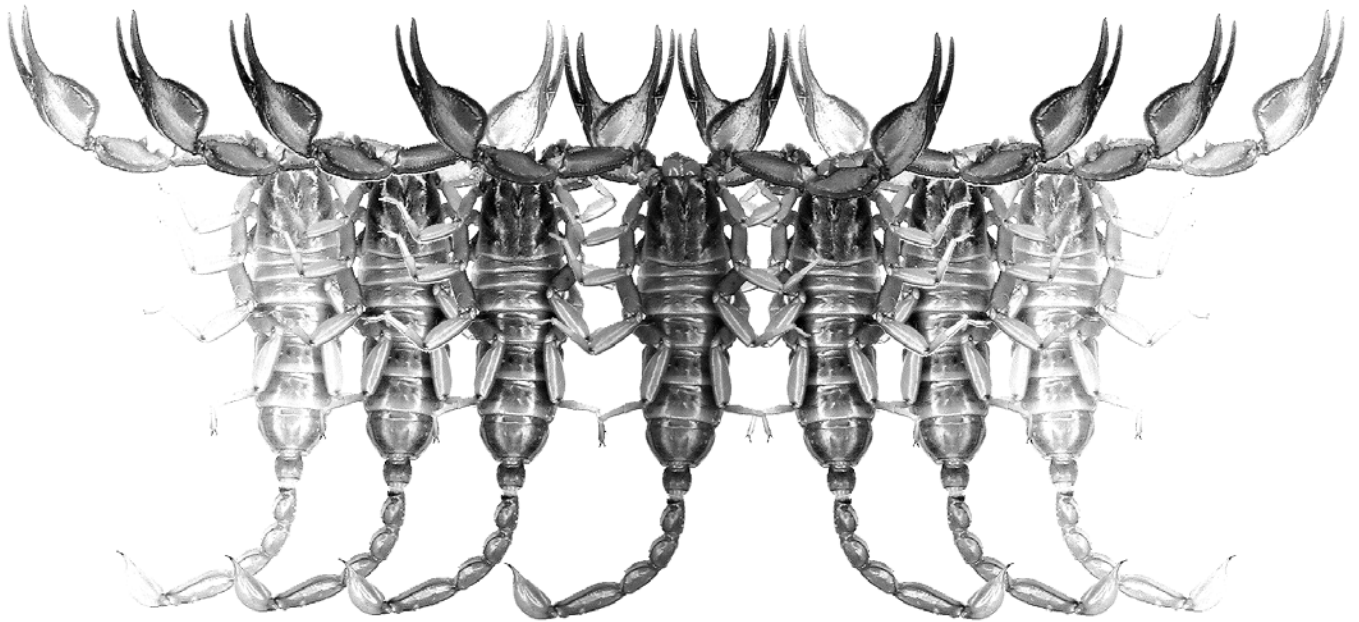


Euscorpius

Occasional Publications in Scorpiology



**Contributions to Scorpion Systematics. IV. Observations
on the *Hadrurus* “*spadix*” Subgroup with a Description
of a New Species (Scorpiones: Caraboctonidae)**

Michael E. Soleglad, Victor Fet & Graeme Lowe

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Contributions to scorpion systematics. IV. Observations on the *Hadrurus* “*spadix*” subgroup with a description of a new species (Scorpiones: Caraboctonidae)

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Summary

In this study new data are presented on the “*spadix*” subgroup of genus *Hadrurus*, including the description of a new species, *H. anzaborrego*, **sp. nov.**, found primarily in the Anza-Borrego Desert State Park (ABDSP) in southern California, USA. This species is distinguished by its internal trichobothrial pattern of the chela and its unique carapace pattern. The status of *Hadrurus obscurus* Williams, 1970 is discussed and new locality data for this species are provided. A phylogenetic key to the genera, species, and subspecies of subfamily Hadrurinae is provided.

Introduction

The first species in the *Hadrurus* “*spadix*” subgroup was named by H. L. Stahnke (1940b; also in 1940a: 107–111 [unpublished]) when he described *Hadrurus spadix* from northern Arizona. *H. spadix* was referenced again by Stahnke (1945, 1969) in two papers; during the same period, Stahnke (1949) also published a photograph of *H. spadix*, probably the first published of this species, in his popular pamphlet on scorpions (photo replicated in our Fig. 1). *H. spadix* was reported from Nevada by Gertsch & Allred (1965), from Utah by Johnson & Allred (1972), and from Idaho by Anderson (1975). Williams (1970) included a detailed description and distribution map of *H. spadix* in his excellent revision of the genus. The other species in the *Hadrurus* “*spadix*” subgroup, *H. obscurus*, was described by Williams in 1970. Hjelle (1972) also referenced *H. obscurus* in his paper on the scorpions of northern California but did not report new localities, listing only the original type locality as reported by Williams (1970). Soleglad (1976: figs. 22–25, 28) presented for the first time the chelal trichobothria pattern of the *Hadrurus* “*spadix*” subgroup.

When Soleglad (1976) published the chelal trichobothria patterns for genus *Hadrurus*, he included a southern population of *H. obscurus* in his data, considerably south of its then known distribution. At that time, Soleglad (1970: 114) wrote:

“... With the possible exception of *H. obscurus* Williams, each species or subspecies was well represented with respect to geographical range. All *H. obscurus* specimens were from Southern California, somewhat south of its recorded range (Williams, 1970, and Hjelle, 1972); the northern most sample came from the southern portion of Joshua Tree National Monument. The other specimens sampled were from the Anza-Borrego State Park or further south, approaching the Mexican border....”.

Based on new trichobothria data on *H. obscurus* and the examination of populations south of its reported range, we have come to the conclusion that the southern population from the Anza-Borrego Desert State Park is a different species altogether and therefore new. New species *Hadrurus anzaborrego*, **sp. nov.**, is described and the status of *H. obscurus* is discussed, where evidence suggests that it may only be a color-variant phenotype of *H. spadix* Stahnke, 1940.

Below we provide a phylogenetic key to subfamily Hadrurinae followed by a short synopsis of each taxon. Discussions on the diagnostic differences between the “*arizonensis*” and “*spadix*” subgroups as well as the species in the “*spadix*” subgroup are presented. An overview of the Fet, Soleglad & Barker (2001) molecular analysis of genus *Hadrurus* with an emphasis on the “*arizonensis*” group is provided, followed by the description of new species *Hadrurus anzaborrego*. Finally, phylogenetic and biogeographic observations

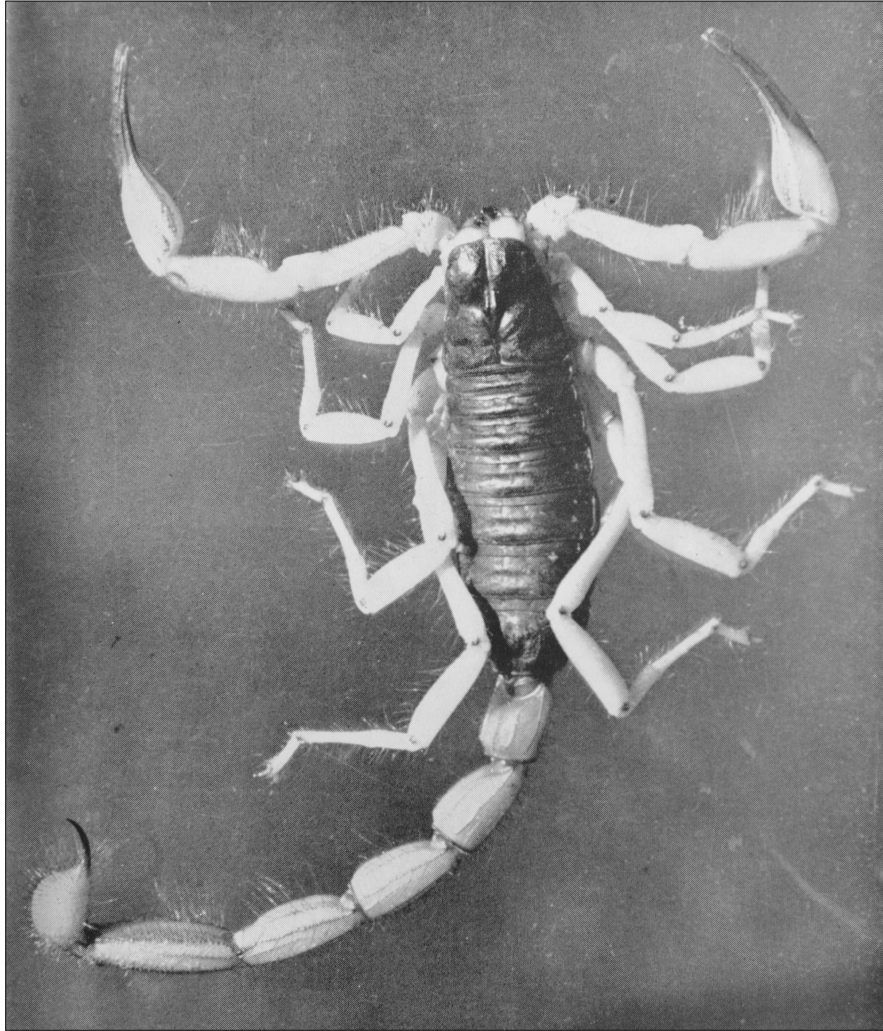


Figure 1: Photo of *Hadrurus spadix* Stahnke, 1940, from Herbert Stahnke's popular pamphlet on scorpions, "Scorpions" (1949), inside back cover.

for the "*arizonensis*" group are presented, factoring in the cladistic analysis results of Fet & Soleglad (2008).

Informal taxonomic grouping in *Hadrurus*

"Species groups" (complexes) or even further "subgroups" are sometimes used in scorpion genera where a recognition of categories such as subgenus has not been common. Such informal groupings, to some extent, reflect phylogenetic relationships within a genus, and must be taken into account in further phylogenetic analyses. The first taxonomic partitioning of the "giant hairy-scorpion" *Hadrurus* was presented by Williams (1970) in his extensive revision of the genus. In his study, *Hadrurus* was divided into three informal "subgroups": (a) one mainland Mexican species *Hadrurus aztecus* Pocock, 1902 (now placed in genus *Hoffmannihadrurus*); (b) three Baja California (Mexico) species: *Hadrurus hirsutus* (Wood, 1863), *H. concolorous* Stahnke, 1971, and *H. pinteri* Stahnke, 1971;

and (c) three species occurring primarily in the United States, *H. arizonensis* Ewing, 1928, *H. spadix* Stahnke, 1940, and *H. obscurus* Williams, 1970.

Soleglad (1976), using neobothriotaxy of the pedipalp chela as a taxonomic character, which endorsed Williams's suggested phylogeny, broke *Hadrurus* into two "groups", the "*aztecus*" group (to which *Hadrurus gertschi* Soleglad, 1976, now placed in *Hoffmannihadrurus*, was added) and the "*hirsutus*" group. Each group was split into two "subgroups". These distinctions were based, in most part, on the presence/absence of neobothriotaxy on the chela as well as the number of accessory trichobothria. Many years later, Fet, Soleglad & Barker (2001) presented a molecular- and morphology-based cladistic analysis of genus *Hadrurus*. In this paper, details were provided on the coloration and patterns of these species, using the term "complex" for these subdivisions.

While the southern Mexican species are now recognized as quite distinct from the United States and Baja

California species and therefore placed in a separate genus *Hoffmannihadrurus* (Fet et al., 2004; Fet & Soleglad, 2008; Soleglad & Fet, 2010), the remaining species of genus *Hadrurus* can be partitioned into informal taxonomic “groups” and “subgroups”, terms used in this paper.

Material and Methods

Abbreviations

List of depositories: GL, Personal collection of Graeme Lowe, Philadelphia, Pennsylvania, USA; MES, Personal collection of Michael E. Soleglad, Borrego Springs, California, USA.

Other: ABDSP, Anza-Borrego Desert State Park, San Diego and Riverside Counties, California, USA.

Terminology and conventions

The systematics adhered to in this paper follows the classification as established in Fet & Soleglad (2005) and as modified in Fet & Soleglad (2008). Terminology describing pedipalp chelal finger dentition follows that described and illustrated in Soleglad & Sissom (2001), that of the sternum follows Soleglad & Fet (2003a), and the metasomal and pedipalp carination, and leg tarsus armature follows Soleglad & Fet (2003b). Hemispermatophore terminology is from Soleglad & Fet (2008) and Kovářik et al. (2010). Trichobothrial nomenclature and hypothesized homologies are those described and illustrated in Vachon (1974) and Soleglad (1976). Techniques using maximized morphometric ratios follow those described in Kovářik et al. (2010).

References to the *Colorado Desert* in this paper apply to the geographic area addressed as “the Lower Colorado Valley”, in part, by Shreve & Wiggins (1964: map 1) and the “Salton Trough” by MacMahon (1985: 34).

SEM microscopy

To investigate *Hadrurus* morphology, various structures of specimens kept in 70 % ethanol were air-dried and coated with gold/palladium (ca. 10 nm thickness) in a Hummer sputter coater. Digital SEM images were acquired with a JEOL JSM-5310LV at Marshall University, West Virginia. Acceleration voltage (10–20 kV), spot size, and working distance were adjusted as necessary to optimize resolution, adjust depth of field, and to minimize charging.

UV photography

Images of chelal trichobothria patterns were acquired by UV epifluorescence imaging (Prendini, 2003;

Volschenk, 2005). Scorpions were illuminated by a primary 198 UV LED array (395 nm), with a secondary 168 UV LED array used for fill lighting (Lowe, Kutcher & Edwards, 2003). A vertical translation stage (Ealing) was used to adjust specimen position. Images were acquired at a series of focal planes with a Canon EOS 7D camera, and MP-E 65 mm macro lens with long pass filter (475 nm), and combined with Zerene Stacker software (Zerene Systems, LLC).

Map generation

Maps were generated from Earth Explorer 6.1, with positional and altitude data compiled through Google Maps and Topo! Interactive Maps for the San Diego, San Jacinto Wilderness, and Anza-Borrego Desert areas.

Material examined

The following material of the *Hadrurus* “*arizonensis*” group was examined and/or contributed to the statistical data presented in this paper (430 specimens). In particular, the material from the Anza-Borrego Desert State Park area was collected by the first author throughout the years from 1968 to the present. Exact positional data is presented as (latitude (N), -longitude (W); elevation a.s.l. (feet))

Hadrurus “*arizonensis*” subgroup

Hadrurus arizonensis arizonensis Ewing, 1928 (282 specimens):

Mexico. Baja California: 3 mi. N of San Felipe (31.051, -114.872; 177'), 2 juvenile ♂, 5 April 1969 (M. Soleglad) (MES); 5.5 mi. N of San Felipe (31.079, -114.884; 152'), 1 adult ♂, 29 May 1971 (M. Soleglad) (MES); 5 mi. N of San Felipe (31.074, -114.881; 136'), 2 juvenile ♂, 1 adult ♀, 3 May 1975 (M. Soleglad) (MES); 5 mi. N of Puertocitos (30.416, -114.643; 61'), 1 subadult ♂, 3 adult ♀, 2 subadult ♀, 1 juvenile ♀, 25 May 1974 (M. Soleglad) (MES); 25.1 mi. N of Puertocitos (30.723, -114.718; 42'), 4 adult ♂, 2 subadult ♂, 7 juvenile ♂, 2 adult ♀, 1 subadult ♀, 6 juvenile ♀, 26 July 1975 (M. Soleglad) (MES). **Sonora:** Mex-2, 66 mi. W of Sonoyta (32.148, -113.942; 1226'), 2 adult ♀, 4 September 1971 (M. Soleglad) (MES); Puerto Peñasco (31.309, -113.538; 33'), 5 adult ♂, 1 subadult ♂, 2 juvenile ♂, 2 adult ♀, 1 subadult ♀, 4 September 1971 (M. Soleglad), 1 juvenile ♂, 1 adult ♀, 3 subadult ♀, 1 juvenile ♀, 28 March 1970 (M. Soleglad) (MES); 11 mi. S of Guaymas (27.956, -110.779; 28'), 1 subadult ♂, 1 juvenile ♂, 2 adult ♀, 1 subadult ♀, 3 juvenile ♀, 13 July 1973 (M. Soleglad) (MES); Mex-2, 41.2 mi. E of San Luis (32.291, -114.147; 761'), 4 adult ♂, 1 subadult ♂, 2 juvenile ♂, 3 adult ♀, 1 subadult ♀, 1 juvenile ♀, 11 July 1973 (M. Soleglad) (MES).

USA. Arizona: Maricopa County: 5 mi. NE of Mesa (33.477, -111.716; 1387'), 7 adult ♂, 10 subadult ♂, 3 juvenile ♂, 5 adult ♀, 17 subadult ♀, 6 juvenile ♀, 3-4 July 1970 (M. Soleglad) (MES); 10 mi. NE of Mesa (33.551, -111.579; 1435'), 6 adult ♂, 4 juvenile ♂, 3 adult ♀, 5 subadult ♀, 5 juvenile ♀, 3-4 July 1970 (M. Soleglad) (MES). **California: Imperial County:** Picacho Recreation Area, 23 mi. N of Winterhaven (32.923, -114.472; 183'), 1 adult ♂, 1 subadult ♂, 1 adult ♀, 1 subadult ♀, 28 February 1970 (M. Soleglad), 5 subadult ♂, 1 juvenile ♂, 2 adult ♀, 1 subadult ♀, 24 April 1970 (M. Soleglad), 1 adult ♂, 1 subadult ♂, 1 adult ♀, 1 subadult ♀, 15 August 1970 (M. Soleglad), 3 adult ♀, 16 May 1971 (M. Soleglad) (MES); 3 mi. NW of Ocotillo (32.751, -116.038; 603'), 1 subadult ♂, 2 subadult ♀, 3 February 1968 (M. Soleglad), 1 subadult ♂, 2 subadult ♀, 2 September 1968 (M. Soleglad) (MES). **Inyo County:** Tecopa Hot Springs, Old Spanish Trail, 0.8 mi. off Rte. 127 (35.848, -116.226; 1341'), 1 adult ♂, 19 July 1985 (G. Lowe, B. Hébert) (GL); Rte 178, 0.5 W Rte 127 (35.997, -116.284; 1690'), 2 juvenile ♂, 20 July 1985 (G. Lowe, B. Hébert) (GL). **Los Angeles County:** Rocky Buttes, Antelope Valley, 0.5 mi. S M Ave/150th St. (34.647, -117.872; 2657'), 1 adult ♂, 3 July 1987 (G. Lowe, B. Hébert) (GL); E-side Lovejoy Buttes and Rawhide St. (34.600, -117.857; 3036'), 1 adult ♂, 22 July 1985 (G. Lowe, B. Hébert) (GL). **Riverside County:** 2.5 mi SE Cabazon (33.891, -116.756; 1679'), 2 adult ♂, 17 September 1983 (G. Lowe, C.P. Kristensen) (GL); 1.2 mi. N of Varner and Rio Del Sol, near Thousand Palms (33.839, -116.411; 401'), 1 adult ♂, 31 January 1970 (M. Soleglad), 1 adult ♀, 11 April 1970 (M. Soleglad), 1 subadult ♂, 2 adult ♀, 2 subadult ♀, 15 May 1970 (M. Soleglad), 1 adult ♂, 1 juvenile ♂, 1 adult, 1 juvenile ♀, 17 October 1970 (M. Soleglad), 1 subadult ♂, 23 March 1971 (M. Soleglad), 2 subadult ♂, 28 August 1971 (M. Soleglad) (MES); Cottonwood Springs, Joshua Tree National Monument (33.743, -115.815; 3068'), 1 subadult ♂, 1 juvenile ♂, 3 May 1970 (M. Soleglad), 1 subadult ♂, 1 juvenile ♂, 6 September 1970 (M. Soleglad) (MES). **San Bernardino County:** 1 mi. N of Saratoga Springs, Death Valley National Monument (35.735, -116.385; 740'), 1 subadult ♀, 23 October 1971 (M. Soleglad) (MES). **San Diego County:** 3 mi. NE of Borrego Springs (33.255, -116.291; 534'), 2 juveniles, 2 September 1968 (M. Soleglad), 2 ♂, 26 June 1970 (M. Soleglad) (MES); Carrizo Badlands, 1 mi. E of Palm Springs, ABDSP (32.919, -116.201; 902'), 1 ♀, 7 November, 1970 (M. Soleglad) (MES); Borrego Badlands, 1 mi. SW of Seventeen Palms Oasis, ABDSP (33.245, -116.123, 462'), subadult ♀, 12 June 1971 (M. Soleglad), 1 subadult ♀, 14 August 1971 (M. Soleglad) (MES); Coyote Creek, 10 mi. NW Borrego Springs, ABDSP (33.399, -116.462; 1525'), 1 April 1972, 2 subadult ♂, 1 juvenile ♂, 2 subadult ♀, 1 juvenile ♀ (M. Soleglad), 29 July 1972, 5 ♂ (M. Soleglad) (MES); DiGiorgio Road/ Coyote Creek juncture, ABDSP (33.329, -116.368; 731'), 2 subadult ♂, 1 subadult ♀, 13 July 1996 (M. Soleglad) (MES); 0.25 mi. N of Salton Sea Expressway, Rd to Clark's Dry Lake, ABDSP (33.297, -116.287; 652'), 1 subadult ♂, 21 July 1996 (M. Soleglad) (MES); Borrego Badlands, Buttes Pass, 0.3 mi. N Hawk's Canyon exit, ABDSP (33.183, -116.199; 603'), 1 ♂, 1 ♀, 22 July 1996 (M. Soleglad) (MES); Borrego Badlands, Palo Verde Wash entry, off Salton Sea Expressway, ABDSP (33.295, -116.181; 843'), 1 ♂, 1 ♀, 5 August 1996 (M. Soleglad), 1 ♂, 1 ♀, 19 October 1998 (M. Soleglad), 1 ♂, 14 July 1999 (M. Soleglad) (MES); Borrego Badlands, Arroyo Salado, 1.5 mi. S of Salton Sea Expressway, ABDSP (33.274, -116.128; 623'), 1 subadult ♂, 1 juvenile ♂, 2 subadult ♀, 2 juvenile ♀, 7 August 1996 (M. Soleglad) (MES); Borrego Badlands, Hawk's Canyon, ABDSP (33.181, -116.205; 800'), 1 subadult ♂, 20 August 1996 (M. Soleglad) (MES); Borrego Badlands, Buttes Pass, 0.5-1.5 mi. N Hawk's Canyon exit, ABDSP (33.178, -116.194; 442'), 1 juvenile ♀, 27 August 1997 (M. Soleglad) (MES); Country Club and Borrego Springs Roads, Borrego Springs (33.242, -116.376; 600'), 3 subadult ♂, 1 adult ♂, 2 subadult ♀, 2 juvenile ♀, 3 September 1996 (M. Soleglad) (MES); Borrego Badlands, Blow Sand Canyon, 1 mi. S of San Felipe Wash, ABDSP (33.183, -116.182; 433'), 1 juvenile ♀, 5 November 1996 (M. Soleglad), 1 juvenile ♀, 2 June 1997 (M. Soleglad) (MES); Palm Canyon Hiking Trail, primary trail, ABDSP (33.273, -116.423; 915'), 3 subadult ♂, 1 juvenile ♂, 1 subadult ♀, 10 March 1997 (M. Soleglad) (MES); Borrego Badlands, Calcite Mine area (just N. of S-22), ABDSP (33.283, -116.098; 561'), 1 ♂, 1 subadult ♀, 1 juvenile ♀, 29 April 1997 (M. Soleglad) (MES); Cactus Garden, 2.2 mi. S HWY-78, ABDSP (33.136, -116.226, 787'), 3 subadult ♂, 1 juvenile ♂, 2 subadult ♀, 1 juvenile ♀, 13 May 1997 (M. Soleglad) (MES); Coyote Creek Road, 0.2 mi. N of DiGiorgio Road, ABDSP (33.332, -116.369; 741'), 1 subadult ♂, 27 May 1997 (M. Soleglad) (MES); 1.65 mi. W of Travertine Rock (off HWY-86), ABDSP (33.400, -116.077; 16'), 1 adult ♂, 1 juvenile ♂, 1 adult ♀, 26 August 1997 (M. Soleglad) (MES); Borrego Badlands, Palo Verde Wash, 1.2 mi. S of Salton Sea Expressway, ABDSP (33.284, -116.279; 757'), 1 adult ♂, 1 subadult ♂, 1 adult ♀, 12 September 1997 (M. Soleglad) (MES); Carrizo Badlands, Vallecito Creek, 3.3 mi. E S-2, ABDSP (32.910, -116.206; 787'), 1 adult ♂, 1 juvenile ♂, 1 subadult ♀, 1 juvenile ♀, 2 October 1997 (M. Soleglad) (MES); Borrego Badlands, Palo Verde Wash, 1 mi. S of Salton Sea Expressway, ABDSP (33.286, -116.170; 774'), 1 ♂, 20 July 1998 (M. Soleglad) (MES); Borrego Springs area, Montezuma Grade, 0.5 mi. from S-22, ABDSP (33.250, -116.380; 656'), 1 ♂, 3 August 1998 (M. Soleglad) (MES); West Star Road, Borrego Springs (33.230, -116.381; 692'), 1 ♂, 13 October 1998 (M. Soleglad) (MES); W end of Tilting-T, Borrego Springs (33.242, -116.388; 764'), 1 ♂, 15 October 1998 (M. Soleglad)

(MES); W end of Weather Vane, Borrego Springs (33.245, -116.380; 585'), 1 ♂, 12 September 2010 (M. Soleglad) (MES).

***Hadrurus arizonensis austrinus* Williams, 1970 (13 specimens):**

Mexico. Baja California: Oakies Landing (30.052, -114.584; 15'), 1 adult ♀, 1 juvenile ♀, 26 May 1974 (M. Soleglad), 1 adult ♂, 2 juvenile ♂, 3 adult ♀, 3 subadult ♀, 2 juvenile ♀, 27 July 1975 (M. Soleglad) (MES).

***Hadrurus "spadix"* subgroup**

***Hadrurus anzaborrego* Soleglad, Fet et Lowe, sp. nov. (51 specimens, including holotype and 19 paratypes; see below):**

USA. California: Riverside County: 1 mi. S of Cottonwood Springs, Joshua Tree National Monument (33.731, -115.813; 2988'), 1 adult ♂, 26 June 1971 (M. Soleglad) (MES). **San Diego County:** 0.25 mi. SE of Salvador Canyon, off Coyote Creek, ABDSP (33.396, -116.476; 1548'), 1 subadult ♀, 27 April 1974 (M. Soleglad) (MES); Culp Valley Camp, ABDSP (33.224, -116.460; 3412'), 3 subadult ♂, 1 adult ♀, 2 subadult ♀, 1 juvenile ♀, 23 July 1996 (M. Soleglad), 1 adult ♂, 27 August 1998 (M. Soleglad) (MES); Montezuma Grade, in Culp Valley area, 2.1 mi. E of Culp Valley Camp, ABDSP (33.211, -116.431; 2644'), 1 subadult ♂, 5 September 1996 (M. Soleglad) (MES); Hellhole Hiking Trail, 1–2 mi. W of Montezuma Grade, ABDSP (33.241, -116.408; 1279'), 1 subadult ♂, 1 subadult ♀, 29 July 1996 (M. Soleglad) (MES); Palm Canyon Hiking Trail, alternate back trail, ABDSP (33.271, -116.424; 997'), 1 subadult ♂, 14 September 1996 (M. Soleglad) (MES); Palm Canyon Hiking Trail, primary trail, ABDSP (33.272, -116.425; 1036'), 1 subadult ♂, 1 adult ♀, 1 juvenile ♀, 16 April 1997 (M. Soleglad) (MES); Borrego Springs area, W end of Tilting T Road, ABDSP (33.242, -116.388; 764'), 1 adult ♀, 5 March 1997 (M. Soleglad), 1 adult ♀, 15 October 1998 (M. Soleglad), 1 adult ♂, 14 July 1999 (M. Soleglad) (MES); Yaqui Pass Road, 3 mi. N of HWY-78, ABDSP (33.159, -116.342; 1466'), 1 adult ♂, 1 adult ♀, 2 juvenile ♀, 16 March 1968 (M. Soleglad) (MES); Yaqui Pass Road, 3.2 mi. N of HWY-78, ABDSP (33.160, -116.340; 1437'), 3 adult ♂, 3 subadult ♂, 1 adult ♀, 1 subadult ♀, 26 June 1970 (M. Soleglad), 2 adult ♂, 1 subadult ♂, 2 adult ♀, 1 subadult ♀, 23 October 1970 (M. Soleglad), 2 adult ♂, 1 adult ♀, 17 July 1996 (M. Soleglad) (MES); Pinyon Mountain Road, 4.3 mi. E. HWY-S2, ABDSP (33.054, -116.353; 3577'), 1 adult ♀, 4 June 1997 (M. Soleglad), 1 adult ♂, 1 subadult ♀, 20 July 1999 (M. Soleglad) (MES); Split Mountain, ABDSP (32.999, -116.116; 534'), 2 ♂, 1 adult ♀, April 28, 1997 (M. Soleglad) (MES); Indian Gorge Canyon, 1.7 mi. W. S-2, ABDSP (32.874, -116.235; 1083'), 2 adult ♀, 22 June 1998 (M. Soleglad) (MES); Indian Gorge Canyon, 1.4 mi.

W. S-2, ABDSP (32.871, -116.230; 1003'), 1 adult ♂, 15 July 1999 (M. Soleglad) (MES). **Imperial County:** Jacumba Wilderness Area, 2.9 mi. SW of HWY-98 (6.3 S of HWY-8) (32.669, -115.969; 1055'), 1 subadult ♂, 26 February 1972 (M. Soleglad) (MES).

***Hadrurus obscurus* Williams, 1970 (18 specimens):**

California: Kern County: Jawbone Canyon Road (35.321, -118.112; 2896'), 1 adult ♂, 1 August 1997 (G. Lowe, B. Hébert) (GL); Jawbone Canyon Road (35.318, -118.082; 2,630'), 3 adult ♂, 1 adult ♀, 1 subadult ♀, 1–2 August 1997 (G. Lowe, B. Hébert) (GL); Nine Mile Canyon Road (35.846, -117.947; 4,222'), 1 juvenile ♂, 2 August 1997 (G. Lowe, B. Hébert) (GL); Nine Mile Canyon Road (35.856, -118.027; 6,485'), 1 adult, 1 juvenile ♂, 2 August 1997 (G. Lowe, B. Hébert) (GL); Nine Mile Canyon Road (35.858, -117.997; 5,978'), 1 adult ♂, 2 August 1997 (G. Lowe, B. Hébert) (GL); Bird Spring Canyon Road (35.547, -118.132; 5,241'), 1 adult ♂, 1 subadult ♀, 3 August 1997 (G. Lowe, B. Hébert) (GL); Antelope Valley, SE Mohave (34.950, -118.287; 2,976'), 1 adult ♂, 5 August 1997 (G. Lowe, B. Hébert) (GL). **Los Angeles County:** Cheseboro Rd., 0.25 mi. S of Aqueduct, 4.5 mi SE of Palmdale (34.518, -118.028; 2949'), 2 adult ♂, 7 June 1985 (G. Lowe, B. Hébert) (GL); Edwards Airforce Base (34.789, -118.114; 2284'), 2 juvenile ♂, 4 October 1980 (G. Lowe, J. & E. Strauss) (GL); Pearblossom Hwy, Rte. 135, 0.85 mi. SE junction of Ave T, S of Palmdale (34.535, -118.018; 2804'), 1 adult ♂, 7 June 1985 (G. Lowe, B. Hébert) (GL).

***Hadrurus spadix* Stahnke, 1940 (66 specimens):**

General localities used in trichobothrial analysis (Soleglad, 1976; Fet, Soleglad & Barker, 2001): **Arizona: Coconino County:** Grand Canyon, 1 specimen, Wupatki National Monument, 4 specimens. **Idaho: Elmore County:** Mountain Home, 5 specimens. **Owyhee County:** Hammet State Park, 1 specimen, Hot Creek Falls, 27 specimens. **Nevada: Humboldt County:** Winnemucca, 2 specimens. **Mineral County:** Hawthorne, 1 specimen. **Nye County:** Mercury, 1 specimen. **Oregon: Malheur County:** 1 specimen. **Utah: Grand County:** Moab, 2 specimens, area of HWY-128/HWY-6 intersection, 13 specimens. **San Juan County:** Bluff, 1 specimen.

Specimens examined in this study: **California: Inyo County:** 3.4 SSW Towne Pass, Panamint Range (36.393, -117.279; 4935'), 1 adult ♀, 27 July 1987 (G. Lowe, C. R. Bowers) (GL); Eureka Dune (37.085, -117.674; 3043'), 1 adult ♂, 20 August 1990 (G. Lowe, S. C. Williams, et al.) (GL); **San Bernardino County:** HWY 15/Cima road intersection (35.444, -115.675; 3730'), 1 subadult ♂, 1 July 1984 (G. Lowe, J. Larson et al.) (GL). **Nevada: Lincoln County:** 4 mi. E Elgin (37.351, -114.442; 5204'), 1 adult ♀, 17 August 1998 (G. Lowe, S. C. Williams, V. F. Lee, J. S. Chinn) (GL);

Mineral County: 3.3 km N Thorne (38.633, -118.596; 4520'), 1 adult ♂, 10 August 1990 (G. Lowe, S. C. Williams, et al.) (GL); **Utah: San Juan County:** Valley of the Gods (37.276, -109.867; 4704'), 1 adult ♂, 20 September 2004 (G. Lowe) (GL). **Washington County:** Apex Mine, Curly Hollow Wash (37.070, -113.724; 3341'), 1 adult ♂ (G. Lowe, W. Icenogle) (GL).

Systematics

For details on the phylogenetic characters supporting the hadrurine topology in the following key refer to Fet & Soleglad's (2008) cladistic analysis of superfamily Iuroidea and the recent contribution by Soleglad & Fet (2010) on *Hadrurus pinteri* Stahnke. Also refer to the discussion on phylogeny and biogeography at the end of this paper. Species level distinctions refer to typical and/or statistically dominant characters, therefore some minor exceptions may exist, see discussions below. Numerical ranges are defined as minimum–maximum (mean).

Phylogenetic key to genera, species, and sub-species of subfamily Hadrurinae

- 1:** Internal accessory trichobothria absent on chela, trichobothria *ib–it* positioned basally on the fixed finger; dorsosecondary (*D3*) and dorsomarginal (*D4*) carinae of chela not rounded basally but discretely formed, not covered with coarse granulation, intercarinal area wide, distinct and smooth; patellar proximal area with conspicuous projection; extreme carapace anterior edge considerably convex, *anterior edge length / median tubercle position* ratio 0.327–0.383 (0.354); leg tarsus and basitarsus with weak or obsolete ridges on fused spinule clusters (genus *Hoffmannihadrurus* Fet et Soleglad, 2004) **2**
- : 2–7 internal accessory trichobothria present on chela, trichobothria *ib–it* positioned suprabasally on the fixed finger; *D3* and *D4* carinae of chela rounded basally, covered with coarse granulation, intercarinal area narrow due to dense granulation; patellar proximal area essentially flat; extreme carapace anterior edge modestly convex, *anterior edge length / median tubercle position* ratio 0.206–0.267 (0.240); leg tarsus and basitarsus with well developed ridges on fused spinule clusters (genus *Hadrurus* Thorell, 1876) **3**
- 2:** 3–4 external accessory trichobothria present on chela; 20–25 (21.143) ventral trichobothria present on chela; aculear glands absent on telson in mature male; pedipalps, metasoma, and telson brown in color *Hoffmannihadrurus gertschi* (Soleglad, 1976)
- : External accessory trichobothria absent on chela; 16–19 (17.227) ventral trichobothria present on chela;

aculear glands present on telson in mature male; pedipalps, metasoma, and telson yellow in color *Hoffmannihadrurus aztecus* (Pocock, 1902)

3: 1–5 external accessory trichobothria present on chela (“*hirsutus*” group) **4**

■: External accessory trichobothria absent on chela (“*arizonensis*” group) **6**

4: 1–2 external accessory trichobothria present on chela, none located on base of fixed finger; 3–5 (4.1) internal accessory trichobothria present on chela; 14–20 (17.5) ventral trichobothria on chela **5**

■: 3–5 external accessory trichobothria present on chela, one located on base of fixed finger; 5–7 (5.6) internal accessory trichobothria present on chela; 22–32 (25.6) ventral trichobothria on chela *Hadrurus pinteri* Stahnke, 1969

5: Aculear gland absent on telson in mature male; 14–16 (15.7) ventral trichobothria on chela; pectinal teeth 28–35 in males and 22–27 in females *Hadrurus hirsutus* (Wood, 1863)

■: Aculear gland present on telson in mature male; 15–20 (17.8) ventral trichobothria on chela; pectinal teeth 34–40 in males and 27–33 in females *Hadrurus concolorous* Stahnke, 1969

6: 4–7 (5.5) internal accessory trichobothria on chela; 15–22 (19.0) ventral trichobothria on chela; metasomal ventromedian intercarinal area lacking setae; chelal fingers yellow in color not contrasting with palm (“*arizonensis*” subgroup) **7**

■: 2–4 (2.4) internal accessory trichobothria on chela; 13–17 (15.0) ventral trichobothria on chela; metasomal ventromedian intercarinal area with irregularly positioned setae; chelal fingers reddish-orange in color contrasting with palm (“*spadix*” subgroup) **8**

7: Dorsal carinae of metasoma segment III with setae; 4–7 (5.5) internal accessory trichobothria on chela; 16–22 (19.1) ventral trichobothria on chela *Hadrurus arizonensis arizonensis* Ewing, 1928

■: Dorsal carinae of metasoma segment III lacking setae; 4–5 (4.8) internal accessory trichobothria on chela; 15–20 (18.1) ventral trichobothria on chela *Hadrurus arizonensis austrinus* Williams, 1970

8: 2–3 (2.1) internal accessory trichobothria on chela; carapace interocular area variable, completely melanic or with irregular shallow crescent-shaped clear pattern extending from lateral eyes towards but not reaching the median eyes **9**

■: 2–4 (3.0) internal accessory trichobothria on chela; carapace interocular area with distinct V-shaped clear

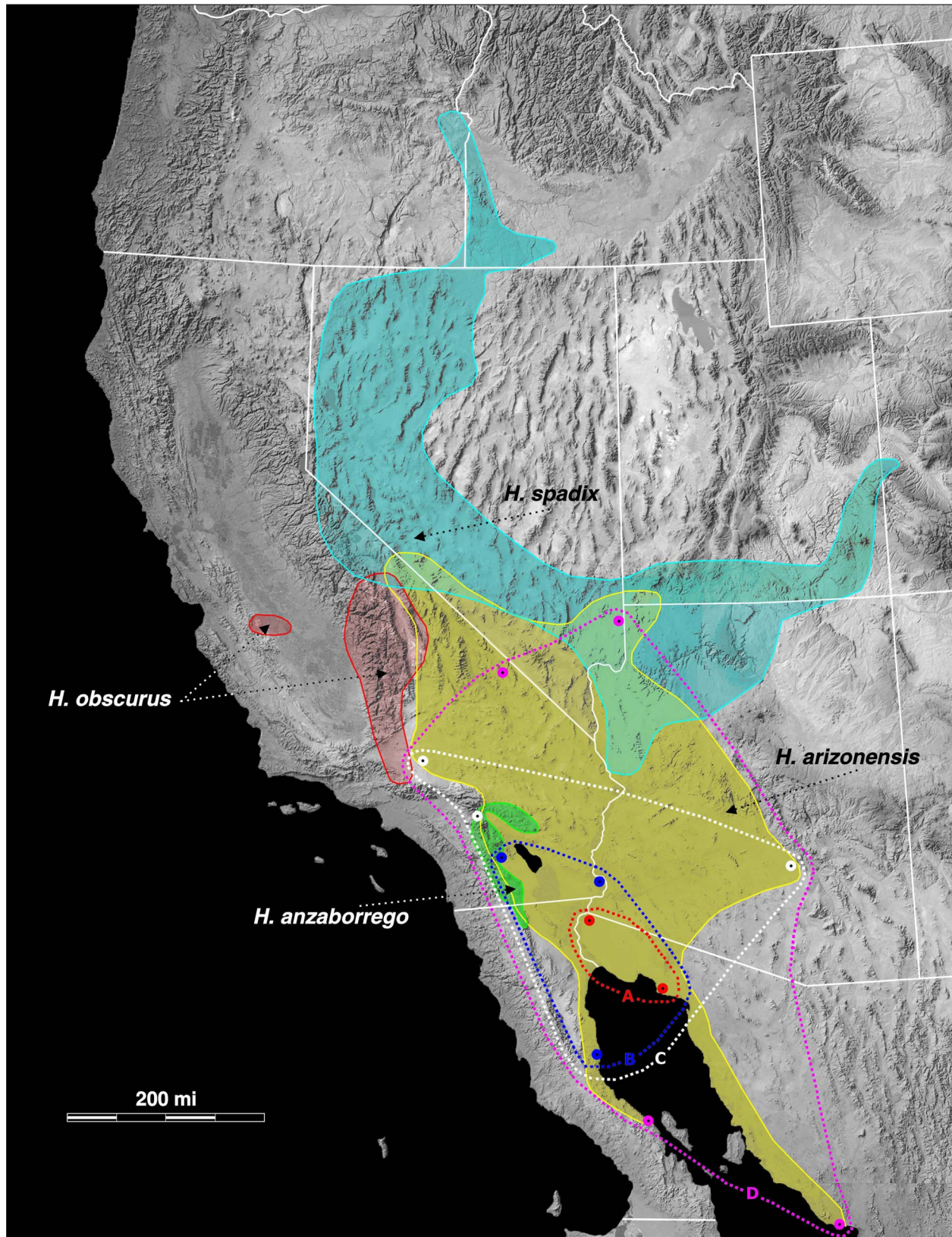


Figure 2: Reported distribution of *Hadrurus* “*arizonensis*” group. Distribution based primarily on Williams (1970, 1980), Fet & Soleglad (2008), and new locality data reported in this study for *H. obscurus*. Concentric polygons represent numbers of accessory trichobothria (decreasing from A to D) in *H. arizonensis*, see Table 1 for details.

	Internal Accessory	Ventral *
<i>H. arizonensis arizonensis</i>		
Puerto Peñasco, Sonora, Mexico - A	5–7 (6.091) [022]	18–22 (19.909) [022]
San Luis, Sonora, Mexico - A	5–6 (5.833) [024]	18–22 (19.826) [023]
San Diego Co. (ABDSP), California, USA - B	5–7 (5.714) [035]	17–22 (19.139) [036]
Imperial Co. (Picacho), California, USA - B	5–6 (5.706) [017]	16–22 (19.471) [017]
Puertocitos, Baja California, Mexico - B	5–6 (5.571) [021]	18–21 (19.476) [021]
Maricopa Co. (E. Mesa), Arizona, USA - C	4–6 (5.527) [074]	16–22 (19.026) [076]
Los Angeles & Riverside Co., California, USA - C	5–6 (5.235) [017]	17–20 (18.188) [016]
Clark Co. (Mesquite Valley), Nevada, USA ** - D	5–6 (5.083) [012]	17–20 (18.500) [012]
Inyo Co., California, USA - D	5–5 (5.000) [008]	17–20 (18.125) [008]
Southern (Guaymas) Sonora, Mexico - D	4–5 (4.875) [016]	16–19 (17.625) [016]
<i>H. arizonensis austrinus</i>		
Oakies Landing, Baja California, Mexico - D	4–5 (4.769) [026]	15–20 (18.083) [024]
“arizonensis” subgroup Total	4–7 (5.474) (± 0.594) [274] (4.880–6.068)	15–22 (18.978) (± 1.234) [273] (17.75–20.21)
“spadix” subgroup Total	2–4 (2.399) (± 0.513) [268] (1.886–2.912)	13–17 (14.898) (± 0.846) [235] (14.05–15.74)
Statistical comparisons between subgroups (internal / ventral): *** MVD = 128.18 / 27.39 % SERS = 191.81 / 118.93 % ANOVA <i>p</i> -value = 1E-255/ 3.5E-170		

Table 1: Chelal neobothriotaxy statistical comparisons for the *Hadrurus* “arizonensis” and “spadix” subgroups. Localities for “arizonensis” subgroup are ordered from largest to smallest numbers as indicated by the internal accessory trichobothria (see map in Fig. 2 where four concentric polygons illustrate these localities, identified as A–D). Statistical data group = minimum–maximum (mean) (\pm standard error) [N] (standard error range). * includes orthobothriotaxic trichobothria V_1 – V_4 . ** data courtesy of Mathew R. Graham. *** Mean Value Difference, Standard Error Range Separation, Analysis of Variance.

pattern extending from lateral eyes to the median eyes...
Hadrurus anzaborrego Soleglad, Fet et Lowe, **sp. nov.**

- 9: Carapace completely melanic.....
*Hadrurus spadix* Stahnke, 1940
 ■: Carapace interocular area with irregular shallow
 crescent-shaped clear pattern extending from lateral eyes
 towards but not reaching the median eyes
*Hadrurus obscurus* Williams, 1970

Hoffmannihadrurus

Hoffmannihadrurus is comprised of two species, both distributed in southern mainland Mexico. *H. aztecus* has been reported from the states of Oaxaca, Puebla, and Veracruz (questionable?). *H. gertschi* has only been reported from the state of Guerrero. In addition to the important six diagnostic characters stated in the key above, species of this genus also can be separated from its northern sister genus *Hadrurus* by the absence of the paired median carinae on sternite VII,

lesser setation of the pedipalp patella internal surface and dorsal aspects of metasomal segments IV–V, and by the distinct reddish pigmented ventral carinae of the metasoma.

Hadrurus

As shown in the phylogenetic key, *Hadrurus* is divided into two groups, the “hirsutus” group, exclusively found in the Baja California peninsula, and the “arizonensis” group, occurring in the southwestern United States and northern Baja California and Sonora, Mexico. These two groups, plus the genus *Hoffmannihadrurus*, comprise the three original phylogeographic partitions of *Hadrurus* suggested by Williams (1970: 31–32).

The “hirsutus” group of *Hadrurus* is comprised of three species, *H. pinteri*, occurring in the central-east portion of the Baja California peninsula in primarily volcanic areas, *H. concolorous*, occurring throughout most of central and southern Baja California, and *H.*