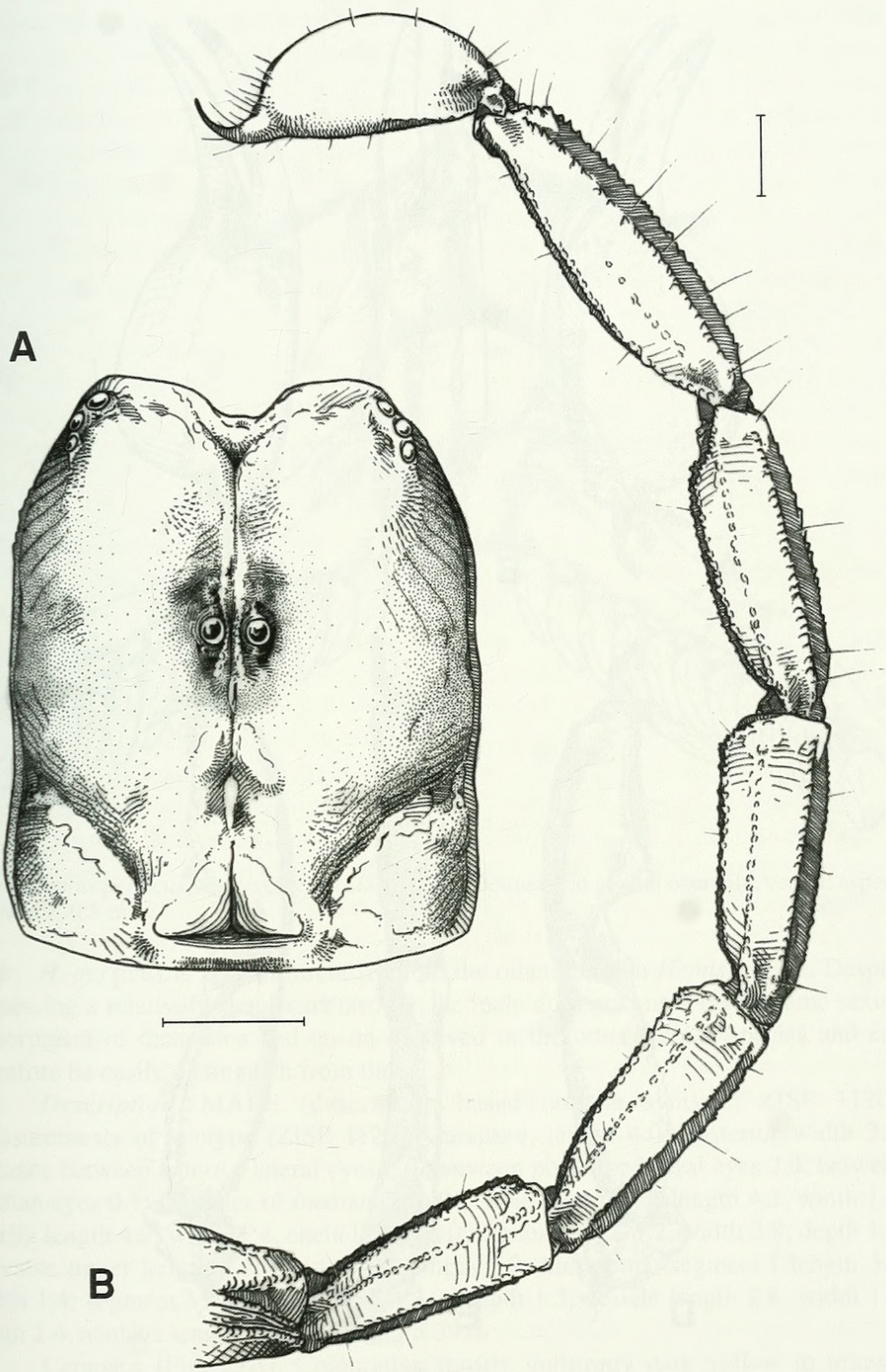

FIG. 23
Hemiscorpius persicus, male syntype (*ZISP 1120*): A, carapace, dorsal aspect; B, metasoma, lateral aspect. Scale lines, 1 mm.

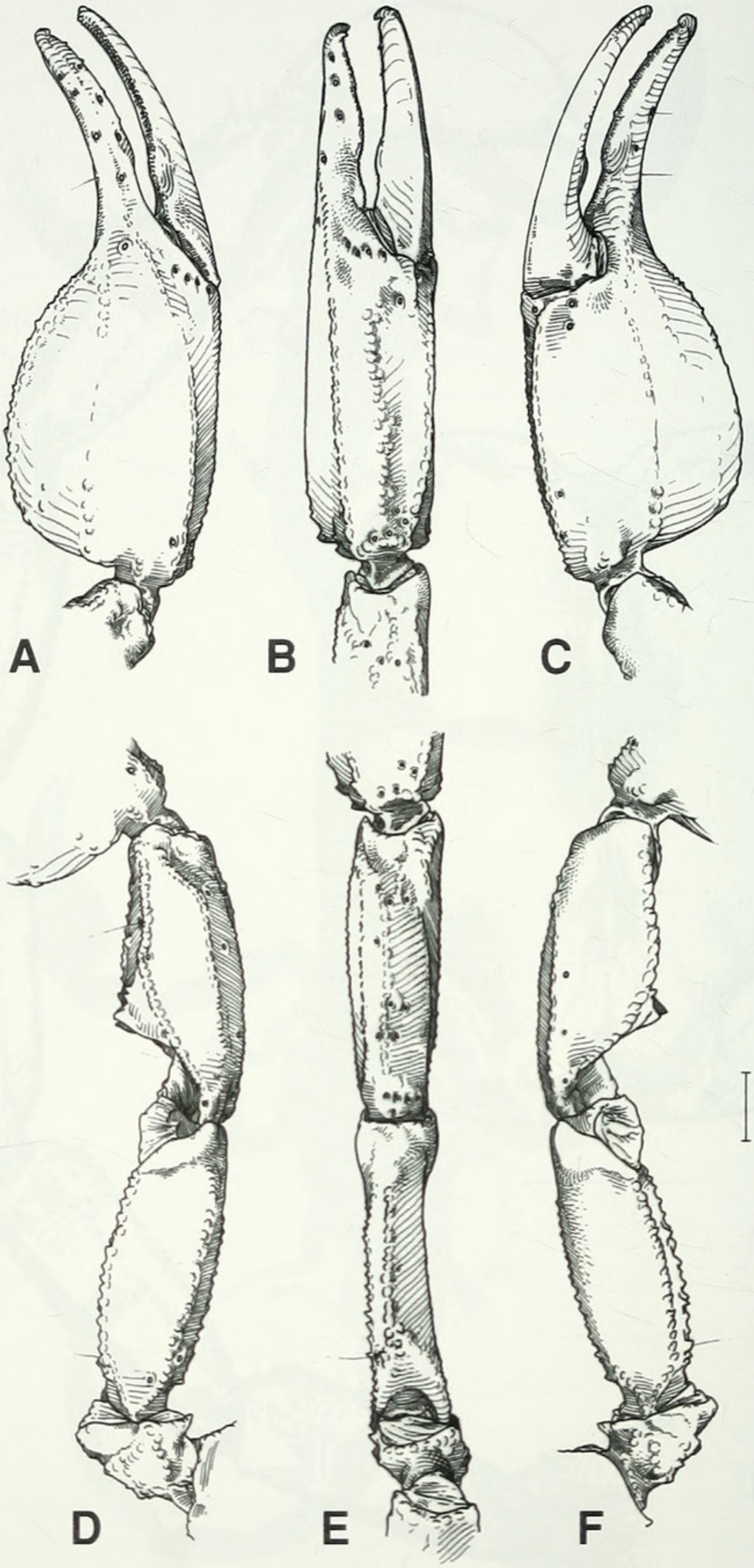

FIG. 24

Hemiscorpius persicus, male syntype (*ZISP 1120*), pedipalp with trichobothrial pattern: A, chela, dorsal aspect; B, idem, external aspect; C, idem, ventral aspect; D, femur and patella, dorsal aspect; E, idem, external aspect; F, idem, ventral aspect. Scale line, 1 mm.

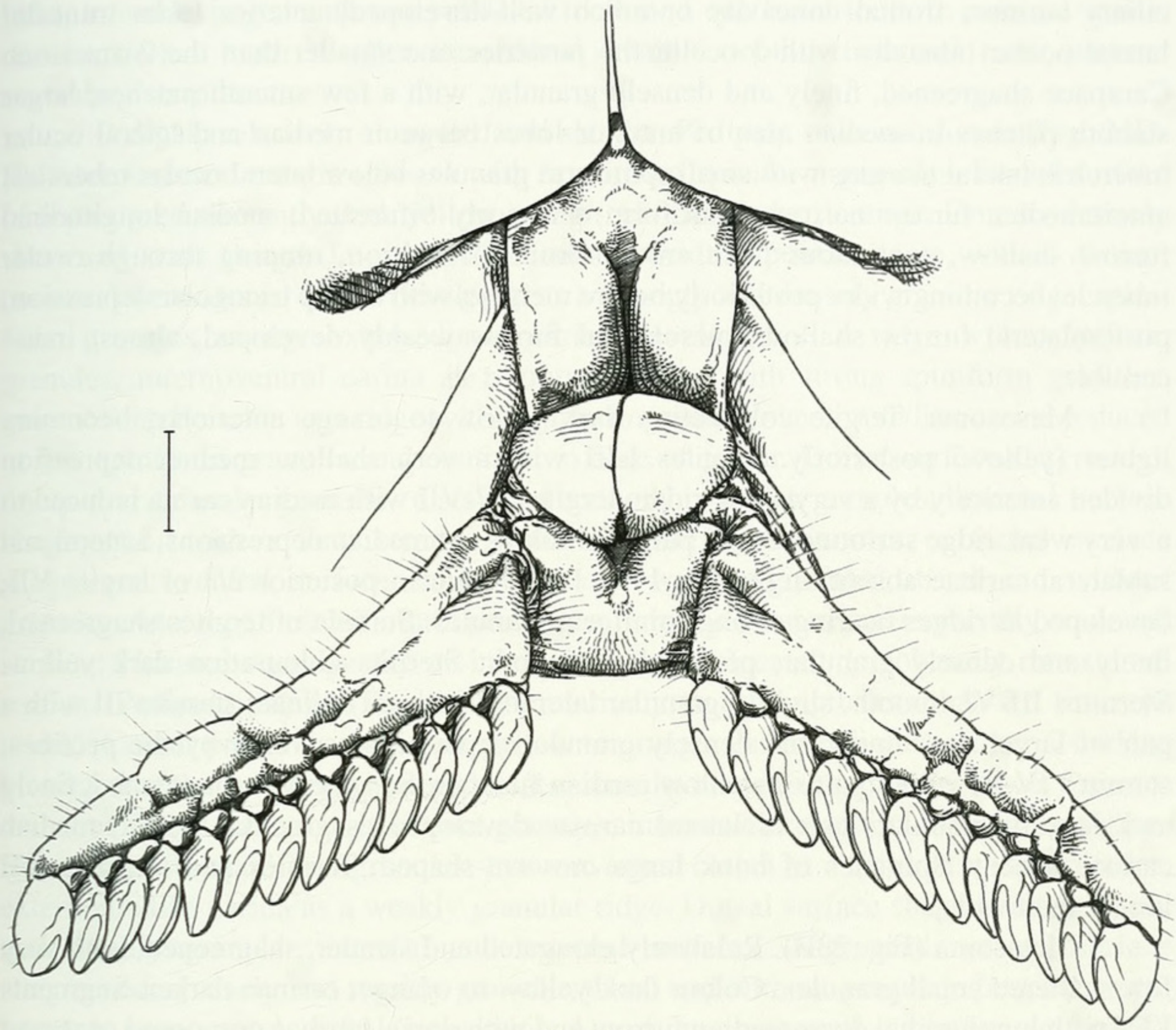

FIG. 25
Hemiscorpius persicus, male syntype (*ZISP 1120*): pectines and genital opercula, ventral aspect. Scale line, 0.5 mm.

H. persicus is very different from all the others Iranian *Hemiscorpius*. Despite possessing a relatively slender metasoma, the male does not show the extreme sexual dimorphism of metasoma and telson observed in the other Iranian species and can therefore be easily distinguish from them.

Description. MALE (description based on the syntype, ZISP 1120). Measurements of syntype (ZISP 1120). Carapace, length 4.0; posterior width 3.4; distance between anterior lateral eyes 2.0, between posterior lateral eyes 2.4, between median eyes 0.1; diameter of median eyes 0.1. Pedipalp, femur length 4.2, width 1.5; patella length 4.2, width 1.4, chela length 8.0; manus length 4.2, width 2.8, depth 1.7; movable finger length 4.1; fixed finger length 3.2. Metasoma, segment I length 3.2, width 1.4; segment V length 4.6, width 1.1, depth 1.3; vesicle length 2.8, width 1.1, depth 1.4, aculeus length 0.9. Total length 39.0.

Carapace (Fig. 23A). Colouration mostly uniformly dark yellow to orange; median and lateral ocular tubercles black. Carapace dorsodistally flattened, longer than wide, almost rectangular in shape, with sides nearly parallel; median ocular tubercle weakly developed, low, distinctly situated anteriorly, with weak, finely granular superciliary carinae; frontal concavity or notch well-developed; anterior lobes truncate; lateral ocular tubercles with 3 ocelli, the posterior one smaller than the 2 anteriors. Carapace shagreened, finely and densely granular, with a few smooth patches; larger smooth patches in median area of anterior lobes between median and lateral ocular tubercles; lateral margins with small spiniform granules below lateral ocular tubercles; anteromedian furrow narrow, suturiform, anteriorly bifurcated; median longitudinal furrow shallow, continuous from anterior suture furcation, running through ocular tubercle, becoming wider posteriorly before merging with a deep triangular depression; posterolateral furrow shallow; mesolateral furrow weakly developed, almost indiscernible.

Mesosoma. Tergite colouration dark yellow to orange anteriorly, becoming lighter (yellow) posteriorly. Tergites I-III with a very shallow median depression divided anteriorly by a very weak ridge, tergites IV-VII with median carina reduced to a very weak ridge surrounded by a pair of shallow, submedian depressions. Lateral and sublateral carinae absent on tergites I-VI, but present in posterior 2/3 of tergite VII, developed as ridges bearing strong spiniform granules. Surface of tergites shagreened, finely and densely granular; pre-tergites smooth. Sternite colouration dark yellow. Sternites III-VI smooth, slightly granular laterally, without carinae; sternite III with a pair of large, very finely and densely granular depressions covered by the pectines; sternites IV-VI with a pair of shallow median furrows. Sternite VII shagreened, finely and densely granular; pair of lateral carinae developed as granular ridges; median carinae absent. Spiracles of book lungs crescent-shaped. Tergites and sternites VII longer than wide.

Metasoma (Fig. 23B). Relatively elongated and slender, shagreened, with very few scattered small granules. Colour dark yellow to orange, carinae darker. Segments I-IV with longitudinal dorsomedian furrow and with dorsal carinae composed of strong spiniform granules. Segments I-IV with lateral carinae developed as ridges bearing sparse spiniform granules, lateral carinae on segments III-IV less granular than those on segments I-II. Segments I-II with ventrolateral carinae developed as ridges with weak granules; segments III-IV with ventrolateral carinae as ridges of spiniform granules. Segment I-II with ventral carina a ridge with few very weak granules, almost smooth; segments III-IV with ventral carina a ridge with more distinct spiniform granules. Segment V: longitudinal dorsal furrow present in anterior half, dorsal carinae with strong spiniform granules; lateral carina vestigial, only visible in anterior 2/3 as a row of small scattered granules; ventrolateral and ventromedian carinae with spiniform granules.

Telson (Fig. 23B). Vesicle yellow to orange; aculeus darker, tan, due to stronger sclerotisation; vesicle elliptical or ovate, without blunt tuberculiform projections at base of aculeus; ventrolateral furrows and ventromedian ridge absent; lateral surfaces smooth, with sparse weak granules; dorsal surface with very small spiniform granules and a median shallow depression anteriorly. Macrosetae very sparse basally, becoming more numerous near base of aculeus. Aculeus short and stout, strongly curved, becoming markedly narrower approximately midway.

Chelicerae. Colour dark yellow; teeth of fingers darker, orange. Teeth arrangement as in Scorpionidae (see Vachon, 1963); fixed finger with median and basal teeth bifid; movable finger with one subdistal tooth and one basal tooth in external series; distal external tooth smaller than distal internal tooth; cheliceral teeth without secondary serrations.

Pedipalp relatively elongated and slender. Pedipalp coxa and femur (Fig. 24D-F). Internoventral margin of coxa with few strong spiniform granules. Dorsal surface of femur predominantly dark yellow-orange, carinae darker, orange. Femur relatively short and stout (length less than 2.5 times its width), pentacarinate, with 4 distinct carinae; internodorsal carina developed as a strongly and densely granular ridge, spiniform granules strong; externodorsal carina developed as a ridge with spiniform granules; internoventral carina as a granular ridge with strong spiniform granules; externoventral carina as a ridge with spiniform granules; ventromedian carina reduced to few spiniform granules and confined to base of femur. Dorsal surface shagreened, finely and densely granular, distal end smooth, without granules; internal surface shagreened, with a few strong scattered spiniform granules; external surface shagreened; ventral surface shagreened and weakly granular, distal end without granules. A total of 3 trichobothria present on femur; *d* located externobasally on dorsal surface; *i* located dorsobasally on internal surface; *e* located dorsobasally on external surface. Pedipalp patella (Fig. 24D-F) relatively stout (length less than 2.5 times its width). Colour predominantly dark yellow to orange; carinae slightly darker. 7 carinae present, 6 of them distinct; internodorsal carina developed as a granular ridge; externodorsal carina as a ridge of indistinct granules; internoventral carina as a strongly granular ridge with spiniform granules; externoventral carina as a ridge of weak granules; externomedian carina as a weakly granular ridge. Dorsal surface shagreened, sparsely and weakly granular; internal and external surfaces shagreened; ventral surface shagreened, sparsely and weakly granular, distal end without granules. Internal protuberance pronounced, bifid (internodorsal and internoventral tubercles separated), internodorsal carina with 2 strong spiniform granules. A total of 19 trichobothria present on patella, orthobothriotaxy; d_1 located basally, external to internodorsal carina; d_2 located midway on patella; d_3 absent; *i* in distal half of patella, located dorsally on internal surface. External (*e*) trichobothrial groups discernible and orthobothriotaxic: *eb* group composed of 5 trichobothria, *esb* group of 2 trichobothria, *em* group of 2 trichobothria, *et* group of 3 trichobothria; *est* midway between *em* to *et* groups. Ventral (*v*) group of 3 trichobothria (orthobothriotaxic). Pedipalp chela manus (Fig. 24A-C). Colour predominantly orange to red-brown; carinae reddish brown to almost black. Chela relatively stout (length less than 2.5 times its width) with 5 distinct carinae; internodorsal carina continuous, with spiniform granules, stronger basally; subdigital carina vestigial, visible basally as a smooth ridge with weak granules; externodorsal carina distinct, visible as a ridge of indistinct fused granules, almost smooth; digital carina as a smooth ridge with few weak granules basally; dorsal secondary carina (dorsomedian) as a smooth ridge with very few strong granules basally and few weak granules distally; internoventral carina continuous, visible as a weak ridge with very weak granules; externoventral carina continuous, developed as a granular ridge, becoming almost smooth distally, running parallel to longitudinal axis of chela, its distal edge disconnected from external movable finger condyle and directed between external and internal movable finger condyles; ventromedian carina vestigial, reduced to few coarse granules basally; internal (internomedian) carina vestigial, reduced to few weak spiniform granules in distal half; external (externomedian) carina indistinct, visible as raised rows of granules. Dorsal surface shagreened and sparsely granular; internal surface shagreened, sparsely granular, with a denser patch of bigger spiniform granules dorsodistally; external surface shagreened, sparsely and weakly granular; ventral surface shagreened and sparsely granular, distal end smooth and pitted. A total of 15 trichobothria present on chela manus; *Db* trichobothria located externobasally on dorsal surface; *Eb* group (3 trichobothria) orthobothriotaxic, located basally on external surface; *Esb* very close to *Eb* group; *Em* absent; *Est* located distally, very close to *Et* group; *Et* group composed of 5 trichobothria, Et_1 located ventrally; *V* group comprising 4 trichobothria, *V3* and *V4* located in basal third of manus, *V1* and *V2* located very far distally. Pedipalp chela fingers (Fig. 24A-C). Basally reddish tan, becoming gradually lighter distally, tips of fingers yellow, edges black. Dorsal and ventral surfaces predominantly smooth and pitted, slightly shagreened basally. Fingers slightly shorter than chela manus. Fixed finger with weak basal concavity, movable finger with corresponding lobe weakly developed. Tips of fingers with pronounced terminal hook. Fingers with distal diastema; edges of fingers composed of 2 rows of denticles becoming fused basally, interrupted at regular intervals by stronger granules, each of them coupled with an accessory granule; rows fused into a single row above concavity on fixed finger and on notch of movable finger, single basal row running towards base of fingers. A total of 11 trichobothria present on chelal fingers; *Dt* located very basally on dorsal surface; *db* located dorsally on internal surface, in the basal half of fixed finger; *dsb*, *dst* and *dt* on dorsal surface, in distal half of finger; *eb* located dorsally on external surface, in basal 1/3 of fixed finger, opposite *db*; *esb*, *est* and *et* in distal half of fixed finger, opposite *dsb*, *dst* and *dt*, respectively; *it* and *ib* located in median 1/3 of fixed finger.

Coxosternal sclerites. Dark yellow to orange; smooth, with shagreened patches. Anterior margin of coxapohysis I with few weak granules, expanded but not sub-triangular in shape. Sternum of type 2 (Soleglad & Fet, 2003), longer than wide, pentagonal, slightly shagreened; median furrow deep, more pronounced in posterior half; posterior pit absent.

Legs. Pale yellow. Predominantly shagreened; ventral surface smooth; dorsal surfaces of trochanter and femur finely and weakly granular. Tarsus with a ventromedian row of microspinules and with 2 rows of ventral rigid "spinoid" macrosetae; tarsi I-II: prolateral row with 4/5 macrosetae, retrolateral row with 5/6 macrosetae; tarsi III-IV: prolateral row with 5/6 macrosetae, retrolateral row with 6 macrosetae; setae acuminate; tarsal claws of equal length.

Pectines and genital operculum (Fig. 25). Dark yellow; genital operculum composed of 2 subtriangular plates; genital papillae short, not protruding from beneath operculum; pectines with 13/12 teeth.

Hemispermatophore. The presence of fully developed paraxial organs was assessed by cutting a small slit into the lateral pleural membrane between tergites and sternites. We did not have the permission to dissect the specimen.

Intraspecific variation. The other specimen examined, a subadult male, has pectines with 15-15 teeth.

Remarks. Apparently more male and female specimens of *H. persicus* from the type locality are lodged in the collections of the Zoological Institute of Saint Petersburg (Fet, pers. comm.) but unfortunately we could not get this material on loan.

DISCUSSION

Taxonomic characters

Sexual dimorphism. Apart from *H. persicus*, all Iranian species of the genus *Hemiscorpius* show a pronounced sexual dimorphism: mature males have a distinctly more elongated metasoma and telson than females (subadult males do not exhibit this sexual dimorphism) (Figs 4, 27). In *H. acanthocercus* sp. n., *H. enischnochela* sp. n., *H. lepturus* and probably also in *H. gaillardi* this dimorphism reaches extreme levels. Among scorpions extreme elongation of the metasoma in males is fairly common. It is encounter in the buthid genera *Centruroides*, *Compsobuthus* and *Isometrus*, as well as in genera belonging to families that are closely related to Hemiscorpiidae, i. e. *Hadogenes* Kraepelin, 1894 (Liochelidae), *Heteroscorpion* Birula, 1903 (Heteroscorpionidae) and *Urodacus* Peters, 1862 (Urodacidae).

Hadogenes spp. are ultralithophilous scorpions occurring in the Afrotropical region. They inhabit weathered rock outcrops where their extremely flattened morphology allows them to creep into narrow crevices and fissures. The very long tails of the males of most *Hadogenes* species are an essential adaptation to this specialized environment. During courtship the male usually stings the female in the pleural membrane between the sternites and tergites. This behaviour is known as sexual sting. In very narrow cracks where courtship usually takes place, the male must reach around the side of the female's body to sting her (Leeming, 2003).

The endemic Malagasy genus *Heteroscorpion* is closely related to the Urodacidae. As in *Hadogenes*, the four known *Heteroscorpion* species are well adapted to live in rocky habitats and occur in narrow fissures between layers of splintered but still standing rocks. The metasoma of males is also very elongated compared to females (Lourenço & Goodman, 2002, 2004; Lourenço *et al*., 2004). However, these scorpions do not show an extreme dorsoventral depression of the body as in *Hadogenes*.

On the other hand, scorpions of the genus *Urodacus* are mostly burrowers, therefore they are usually very stocky. However, males of four species, i. e. *U. elongatus* L.E. Koch, 1977, *U. megamastigus* L.E. Koch, 1977, *U. mckenziei* Volschenk, Smith & Harvey, 2000 and *U. varians* Glauert, 1963, show an extreme elongation of their metasoma (L. E. Koch, 1977; Volschenk *et al*., 2000) but they are not strictly lithophilous. *U. varians* is a burrowing species and the others excavate shallow scrapes under stones and are sometimes found in rock crevices (Volschenk, pers. com.). Ecomorphological adaptations to rocky habitats also occur in the scorpionid genus *Opisthophthalmus* C.L. Koch, 1837, which is mostly composed of burrowing species (Prendini, 2001). Because of soil hardness in their habitats, *O. austerus* Karsch, 1879, *O. karooensis* Purcell, 1898 and *O. pattisoni* Purcell, 1899 have abandoned burrow construction in favour of a semi-litophilous existence under slabs of rock. All these species display morphological adaptations similar to those in *Hadogenes*, i. e. dorsoventral depression of the body and greatly elongated pedipalp chelae.

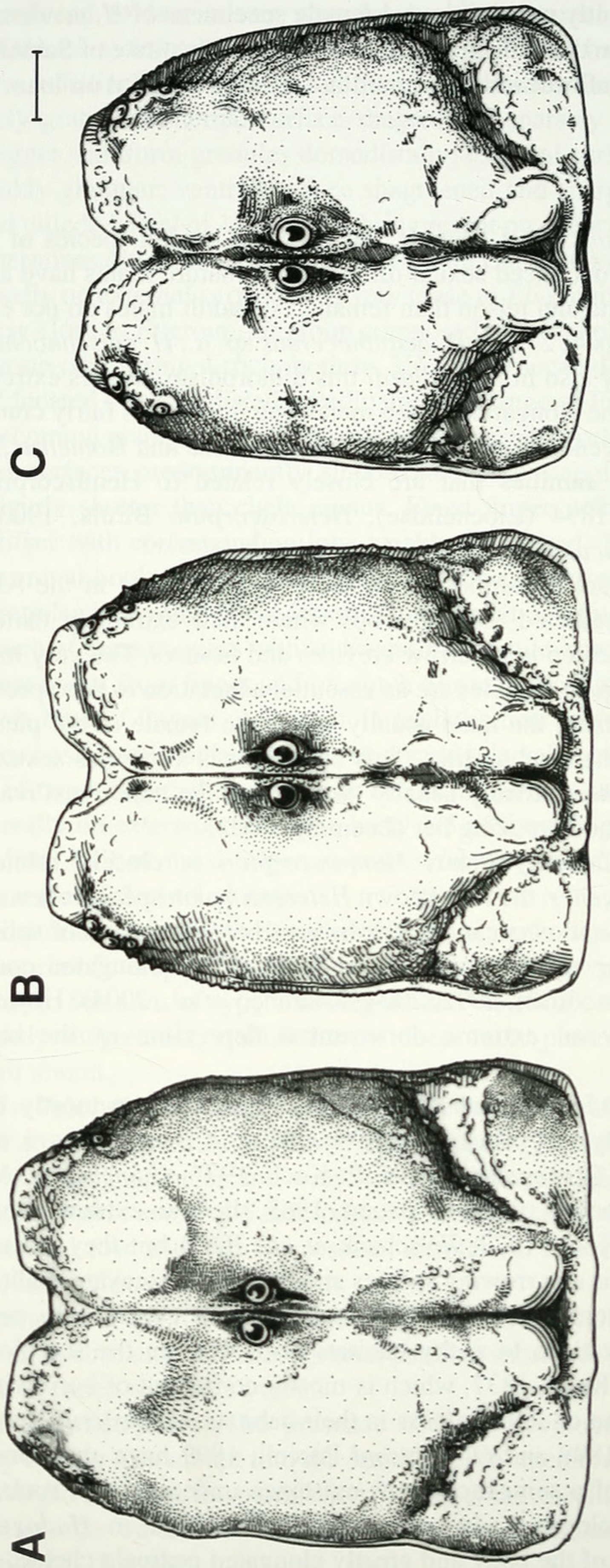

FIG. 26

Hemiscorpius spp., carapace, dorsal aspect. *Hemiscorpius enischnochela* sp. n.: A, male holotype; B, female paratype (*NHMW 76*). *H. gaillardi*: C, female holotype. Scale line, 1 mm.

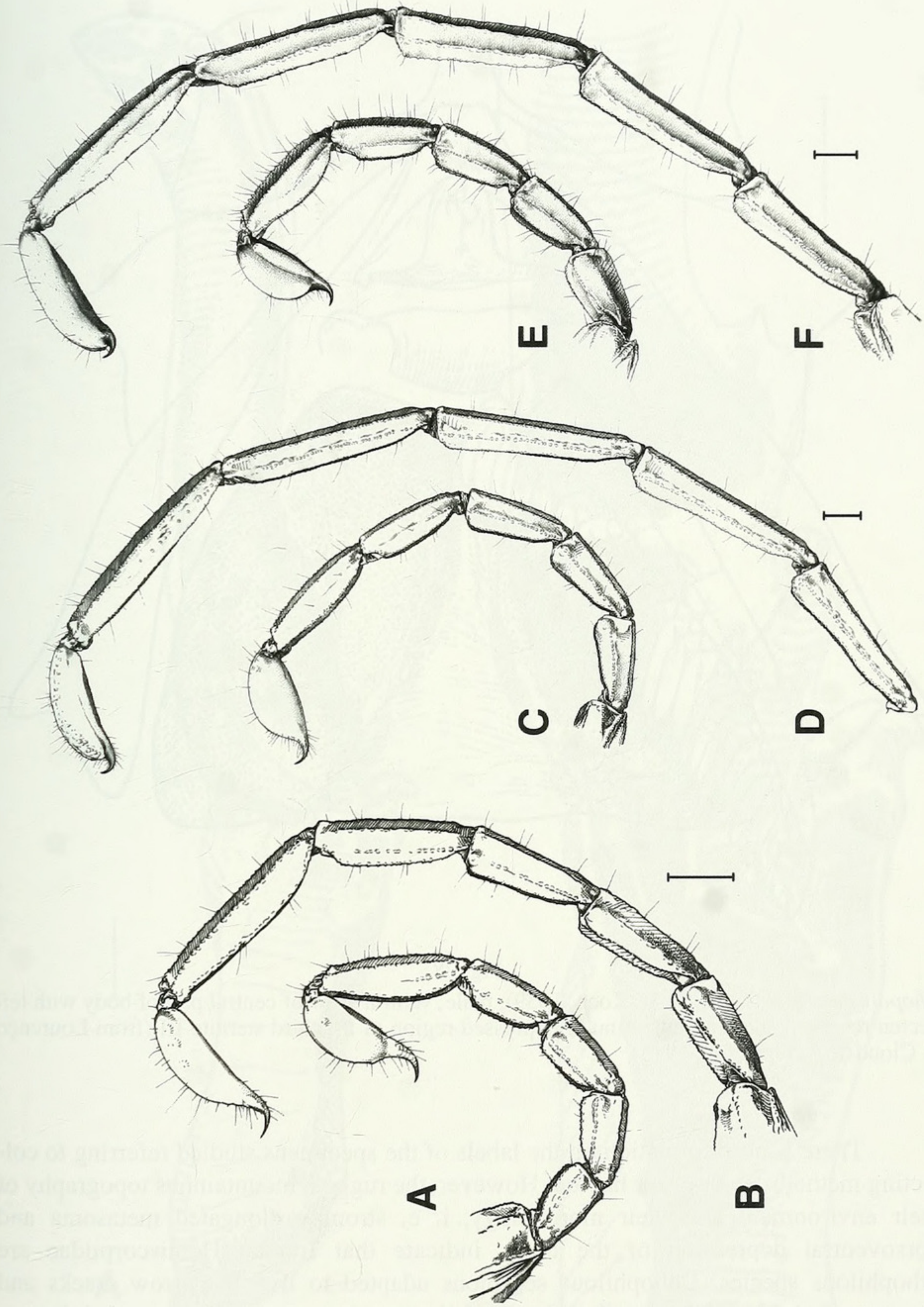

FIG. 27

Hemiscorpius spp., metasoma, lateral aspect. *Hemiscorpius maindroni*: A, female syntype; B, male syntype. *Hemiscorpius enischnochela* sp. n.: C, female paratype (*MNHG*, Masdyed-Soleyman); D, male holotype. *Hemiscorpius lepturus*: E, female (*MNHN*, Ahwaz); F, male (*MNHN*-RS 5232). Scale lines, 2 mm.

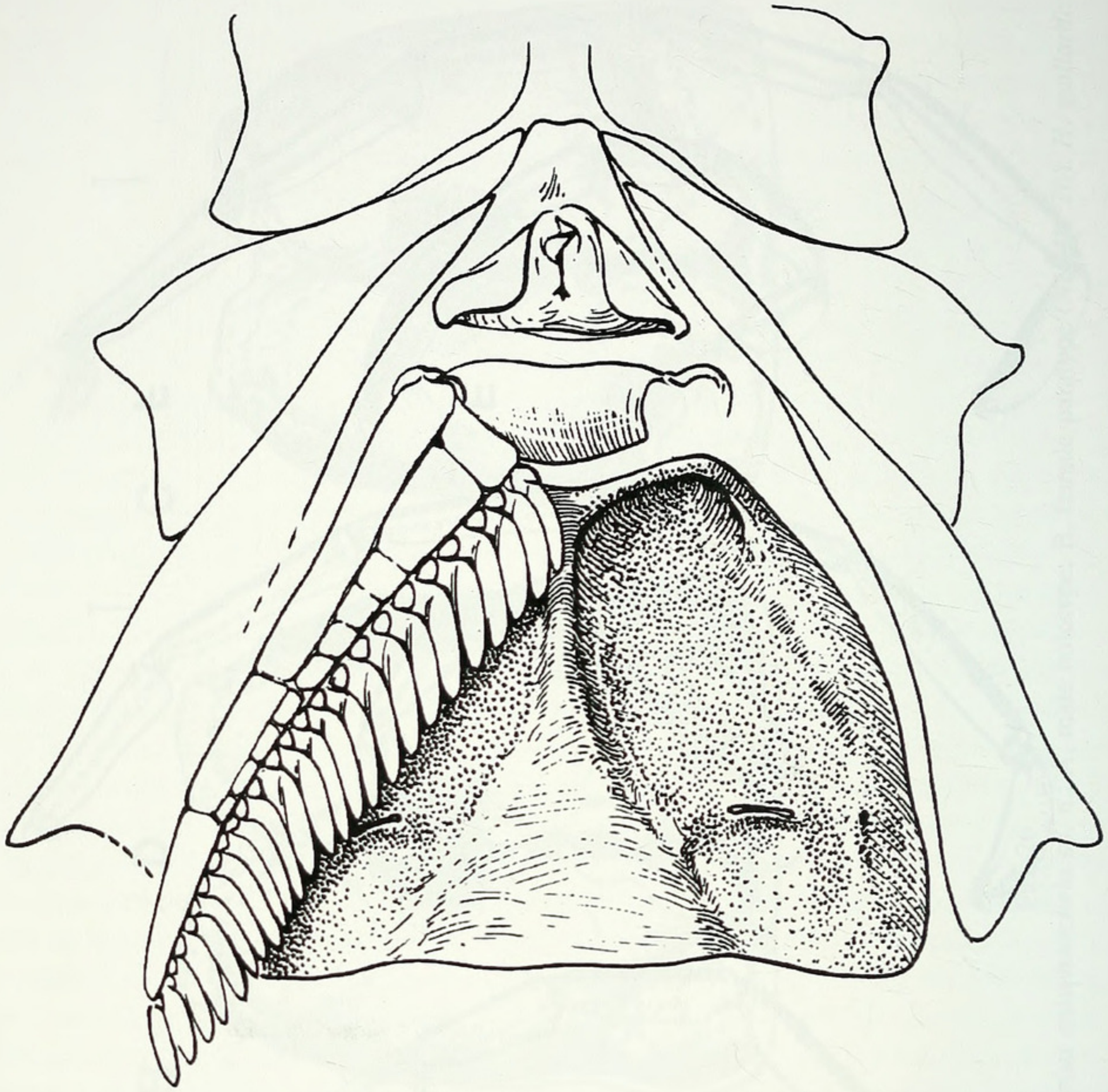

Fig. 28
Rhopalurus agamemnon (C. L. Koch, 1839), male, ventral view of central part of body with left pecten removed showing the granular depressed region of the third sternite III (from Lourenço & Cloudsley-Thompson, 1995).

There is no information on the labels of the specimens studied referring to collecting methods, ecology, or habitat. However, the rugged, mountainous topography of their environment and their morphology, i. e. strongly elongated metasoma and dorsoventral depression of the body, indicate that Iranian Hemiscorpiidae are lithophilous species. Lithophilous scorpions adapted to live in narrow cracks and crevices of rocks are characterized by the following features: (1) dorsoventral depression of the body; (2) elongation of the metasoma and/or pedipalps; (3) spiniform macrosetae on the telotarsi, operating in conjunction with highly curved telotarsal ungues to provide grip on rock surfaces (Prendini, 2001). All these adaptations are present in hemiscorpiids.

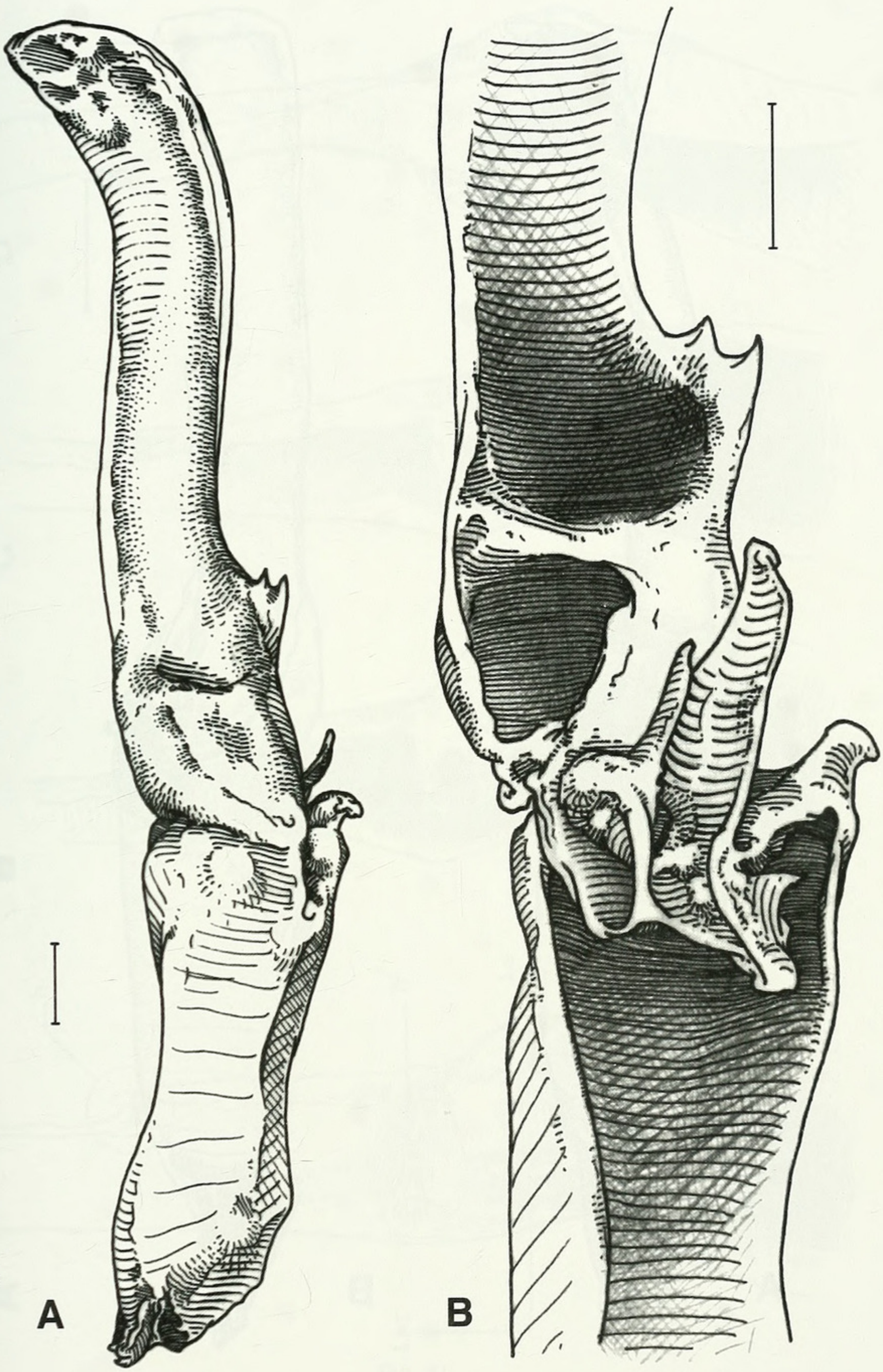

FIG. 29
Hemiscorpius maindroni, male syntype (*MNHN-RS 4328*), hemispermatophore: A, hemispermatophore in toto; B, detail of the capsular region, internal aspect. Scale lines, 0.25 mm.

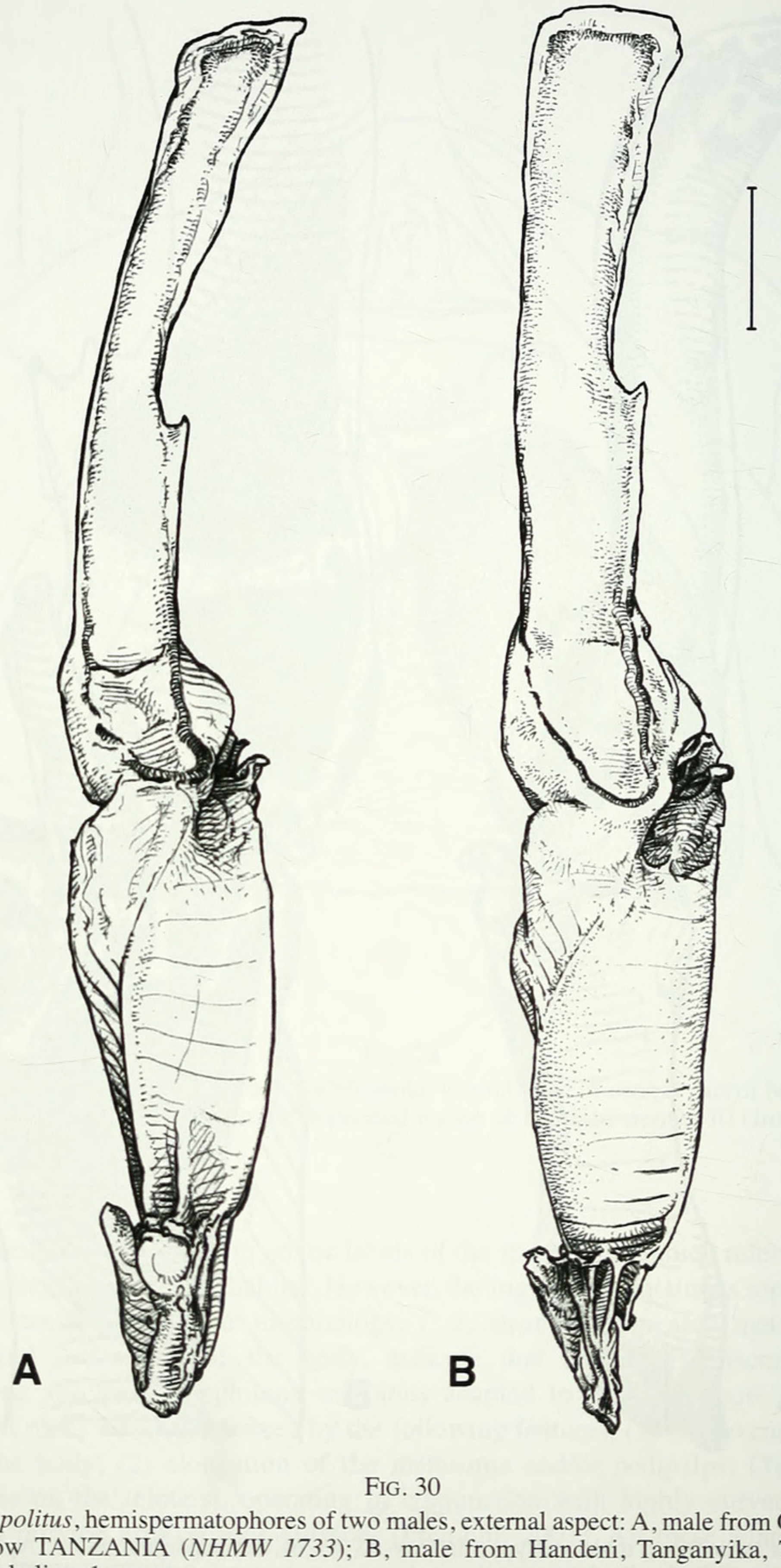

FIG. 30

Iomachus politus, hemispermatophores of two males, external aspect: A, male from German East Africa, now TANZANIA (*NHMW 1733*); B, male from Handeni, Tanganyika, TANZANIA (*CAS*). Scale line, 1 mm.

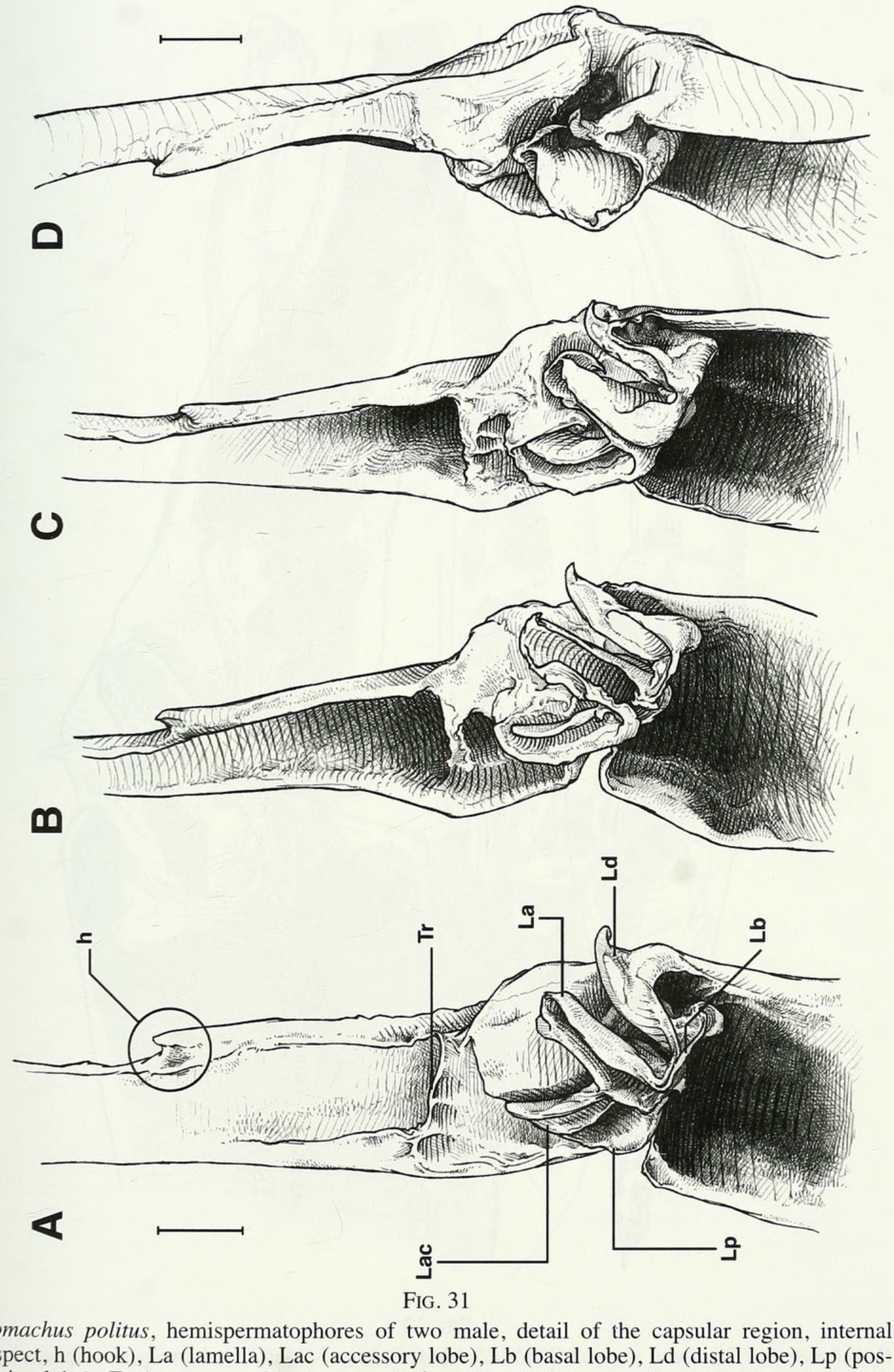

FIG. 31

Iomachus politus, hemispermatophores of two male, detail of the capsular region, internal aspect, h (hook), La (lamella), Lac (accessory lobe), Lb (basal lobe), Ld (distal lobe), Lp (posterior lobe), Tr (transverse ridge): A, male from Handeni, Tanganyika, TANZANIA (*CAS*); B-D, male from German East Africa, now TANZANIA (*NHMW 1733*). Scale line, 0.5 mm.

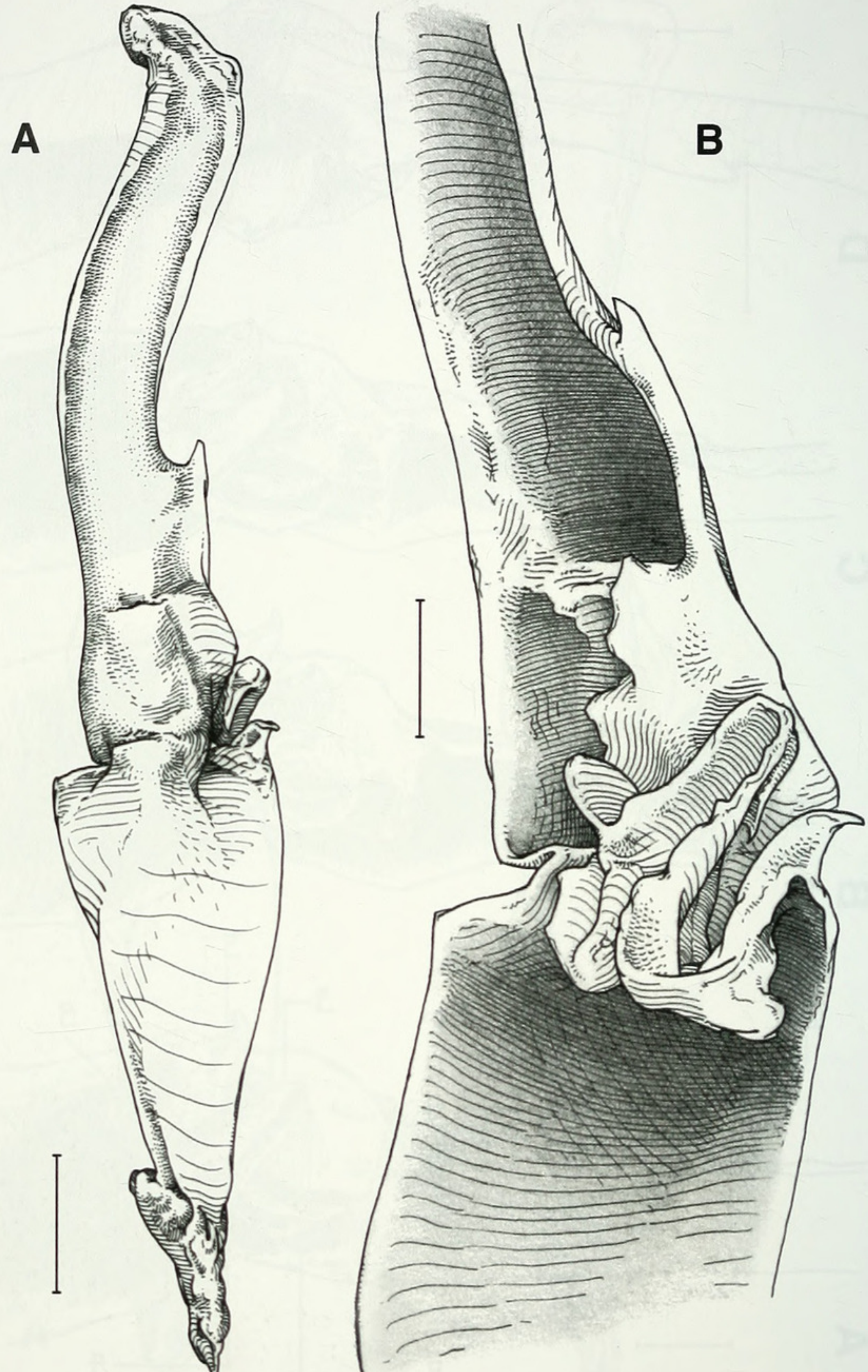

FIG. 32

Opisthacanthus lecomtei, male (*MNHN-RS 6264*, Belinga, GABON), hemispermatophore: A, hemispermatophore in toto (scale line, 1 mm); B, detail of the capsular region, internal aspect (scale line, 0.5 mm).

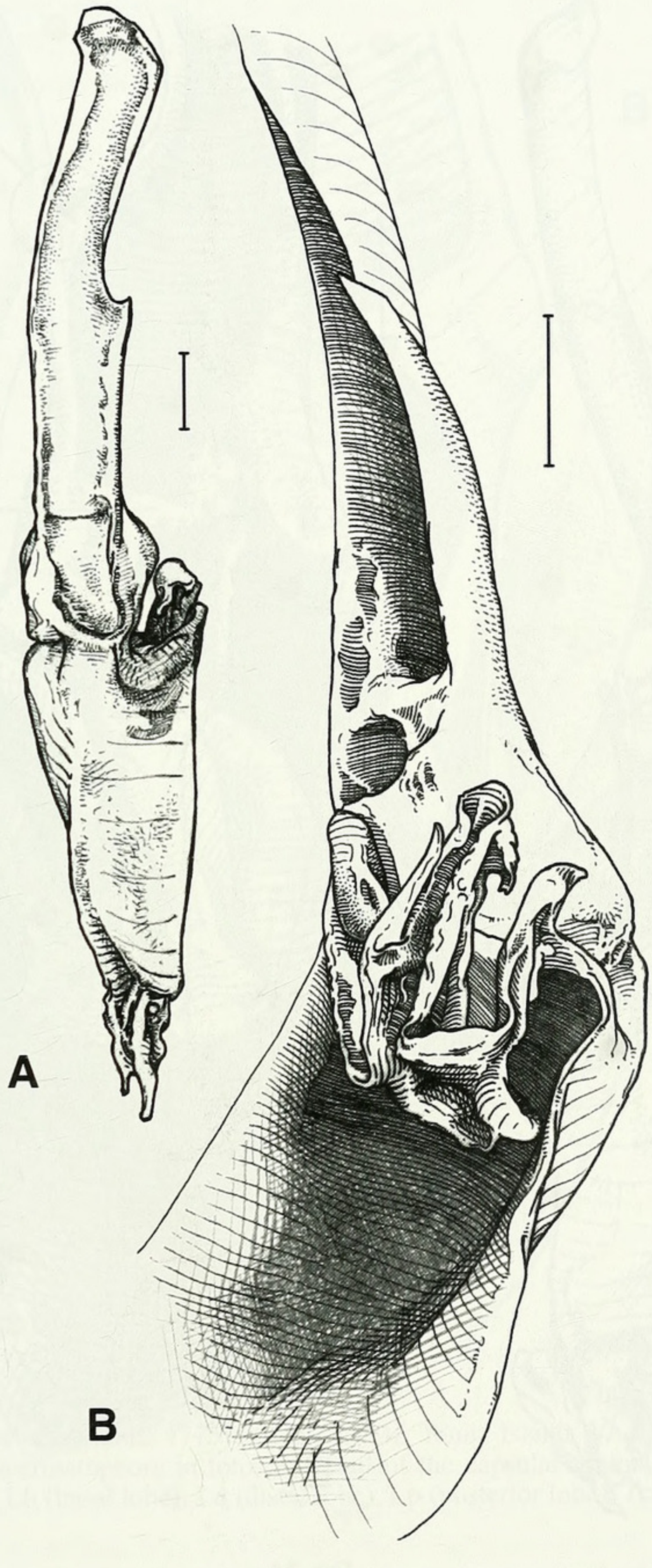

FIG. 33
Opisthacanthus cayaporum Vellard, 1932, male (*MHNG*, Campos de Cayapos, BRASIL), hemispermatophore: A, hemispermatophore in toto; B, detail of the capsular region, internal aspect. Scale lines, 1 mm.

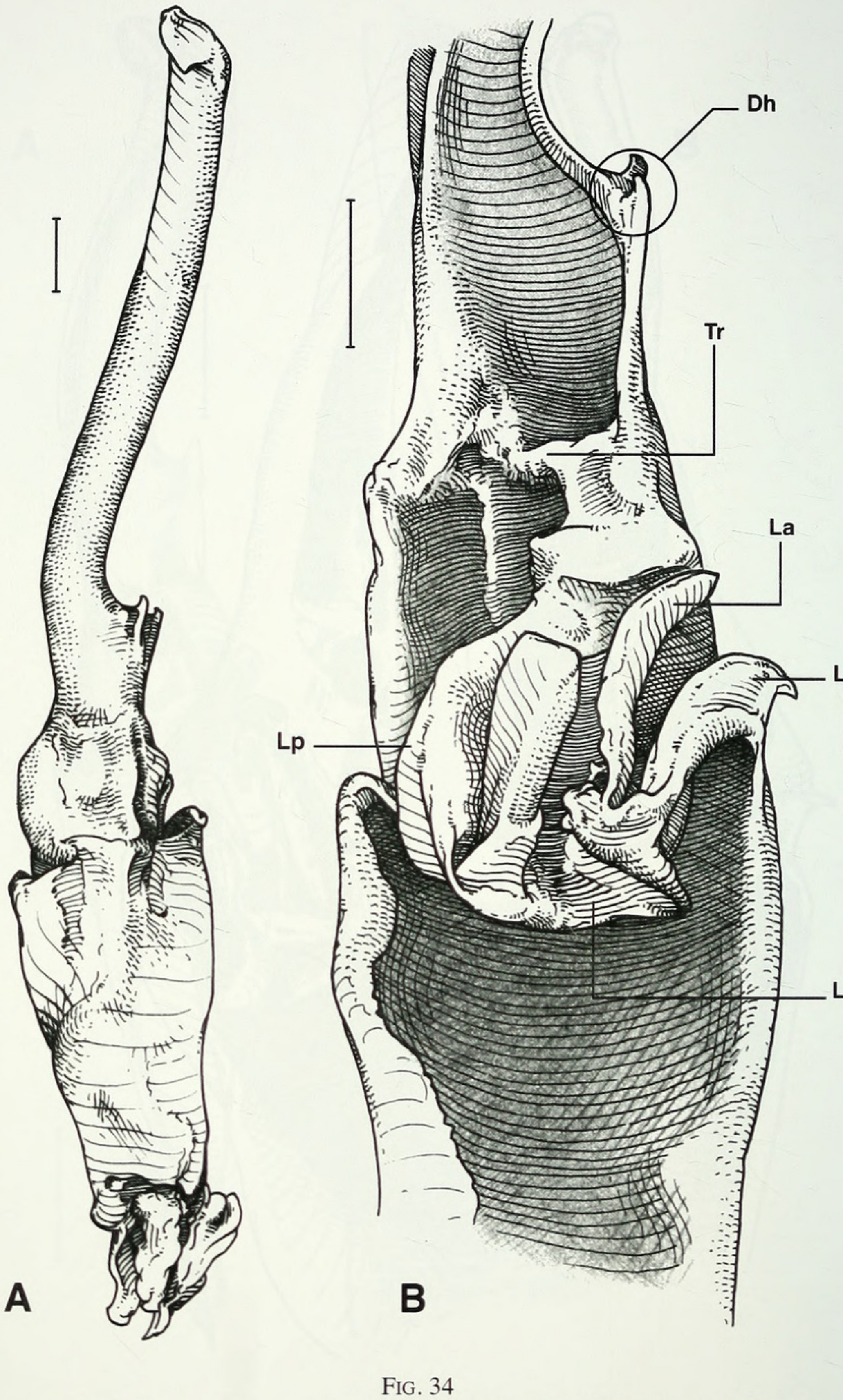

FIG. 34

Hadogenes troglodytes (Peters, 1861b), male (*NHMW 1703*, South Rhodesia, now ZIMBABWE), hemispermatophore: A, hemispermatophore with in toto; B, detail of the capsular region, internal aspect, Dh (double hook), La (lamella), Lb (basal lobe), Ld (distal lobe), Lp (posterior lobe), Tr (transverse ridge). Scale line, 1 mm.

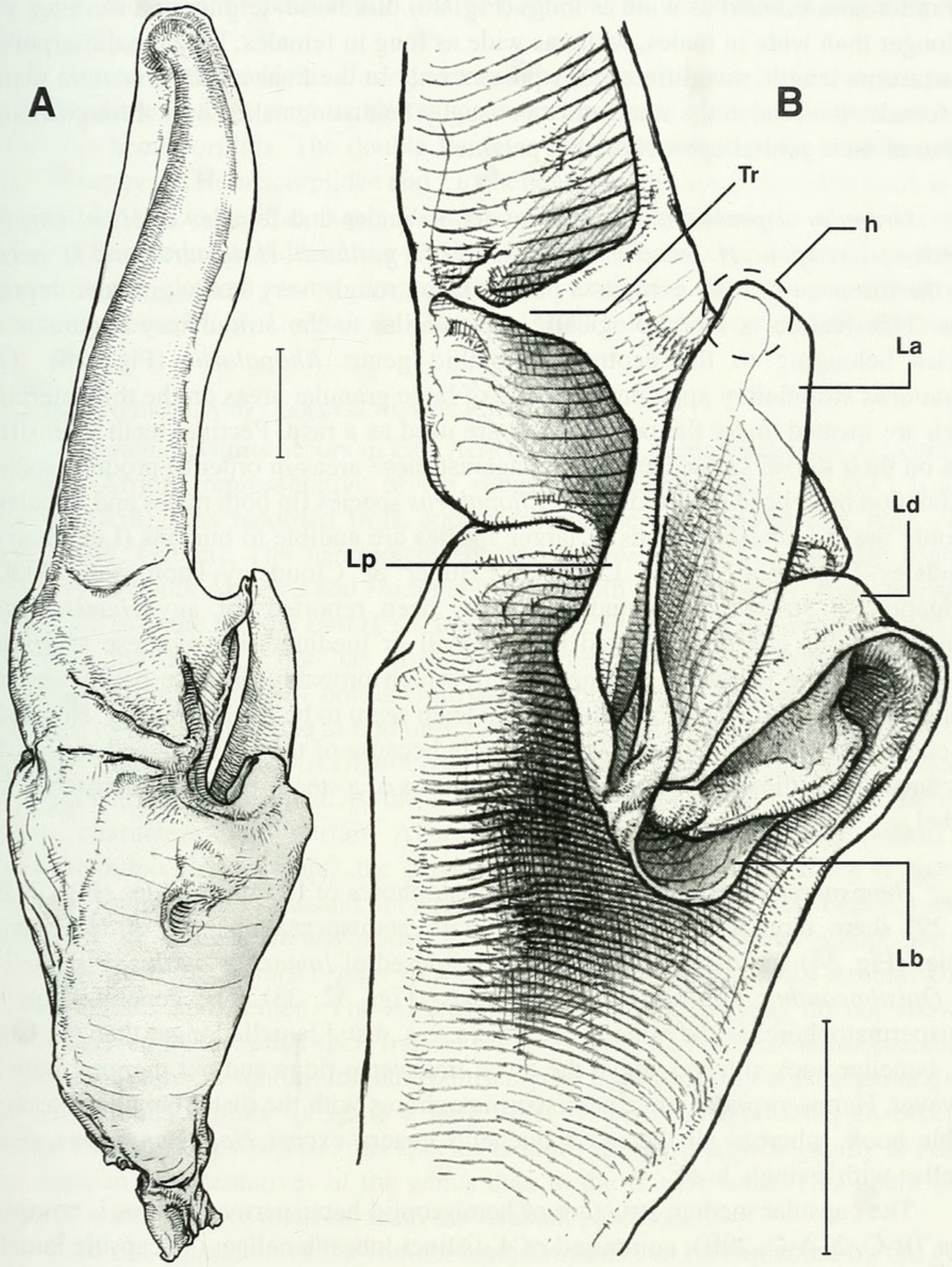

FIG. 35

Liocheles australasiae (Fabricius, 1775), male (*BPBM*, Tanna Island, VANUATU), hemispermatophore: A, hemispermatophore in toto; B, detail of the capsular region, internal aspect, h (hook), La (lamella), Lb (basal lobe), Ld (distal lobe), Lp (posterior lobe), Tr (transverse ridge). Scale lines, 0.5 mm.

In male hemiscorpiids the genital operculum is composed of two overlapping plates, whereas in females it is a single undivided plate. Like in other scorpions, males have bigger pectines with a higher pectinal teeth count than in females. In the *H. lepturus* species group the carapace is usually more elongated in males (longer than wide) than in females (almost as wide as long) (Fig. 26). Likewise, tergites and sternites VII are longer than wide in males, while as wide as long in females. Like the dimorphism in metasoma length, this difference is present only in the final instar. Immature males and females look much the same and can usually be distinguished only through examination of their genital operculum and pectines.

Granular depressions on sternites III. In males and females of *Hemiscorpius acanthocercus* sp. n., *H. enischnochela* sp. n., *H. gaillardi*, *H. lepturus* and *H. persicus*, the foremost sternite exhibits a pair of large, rough, very finely granular depressions. This feature is morphologically very similar to the stridulatory apparatus of species belonging to the neotropical buthid genus *Rhopalurus* (Fig. 28). The *Rhopalurus* stridulatory apparatus consists of large granular areas on the third sternite, which are located under the pectines and are used as a rasp. Pectinal teeth with striations on their dorsal surface are rubbed against these areas in order to produce sound. Stridulation have been reported for all *Rhopalurus* species (in both males and females), but only the stridulatory sounds of larger species are audible to humans (Lourenço & Cloudsley-Thompson, 1995; Lourenço, Huber & Cloudsley-Thompson, 2000). Production of stridulatory sound has never been reported for any *Hemiscorpius* species, but this can be attributed to the small or medium size of these scorpions (regardless of the length of the metasoma), which probably produce barely audible sounds. The dorsal surfaces of their pectinal teeth seem to be finely granular. However, this character could not be assessed accurately because of the very reduced size of the structures. More thorough investigations by means of a stereo-electron microscope are needed.

Hemispermatophores. The hemispermatophores of Hemiscorpiidae (Figs 7, 20, 21, 29) share morphological similarities with hemispermatophores of *Hadogenes* species (Fig. 34) and of a liochelid group composed of *Iomachus politus* (Fig. 30-31) and *Opisthacanthus* (*Opisthacanthus*) species (Figs 32, 33). The general shape of hemispermatophores is the same in these taxa, i. e. distal lamella longer than the basal part, lamellar hook situated above the distal transverse ridge and not merging with it. However, Hemiscorpiidae have hemispermatophores with the distal lamella bearing a double hook, whereas all the other liochelid genera except *Hadogenes* have distal lamellae with a single hook.

The capsular median structure of hemiscopiid hemispermatophores is complex (Figs 7B-C, 21A-C, 29B), composed of 4 distinct lobes/lamellae: (1) capsule lamella (La) complex, bearing a strong hook on his external surface and an accessory lobe (Lac) pointing to the posterior side, (2) distal lobe (Ld) forming a strong hook pointing anteriad, (3) basal lobe (Lb) very reduced, (4) posterior lobe (Lp) costate. *Iomachus politus* and *Opisthacanthus* (*Opisthacanthus*) species (both African and neotropical representatives) possess hemispermatophores (Figs 30-33) very similar to those encounter in hemiscorpiids, i. e. with distal lobe with a strong hook pointing anteriorly and with a complicated capsular lamella bearing an internal hook and an additional basal lobe. In *Hadogenes* (Fig. 34) and other liochelid genera the capsule lamella is much more simple, without any hook or accessory lobe. In *Liocheles* Sundevall, 1833 the distal lobe is not modified into a large hook and the basal lobe is much more developed (Fig. 35).

Based on this analysis *Hadogenes* and the group composed of *Iomachus politus* and *Opisthacanthus* (*Opisthacanthus*) spp. are considered to be liochelid taxa closely related to hemiscorpiids. The double lamellar hook can therefore be considered as a plesiomorphy for Hemiscorpiidae and Liochelidae, and the single lamellar hook is apomorphic for all Liochelidae except *Hadogenes*. On the other hand, the complex capsule lamella can also be considered as a plesiomorphy for Hemiscorpiidae and Liochelidae. However, the derived, more simple structure examined in *Hadogenes* and other liochelid genera (e. g., *Liocheles*) is assumed to have evolved independently in these two groups.

BIOGEOGRAPHICAL AND GEOLOGICAL IMPLICATIONS

Iomachus politus occurs in East Africa (Ethiopia, Kenya Tanzania, Uganda) and the only African representative of the subgenus *Opisthacanthus*, *O.* (*O.*) *lecomtei* (Lucas, 1858), was recorded from approximately the same latitude in West Africa (Cameroon, Gabon). The neotropical species of *Opisthacanthus* (*O.*) are found in Central and South America and *Hadogenes* is a South African genus. *Hemiscorpius* is present all over the Middle East (Iran, Iraq, Oman, Pakistan, Saudi Arabia, United Arab Emirates and Yemen), but has also some representatives in north-eastern Africa (Djibouti, Eritrea, Somalia), not far from the distribution area of *Iomachus politus*. The presence of Hemiscorpiidae in Djibouti, Eritrea, Somalia, and on the island of Socotra indicates that the ancestor of *Hemiscorpius* was probably present on Gondwanaland.

Since Hemiscorpiidae is the sister group of Liochelidae and *Hemiscorpius* shares characters with certain African liochelids, i. e. *Iomachus politus* and *Opisthacanthus* (*O.*) *lecomtei*, the occurrence of *Hemiscorpius* in Africa is probably due to a Gondwanian origin and not a recent invasion from the Middle East (Laurasia). However, the Iranian *Hemiscorpius*, i. e. the *H. lepturus* species group, are very divergent from the *Hemiscorpius* species from Africa, Oman, Saudi Arabia, United Arab Emirates and Yemen. The African species of *Hemiscorpius* do not show the highly derived features that their Iranian relatives possess, i. e. extreme sexual dimorphism and cytotoxic venom. Iranian *Hemiscorpius* have probably been separated from the other hemiscorpiids for quite a long time. *H. persicus* represents an exception among Iranian *Hemiscorpius*; this species is more similar morphologically to African and Arabian representatives of the genus than to the Iranian ones. This could be the result of a more recent invasion from the Arabian peninsula.

An old separation of the Iranian hemiscorpiids can be explained by the geological history of the region. In the Precambrian and Palaeozoic the Cimmerian terrane, which included Iran, was part of Gondwana (Fig. 37, 38A). The common ancestor of Liochelidae and Hemiscorpiidae was probably widespread on this super-continent. Approximately 250 Ma BP (Fig. 38B) the Neotethys ocean started to open (Golonka, 2000; Scotese, 2000; Stampfli & Borel, 2002), inducing the rift of the Cimmerian super terrane off the northern margin of Gondwana and its northward drift toward Laurasia. Iran was separated from Gondwana in the Middle Triassic. The ancestor population of the Middle East hemiscorpiids was probably isolated on this rafting continent and diverged from its relatives.

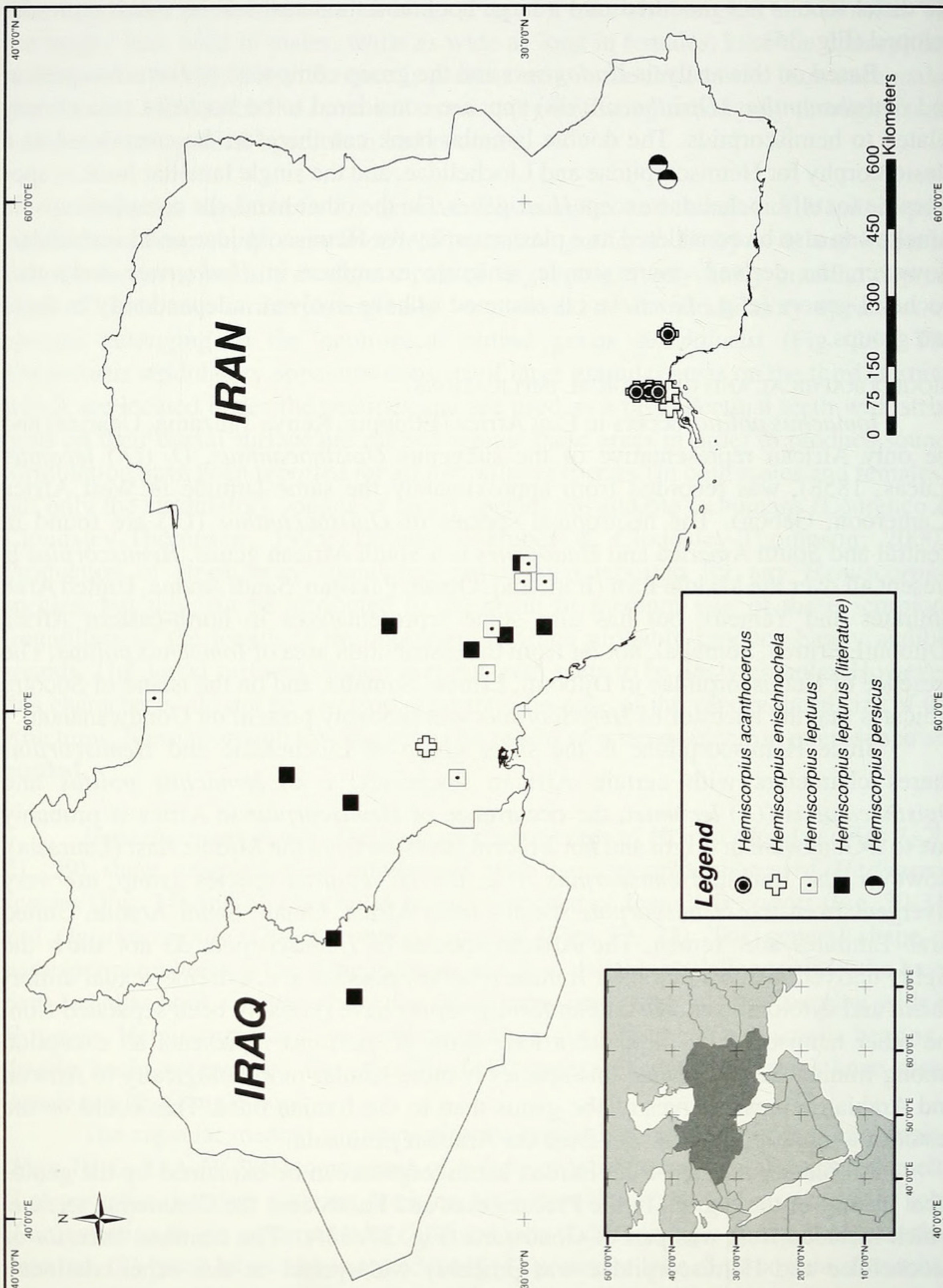

FIG. 36
Distribution map of *Hemiscorpius* spp. In Iran and Iraq.

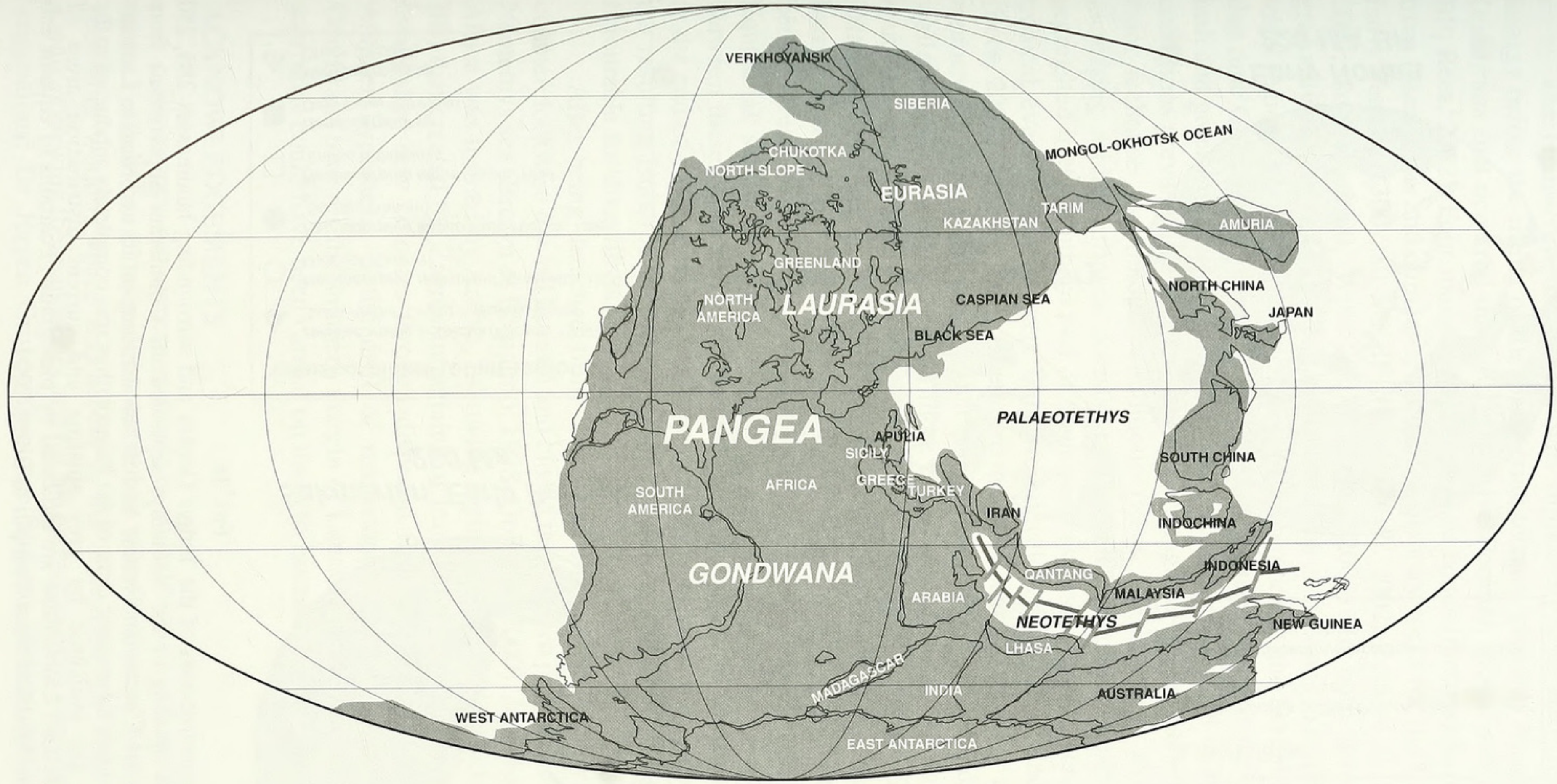

FIG. 37

Palaeogeographic reconstruction of the Earth during the late Permian (269-248 Ma BP). Landmasses are indicated by grey shading. The Neotethys started to open, inducing the rifting of the Cimmerian Superterrane from Gondwana. Modified from Golonka, 2000.

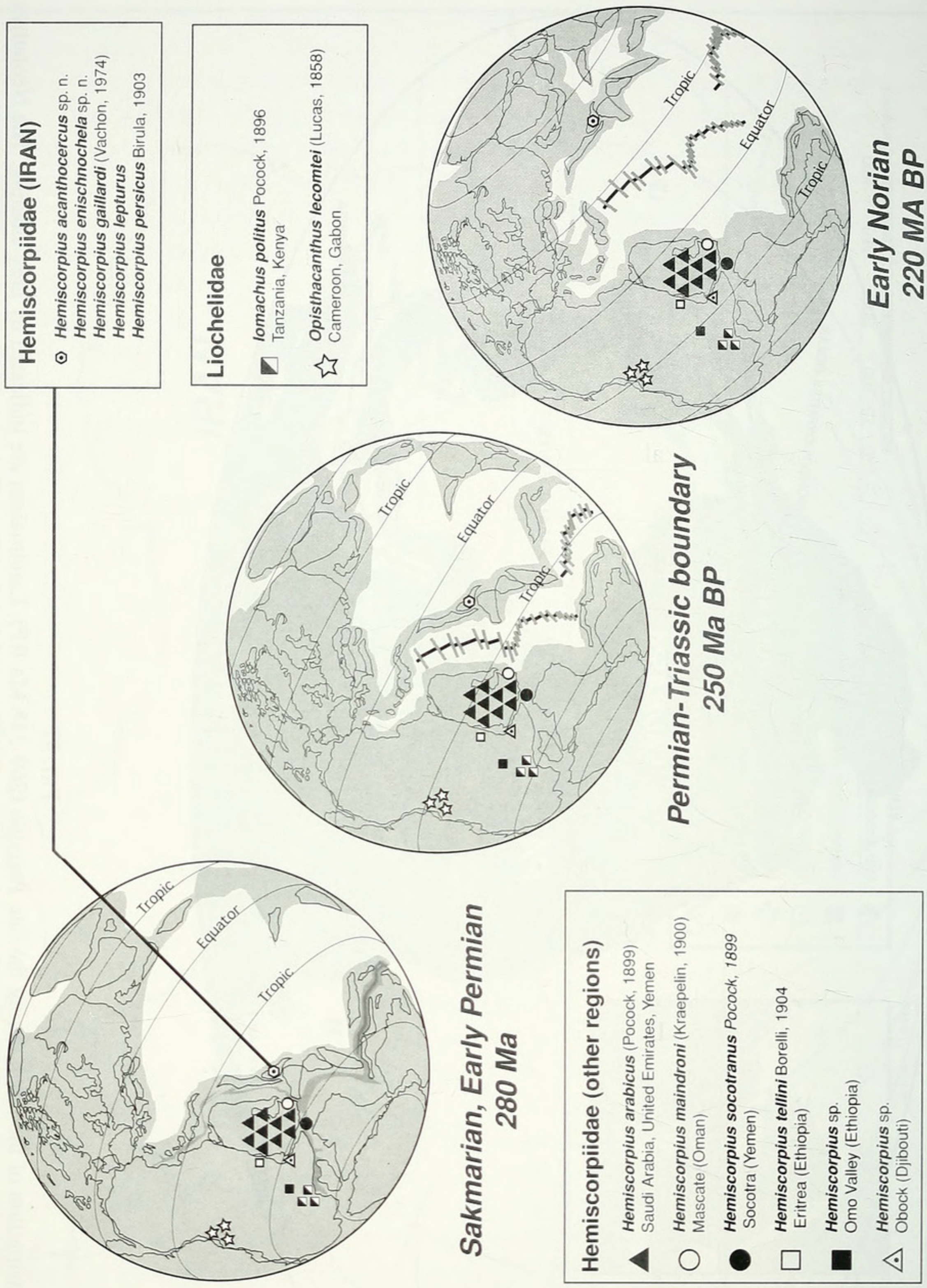

FIG. 38

Palaeogeographic reconstructions of the Tethys Oceans and surrounding landmasses 280, 250 and 220 Ma BP. The opening of the Neotethys separated the Cimmerian Superterrane from Gondwana, inducing the Cimmerian Terrane to drift toward Eurasia. Its accretion to Laurasia occurred 220 Ma BP when the oceanic crust of the Palaeotethys was completely subducted to the north. Landmasses are indicated by grey shading and current distribution areas of Hemiscorpiidae and related Liochelidae are indicated by pictograms. Positions of equator and tropics are also shown. Modified from Stampfli & Borel, 2002.

The Hemiscorpiidae lineage was supposedly separated from the Liochelidae lineage before the rifting of the Cimmerian terrane, probably by climatic changes on Gondwana that occurred during the massive Permian global warming (290-250 Ma BP; Rees, 2002). Four main terrestrial climate zones (biomes) have been determined from fossil floras and climate-sensitive sedimentary rocks for the Late Carboniferous-Early Permian (300-280 Ma BP) (Gibbs *et al.*, 2002; Rees *et al.*, 1999; Rees *et al.*, 2002; Scotese, 2000; Willis & McElwain, 2002). In both hemispheres, climates gradually changed from the equator to the poles as follow: (1) tropical everwet (equatorial region), (2) subtropical desert, (3) cool temperate and (4) cold (polar region). At that time Gondwana was situated south of the equator and was therefore under mostly lush and green vegetation (cool temperate), except for its north-eastern part where arid conditions prevailed (subtropical desert). Throughout the Permian, the climate change from icehouse to hothouse conditions (Rees, 2002). With global warming and increasing aridity, tropical forests disappeared and cool temperate biotopes were segregated in the southern part of Gondwana as deserts spread across central Pangea; tropical everwet biomes were only well-developed on the Chinese microcontinent (Rees, 2002; Scotese, 2000). Therefore the hemiiscorpiid ancestor adapted to an environment (in Africa and Arabia) that became more and more arid during the Permian, while liochelids remained in the more humid and cool ecosystems prevailing in the southern part of Gondwana (Scotese, 2000; Willis & McElwain, 2002). By the Late Triassic-Early Jurassic (210-200 Ma BP), large subtropical deserts formed a climatic barrier (Rees, 2002; Rees *et al.*, 1999) between the liochelid ancestor in warm temperate forests of Southern Gondwana and the African hemiscorpiid ancestor in the Equatorial summerwet biotopes of the Arabian region, and interrupted gene flow between these two lineages. Most of the modern scorpion families probably emerged at the end of the Palaeozoic Era, when changing biomes, high rates of extinction and the resulting isolation of surviving populations in scattered "biotopes islands" were favourable for diversification.

After being detached from North and South America, Africa began to rotate counterclockwise toward Eurasia and closed the western part of the formerly extensive Neotethys sea (Brown & Lomolino, 1998; Golonka, 2000). A bridge between Asia and Africa was formed by Arabia, following their collision in the middle Tertiary (35 Ma BP) that created the Zagros mountains of Iran. Then hemiscorpiids could have easily established new colonies through dispersal from the Arabian peninsula to Eurasia. Another hypothesis is the drift of microcontinents from the northern margin of Gondwana towards the southern margin of Laurasia during the last 200 million years, scorpions could have been carried on them to Eurasia.

ACKNOWLEDGEMENTS

We express our sincere gratitude to all individuals and institutions that assisted in the realization of the present study: the Natural History Museum of Geneva for providing working space and access to the collection; Dr Peter Schwendinger for kindly reviewing the manuscript and for his extensive help, constructive comments and suggestions; Dr Jürgen Gruber from the Natural History Museum of Vienna for arranging loans, providing information on collectors and help in deciphering old labels; Dr Victor Fet and Dr Graeme Lowe for kindly allowing the examination of the type specimens of *Hemiscorpius persicus* and for constructive criticism on the manuscript; Dr Erich Volschenk for further discussion; to M. Claude Ratton for taking the habitus photographs.

REFERENCES

ANDERSON, P. C. 1998. Missouri Brown Recluse Spider: a review and update. *Missouri Medicine* 95: 318-322.

BIRULA, A. A. 1903. Beiträge zur Kenntnis des Scorpionenfauna Ost-Persiens. (2. Beitrag). *Bulletin de l'Académie Impériale des Sciences de St.-Petersbourg* (5), 19(2): 67-80.

BORELLI, A. 1904. Di alcuni scorpioni della Colonia Eritrea. *Bolletino dei Musei di Zoologia ed Anatomia Comparata della Reale Università di Torino* 19(463): 1-5.

BUTZ, W. C. & EMORY UNIVERSITY SCHOOL OF MEDICINE 1971. Envenomation by the Brown Recluse Spider (Araneae, Scytodidae) and related species. A public health problem in the United States. *Clinical Toxicology* 4(4): 515-524.

BROWN, J. H. & LOMOLINO, M. V. 1998. Chapter 6. The changing Earth (pp. 135-176). *In:* BROWN, J. H. & LOMOLINO, M. V. (eds). Biogeography, 2nd edition. *Sinauer Associates, Sunderland.*

DILLAHA, C. J., JANSEN, G. T., HONEYCUTT, W. M. & HAYDEN, C. R. 1964. North American loxoscelism: necrotic bite of the Brown Recluse Spider. *Journal of the American Medical Association* 188: 33-36.

FABRICIUS, J. C. 1775. Systema entomologiae sistens insectorum classes, ordines, genera, species, adjectis synonymis, locis, descriptionibus, observationibus. *Flensburgi et Lipsiae, Leipzig.*

FARZANPAY, R. 1988. A catalogue of the scorpions occurring in Iran, up to January 1986. *Revue Arachnologique* 8: 33-44.

FARZANPAY, R. & PRETZMANN, G. 1974. Ergebnisse einiger Sammelreisen nach Vorderasien 4. Teil: Skorpione aus Iran. *Annalen des Naturhistorischen Museums in Wien* 78: 215-217.

FET, V. & BECHLY, G. 2001. Case 3120a. Liochelidae, fam. nov. (Scorpiones): proposed introduction as a substitute name for Ischnuridae Simon, 1879, as an alternative to the suggested emendment of Ischnurinae Fraser, 1957 (Insecta, Odonata) to Ischnurainae in order to remove homonymy. *Bulletin of Zoological Nomenclature* 58: 280-281.

FET, V. 2000. Subfamily Hemiscorpiinae Pocock, 1893 (pp. 428-431). *In:* FET, V., SISSOM, D. W., LOWE, G. & BRAUNWALDER, M. E. Catalogue of the scorpions of the world (1758-1998). *The New York Entomological Society, New York.*

FILMER, M. R. 1999. Southern African spiders. An identification guide. *Struik Publishers, Cape Town,* 128 pp.

FOIL, L. D., FRAZIER, J. L. & NORMENT, B. R. 1979. Partial characterization of lethal and neuroactive components of the Brown Recluse Spider (*Loxosceles reclusa*) venom. *Toxicon* 17: 347-354.

GERTSCH, W. J. & MULAIK, S. 1940. The spiders of Texas. I. *Bulletin of the American Museum of Natural History* 77: 307-340.

GIBBS, M. T., REES, P. M., KUTZBACH, J. E., ZIEGLER, A. M., BEHLING, P. J. & ROWLEY, D. B. 2002. Simulations of Permian climate and comparisons with climate-sensitive sediments. *Journal of Geology* 110: 33-55.

GLAUERT, L. 1963. Notes on *Urodacus* scorpions. *Western Australian Naturalist* 8(6): 132-135.

GOLONKA, J. 2000. Cambrian - Neogene: plate tectonic maps. *Online at: http://www.dinodata.net/Golonka/Golonka.htm.*

HABIBI, T. 1971. Liste des scorpions de l'Iran. *Bulletin of the Faculty of Science of Teheran University* 2: 42-47.

HEINEKEN, C. & LOWE, R. T. 1832. *In:* LOWE, R. T. 1835. Description of two species of Araneidae native of Madeira. *Zoological Journal* 5: 320-323.

HJELLE, J.T. 1990. Anatomy and Morphology (pp. 9-63). *In:* POLIS, G.A. (ed.). The Biology of Scorpions. *Stanford University Press, Stanford.*

KARSCH, F. 1879. Scorpionologische Beiträge. Part II. *Mitteilungen des Münchener Entomologischen Vereins* 3: 97-136.

KINZELBACH, R. 1985. Vorderer Orient. Skorpione (Arachnida: Scorpiones). *Tübinger Atlas des Vorderen Orients (TAVO), Karte Nr. A VI 14.2.*

KOCH, C. L. 1837. Die Arachniden. 4: 1-135. *C. H. Zeh'sche Buchhandlung, Nürnberg.*

KOCH, C. L. 1839. Die Arachniden. 5: 125-158 (340-431); 6: 1-156 (432-540); 7: 1-130 (541-594). *C. H. Zeh'sche Buchhandlung, Nürnberg.*

KOCH, L.E. 1977. The taxonomy, geographic distribution and evolutionary radiation of Australo-Papuan scorpions. *Records of the Western Australian Museum* 5: 83-367.

KOVAŘÍK, F. 1997. Results of the Czech Biological Expedition to Iran. Part 2. Arachnida: Scorpiones, with descriptions of *Iranobuthus krali* gen. n. and *Hottentatta zagroensis* sp. n. (Buthidae). *Acta Societatis Zoologicae Bohemoslovenicae* 61: 39-52.

KRAEPELIN, K. 1894. Revision der Scorpione. II. Scorpionidae und Bothriuridae. *Beiheft zum Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* 11: 1-248.

KRAEPELIN, K. 1900. Über einige neue Gliederspinnen. *Abhandlungen aus dem Gebiete der Naturwissenschaften, herausgegeben vom Naturwissenschaftlichen Verein in Hamburg,* 16, 1(4): 1-17.

LAMORAL, B. H. 1979. The Scorpions of Namibia (Arachnida: Scorpionida). *Annals of the Natal Museum* 23: 497-784.

LATREILLE, P. A. 1802. Histoire naturelle, générale et particulière des crustacées et des insectes. Ouvrage faisant suite à l'histoire naturelle générale et particulière, composée par Leclerc de Buffon, et rédigée par C. S. Sonnini. *F. Dufart, Paris.*

LEEMING, J. 2003. Scorpions of southern Africa. *Struik Publishers, Cape Town,* 88 pp.

LOURENÇO, W. R. 2000. Panbiogéographie, les familles des scorpions et leur répartition géographique. *Biogeographica* 76(1): 21-39.

LOURENÇO, W. R. & CLOUDSLEY-THOMPSON, J. L. 1995. Stridulatory apparatus and the evolutionary significance of sound production in *Rhopalurus* species (Scorpiones: Buthidae). *Journal of arid environments* 31: 423-429.

LOURENÇO, W. R. & GOODMAN, S. M. 2002. Scorpions from the Daraina region of northeastern Madagascar, with special reference to the family Heteroscorpionidae Kraepelin, 1905. *Revista Ibérica de Aracnologìa* 6: 53-68.

LOURENÇO, W. R. & GOODMAN, S. M. 2004. Description of a new species of *Heteroscorpion* Birula (Scorpiones, Heteroscorpionidae) from the eastern lowland humid forest of southeastern Madagascar. *Revista Ibérica de Aracnologìa* 9: 319-323.

LOURENÇO, W. R., GOODMAN, S. M., RAHERIARISENA, M. & RAMILIJAONA, O. 2004. Description of the male of *Heteroscorpion magnus* Lourenço & Goodman, 2002 (Scorpiones, Heteroscorpionidae). *Revista Ibérica de Aracnologìa* 8: 111-115.

LOURENÇO, W. R., HUBER, D. & CLOUDSLEY-THOMPSON, J. L. 2000. Description of the stridulatory apparatus in some species of the genus *Rhopalurus* Thorell (Scorpiones, Buthidae). *Ekológia* 19 (3): 141-144.

LUCAS, M. H. 1858. Arachnides. *In:* THOMPSON, J. Histoire naturelle des insectes et des arachnides recueillis pendant un voyage fait au Gabon en 1856 et en 1857. *Archives entomologiques* 2: 428-430.

MONOD, L. & VOLSCHENK, E. S. 2004. *Liocheles litodactylus* (Scorpiones: Liochelidae): an unusual new *Liocheles* species from the Australian Wet Tropics (Queensland). *Memoirs of the Queensland Museum* 49(2): 675-690.

NICOLET, A. C. 1849. Aracnidos (pp. 322-341). *In:* GAY, C. (ed.). Historia física y política de Chile. 3. Zoologia. *Paris.*

PATEK, K. D., MODUR, V., ZIMMERMAN, G. A., PRESCOTT, S. M. & MACINTYRE, T. M. 1994. The necrotic venom of the Brown Recluse Spider induces dysregulated endothelial cell-dependant neutrophil activation. *Journal of Clinical Investigation* 94: 631-642.

PEREZ-MINNOCCI, S. 1974. Un inventario preliminar de los escorpiones de la region Paleartica y claves para la identification de los generos de le region Paleartica oriental. *Cátedra de Artrópodos* 7: 1-45.

PETERS, W. 1861a. Eine neue Untergattung von Skorpionen. *Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin* 1861: 426-427.

PETERS, W. 1861b. Über eine neue Eintheilung der Skorpione und über die von ihm in Mossambique gesammelten Arten von Skorpionen. *Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin* 1861: 507-516.

POCOCK, R. I. 1893. Notes on the classification of scorpions, followed by some observations on synonymy, with descriptions of new genera and species. *Annals and Magazine of Natural History* (6) 12: 303-330.

POCOCK, R. I. 1896. Notes on some Ethiopian species of Ischnurinae contained in the collection of the British Museum. *Annals and Magazine of Natural History* (6), 17: 312-319.

POCOCK, R. I. 1899a. Descriptions of some new species of scorpions. *Annals and Magazine of Natural History* (7) 3: 411-420.

POCOCK, R. I. 1899b. Description of new species of scorpions, centipedes and millipedes. The Expedition to Sokotra. *Bulletin of the Liverpool Museum* 2: 7-9.

PRENDINI, L. 2000. Phylogeny and classification of the superfamily Scorpionoidea Latreille, 1802 (Chelicerata, Scorpiones): an exemplar approach. *Cladistics* 16: 1-78.

PRENDINI, L. 2001. Substratum specialization and speciation in southern African scorpions: the Effect Hypothesis revisited (pp. 113-138). *In:* FET, V. & SELDEN, P. A. (eds). Scorpions 2001: In memoriam Gary A. Polis. *British Arachnological Society, Burnham Beeches, Bucks.*

PURCELL, W. F. 1898. Description of new South African scorpions in the collection of the South African Museum. *Annals of the South African Museum* 1: 1-32.

PURCELL, W. F. 1899. On the species of *Opisthophthalmus* in the collection of the South African Museum, with descriptions of new forms. *Annals of the South African Museum* 1: 131-180.

RADMANESH, M. 1990. Clinical study of *Hemiscorpius lepturus* in Iran. *Journal of Tropical Medicine and Hygiene* 93: 327-332.

RADMANESH, M. 1998. Cutaneous manifestations of the *Hemiscorpius lepturus* sting: a clinical study. *International Journal of Dermatology* 37: 500-507.

REES, P. M. 2002. Land-plant diversity and the end-Permian mass extinction. *Geology* 30: 827-830.

REES, P. M., ZIEGLER, A. M. & VALDES, P. J. 1999. Jurassic phytogeography and climates: new data and model comparisons (pp. 297-318). *In:* HUBER, B. T., MC LEOD, K. G. & WING, S. L. (eds). Warm climates in earth history. *Cambridge University Press, Cambridge.*

REES, P. M., ZIEGLER, A. M., GIBBS, M. T., KUTZBACH, J. E., BEHLING, P. J. & ROWLEY, D. B. 2002. Permian phytogeography patterns and climate data/model comparisons. *Journal of Geology* 110: 1-31.

SCOTESE, C. R. 2000. PALEOMAP Project, University of Texas, Arlington. *Online at: http://www.scotese.com/*

SIMON, E. 1879. 3e Ordre. Scorpiones (pp. 79-115). *In:* SIMON, E. (ed.). Les arachnides de France. VII. Contenant les ordres des Chernetes, Scorpiones et Opilions. *Librairie encyclopédique de Roret, Paris.*

SISSOM, W. D. 1990. Systematics, biogeography and paleontology (pp. 64-160). *In:* POLIS, G. A. (ed.). The biology of scorpions *Stanford University Press, Stanford.*

SOLEGLAD, M. E. & FET, V. 2003. High-level systematics and phylogeny of the extant scorpions (Scorpiones: Orthosterni). *Euscorpius* 11: 1-175.

STAMPFLI, G. M. & BOREL, G. D. 2002. A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrons. *Earth and Planetary Science Letters* 196: 17-33.

STAHNKE, H. L. 1970. Scorpion nomenclature and mensuration. *Entomological News* 81: 297-316.

STOCKWELL, S. A. 1989. Revision of the phylogeny and higher classification of scorpions (Chelicerata). *Unpublished Ph. D. thesis, University of California, Berkeley.*

SUNDEVALL, C. J. 1833. Conspectus Arachnidum. *C.F. Berling, Londini Gothorum.*

VACHON, M. 1963. De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les scorpions. *Bulletin du Muséum National d'Histoire Naturelle, Paris* (2), 35(2): 161-166.

VACHON, M. 1966. Liste des scorpions connus en Egypte, Arabie, Israel, Liban, Syrie, Jordanie, Turquie, Iraq, Iran. *Toxicon* 4: 209-218.

VACHON, M. 1974. Etude des caractères utilisés pour classer les familles et les genres de scorpions (Arachnides). *Bulletin du Muséum National d'Histoire Naturelle, 3e série* 140(104): 857-958.

VELLARD, J. 1932. Mission scientifique au Goyaz et au Rio Araguaya. Scorpions. *Mémoires de la Société Zoologique de France* 29(6): 539-556.

VOLSCHENK, E. S., SMITH, G. T. & HARVEY, M. S. 2000. A new species of *Urodacus* from Western Australia, with additional descriptive notes for *Urodacus megamastigus* (Scorpiones). *Records of the Western Australian Museum* 20: 57-67.

WALCKENAER, C. A. 1847. Araneae (pp. 365-564). *In:* WALCKENAER, C. A. & GERVAIS, P. (eds). Histoire naturelles des insectes aptères 4. *Librairie encyclopédique de Roret, Paris.*

WILLIS, K. J. & MC ELWAIN, J. C. 2002. The evolution of plants. *Oxford University Press, Oxford.*