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A Reappraisal of the Geographical Distribution of the Endemic Family Microcharmidae Lourenço (Scorpiones) in Madagascar and Description of Eight New Species and Subspecies

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We review aspects of the distributional patterns of Malagasy scorpions belonging to the endemic family Microcharmidae, genus *Microcharmus*, restricted to dry and wet forest formations in the northern and northwestern portions of the island. Here we describe six species new to science: *M. bemaraha* sp. nov., *M. confluenciatus* sp. nov., *M. duhemi* sp. nov., *M. maculatus* sp. nov., *M. variegatus* sp. nov., and *M. violaceous* sp. nov.; in addition to two new subspecies, *M. pauliani ambre* ssp. nov. and *M. pauliani namoroka* ssp. nov. The distribution of these species is restricted across northeastern Madagascar. The genus *Ankaranocharmus* Lourenço, 2004 is considered a junior synonym of the genus *Microcharmus* Lourenço, 1995.

KEY-WORDS: Scorpion, Microcharmidae, *Microcharmus*, Madagascar, distribution pattern.

Résumé

Des aspects concernant les modèles de distribution des scorpions malgaches, appartenant à la famille des Microcharmidae et au genre *Microcharmus*, sont révisés. Les éléments de cette famille endémique sont distribués exclusivement dans des formations forestières sèches et humides dans les régions Nord et Nord-Ouest de l'île. Six nouvelles espèces, ainsi que deux nouvelles sous-espèces sont décrites dans le présent travail : *M. bemaraha* sp. nov., *M. confluenciatus* sp. nov., *M. duhemi* sp. nov., *M. maculatus* sp. nov., *M. variegatus* sp. nov., *M. violaceous* sp. nov., *M. pauliani ambre* ssp. nov. et *M. pauliani namoroka* ssp. nov. Chacune des ces espèces présente une répartition très limitée, dans des habitats allant de la forêt humide à la forêt sèche. Le genre *Ankaranocharmus* Lourenço, 2004 est également considéré comme un synonyme du genre *Microcharmus* Lourenço, 1995.

MOTS-CLES: Scorpion, Microcharmidae, *Microcharmus*, Madagascar, modèle de distribution.

Soil scorpions are rare throughout their world distribution (Lourenço 2003, 2004, 2005). In Madagascar, the best-studied soil scorpions are represented by members of the endemic family Microcharmidae (Lourenço 1995, 1996, 1999). *Microcharmus* Lourenço was the first genus named in this family (Lourenço 1995), followed within a decade by two other genera: *Neoprotobuthus*

Lourenço and *Ankaranocharmus* Lourenço. To date, six species have been recognized in the genus *Microcharmus* (Appendix Table 1), but both *Neoprotobuthus* and *Ankaranocharmus* remain monotypic. Despite the growing number of new genera and species of Microcharmidae in recent years, no synthesis of their biogeographic distribution has been available. The principal reason has been the scarcity of available specimens; the majority of species have been described on the basis of a single specimen.

Dr. Brian L. Fisher (BLF), colleagues at the California Academy of Sciences, and a team of Malagasy field biologists have been conducting systematic invertebrate surveys at various sites across Madagascar since 2000. These inventories, which employ general hand collecting, pitfall traps, and various methods of soil litter extraction, have collected considerable numbers of Microcharmidae, specifically of the genus *Microcharmus*. The vast majority of specimens come from sites in the northern portion of the island. (See the diagnoses for the genus *Microcharmus* in a following section). Using this new material and associated morphological studies, we describe eight new taxa of *Microcharmus* from several different sites in the northern half of the island (Appendix Table 1; Fig. 1).

Material and Methods

Specimens in this study are based primarily on samples from pitfall traps and leaf litter extractions. At each locality surveyed by the CAS inventory team, 50 pitfall traps were placed every 1–5 m along a transect (see Fig. 2). Pitfall traps consisted of plastic containers with an internal top diameter of 11.5 cm by 7.5 cm deep, partly filled with 250 ml of water, two drops of concentrated (40%) formalin, and two drops of liquid soap. Each device was buried so that the rim was flush with the soil surface, and each was left in place for two days. An opaque plastic lid (roof) was placed approximately 40 mm above the trap and supported by a tripod brace of fine-gauge wire.

The leaf litter samples involved establishing 50, 1 m^2 plots every 5 m along the transect line. Leaf litter inside each plot was collected and minced with a machete to disturb invertebrates within small twigs and decaying wood. The material was then sifted through a wire sieve with a 1 cm grid size to remove large organic or inorganic matter. (Fig. 3). Approximately 2 l of sifted litter was taken from each 1 m^2 plot and the invertebrates extracted for a 48-hour period using mini-Winkler sacks (for a detailed discussion of the method, see Fisher 1999).

Color and pigmentation are the most conspicuous external characters in scorpions, especially amongst buthoids. There are two important aspects to scorpion coloration. One is the color of the cuticle itself, which can vary from clear (transparent) to black. Among some scorpions, cuticle coloration changes with age. Several species are variegated yellow as juveniles but turn black as they mature. A second type of coloration is due to the presence of sub-cuticular pigments, which form a variety of seemingly etched patterns over the body, pedipalps, and chelicerae. This second type of pigmentation does not normally change with age, but it can be masked by sclerification (Lourenço 1983; Lourenço and Cloudsley-Thompson 1996). In the case of microbuthoid scorpions, color and pigmentation are useful characters for species identification, as they are among other scorpion genera such as *Ananteris* (Lourenço, 1982) and *Tityobuthus* (Lourenço, 1996). In the present study, the diagnosis and descriptions of the different new taxa were largely based on precise patterns of pigmentation.

Illustrations and measurements were produce using a Wild M5 stereo-microscope with drawing tube and ocular micrometer set at 25×. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974, 1975), and morphological terminology mostly follows Vachon (1952), Hjelle (1990), and Sissom (1990). Hemispermatophore terminology mostly follows Lamoral (1979). Distributions of *Microcharmus* species were mapped on major biocli-

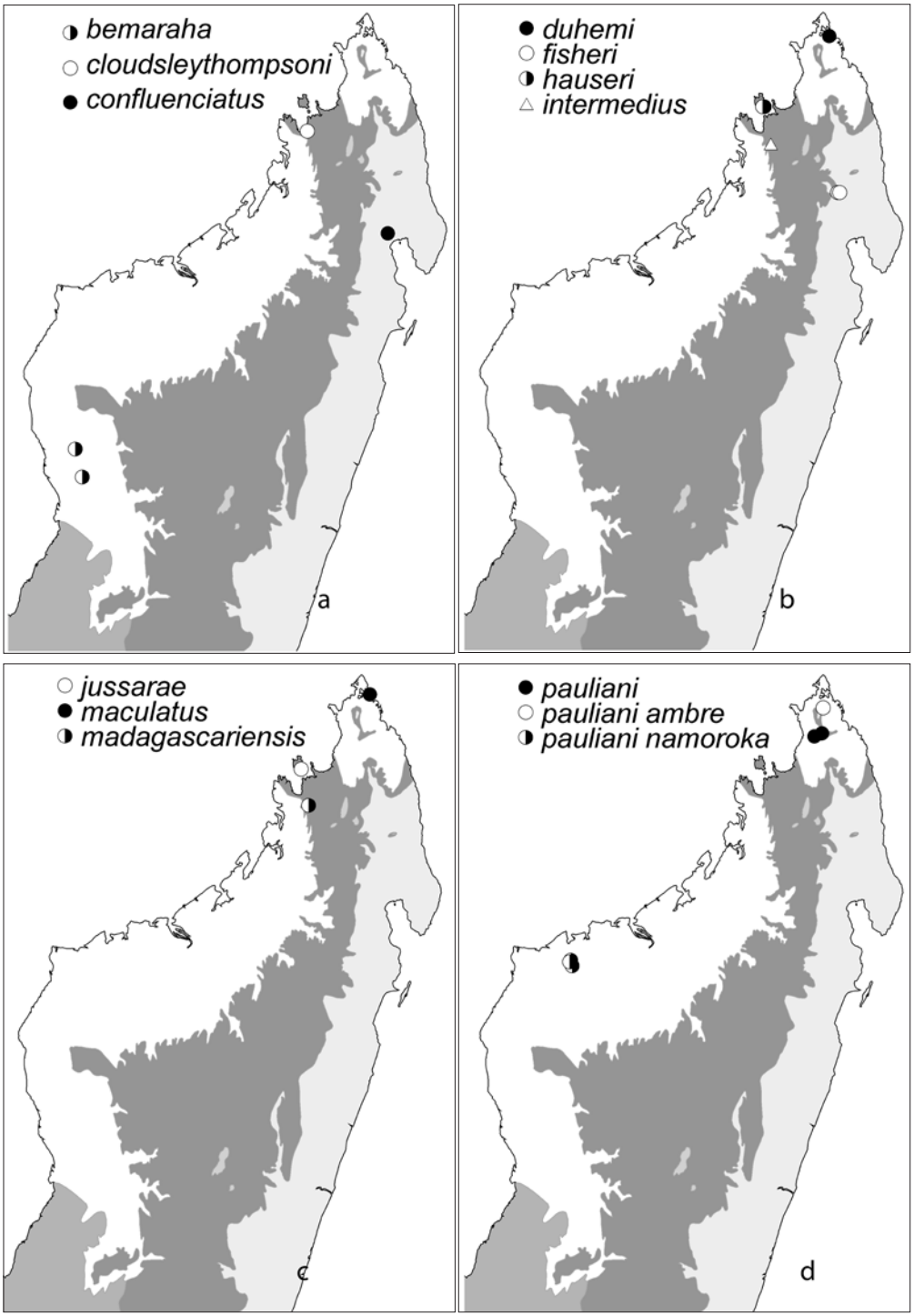


FIGURE 1a–e. Known distribution of *Microcharmus* species mapped on major bioclimatic zones (after Cornet 1974; see Schatz 2000).

matic zones (after Cornet 1974; see Schatz 2000) using ESRI ArcMap 9 (ESRI 2004). Specimens used in this current taxonomic revision come from the California Academy of Sciences, San Francisco (CAS) and Muséum national d'Histoire naturelle, Paris (MNHN).

FIGURE 1f (continued). Known distribution of *Microcharmus* species mapped on major bioclimatic zones (after Cornet 1974; see Schatz 2000).

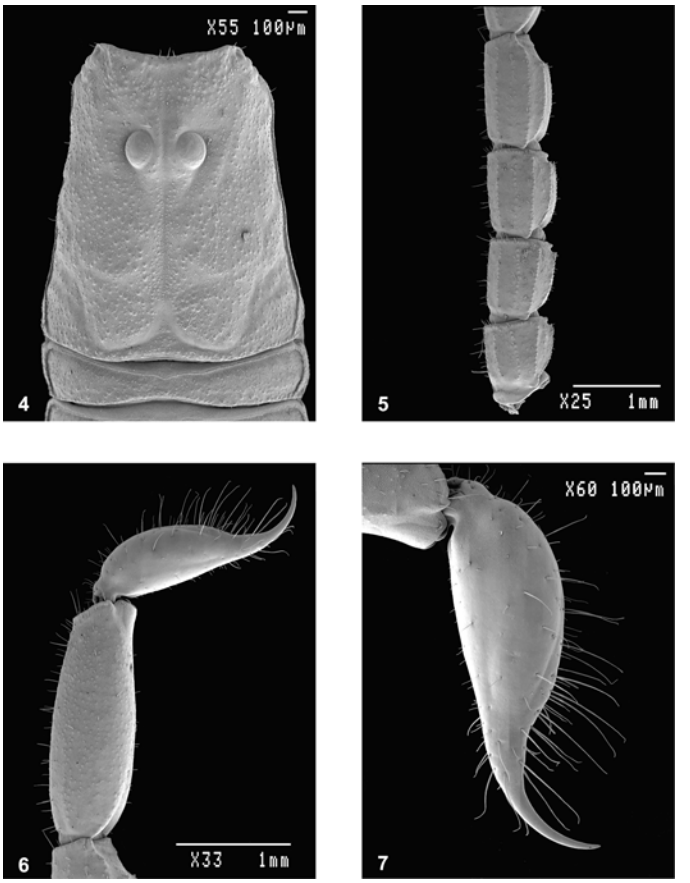
TAXONOMIC TREATMENT

Diagnosis of the genus *Microcharmus* (Lourenço, 2002; see Figs. 4–21)

Scorpions of small size, ranging from 8 to 18 mm in total length. Carapace: anterior margin with a weak concavity or almost straight; carinae and granulations generally very weak; furrows inconspicuous; median ocular tubercle distinctly located on the anterior third of the carapace (Fig. 4); three pairs of lateral eyes (in one case only two pairs). Sternum pentagonal (Figs. 8–9); one median carina moderate or sometimes weak in all tergites. Tergite VII pentacarinate. Pectines, generally moderate to small in size, although may be large in some taxa; the distal extremity or distal tooth is always rounded (diagnostic character); basal middle lamellae of the pectines not dilated; fulcra absent (Figs. 8–10). Images made with a scanning electron microscope show that the peg-shaped sensillae of the pectines have a rounded structure (diagnostic character) that is somewhat bottle-shaped (Figs. 11–13). Most buthid groups, by comparison, have very short peg-shaped sensillae of a spatulateshape. Sternites have short, semi-oval spiracles (diagnostic character) (Fig. 8); in a few species these are completely oval. Metasoma: all segments show strongly marked carinae (Fig. 5); in some species dorsal and latero-dorsal carinae of segments II to IV present one pos-

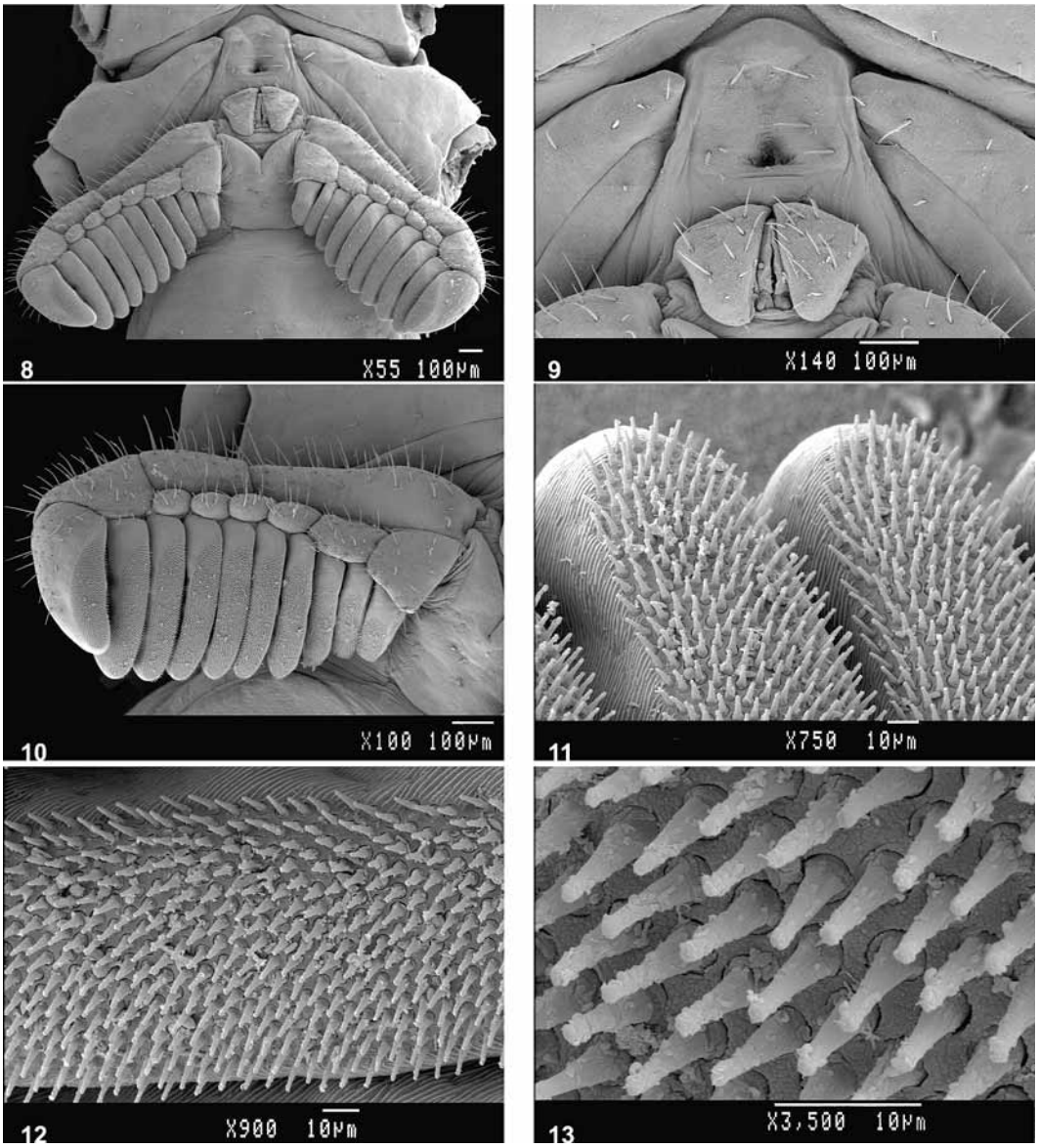
FIGURES 2–3. Field Methods. 2. Pitfall trapping in Parc National Tsingy de Bemaraha, Tombeau Vazimba, on the south bank of the Manambolo River, north of Andadoany. 3. Leaf litter sifting in Réserve spéciale de l'Ambre, 3.5 km SW of Sakaramy, at the foot of Montagne d'Ambre.

terior spinoid granule. Telson with a very elongated pear-shaped structure, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent (Figs. 6–7). Cheliceral dentition characteristic of buthoid; fixed finger with two well-marked basal teeth; movable finger with external distal tooth shorter than internal distal tooth, and two very weak and sometimes fused basal teeth. Internal face of pedipalp patella has two to six spinoid granules; fixed and movable fingers of pedipalp chela has six to seven almost linear rows of granules (Fig. 16); two accessory granules are present at the base of each row; the extremities of fixed and movable fingers include one long and sharp denticle (Fig. 17). Trichobothriotaxy; orthobothriotaxy A-α. Legs: tarsus with numerous fine ventrally-located median setae (Fig. 15). Pedal spurs reduced in general; tibial spurs reduced to absent on leg III, and moderate to absent on leg IV (Figs. 14–15).

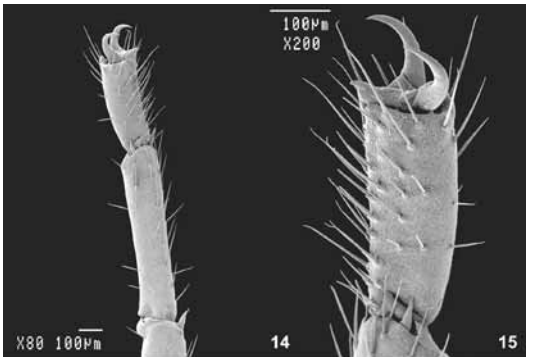


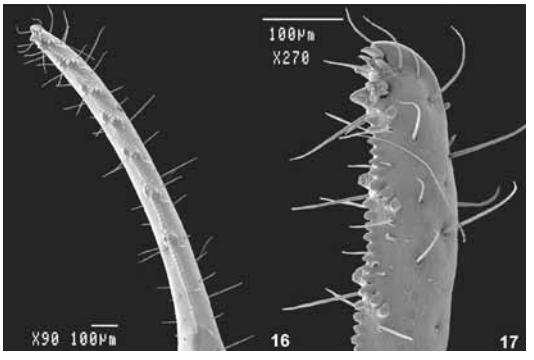
FIGURES 4–7. Morphological characters of *Microcharmus fisheri* (male paratype). 4. Carapace and tergite I. 5. Metasomal segments I-IV, lateral aspect. 6. Metasomal segment V and telson, lateral aspect. 7. Details of telson, lateral aspect, showing strongly marked setation.

HEMISPERMATOPHORE: Two basic types of spermatophores or hemispermatophores have been initially defined for scorpions (Hjelle, 1990): flagelliform and lamelliform. The first type is typical of buthids, and while the second type is typical to all other scorpion families. Stockwell (1989) defined a third type, fusiform, restricted to the family Chaerilidae. The flagelliform type is defined by a rather long and thin trunk terminating in its distal portion by a long filament referred to as the flagellum (Figs. 18–20). The few studies carried out on the structure of the microcharmid hemispermatophore indicate that it is somewhat different from the typical flagelliform type. The trunk is somewhat elongated, but larger at its base; a truncal flexure is not clearly observed, and two structures (the small hook and the flagellum) appear to be absent from the distal portion (Fig. 21) (diagnostic character). Further studies are needed to define this kind of spermatophore conclusively, but preliminary work indicates that in these animals, spermatophores are rather simple. This suggests that the condition in *Microcharmus* could be the primitive form leading to the evolution of the different types.

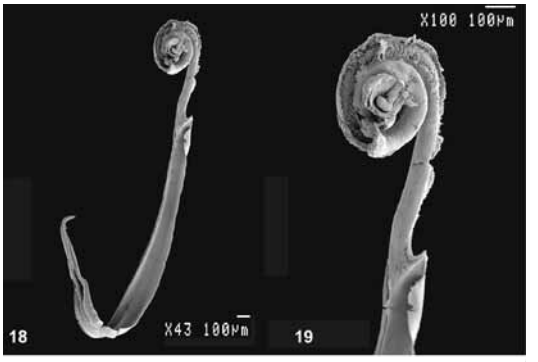


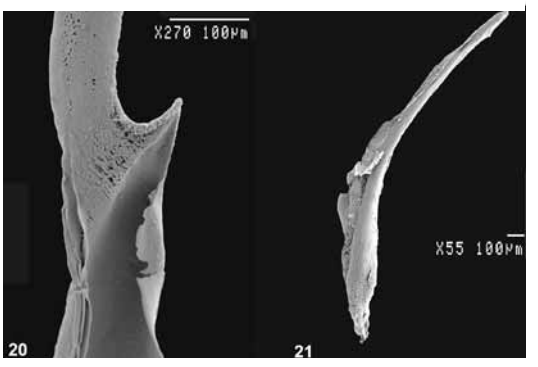
FIGURES 8–13. Morphological characters of *Microcharmus fisheri* (male paratype). 8. Ventral region showing sternum, genital operculum, pectines and sternite III. 9. Sternum and genital operculum, in detail. 10. Pecten with the distal extremity or distal tooth rounded. 11. External surface of teeth with peg-shaped sensillae. 12–13. Peg-shaped sensillae, in detail, with their rounded structure.





FIGURES 14–17. Morphological characters of *Microcharmus fisheri* (male paratype). 14. Tarsus and tibia of leg IV, showing pedal and tibial spurs. 15. Tarsus of leg IV, showing numerous fine median setae ventrally. 16. Pedipalp chela movable finger with almost linear rows of granules. 17. Extremity of movable finger of pedipalp chela, showing accessory granules and sharp denticles.





FIGURES 18–21. Hemispermatophores. 18–20. *Ananteris sabineae* Lourenço, a typical micro buthid. 18. Typical flagelliform type. 19. Detail of the flagellum. 20. Detail of the hook. 21. Hemispermatophore of *Microcharmus fisheri*, showing absence of truncal flexure, flagellum and hook.

Description of New Species and Subspecies

Microcharmus variegatus Lourenço, Goodman, and Fisher, sp. nov.

Figures 22–29, map figure 1e.

TYPE MATERIAL.— MADAGASCAR: **Province d'Antsiranana**: Forêt d'Analabe (Sahaka), 30 km 72° ENE Daraina, 30 m, 13°05′00″S, 49°54′5″E, littoral forest, sifted litter, leaf mold, rotten wood, 27–29/XI/2003 (B.L. Fisher et al.), 1 female holotype (CAS); 2 males, 4 female paratypes (CAS); Forêt d'Ampondrabe, 26.3 km 10° NNE Daraina, 175 m, 12°58′12″S, 49°42′00″E, tropical dry forest, sifted litter, leaf mold, rotten wood, 10/XII/2003 (B. L. Fisher et al.), 1 female paratype (CAS); Forêt de Bekaraoka, 6.8 km 60° ENE Daraina, 150 m, 13°10′00″S, 49°42′36″E, tropical dry forest, sifted litter, leaf mold, rotten wood, 7/XII/2003 (B.L. Fisher et al.), 1 male, 1 female, 3 juvenile paratypes (MNHN); Forêt de Binara, 7.5 km 230° SW Daraina, 375 m, 13°15′18″S, 49°37′00″E, semi-deciduous tropical forest, pitfall trap, 1/XII/2003 (B.L. Fisher et al.), 2 male paratypes (MNHN); Forêt de Binara, 7.5 km 230° SW Daraina, 375 m, 13°15′18″S, 49°37′00″E, semi-deciduous tropical forest, sifted litter, leaf mold, rotten wood, 1/XII/2003 (B.L. Fisher et al.), 1 female paratype (CAS); Forêt de Binara, 9.4 km 235° SW Daraina, 1100 m, 13°15′48″S, 49°36′00″E, montane rainforest, sifted litter mold, rotten wood, 5/XII/2003 (B.L. Fisher), 1 male paratype (CAS); Forêt d'Antsahabe, 11.4 km 275° W, Daraina, 550 m, 13°13′7″S, 49°33′4″E, tropical dry forest, sifted litter, leaf mold, rotten wood, 12–14/XII/2003 (B.L. Fisher et al.), 1 male paratype (CAS).

ETYMOLOGY.— The specific name refers to the scorpion's variegated pigmentation.

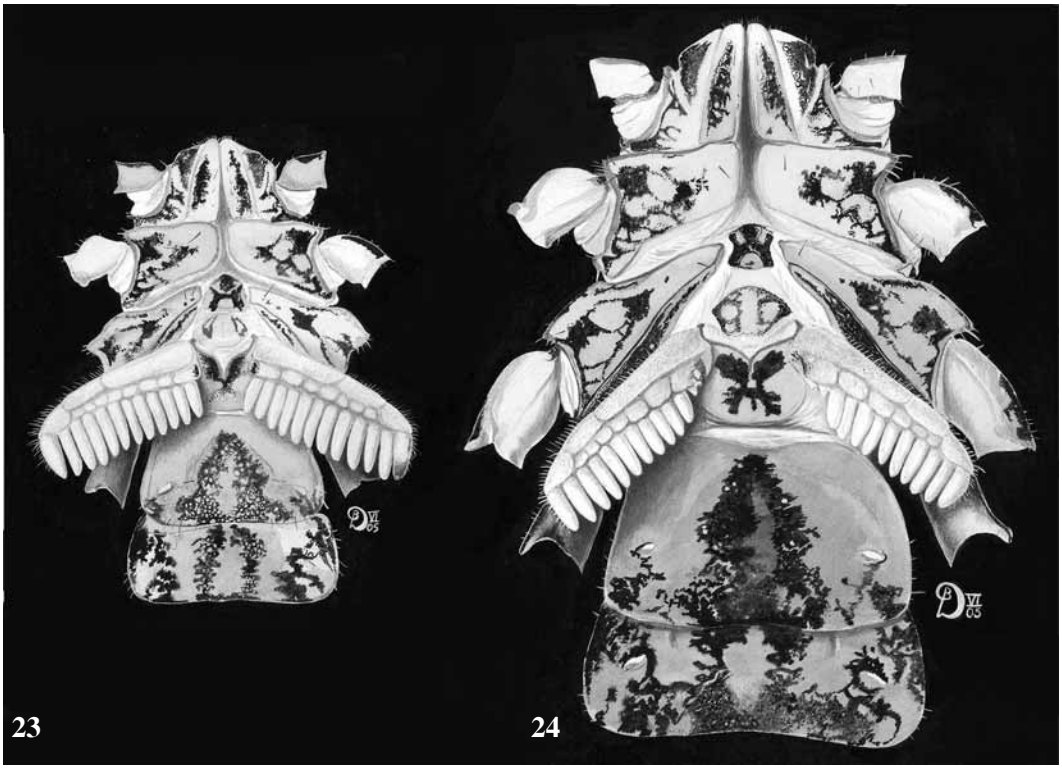
DIAGNOSIS.— Scorpions of average size when compared with most species of the genus *Microcharmus*, up to 12.9 mm total length in males and 17.8 mm in females (see morphometric values). General coloration yellowish to reddish-yellow with variegated spots over the body and appendages. Carinae and granulations moderately marked on body and appendages.

RELATIONSHIPS.— The new species can be readily distinguished from all other species in the genus by intense, variegated pigmentation on the body and appendages that is especially marked ventrally and on the vesicle.

FIGURE 22. *Microcharmus variegatus* sp. nov. Habitus of female holotype, showing typical pigmentation pattern.

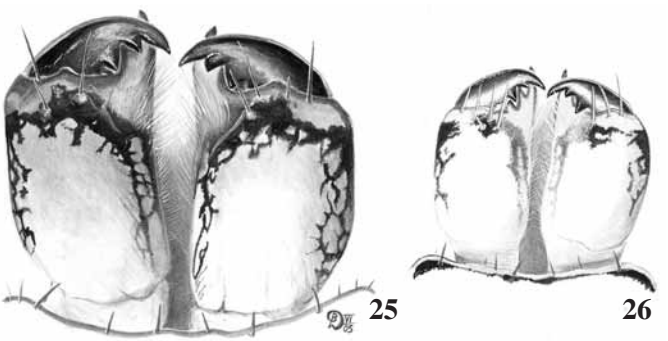
DESCRIPTION (based on female holotype and one male paratype).— COLORATION: Basically yellowish to reddish-yellow with dark variegated spots over the body and appendages. Carapace, tergites, metasomal segments, and vesicle with variegated dark spots; pedipalp femur and patella intensely marked with dark spots except on zones where trichobothria are inserted; chela hand yellowish with minute dark spots; proximal two-thirds of fingers dark and the extremity yellowish; chelicerae yellowish with variegated spots on the lateral margins and base of the fingers; fingers and teeth yellowish with some dark spots; venter with variegated spots on coxapophysis, sternum, genital operculum, middle basal lamella of pectines, and sternites; legs heavily spotted.

MORPHOLOGY: Carapace with moderate granulation; anterior margin with a weak concavity, almost straight. Carinae weak; furrows inconspicuous. Median ocular tubercle located distinctly on the anterior third of the carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites with a thin but intense granulation. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate being more or less triangular in shape. Pectines moderate to small: pectinal tooth count 11-11 for female holotype (mode in paratypes 12-12 for males and 11-11 for females); basal middle lamellae of the pectines not dilated; fulcra absent. Sternites with some minor granulations, almost smooth, and with short semi-oval to semi-slit-like spiracles; VII with a few more granulations and vestigial carinae. Metasoma: segments I to III with ten carinae, crenulate; segment IV with eight carinae and ventral carinae vestigial; intercarinal spaces weakly to mod-



FIGURES 23–24. *Microcharmus variegatus* sp. nov. Ventral aspect, showing typical pigmentation pattern of coxapophysis, sternum, genital operculum, pectines, and sternites. 23. Male paratype. 24. Female holotype.

erately granular. Segment V rounded with 5 carinae. Telson with a very elongated pear-shaped structure, smooth with strong setation; aculeus short and weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of buthoid (Vachon 1963); fixed finger with two strong basal teeth; movable finger with two very weak but fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with vestigial carinae; internal face of patella with four to five spinoid granules; chela without carinae, smooth; all faces weakly granular to smooth. Fixed and movable fingers with almost seven linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long and sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine ventral median setae. Pedal spurs reduced; tibial spurs moderate on legs III and IV.



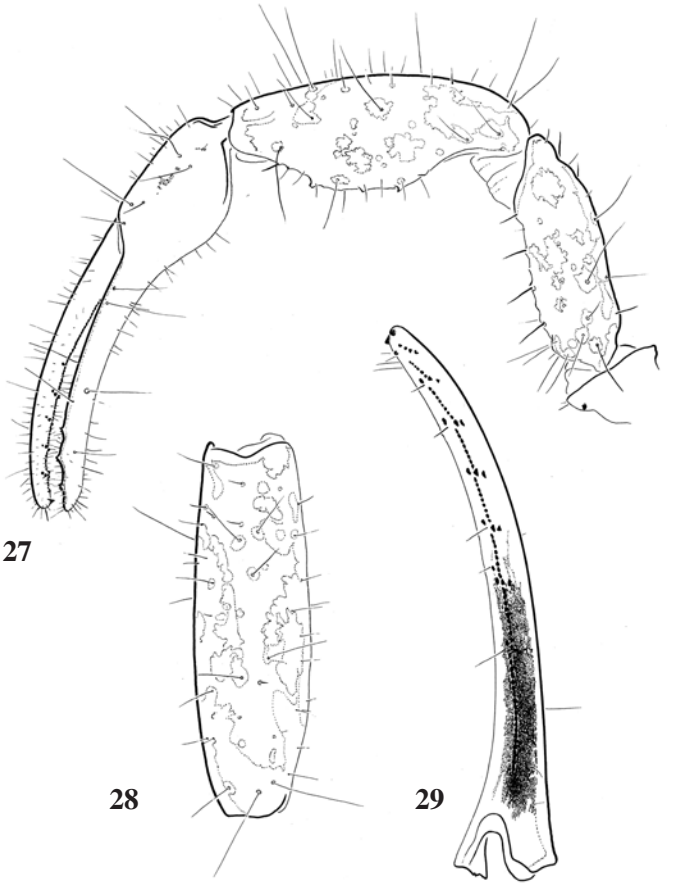
FIGURES 25–26. *Microcharmus variegatus* sp. nov. Chelicera with typical pigmentation pattern. 25. Female holotype. 26. Male paratype.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE PARATYPE AND FEMALE HOLOTYPE: Total

length, 12.80/16.40. Carapace: length, 1.56/2.14; anterior width, 0.99/1.56; posterior width, 1.53/2.38. Metasomal segment I: length, 0.90/1.06; width, 0.93/1.38. Metasomal segment V: length, 2.61/3.01; width, 0.78/1.07; depth, 0.79/1.12. Vesicle: width, 0.44/0.74; depth, 0.39/0.70. Pedipalp: femur length, 1.20/1.80, width, 0.41/0.69; patella length, 1.54/2.32, width, 0.60/0.94; chela length, 1.99/3.24, width, 0.43/0.74, depth, 0.45/0.73; movable finger length, 1.53/2.18.

Distribution and ecology.—On the basis of current information, *Microcharmus variegatus* is limited to the northeastern portion of Madagascar, specifically to forests surrounding the village of Daraina. It has been found at several different localities within this area, ina natural habitats ranging from the lowland dry forest at Ampondrabe at 175 m to the montane forest of Binara at 1100 m.

The Loky-Manambato area, formerly known as the Daraina region, includes a considerable range of natural forest habitats within a geographically limited region; it has been severely fragmented and degraded due to human activities. Topography, orography, and geology are important factors dictating the natural vegetation of the remaining forests (Gautier et al. 2006). Floristically, the Forêt de Bekaraoka consists of dry forest; it receives virtually no rain during a substantial portion of the year, and the vast majority of trees lose their leaves. Soil leaf litter at this site is notably reduced and there is little organic matter in the upper soil layer. On the slopes of Mount Binara, the ecology shifts dramatically over a relatively short distance and change in elevation. The lowest-lying forest (best classified as semi-deciduous tropical) grows at around 375 m, where there are permanently flowing streams and moderate levels of soil leaf litter, while the summit zone at around 1100 m is dominated by distinctly eastern montane rainforest and soil litters with extensive organic matter. The majority of specimens of *M. variegatus* came from the leaf litter samples.



Figures 27–29. *Microcharmus variegatus* sp. nov., female holotype. 27. Pedipalp showing trichobothrial pattern. 28. Idem, Patella, external aspect. 29. Pedipalp chela movable finger with almost linear rows of granules.

The CAS field inventory team has visited several littoral forests in Madagascar to conduct invertebrate surveys using parallel sampling techniques. These sites include (from north to south): Analabe Forest (Lac Sahaka) north of Vohémar; Ambondrobe Forest south of Vohémar; Tampolo Forest along the Masoala Peninsula; Ambohidena Forest on Isle Sainte Marie; Mandrisy Forest

south of Antanambe; Tampolo Forest north of Fénérive-Sud; Sainte. Luce (Manafiafy) and Mandena north of Tolagnaro; and Petriky to the west of Tolagnaro. Analabe is the only littoral forest where an example of *Microcharmus* has been found.

Given the variety of forest types where *Microcharmus variegatus* has been recorded, this genus does not appear sensitive to differences in habitat within the Loky-Manambato region. Rather, some aspect of geologic history likely limited the range of this microendemic. Just to the south of the Loky-Manambato region, a band of humid forests known as the Northern Highlands links the east and west coasts and pass across the mountainous Marojejy, Anjanaharibe-Sud, Tsaratanana, and Manongarivo regions. Endemic *Microcharmus* scorpion species have been recorded at most of these sites (Appendix Table 2). Further to the north and west are areas with exposed sedimentary rock, including the east-west aligned Andrafiamena Mountains. that form a precipitous wall, and distinctly drier climates (Goodman and Wilmé 2006). Madagascar as a whole experienced remarkable vegetation shifts during the Quaternary that were associated with changes in climatic patterns (Burney 1997); these vegetation changes were accentuated in montane regions. Given the geographic proximity of this transitional zone to the Northern Highlands, southern lowland humid forests, and northern and western dry deciduous forests, we assume that the forests of the Loky-Manambato region have served as an important zone of biotic exchange. As a result of this recent geologic history, Loky-Manambato has a remarkable regional mixture of both eastern and western fauna and flora (Goodman and Wilmé 2006), including several other endemic scorpion species (Lourenço and Goodman 2002, 2006a; Lourenço et al. 2004).

***Microcharmus duhemi* Lourenço, Goodman, and Fisher, sp. nov.**
Figures 30–33, map figure 1b.

TYPE MATERIAL.— MADAGASCAR: **Province d'Antsiranana**: Montagne des Français, 7.2 km 142° SE Antsiranana (Diégo Suarez), 180 m, 12°19′22″S, 49°20′17″E, tropical dry forest, sifted litter, 22–28/II/2001 (B.L. Fisher & C. Griswold et al.), 1 male holotype (CAS), 3 female paratypes (2 CAS; 1 MNHN).

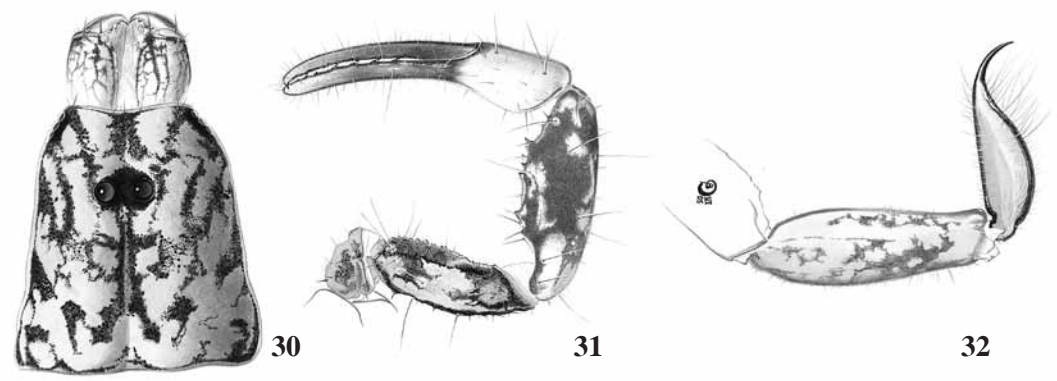
ETYMOLOGY.— Patronym in honor of Bernard Duhem, Muséum national d'Histoire naturelle, Paris, who prepared the illustrations for this paper.

DIAGNOSIS.— Scorpions of average size when compared with most species of the genus, up to 14.6 mm in total length in males and 17.6 mm in females (see morphometric values). General coloration yellowish, with brownish spots over the carapace, tergites and appendages; spots on metasoma very diffuse, and absent from ventral aspect and from the vesicle. Carinae and granulations are moderate on body and appendages.

RELATIONSHIPS.— The new species is readily distinguished from all other species of the genus *Microcharmus* by (i) much paler, yellowish coloration with moderately to weakly marked spots on body and appendages; and (ii) the ventral aspect lacks spots in males and is only diffuseon the sternites of females.

DESCRIPTION (based on male holotype and one female paratype).— COLORATION: Yellowish to pale yellow, with brownish spots over carapace, tergites, and appendages. Carapace, pedipalps, and legs with variegated brownish spots; tergites with four longitudinal brownish stripes; metasomal segments I to V with some diffuse spots; spots on ventral aspect of segments IV toV more intensely marked. Venter without spots on males and diffuse spots on sternites IV to VII of females; the entire surface of the chelicera covered with variegated spots.

MORPHOLOGY: Carapace with moderately marked granulation; anterior margin with a weak concavity. Carinae weak to obsolete; furrows inconspicuous. Median ocular tubercle distinct on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately to weakly granular. Median carina mod-



FIGURES 30–32. *Microcharmus duhemi* sp. nov. Male holotype. Pigmentation pattern. 30. Carapace and chelicerae. 31. Pedipalp, dorsal aspect. 32. Metasomal segment V and telson, lateral aspect.

erate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate more or less triangular in shape. Pectines large: pectinal tooth count 13–14 for male holotype (mode 12–12 for female paratypes); basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slitlike spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to IV with ten carinae, crenulate; ventral carinae moderate on segments III to IV; intercarinal spaces moderately to weakly granular. Segment V rounded with five carinae. Telson with a very elongated, pear-shaped structure, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of buthoids (Vachon 1963); fixed finger with two strong basal teeth; movable finger with two very weak and fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with some vestigial carinae; internal face of patella with three to four spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent on leg III, reduced on leg IV.

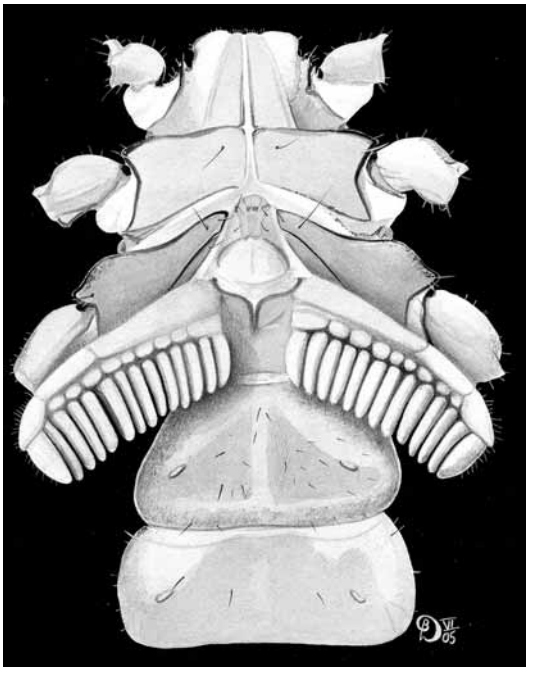


FIGURE 33. *Microcharmus duhemi* sp. nov. Male holotype. Ventral aspect, showing coxapophysis, sternum, genital operculum, pectines, and sternites.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE HOLOTYPE AND FEMALE PARATYPE: Total length, 14.60/17.60. Carapace: length, 1.82/2.20; anterior width, 1.24/1.56; posterior width, 1.79/2.25. Metasomal segment I: length, 1.04/1.16; width, 1.11/1.39. Metasomal segment V: length,

2.58/3.07; width, 0.94/1.09; depth, 0.97/1.13. Vesicle: width, 0.74/0.74; depth, 0.74/0.75. Pedipalp: femur length, 1.59/1.94, width, 0.51/0.70; patella length, 1.94/2.37, width, 0.72/0.91; chela length, 2.58/3.35, width, 0.57/0.74, depth, 0.56/0.76; movable finger length, 1.74/2.33.

Distribution and ecology.— The single collection site for this new species is from Montagne des Français, an isolated, relatively dry limestone massif in close proximity to the town of Antsiranana (Fig. 34, 35). Much of the massif is sparsely vegetated with tropical dry forest, largely deciduous, along often precipitous cliff faces and on its upper plateau. The zone receives little annual rainfall, has a very pronounced dry season, and offers few permanent water sources. Soil leaf litter is sparse within the remaining areas of forest, although all four specimens of this new taxon were collected in leaf litter samples. The north-facing slope is grazed heavily by cattle and the plateau is under pressure from firewood collection and some charcoal production.

Figures 34–35. Montagne des Français. 34 (left). Calcareous rocks and limestone crevices near the northern summit looking across the Antsiranana bay towards Ramena. 35 (right). The calcareous substrates of the plateau are drier than the shaded crevices filled with pockets of litter.

Just to the northeast of the Montagne des Français is the Orangea region, which is marked by dry deciduous thicket growing atop a sandy substrate. The region also features at least one other unique microendemic species of *Microcharmus* (see next description). To the south of the Montagne des Français is a largely continuous zone of exposed limestone passing through the region of Analamerana to the Andrafiamena Mountains. The CAS field team conducted a biological inventory of Analamerana in 2004, but found no *Microcharmus* scorpion. To the south of the Andrafiamena Mountains, there is a notable shift in geology in the Loky-Manambato region, which is within the range of *M. variegatus.*

The description of *M. duhemi* adds to the growing number of endemic animals and plants known from the Montagne des Français (e.g., Baum 1995; Glaw et al. 2005), as well as scorpions (Lourenço and Goodman 2006b).

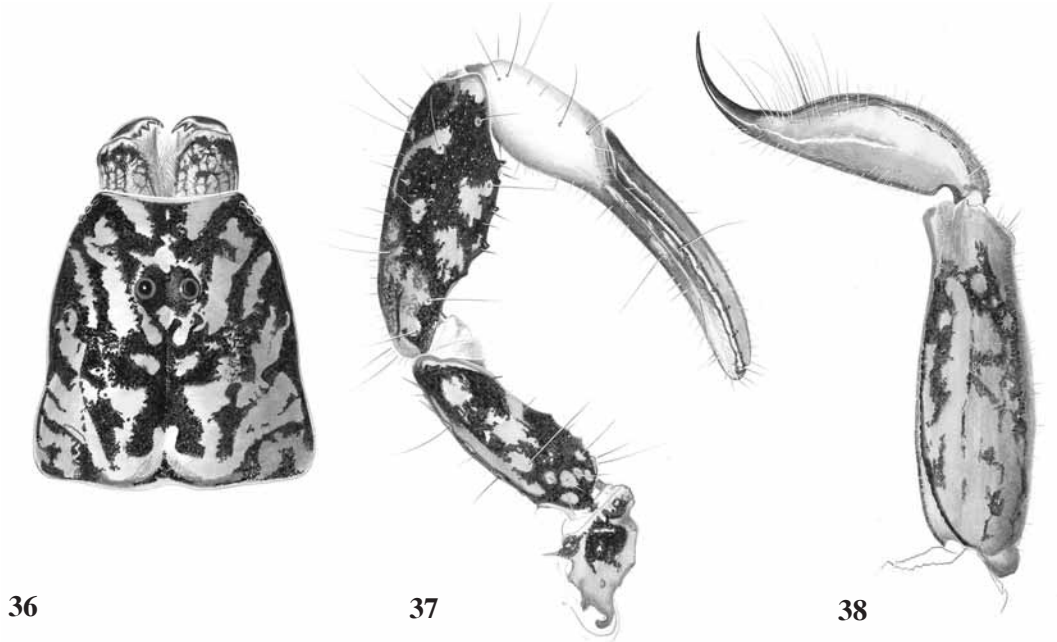
Microcharmus maculatus Lourenço, Goodman, and Fisher, sp. nov.

Figures 36–38, map figure 1c.

Type material.— Madagascar: **Province d'Antsiranana**: Forêt d'Orangea, 3.6 km 128° SE Ramena, 90 m, 12°15′32″S, 49°22′29″E, dry deciduous thicket, pitfall trap, 22–28/II/2001 (B.L. Fisher & C. Griswold et al.), 1 female holotype (CAS); Forêt d'Orangea, 3.6 km 128° SE Ramena, 90 m, 12°15′32″S, 49°22′29″E, dry deciduous thicket, 22–28/II/2001 (L.J. Boutin), 1 male paratype (MNHN).

Etymology.— The specific name refers to the dark, heavily spotted pigmentation of the new species.

Diagnosis.— Scorpions of small size when compared with most species of the genus, up to



FIGURES 36–38. *Microcharmus maculatus* sp. nov. Female holotype. Pigmentation pattern. 36. Carapace and chelicerae. 37. Pedipalp, dorsal aspect. 38. Metasomal segment V and telson, lateral aspect.

10.6 mm in total length in males and 13.8 mm in females (see morphometric values). General coloration dark reddish-yellow, with blackish spots over the body and appendages, spotting pattern less marked on metasoma. Carinae and granulations moderately marked on body and appendages.

RELATIONSHIPS.— The new species is readily distinguished from all other species in the genus *Microcharmus* by (i) a smaller overall size; and (ii) strongly marked blackish pigmentation on body and appendages.

DESCRIPTION (based on female holotype and male paratype).— COLORATION: Basically dark reddish-yellow with blackish spots over the body and appendages; spots less marked on metasomal segments; vesicle without spots. Carapace, tergites, pedipalps, and legs with very dense variegated blackish spots; metasomal segments paler than carapace, yellowish with diffuse spots. Venter heavily spotted on coxapophysis, sternum, genital operculum, and sternites; pectines with only two minute diffuse spots; chelicera yellowish with variegated spots over the entire surface.

MORPHOLOGY: Carapace with a moderately marked granulation; anterior margin with a very weak concavity, almost straight. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately to weakly granular. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate more or less triangular in shape. Pectines large: pectinal tooth count 12-12 in male paratype and 10-10 in female holotype; basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slitlike spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to III with ten carinae, crenulate; IV with eight carinae; ventral carinae vestigial on segments III-IV; intercarinal spaces weakly granular. Segment V rounded with five carinae. Telson with a very elongated pear-shaped structure, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral den-

tition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two very weak and almost fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with some vestigial carinae; internal face of patella with three to four weakly spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent on leg III, very reduced or absent on leg IV.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE PARATYPE AND FEMALE HOLOTYPE: Total length, 10.60/13.80. Carapace: length, 1.32/1.63; anterior width, 0.97/1.03; posterior width, 1.37/1.66. Metasomal segment I: length, 0.72/0.82; width, 0.81/1.00. Metasomal segment V: length, 1.74/1.94; width, 0.74/075; depth, 0.64/0.74. Vesicle: width, 0.51/0.52; depth, 0.47/0.49. Pedipalp: femur length, 1.09/1.33, width, 0.38/0.43; patella length, 1.32/1.57, width, 0.51/0.59; chela length, 1.82/2.28, width, 0.41/0.48, depth, 0.38/0.47; movable finger length, 1.22/1.58.

DISTRIBUTION AND ECOLOGY.—*Microcharmus maculatus* is known from two specimens, both collected in the Forêt d'Orangea in the extreme north of the island. One of the specimens was obtained in a pitfall trap and the other by an undesignated method. The site has a degraded formation of dry deciduous thicket resting on sandy soils (Fig. 39) that is located relatively close to the sea, with little surface litter and reduced levels of organic matter. Even though the natural forest formation has suffered considerably from human-induced habitat degradation, it still contains interesting invertebrates such as *M. maculatus* and a wide assortment of plants endemic to the region (Baum 1995; Bardot-Vaucoulon 2001; La Croix et al. 2002; Miller 2002). This forest deserves protection and will continue to degrade and eventually disappear unless conservation efforts commence in the very near future.

FIGURE 39. As seen in this February 2001 photo, the Forêt d'Orangea still had a few larger trees emerging above the sublittoral thicket.

Microcharmus bemaraha Lourenço, Goodman, and Fisher, sp. nov.

Figure 40; map figure 1a.

TYPE MATERIAL.— Madagascar: **Province de Mahajanga**: Parc National Tsingy de Bemaraha, 10.6 km 123° ESE Antsalova, Andranopasazy, 150 m, 19°42′34″S, 44°43′5″E, tropical dry forest on tsingy, sifted litter, leaf mold, rotten wood, 16–20/XI/2001 (B.L. Fisher et al.), 1 female paratype (MNHN); Parc National Tsingy de Bemaraha, 3.4 km 93° E Bekopaka, Tombeau Vazimba, 50 m, 19°8′31″S, 44°49′41″E, tropical dry forest, sifted litter, 6–10/XI/2001 (B.L. Fisher & C. Griswold et al.), 1 female holotype (CAS).

ETYMOLOGY.— The specific name refers to the type locality of the new species.

DIAGNOSIS.— Scorpions of average size when compared with most species of the genus, up to 16.4 mm in total length for females (see morphometric values). General coloration yellowish with dark variegated spots over the body and appendages. Carinae and granulations moderately marked on body and appendages.

RELATIONSHIPS.— The new species can be readily distinguished from all other species of the genus *Microcharmus* by (i) a paler general coloration and a less intense pigmentation pattern; and

(ii) the lack of pigmentation at the point of articulation of the dorsal trichobothria d_1, d_3 and d_4 of the femur.

DESCRIPTION (based on female holotype).— COLORATION: Basically yellowish with dark variegated spots over the body and appendages. Carapace, pedipalps, and legs with variegated dark spots; chela hand yellowish; tergites with four approximately longitudinal dark stripes; the two central strips more or less fused; metasomal segments I to V densely spotted; carinae more intensely pigmented. Venter moderately spotted; coxapophysis with diffused spots; sternum, genital operculum, and basal middle lamellae of pectines with conspicuous spots; sternites with four longitudinal dark spots; the most central more or less fused; chelicerae yellowish with a dark variegated spots covering the entire surface.

FIGURES 40. *Microcharmus bemaraha* sp. nov. Female holotype. Pigmentation pattern of pedipalps, dorsal aspect.

MORPHOLOGY: Carapace with weakly to moderately marked granulation; anterior margin with a very weak concavity, almost straight. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately granular. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate more or less triangular in shape. Pectines moderate: pectinal tooth count 10-11 in female holotype, 11-12 in female paratype; basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slitlike spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to III with 10 carinae, crenulate; segment IV with eight carinae, ventral carinae less marked on segment IV; dorsal and latero-dorsal carinae of segments II to IV with a posterior spinoid granule; intercarinal spaces weakly granular. Segment V rounded with five vestigial carinae. Telson with a very elongated pear-shaped structure, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two very weak, almost fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella vestigial carinae; internal face of patella with four to five spinoid granules; chela smooth; all faces moderately to weakly granular. Fixed and movable fingers with seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent on leg III, reduced on leg IV.

MORPHOMETRIC MEASUREMENTS (in mm) of the female holotype: Total length, 16.40. Carapace: length, 2.03; anterior width, 1.34; posterior width, 2.06. Metasomal segment I: length, 0.97; width, 1.19. Metasomal segment V: length, 2.66; width, 1.03; depth, 1.03. Vesicle: width, 0.72; depth,

0.69. Pedipalp: femur length, 1.82, width, 0.62; patella length, 2.22, width, 0.80; chela length, 3.07, width, 0.69, depth, 0.63; movable finger length, 2.22.

DISTRIBUTION AND ECOLOGY.— *Microcharmus bemaraha* is known from two sites, both within the Parc National de Bemaraha (Fig. 41–43) and approximately 64 km from one another. The Tombeau Vazimba site is to the south of the Manambolo River, which traverses the Bemaraha within a deep canyon system incised by water, with walls reaching up to 400 m high above the river level. The second site is at least 60 km to the north of this river. Hence, the river does not appear to have been a barrier for dispersal in this scorpion. Both specimens were obtained from sifted leaf litter.

The Bemaraha Plateau consists of a mid-Jurassic limestone deposit over 200 km long that was uplifted approximately 6 million years ago. Sections of the massif where the limestone has few impurities have been eroded into a remarkable array of sculpted forms, including jagged pinnacles known in Malagasy as *tsingy*.

The local climate has a very pronounced dry season (April to October) with little to virtually no rainfall, and a rainy season (November to March), when the majority of the annual 1000 to 1500 mm of precipitation falls. Deep canyons and crevasses provide extensive shade.

The zone holds several distinctive forest types, which include dense dry deciduous and semideciduous forests (Rabarison 2000), and show considerable levels of plant and animal endemism (Rajeriarison et al. 2000; Rasoloarison and Paquier 2003). Much of the local biota shows remarkable adaptations to the extended dry periods and intensive solar radiation. In most portions of the forest there is limited soil litter, although the deep shaded canyons and eroded rock structures could provide an array of relatively moist sites for invertebrates such as scorpions.

FIGURES 41–42. Parc National Tsingy de Bemaraha. 41. Looking to the north bank along the Manambolo River towards the Tombeau Vazimba. 42 Leaf litter "mini-Winkler" extractors at work near the Tombeau Vazimba.

FIGURE 43. Charcoal preparation in Parc National Tsingy de Bemaraha on the trail from Bekopaka to Ankidrodroa.

To the north of the Bemaraha are several other isolated zones of limestone. The CAS survey team has inventoried two of these sites. These include the Namoroka Massif, about 300 km to the north of the Andranopasazy site in Bemaraha, and the Ankarana Massif, an additional 565 km north of Namoroka; both have endemic *Microcharmus* (see below). To the south of Bemaraha there are several large limestone massifs. These include the Mahafaly Plateau, which has been extensively surveyed by the CAS field team. No evidence of the genus *Microcharmus* has been found there, but rather another genus of soil-dwelling Buthidae, *Pseudouroplectes* (Lourenço and Goodman, 2006).

***Microcharmus pauliani pauliani* (Lourenço, 2004)**
Figure 44, map figure 1d.

= *Ankaranocharmus pauliani*: Lourenço, 2004: pp: 79.
See description in Lourenço (2004).

Based on the study of a large series of *Microcharmus* from the Parc National d'Ankarana and nearby regions, we conclude that the genus *Ankaranocharmus* is best considered a synonym of *Microcharmus*. The former genus was named from a single specimen and not diagnosed properly.

The diagnostic characters used to define *Ankaranocharmus* were: Spiracles short but almost semi-slit-like. Distal tooth of pectines less rounded than in other microcharmids. Peg-shaped sensillae equally rounded, but their bottle shape isless pronounced and their overall size smaller than those of *Microcharmus*. The present study, however, shows that the single specimen used in the diagnoses of the genus was somewhat atypical.

***Microcharmus pauliani namoroka* Lourenço, Goodman, and Fisher, ssp. nov.**
Figure 45, map figure 1d.

TYPE MATERIAL.— MADAGASCAR: **Province de Mahajanga**: Parc National de Namoroka, 9.8 km 300° WNW Vilanandro, Ambovonaomby, 140 m, 16°28′00″S, 45°21′00″E, tropical dry forest, sifted litter, 4–8/XI/2002 (B.L. Fisher & C. Griswold et al.), 1 male paratype (CAS); Parc National de Namoroka, 9.8 km 300° WNW Vilanandro, Ambovonaomby, 140 m, 16°28′00″S, 45°21′00″E, tropical dry forest, pitfall trap, 4–8/XII/2002 (B.L. Fisher & C. Griswold et al.), 1 male holotype (CAS); Parc National de Namoroka, 17.8 km 329° WNW Vilanandro, Mangotroky, 100 m, 16°22′36″S, 45°19′36″E, tropical dry forest, pitfall trap, 8–12/XI/2002 (B.L. Fisher & C. Griswold et al.), 1 female paratype (CAS); Parc National de Namoroka, 17.8 km 329° WNW Vilanandro, Mangotroky, 100 m, 16°22′36″S, 45°19′36″E, tropical dry forest, pitfall trap, 8–12/XI/2002 (B.L. Fisher & C. Griswold et al.), 2 male paratypes (MNHN); Parc National de Namoroka, 16.9 km 317° NW Vilanandro, Andriabe, 100 m, 16°24′24″S, 45°18′36″E, tropical dry forest, pitfall trap, 12–16/XI/2002 (B.L. Fisher & C. Griswold et al.), 1 male juvenile paratype (CAS); Parc National de Namoroka, 16.9 km 317° NW Vilanandro, Andriabe, 100 m, 16°24′24″S, 45°18′36″E, tropical dry forest, sifted litter, leaf mold, rotten wood, 12–16/XI/2002 (B.L. Fisher & C. Griswold et al.), 1 male paratype (CAS).

ETYMOLOGY.— The specific name refers to the type locality of the new subspecies.

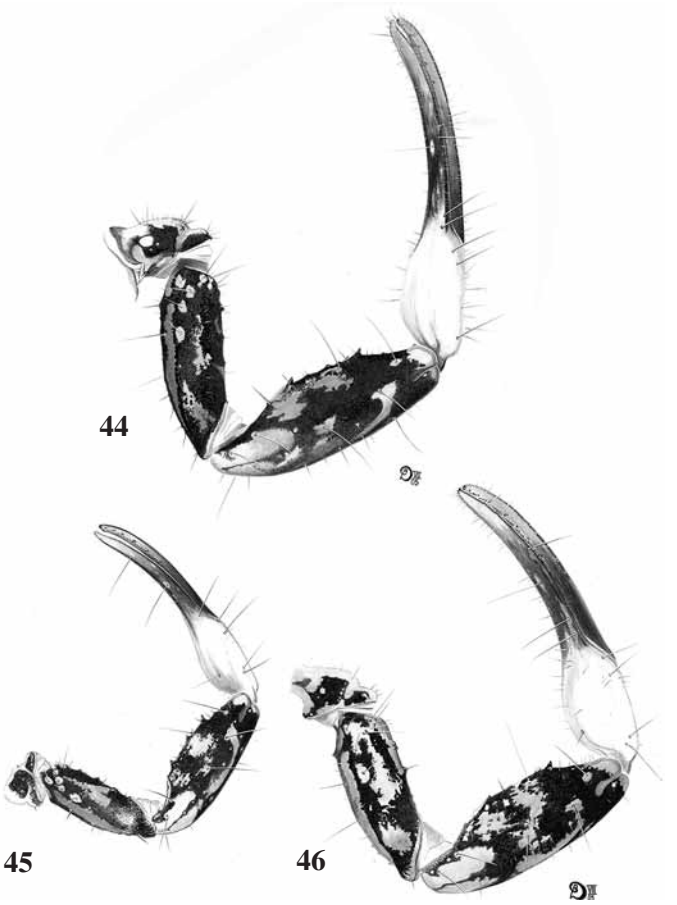
DIAGNOSIS.— Scorpions are of average size when compared with most members of the genus, up to 14.3 mm in total length for males and 17.9 for females (see morphometric values). General coloration yellowish to reddish-yellow with brownish variegated spots over the body and appendages. Carinae and granulations moderately marked on body and appendages.

RELATIONSHIPS.— The new subspecies is readily distinguished from *M. p. pauliani* by (i) a paler pattern of body pigmentation; and (ii) a smaller number of pectinal teeth.

DESCRIPTION (based on male holotype and female paratype).— COLORATION: Basically yellowish to reddish-yellow with brownish variegated spots over the body and appendages. Carapace, pedipalps, and legs with variegated brownish spots; anterior zone to the ocular tubercle without pigments in males; tergites with four longitudinal brownish stripes, the two central fused; metasomal

segments less densely spotted than tergites; venter moderately spotted; coxapophysis, sternum, genital operculum, and sternites with diffused spots; chelicera yellowish with dark variegated spots covering the anterior two-thirds.

MORPHOLOGY: Carapace with moderately marked granulation; anterior margin with very weak concavity. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately granular. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate more or less triangular in shape. Pectines large in males, small in females: pectinal tooth count 11-10 for male holotype and 8-9 for female paratype; basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth, with short semi-oval to semi-slitlike spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to IV with ten carinae, crenulate; ventral carinae reduced on segment IV; intercarinal spaces weakly to moderately granular. Segment V rounded with five carinae. Telson with a very elongated pear-shaped structure, smooth with moderate setation; aculeus short and weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two very weak but not fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with vestigial carinae; internal face of patella with four to five spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent on leg III, moderate on leg IV.



FIGURES 44–46. Pigmentation pattern of pedipalps, dorsal aspect. 44. *Microcharmus pauliani pauliani*. Female holotype. 45. *Microcharmus p. namoroka* ssp. nov. Male holotype. 46. *Microcharmus p. ambre* ssp. nov. Female holotype.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE HOLOTYPE AND FEMALE PARATYPE: Total length, 14.30/17.90. Carapace: length, 1.78/2.09; anterior width, 1.07/1.34; posterior width,

1.82/2.16. Metasomal segment I: length, 0.83/0.90; width, 0.97/1.26. Metasomal segment V: length, 2.32/2.68; width, 0.87/1.03; depth, 0.87/1.04. Vesicle: width, 0.58/0.66; depth, 0.64/0.69. Pedipalp: femur length, 1.47/1.78, width, 0.50/0.59; patella length, 1.74/2.22, width, 0.63/0.82; chela length, 2.41/2.44, width, 0.51/0.63, depth, 0.49/0.61; movable finger length, 1.66/2.09.

Distribution and ecology.— *Microcharmus pauliani namoroka* is described here based on seven specimens, all of which are from the Namoroka Massif of central-west Madagascar. The specimen series comes from several different sites around Namoroka and appears broadly distributed across the massif. The majority of individuals was obtained in pitfall traps.

The massif is composed of limestone deposits and has experienced some of the same types of water erosion mentioned previously for the Bemaraha Massif under the description for *M. bemaraha*. Further, the climatic parameters described for Bemaraha are also similar to those at Namoroka. Separated by at least 200 km, these two massifs possess very different microcharmid fauna, with *M. p. namoroka* being a distinct geographic form of an animal occurring at the north end of the island at the foothills of Montagne d'Ambre and Ankarana. However, Bemaraha and Namoroka share other scorpion taxa such as *Opisthacanthus madagascariensis* (Lourenço and Goodman 2006a), but these larger species are presumed to be more generalists, better dispersers, and less subject to microendemism.

Microcharmus pauliani ambre Lourenço, Goodman, and Fisher, ssp. nov.

Figure 46, map figure 1d.

Type material.— Madagascar: **Province d'Antsiranana**: Réserve spéciale de l'Ambre, 3.5 km 235° SW Sakaramy, 325 m, 12°28′08″S, 49°14′32″E, tropical dry forest, pitfall trap, 26–31/I/2001 (B.L. Fisher & C. Griswold et al.). 1 female holotype (CAS); 3 female paratypes (2 CAS; 1 MNHN).

Etymology.— The specific name refers to the type locality of the new subspecies.

Diagnosis.— Scorpions are of average size when compared to most members of the genus, up to 15.8 mm in total length for females (see morphometric values). General coloration yellowish with pale brown variegated spots over the body and appendages. Carinae and granulations moderate on body and appendages.

Relationships.— The new subspecies is readily distinguished from *M. p. pauliani* and *M. pauliani namoroka* by (i) a paler pigmentation pattern, specifically on metasomal segments and pedipalps; and (ii) the entire surface of the chelicerae are covered with dark variegated spots.

Description (based on female holotype).— Coloration: Basically yellowish with pale brown variegated spots over the body and appendages. Carapace, tergites, pedipalps, and legs with variegated pale brown spots; metasomal segments much less densely spotted than carapace or tergites; spots mainly covering the carinae; venter with pale variegated spots over coxapophysis, sternum, genital operculum, basal middle lamella of pectines, and sternites; chelicera yellowish with a dark variegated pigmentation which covers the entire surface.

Morphology: Carapace with a moderately marked granulation; anterior margin with a moderate concavity. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly located on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately granular. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate more or less triangular in shape. Pectines moderate: pectinal tooth count 11-11 for female holotype (female paratypes with 11-11, 10-10); basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slit-like spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to IV with ten carinae, crenulate; ventral carinae

reduced on segment IV; intercarinal spaces weakly granular. Segment V rounded with five carinae. Telson with a very elongated pear- shaped structure, smooth with moderate setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two very weak and fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with vestigial carinae; internal face of patella with two spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with six to seven almost-linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine ventral median setae. Pedal spurs reduced; tibial spurs absent on leg III, reduced or absent on leg IV.

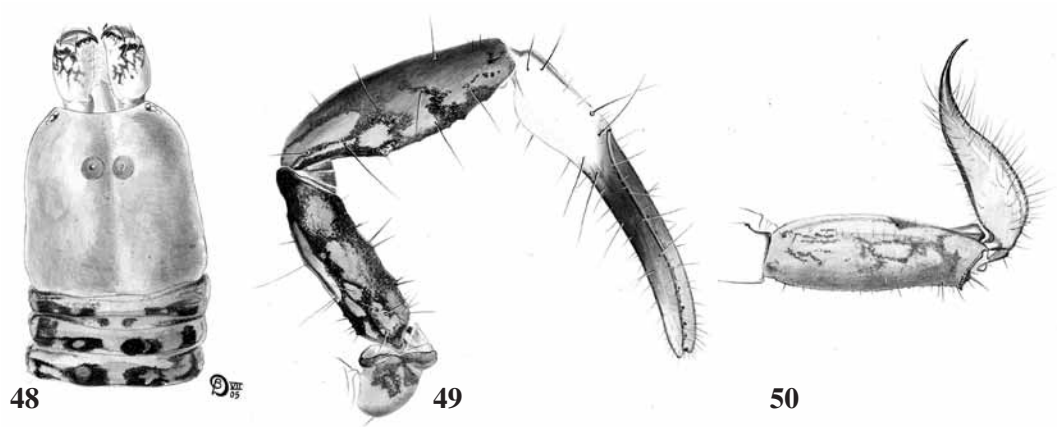
MORPHOMETRIC MEASUREMENTS (IN MM) OF THE FEMALE HOLOTYPE: Total length, 15.80. Carapace: length, 1.82; anterior width, 1.22; posterior width, 1.97. Metasomal segment I: length, 0.88; width, 1.03. Metasomal segment V: length, 2.28; width, 0.84; depth, 0.78. Vesicle: width, 0.59; depth, 0.63. Pedipalp: femur length, 1.53, width, 0.51; patella length, 1.94, width, 0.69; chela length, 2.69, width, 0.57, depth, 0.53; movable finger length, 1.84.

DISTRIBUTION AND ECOLOGY.— The description of *Microcharmus pauliani ambre* is based on four specimens taken in pitfall traps at the same locality in dry forest at the foothills of Montagne d'Ambre in the extreme northern portion of the island (Fig. 3). Two distinct natural forest habitats occur on this massif, which reaches 1475 m above sea level: the dry deciduous tropical forest comprises the lower reaches of the massif and shifts to montane rainforest above approximately 1000 m to the summit. The region near Sakaramy receives about 1300 mm of annual rainfall and has a very pronounced dry season (Donque 1975), and this massif shows very marked patterns of greater rainfall with increasing elevation (Goodman and Wilmé 2006). The lower dry deciduous forests have little surface leaf litter or organic matter in the soil.

FIGURE 47. The area around Andriabe (shown here) in the Parc National de Namoroka is more humid than the sites of Ambovonaomby and Mangotroky, also within the park.

The upper, volcanic portion of the mountain was formed during the Upper Pliocene (Brenon 1972; Rossi 1974) and there is clear evidence of continued significant volcanic activity until about 8000 years ago (Battistini 1965). Volcanic eruptions on Montagne d'Ambre sent lava flows into and around the Ankarana Massif (Cardiff and Befourouack 2003) that destroyed virtually all of the natural vegetation between these two massifs. This could have separated formerly continuous populations of *Microcharmus pauliani* in the extreme north, and led to the subsequent differentiation of *M. p. pauliani* and *M. p. amber*. Even today, Montagne d'Ambre and Ankarana share several floral and faunal elements (Cardiff and Befourouack 2003).

The geographic form of this species from the Namoroka Massif, *M. p. namoroka*, occurs 560 km to the south of Ankarana. Across this zone there are a series of different geological formations, but the natural vegetation would have been dry deciduous tropical forest before human habitat degradation (Fig. 47). The earliest evidence of people on the island dates from about 2300 years ago (Burney et al. 2004); associated anthropogenic changes in the natural vegetation of the island with regards to scorpion evolution are insignificant at this time scale.



FIGURES 48–50. *Microcharmus confluenciatus* sp. nov. Male holotype. Pigmentation pattern. 48. Carapace, chelicerae and tergites I-III. 49. Pedipalp, dorsal aspect. 50. Metasomal segment V and telson, lateral aspect.

Microcharmus confluenciatus Lourenço, Goodman, and Fisher, sp. nov.

Figures 48–50, map figure 1a.

TYPE MATERIAL.— MADAGASCAR: **Province de Toamasina**: Forêt de Makira, Nord d'Ambinanitelo, 650 m, estimated coordinates 15°22′S, 49°34′E, forêt humide, X/1947 (J. Millot). 1 male holotype (MNHN). Poorly preserved.

ETYMOLOGY.— The specific name refers to the confluent pigmentation of the tergites of the new species.

DIAGNOSIS.— Scorpions of small size when compared with most species of the genus, up to 8.1 mm in total length for the male (see morphometric values). General coloration pale yellow with diffuse spots over the body and appendages. Carapace with vestigial spots; tergites with confluent brownish strips; pedipalps, legs, chelicerae, and metasomal segments with diffuse variegated spots; venter without spots. Carinae and granulations weakly marked on body and appendages.

RELATIONSHIPS.— The new species can be readily distinguished from all the other species of the genus *Microcharmus*, by (i) pale coloration and very diffuse pigmentation; (ii) presence of confluent stripes over the tergites; and (iii) absence of any conspicuous pigmentation on the carapace.

DESCRIPTION (based on male holotype).— Coloration. Basically pale yellow with diffuse spots over the body and appendages. Carapace with only vestigial spots; pedipalps, and legs with diffuse variegated brownish spots; tergites with confluent brownish stripes; metasomal segments much less densely spotted than pedipalps or legs. Venter lacks spots, and chelicera are yellowish with variegated brownish spots.

MORPHOLOGY: Carapace with weakly marked granulation; anterior margin with a weak concavity. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly located on the anterior third of the carapace; median eyes separated by slightly less than one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites moderately granular. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate having a more or less subtriangular shape. Pectines large: pectinal tooth count 11-11; basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slitlike spiracles; VII with a few granulations and vestigial carinae. Metasoma: segments I to III with 10 carinae, crenulate; ventral carinae weakly marked on segment IV; intercarinal spaces weakly granular. Segment V rounded with five carinae. Telson with very elongated, pear-

shaped structures, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two very weak basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with vestigial carinae; internal face of patella with two to three weakly spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long, sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs reduced on legs III and IV.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE HOLOTYPE: Total length, 8.10. Carapace: length, 1.22; anterior width, 0.76; posterior width, 1.22. Metasomal segment I: length, 0.63; width, 0.63. Metasomal segment V: length, 1.41; width, 0.59; depth, 0.56. Vesicle: width, 0.41; depth, 0.38. Pedipalp: femur length, 1.06, width, 0.31; patella length, 1.31, width, 0.44; chela length, 1.69, width, 0.34, depth, 0.31; movable finger length, 1.22.

DISTRIBUTION AND ECOLOGY.— This species is only known from the Ambinanitelo region of the Makira Forest, a large block of relatively intact habitat northwest of Maroantsetra. The single known specimen comes from a site at 650 m, within the lowland humid forest that dominates the Makira Forest. Annual rainfall in this area is several meters per year, with the dry season notably less pronounced than in tropical dry forests; soil leaf litter and organic matter are well developed. Little is known about the scorpion fauna of the Makira Forest, but it does include biogeographically interesting taxa such as the buthid *Grosphus simoni*, which is also found in the tropical dry forests of Ankarafantsika (Lourenço et al. 2004).

Microcharmus violaceous Lourenço, Goodman, and Fisher, sp. nov.

Figures 51 to 53, map figure 1e.

TYPE MATERIAL.— MADAGASCAR: **Province d'Antsiranana**: Réserve spéciale d'Ankarana, Encampement des Anglais (Anilotra), 125 m, 12°54′32″S 049°06′35″E, IX/2001 (W.R. Lourenço), tropical dry forest, specifically *tsingy* forest, in leaf litter. 1 male holotype (MNHN).

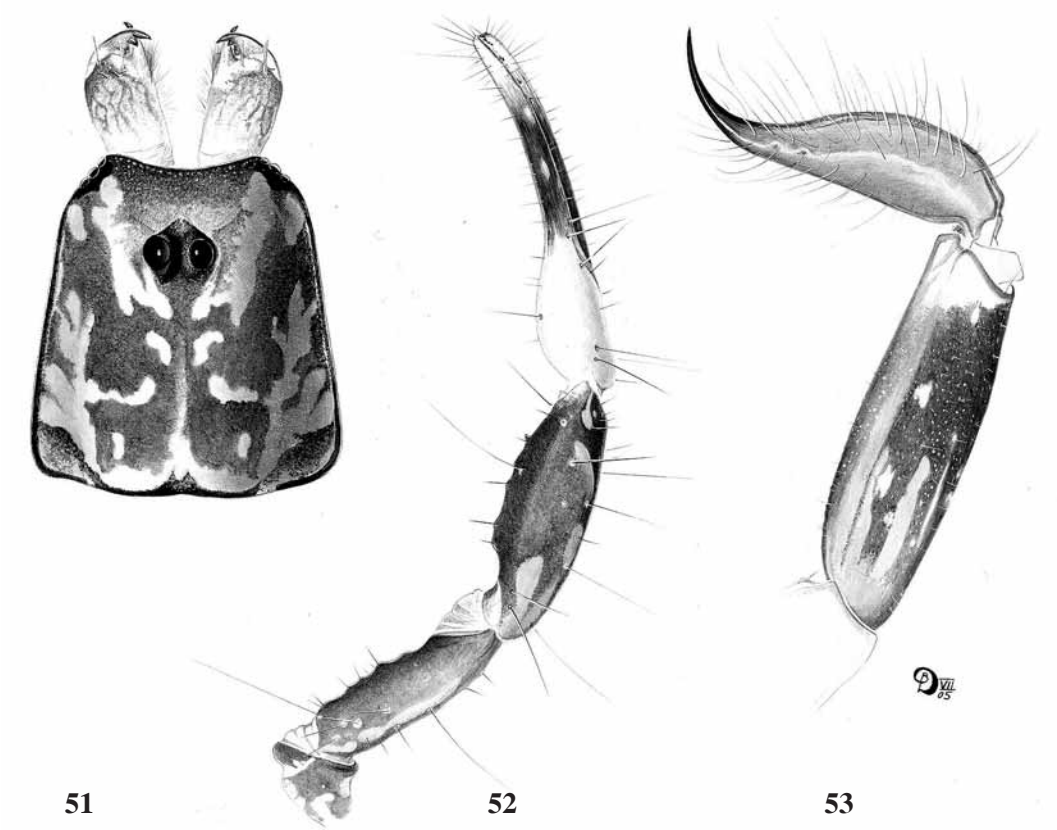
ETYMOLOGY.— The specific name is in reference to the purplish-blue pigmentation of the new species.

DIAGNOSIS.— Scorpions of small size as compared to most species of the genus, up to 8.3 mm in total length for the male (see morphometric values). General coloration yellowish with purplish-blue regular spots over the body and appendages. Carinae and granulations weakly marked on body and appendages.

RELATIONSHIPS.— The new species can be readily distinguished from all other species of the genus *Microcharmus* by (i) general purplish-blue pigmentation forming a regular etched pattern; (ii) small overall size; and (iii) a high pectinial tooth count of 13-13.

DESCRIPTION (based on male holotype).— COLORATION: Basically yellowish with purplish-blue regular spots over the body and appendages. Carapace yellowish with a regular purplish-blue pattern; pedipalp femur, patella, and legs heavily spotted; chela hand yellowish; fingers dark; tergites with four longitudinal stripes, not fused; metasomal segments less densely spotted than carapace or tergites. Venter yellowish without spots; chelicera yellowish with diffused variegated spots.

MORPHOLOGY: Carapace with weakly marked granulation; anterior margin with moderately marked concavity. Carinae weak; furrows inconspicuous. Median ocular tubercle restricted to the anterior third of the carapace; median eyes separated by a little less than one ocular diameter. Three pairs of lateral eyes. Sternum pentagonal. Mesosoma: tergites weakly granular. Median carina mod-



FIGURES 51–53. *Microcharmus violaceous* sp. nov. Male holotype. Pigmentation pattern. 51. Carapace and chelicerae. 52. Pedipalp, dorsal aspect. 53. Metasomal segment V and telson, lateral aspect.

erate to weak in all tergites. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, each plate having a more or less triangular in shape. Pectines moderate: pectinal tooth count 13-13; basal middle lamellae of the pectines not dilated; fulcra absent. Sternites smooth with short semi-oval to semi-slitlike spiracles; VII without granulations and with vestigial carinae. Metasoma: segments I to III with ten carinae, crenulate; IV with eight carinae; ventral carinae weakly marked on segment IV; intercarinal spaces weakly granular to smooth. Segment V rounded with five carinae. Telson with a very elongated, pear-shaped structure, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the buthoids (Vachon 1963); fixed finger with two moderate basal teeth; movable finger with two weak but not fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; patella with vestigial carinae; internal face of patella with 3–4 weakly spinoid granules; chela smooth; all faces weakly granular to smooth. Fixed and movable fingers with six to seven almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long and sharp denticle. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent on leg III, very reduced on IV.

MORPHOMETRIC MEASUREMENTS (IN MM) OF THE MALE HOLOTYPE: Total length, 8.30. Carapace: length, 1.14; anterior width, 0.72; posterior width, 1.01. Metasomal segment I: length, 0.59; width,

0.56. Metasomal segment V: length, 1.22; width, 0.50; depth, 0.47. Vesicle: width, 0.38; depth, 0.34. Pedipalp: femur length, 0.86, width, 0.28; patella length, 1.13, width, 0.39; chela length, 1.59, width, 0.32, depth, 0.28; movable finger length, 1.09.

DISTRIBUTION AND ECOLOGY.— *Microcharmus violaceous* is known from a single specimen taken from a leaf litter sample in the Réserve spéciale d'Ankarana. The site where it was collected, known as the Encampement des Anglais [English Camp] or, in Malagasy, Anilotra, is a zone within a broad and relatively open canyon in the interior portion of the massif. The immediate habitat near the site is tropical dry deciduous forest surrounded by *tsingy* formations. The Ankarana receives slightly less than 2 m of rainfall per year, of which over 90% falls between the months of December to April; hence the region experiences a pronounced dry season (Hawkins et al. 1990; Bardot-Vaucoulon 1997). The soil of the Anilotra forest contains a layer of leaf litter but little organic material. The CAS field inventory team visited this site in 2001 and found no evidence of this species.

The holotype of *Ankaranocharmus pauliani* (here synonomized with the genus *Microcharmus* as *M. p. pauliani*) was obtained in the same forest area as *M. violaceous*. This is the only case we are aware of on mainland Madagascar of completely overlapping geographical distribution in two microendemic *Microcharmus* spp. Molecular phylogenetic investigations of the *M. pauliani* complex and *M. violaceous* should help to resolve the evolutionary and dispersal history of these different forms and modes of speciation and differentiation.

New Material Related to Already-known Species

Microcharmus hauseri Lourenço

Map Fig. 1b, habitat figure 54.

MADAGASCAR: **Province d'Antsiranana**: Nosy Be, Réserve naturelle Intégrale de Lokobe, 6.3 km 112° ESE Hellville (Doany), 30 m, 13°25′10″S, 48°19′52″E, lowland rainforest, sifted litter, 19–24/III/2001 (B.L. Fisher & C. Griswold et al.), 1 female; Nosy Be, Réserve naturelle Intégrale de Lokobe, 6.3 km 112° ESE Hellville (Doany), 30 m, 13°25′10″S, 48°19′52″E, lowland rainforest, pitfall trap, 19–24/III/2001 (B.L. Fisher & C. Griswold et al.), 1 male, 1 female.

FIGURE 54. Dense lowland rainforest still reaches the coast in Réserve naturelle Intégrale de Lokobe on Nosy Be.

Microcharmus pauliani pauliani (Lourenço)

Map figure 1d.

MADAGASCAR: **Province d'Antsiranana**: Réserve spéciale d'Ankarana, 22.9 km 224° SW Anivorano Nord, Encampement des Anglais (Anilotra), 80 m, 12°54′32″S, 49°6′35″E, tropical dry forest, pitfall trap, 10–16/II/2001 (B. L. Fisher & C. Griswold et al.), 1 female (CAS); Réserve spéciale d'Ankarana, 13.6 km 192° SSW Anivorano Nord, Jardin Botanique, 210 m, 12°51′49″S, 49°13′33″E, tropical dry forest, pitfall trap, sifted, 16–21/II/2001 (B.L. Fisher & C. Griswold et al.) 2 females (CAS); Réserve spéciale d'Ankarana, 13.6 km 192° SSW Anivorano Nord, Jardin Botanique, 210 m, 12°51′49″S, 49°13′33″E, tropical dry forest, sifted litter, 16–21/II/2001 (B.L. Fisher & C. Griswold et al.), 1 male (CAS).

Key to the Genera and Species of the Family Microcharmidae

Key to the Genera of the Family Microcharmidae

I. Adult global size from 18 to 20 mm; spiracles semi-slit-like . . . . . *Neoprotobuthus*
Adult global size from 7 to 15 mm; spiracles oval to round . . . . . *Microcharmus*

Key to the Species of the Genus *Microcharmus*

1. Two pairs of lateral eyes . . . . . *M. sabineae*
Three pairs of lateral eyes. 2

2. General coloration very pale, with only vestigial spots; spiracles semi-oval to oval 3
General coloration yellowish with several dark spots over body, pedipalps and legs producing a general variegated appearance; spiracles semi-oval to semi-linear 4

3. Pectinal tooth count 9 to 12. . . . . *M. cloudsleythompsoni*
Pectinal tooth count 7 to 9. . . . . *M. jussarae*

4. Chelicerae recovered with variegated brownish spots; telson yellowish without spots 6
Chelicerae yellowish with some diffuse brownish spots anteriorly; telson yellowish with brownish dorsal surface and large brownish spots laterally. 5

5. Pectinal tooth count females 8, males 10 . . . . . *M. fisheri*
Pectinal tooth count, females 10-11, males 12 . . . . . *M. variegatus* sp. nov

6. Total length 8 to 11 mm in males, 11 to 14 mm in females. 7
Total length 12.5 to 15 mm in males, 15.5 to 18 mm in females 10

7. Carapace with only vestigial spots; tergites with confluent strips. . . . *M. confluenciatus* sp. nov.
Carapace intensely pigmented with variegated or a regular drawing 8

8. Carapace with regular, purplish-blue drawing . . . . . *M. violaceous* sp. nov.
Carapace with variegated brownish or intensely blackish spots 9

9. Carapace with brownish spots; hand and fingers of pedipalp chela yellowish
. . . . . *M. madagascariensis*
Carapace with intensely blackish spots; pedipalp chela hand yellowish, fingers dark
. . . . . *M. maculatus* sp. nov.

10. General coloration yellowish, with moderate to weak pigmentation over the body and appendages 11
General coloration yellowish to reddish-yellow, with intense, dark pigmentation over the body and appendages. 13

11. Venter almost unpigmented with only some vestigial spots . . . . . *M. duhemi* sp. nov.
Venter moderately pigmented with brownish variegated spots 12

12. Zones around trichobothria d1, d3 and d4 of femur, pigmented . . . . . *M. hauseri*
Zones around trichobothria d1, d3 and d4 of femur without any pigments
. . . . . *M. bemaraha* sp. nov.

13. Dorsal and ventral aspects of the body intensely pigmented; femur almost blackish

. . . . . *M. pauliani pauliani*
Dorsal aspect of the body intensely pigmented; ventral aspect weakly pigmented 14

14. Pectinial tooth count in females 8 to 9 . . . . . *M. pauliani namoroka* ssp. nov.
Pectinial tooth count in females 10 to 11 . . . . . *M. pauliani ambre* ssp. nov.

The pattern of distribution and habitat utilization by members of the family Microcharmidae (Appendix: Tables 1 and 2).

The distributional pattern of this family, based on the previously known species of *Microcharmus* and *Neoprotobuthus*, is restricted to the northern third of the island in vegetation ranging from tropical dry forests to montane rainforests. In general, these geographical and ecological distributions are supported by more recent collections. The description of several new species and subspecies herein extends the known distribution of the genus slightly further south in two different portions of the island: the western lowland tropical dry forests to Bemaraha (19°S) and eastern lowland rainforests to the Makira region (about 15°S). Some of the new species, however, are confined to tropical dry thickets or forests that experience long and dramatic dry seasons, such as Forêt d'Orangea and Montagne des Français in the extreme north of the island, and include areas of unconsolidated sand and calcareous substrates, respectively.

The family Microcharmidae utilizes an even wider variety of habitats, from dry areas to some of the wettest forests on the island. In most cases, the different species and subspecies of this family show very fine levels of microendemism to specific sites and local habitats. The only exception to this rule is *Microcharmus variegatus*, which occurs in the forests of the Loky-Manambato region in lowland tropical dry forests to montane rainforests across an elevational gradient from 175 to 1100 m. Since the current distribution of this species does not appear to be limited by habitat type, why it is confined to the Loky-Manambato region remains unclear (see Goodman and Wilmé 2006, for a discussion of the regional geology and biogeography).

The recent reappraisal of the geographic distribution of the endemic buthid genus *Pseudouroplectes* Lourenço (Lourenço and Goodman 2006c), confirmed that this genus is restricted to spiny bush and transitional spiny bush-dry deciduous vegetation from the south to southwestern portions of the island. As small animals presumed to dwell on the soil, this genus shows several convergent parallels to *Microcharmus.* With the extension of the range of *Microcharmus* along the west portion of the island south to Bemaraha, it appears that *Microcharmus* and *Pseudouroplectes* present an almost parapatric distribution, and thus form a contiguous but not overlapping distribution.

Of the currently recognized 15 species and subspecies of *Microcharmus* from Madagascar, eight (53%) are only known from tropical dry forest, six (40%) from rainforest formations (lowland and montane), and one (7%) occurs across these two distinct habitats (*M. variegatus*). In the case of *Microcharmus*, current taxonomic diversity is nearly split between habitat extremes of dry and wet forests, but no example of *Pseudouroplectes* has been obtained in wet forest formations. *P. pidgeoni* is known from spiny bush habitat a short distance from the dramatic transitional zone between dry and wet forests separating parcels 1 and 2 of the Parc National d'Andohahela (Lourenço and Goodman 2006c). Thus, one of these genera of small, soil-dwelling scorpions includes approximately half of the forms found in wet forest formations, while no taxon of the other genus is known to occur in this habitat. These differences could be attributed to the lack of appropriate collecting methods in the east. This hypothesis can be eliminated *a priori* since similar sampling methods have been used by the CAS field inventory team at a wide variety of sites in differ-

ent regions of the island. The exclusive presence of the genera *Pseudouroplectes* in the south and southwest, and that of *Microcharmus* and *Neoprotobuthus* in the northern and northwestern portions of the island, implies that specific ecological or physical barriers prevent dispersion.

The genus *Pseudouroplectes* contains a lower level of microendemism than *Microcharmus*. For example, *P. pidgeoni* has a broad distribution across much of the southern portion of the island, from parcel 2 of the Parc national d'Andohahela, west to the Parc national de Tsimanampetsotsa, and south to the southernmost tip of the island at the Réserve spéciale de Cap Sainte Marie (Lourenço and Goodman, 2006). No *Microcharmus* species is distributed this broadly. In addition, all *Pseudouroplectes* show a fine regional level of microendemism. For a species such as *M. variegatus,* which occurs in a wide variety of habitats in a restricted zone within the Loky-Manambato region, geographic rather than habitat barriers must be invoked to explain its distribution. Further, *M. hauseri* and *M. jussarae* are restricted to the offshore island of Nosy Be. The ocean floor between Nosy Be and the main island is less than 50 m deep, indicating these two landmasses were connected during the Quaternary, when sea-level depths were over 100 m below modern levels (Camion et al. 2004). Hence, the speciation of these two scorpions on Nosy Be is associated with vicariance. Within the genus *Microcharmus* there are two cases of species occurring in sympatry. The include *M. hauseri* and *M. jussarae* in the Lokobe Forest on Nosy Be, and *M. violaceous* and *M. p. pauliani* in the Anilotra Forest of Ankarana.

Overall, the distribution patterns of the Microcharmidae are characterized by extreme habitat and geographic restriction. The northern half of Madagascar has experienced dramatic geological change and climatic shifts that could have led to the isolation and formation of these taxa. If the recognition of geographical forms within *M. pauliani* is correct, this remains a dynamic process. The factors that established the current geographical ranges of these scorpions, including their origins and radiation patterns, could be greatly elucidated by molecular genetic studies. These types of analyses are of special interest, as phylogenetic affinities between *Pseudouroplectes* and *Microcharmus*/*Neoprotobuthus* with African and Oriental relict elements, such as the genera *Charmus* Karsch and, *Akentrobuthus* Lamoral, remain suspected but totally unstudied.

Acknowledgements

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Appendix

TABLE 1. Checklist of the known elements of the family Microcharmidae with information on their geographical distribution. Distribution maps for the various new taxa (in bold) of *Microcharmus* are presented in Figs. 1a–e.

Genus ***Microcharmus*** Lourenço, 1995

Microcharmus bemaraha sp. nov.

Microcharmus cloudsleythompsoni Lourenço, 1995. Madagascar, northwest, Zangoa [=Djangoa], 1947 (J. Millot leg), 1 female.

Microcharmus confluenciatus sp. nov.

Microcharmus duhemi sp. nov.

Microcharmus fisheri Lourenço, 1998. Madagascar, 9.2 km SSW of Befingotra, Réserve spéciale d'Anjanaharibe-Sud, 14°45′ S, 49°28′ E, 1200 m, 9/XI/1994 (B.L. Fisher leg.), 1 male, 1 female. 6.5 km SSW of Befingotra, Réserve spéciale d'Anjanaharibe-Sud, 14°45′ S, 49°30′ E, 875 m, 19/X/1994 (B.L. Fisher leg.), 1 male, 1 female. Sifted litter, leaf mold, rotten wood in montane rain forest.

Microcharmus hauseri Lourenço, 1996. Madagascar, Sambirano, Nosy Be, Réserve naturelle intégrale n° 6, Forêt de Lokobe, 30/XI/1989 (B. Hauser leg.), 1 male.

Microcharmus jussarae Lourenço, 1996. Madagascar, Sambirano, Nosy Be, Réserve naturelle intégrale n° 6, Forêt de Lokobe, IX/1947 (J. Millot leg.), 1 male.

Microcharmus maculatus sp. nov.

Microcharmus madagascariensis Lourenço, 1999. Madagascar, Province d'Antsiranana, Réserve spéciale de Manongarivo, 12.8 km SW Antanambao, 13°58.6′S, 48°25.4′E, 780 m, 12/X/1998 (B.L. Fisher leg. # 1872). 1 female.

Microcharmus pauliani ambre ssp. nov.

Microcharmus pauliani namoroka ssp. nov.

Microcharmus sabineae Lourenço, 1996. Madagascar, Est, Massif du Marojezy [=Marojejy], Réserve naturelle intégrale n° 12, 600 m, 12/XII/1972 (J.-M. Betsch leg.), 1 male.

Microcharmus variegatus sp. nov.

Microcharmus violaceous sp. nov.

Genus ***Ankaranocharmus*** Lourenço, 2003 = *Microcharmus* Lourenço, 1995 new synonymy.

Microcharmus pauliani (Lourenço, 2003). Madagascar, Province d'Antsiranana, Réserve spéciale d'Ankarana, Encampement des Anglais, Anilotra, 125 m, 12°54′32″S 049°06′35″E, IX/2001 (W. R. Lourenço leg.), 1 female. Undisturbed tsingy forest, in litter.

Genus ***Neoprotobuthus*** Lourenço, 2000

Neoprotobuthus intermedius Lourenço, 2000. Madagascar, Province d'Antsiranana, Réserve spéciale de Manongarivo, 14.5 km SW Antanambao (Sambirano Valley), 14.0°0′S, 48°25.7′E, 1240 m, 12/III/1999 (S.M. Goodman leg.). Primary montane forest.

TABLE 2. Distribution and certain ecological parameters of Malagasy Microcharmidae.

Species	*Known localities*	*Elevation* (m)	*Habitat*
M. bemaraha	Bemaraha	50	tropical dry forest
M. cloudsleythompsoni	Djangoa	about 30	tropical dry forest
M. confluenciatus	Makira	650	lowland rainforest
M. duhemi	Montagne des Français	180	tropical dry forest
M. fisheri	Anjanaharibe-Sud	875–1200	lowland to montane rainforest
M. hauseri	Lokobe (Nosy Be)	30	lowland rainforest1
M. jussarae	Lokobe (Nosy Be)	30	lowland rainforest1
M. maculatus	Orangea	90	dry deciduous thicket
M. madagascariensis	Manongarivo	780	lowland rainforest1
M. p. pauliani	Ankarana (Anilotra)	80–210	tropical dry forest
M. p. ambre	Montagne d'Ambre	325	tropical dry forest
M. p. namoroka	Namoroka	100–140	tropical dry forest