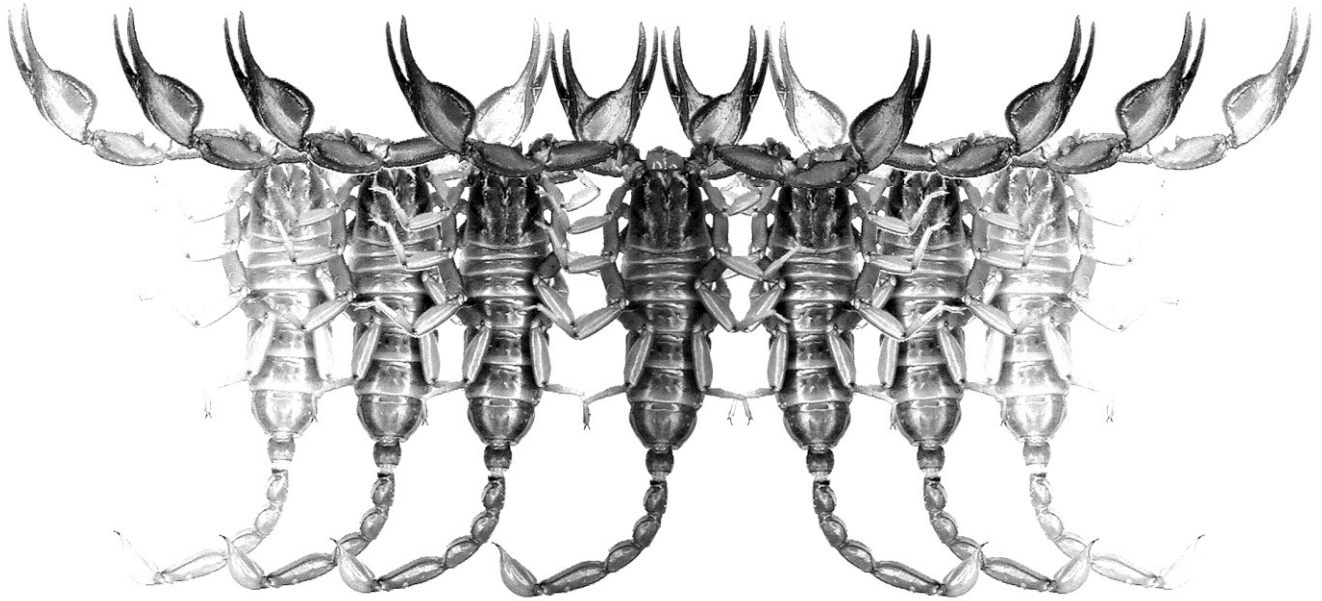


Euscorpium

Occasional Publications in Scorpiology



**Etudes on iurids, IX. Further Analysis of a Rare Species
Protoiurus kadleci (Scorpiones: Iuridae) from Turkey,
Based on Adult Males**

**Ersen Aydın Yağmur, František Kovařík, Victor Fet,
Michael E. Sologlad & Fatih Yeşilyurt**

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Occasional Publications in Scorpiology

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Etudes on iurids, IX. Further analysis of a rare species *Protoiurus kadleci* (Scorpiones: Iuridae) from Turkey, based on adult males

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Summary

Additional material of a rare scorpion species *Protoiurus kadleci* (Kovařík et al., 2010) from Turkey (Antalya Province) was examined, in particular, sexually mature males. New information is presented on the morphometric differences between adult and subadult males of this species, and on the differences between *P. kadleci* and other species of *Protoiurus*. An updated diagnosis of *P. kadleci* is presented, as well as updated key to six species of *Protoiurus*, and a map showing all known localities.

Introduction

This paper presents the first analysis of sexually mature males of *Protoiurus kadleci*. When this species was originally described by Kovařík et al. (2010), the three males available at that time were considered adult, although hemispermatophores had not been found. In 2011 and 2013, four additional males were collected, and were examined in the current study; hemispermatophores were extracted from two of these new specimens. Also, these males exhibited conspicuous secondary movable finger lobes and fixed finger proximal gaps, not noted in the original specimens studied in Kovařík et al. (2010).

We conducted morphometric analysis, comparing the three males originally studied by Kovařík et al. (2010) to three adult males examined in this study. In particular, the metasoma, chela, and telson were compared since they were considered diagnostic. It was demonstrated in Kovařík et al. (2010) that *P. kadleci* was the most slender species of its genus (note, at that time,

all *Protoiurus* were placed in genus *Iurus*), exhibiting considerable differences in the metasoma, telson, and chela from other species. We now discovered that the sexually mature males are not as slender as originally reported, especially with respect to the chelae and telson.

Here, we discuss the differences between subadult and adult males, describe the hemispermatophore, the pedipalp chela structure, and provide an updated diagnosis of the species. We also provide a new key to all six species of *Protoiurus* including the recently described species *P. kumlutasi* Yağmur et al., (2015).

Cave adaptation considerations. As indicated on the map in Figure 3, out of the five known localities of *P. kadleci*, two are caves (Dim Cave and İncekum Cave). Figure 1 shows a subadult female found 25 vertical meters deep inside Dim Cave, Alanya, Antalya Province. This specimen exhibits the same reddish color with darkened chelae as in the holotype female and paratype males from Akseki, Antalya Province (see Kovařík et al., 2010: figs. 182, 196, 199). This species is the lightest in color of all species in *Protoiurus* (and also



Figure 1: *Protoiurus kadleci*, subadult female, shown 25 vertical meters deep inside Dim Cave, Alanya, Antalya Province, Turkey (from Kovařík et al., 2010: fig. 198, in part).



Figure 2: *Protoiurus kadleci*, male, dorsal view. İncekum Cave, Alanya, Antalya Province, Turkey.

Iurus). It is also the most slender of all those species, especially with respect to the metasoma. Therefore, it is tempting to consider this species exhibiting some degree of cave adaptation (i.e., reduction in coloration and attenuation of appendages, commonly found in troglomorphic species of scorpions and many other arthropods). However, the holotype and paratypes from Akseki were not found in caves and were collected sympatrically with specimens of the widespread species *Protoiurus kraepelini* (von Ubisch, 1922) and types of *Neochactas gruberi* (Fet, Soleglad et Kovařík, 2009). In addition, the recently described *P. kumlutasi*, which was collected deep inside the Hidirellez Cave (also in Antalya Province), was found also at the cave's entrance. The latter species shows no troglomorphic characteristics, its coloration being rather dark, resembling that of *P. kraepelini*.

Methods and Material

Abbreviations

AZMM: Alaşehir Zoological Museum, Celal Bayar University of Manisa, Alaşehir, Manisa Province, Turkey; FKCP, personal collection of František Kovařík, Prague, Czech Republic.

Terminology and conventions

The systematics adhered to in this paper follows the classification as established in Fet & Soleglad (2005), and modified in Fet & Soleglad (2008), Kovařík et al. (2010), and Soleglad et al. (2012). Terminology describing pedipalp chelal finger dentition follows that described and illustrated in Soleglad & Sissom (2001), that of the sternum follows that in Soleglad & Fet (2003a), and the metasomal and pedipalp carination, and leg tarsus armature follows that described in Soleglad & Fet (2003b). Hemispermaphore terminology follows that described in Kovařík et al. (2010: 42); types and subtypes of iurid hemispermaphores are as defined by Soleglad et al. (2012). Trichobothrial nomenclature and hypothesized homologies are those described and illustrated in Vachon (1974). Techniques using maximized morphometric ratios follow those described in Kovařík et al. (2010: appendix C). Statistical differences are stated in standard deviation (SD) ranges (i.e., mean-SD – mean+SD) and the percentage of difference in the mean values (i.e., mean value difference (MVD)).

Map generation software package

Maps were generated from Earth Explorer 6.1, with positional and altitude data compiled through Google Maps.

Material examined

We examined four male specimens of *P. kadleci*, three sexually mature and one subadult. Below we list the four specimens examined and five other specimens from three other localities listed in Kovařík et al. (2010). A total of nine specimens of *P. kadleci* are known from five localities (see map in Figure 3).

Protoiurus kadleci (Kovařík, Fet, Soleglad et Yağmur, 2010) (4 specimens)

Turkey: *Antalya Province:* Alanya District, İncekum Cave, 36.6333°N, 31.7569°E, 18 m asl, 31 August 2011, leg. E. A. Yağmur, 2 ♂ (AZMM); Alanya District, N of Alanya, Taşatan Plateau, 36.6384°N, 32.0598°E, 1135 m asl, 8 February 2013, leg. E. A. Yağmur & S. Örgel, 2 ♂ (AZMM).

Other reported localities (5 specimens) (Kovařík et al., 2010)

Turkey: *Antalya Province:* Holotype: ♀, Akseki District, 10.5 km S Akseki, Geriş, 36.9770°N, 31.7217°E, 847 m asl, 11–12 May 2006, leg. F. Kovařík (FKCP). Paratypes: 2 ♂ (FKCP), same label as holotype; Alanya District, Dim Cave, 11 km E of Alanya, 36.5392°N, 32.1092°E, cave entrance at 221 m asl, vertical depth 25 m, 22 April 2007, 1 ♀ sbad., leg. K. B. Kunt, G. Tunsley & R. Gabriel (AZMM); *Mersin Province:* Gülnar District, Gülnar, 36.3333°N, 33.4°E, July 2000, 1 ♂, leg. R. Werner & R. Lizler (FKCP).

Character Analysis

We discuss new morphological data in this section that pertains to our discovery of sexually mature *P. kadleci* males. In particular, the chela finger lobe/gap arrangement is discussed, showing it is unique in the subfamily Iurinae; the hemispermaphore structure based on two specimens; statistical data on the number of dorsal carinal spines of the metasoma; and morphometric analysis which shows that there exists some sexual dimorphism present in mature males.

Pedipalp chelal structure. As presented in Kovařík et al. (2010: figs. 56–59) and Soleglad et al. (2012: appendix B), the chelal finger lobe armament and its placement on the fingers has been analyzed in great detail and used in the diagnosis of species. Over 300 specimens of *Iurus* and *Protoiurus* have been studied statistically. It was shown in the above references that the MF lobe becomes larger and moves more distally on the finger as the specimen matures. It was also demonstrated that the relative placement, shape, and size of the lobe per development stage is species-dependent. Also, differences in lobe placement and the presence or

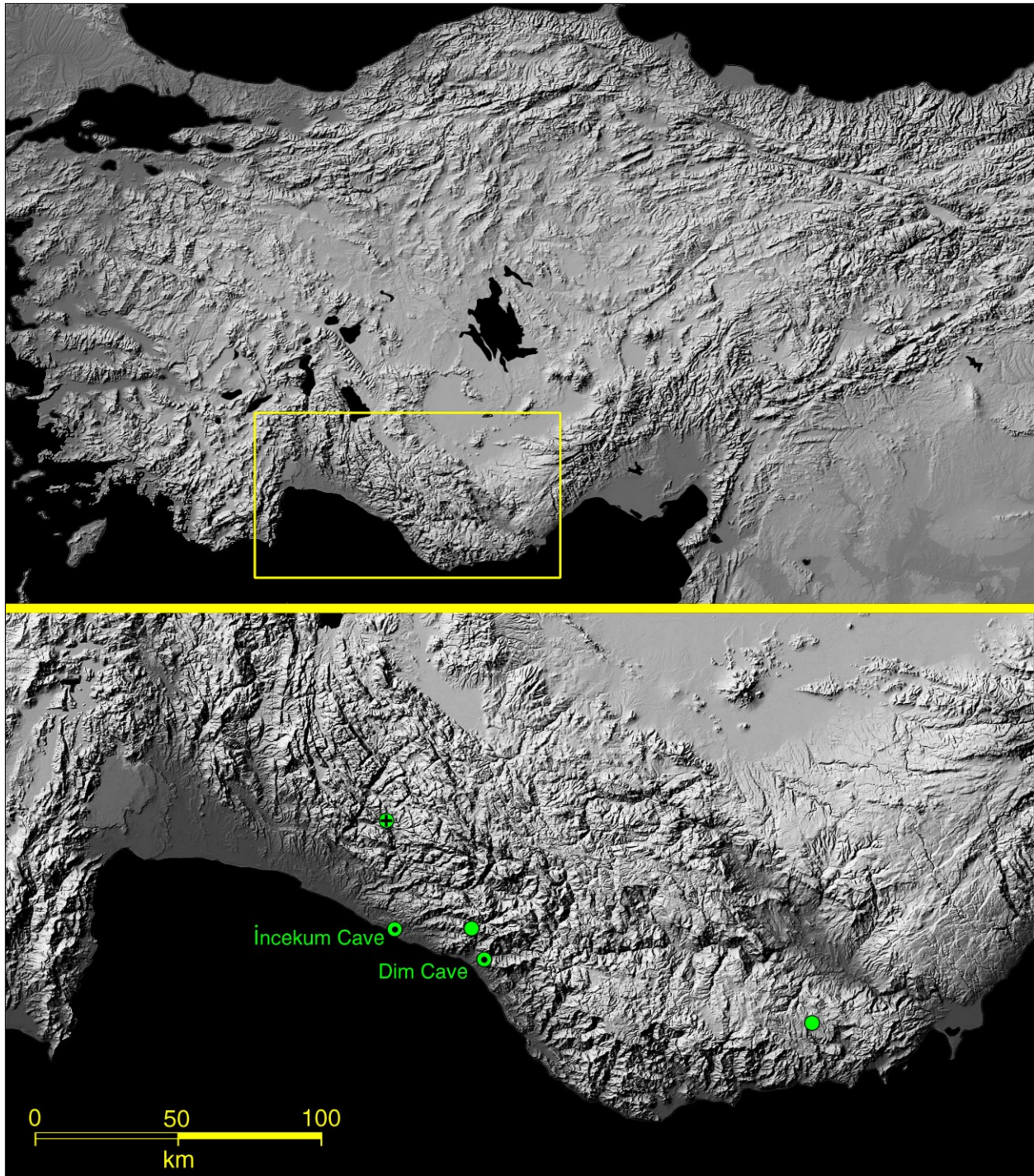


Figure 3: The map on the bottom shows the five known localities of *Protoiurus kadleci* in Turkey (icon with “+” indicates type locality; icons with “•” indicate cave localities which are identified). The rectangle in the top map delineates the area shown in the bottom map.

absence of a fixed finger proximal gap is different between development stages and between sexes. We demonstrated that the movable finger lobe during individual development does move distally down the finger, based on comparisons of the lobe’s placement

with respect to the number of outer denticles (OD) occurring distally of the lobe.

During our analysis of the mature male specimens of *P. kadleci* we discovered the presence of a well-developed secondary movable finger lobe (*sl*) and a cor-

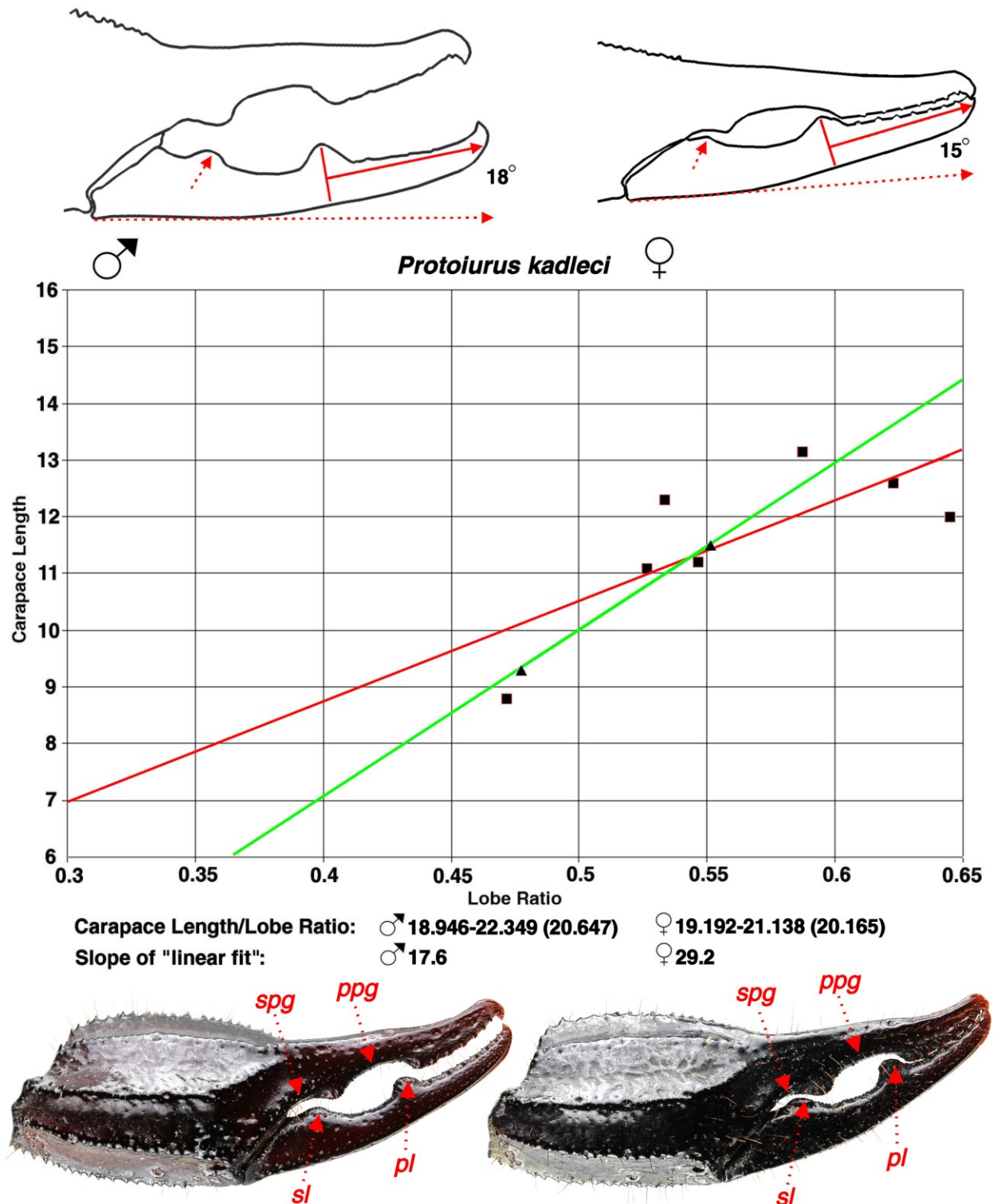


Figure 4: Pedipalp chela of *Protoiurus kadleci*. **Top.** Movable finger lobe signature. Squares = males, triangles = females. The lines depict linear fit by least squares regression, red for males and green for females. Lobe ratio = distance from external condyle to lobe center / movable finger length. **Bottom.** Two males, Taşatan Plateau, Antalya Province. Lateral view of the right pedipalp chela showing the presence of two movable finger lobes and two fixed finger proximal gaps which are unique to this species. Labels: *sl* = secondary and *pl* = primary lobes, *spg* = secondary and *ppg* = primary proximal gaps.

responding secondary proximal gap (*spg*) on the fixed finger. In Figure 4 we show the lateral view of two adult male specimens illustrating the secondary lobe and secondary proximal gap. As apparent from these figures, the secondary lobes and gaps are much smaller than the primary lobe and proximal gap. The secondary lobe and gap are also visible on the holotype female as illustrated in Kovařík et al. (2010: fig. 191), though quite subtle and not as developed as in mature males. Also unique in the female is the presence of a primary proximal gap, not present in females of any other species of *Protoiurus* or *Iurus*.

Figure 4 shows the *lobe signature* of *P. kadleci* based on seven males and two females (see *lobe signature* definition in Soleglad et al. (2012: appendix B)). Both sexes have MF lobe ratios exceeding 0.5, with three males exceeding 0.58, matching similar lobe ratios found in *P. kraepelini* and *P. asiaticus* (Birula, 1903).

Hemispermatochore. *Protoiurus kadleci* has a subtype *Ia* hemispermatochore as illustrated for two specimens in Figure 5. The lamina is shorter than the trunk, exhibiting an essentially straight external edge and a conspicuous pointed internal nodule. The distal portion of the lamina is somewhat short contributing to the overall lamina length.

Eighteen samples spanning all five species of *Protoiurus* with *Ia* subtype hemispermatochore exhibit the following statistical data for two diagnostic morphometric ratios (i.e., lamina length compared to trunk length and lamina distal length compared to lamina basal length, see Yağmur et al. (2015: fig. 4) for methods of measurement):

lam_L/trunk_L: 0.862–0.981 (0.927) (± 0.039) [19]

lam_D/lam_BL: 1.435–1.802 (1.662) (± 0.105) [18]

For *P. kadleci* (i.e., four hemispermatochores extracted from two specimens) exhibit the following statistical data:

lam_L/trunk_L: 0.862–0.918 (0.889) (± 0.023) [4]

lam_DL/lam_BL: 1.614–1.800 (1.731) (± 0.084) [4]

It is clear that the hemispermatochore found in *P. kadleci* is consistent with the other four species with subtype *Ia* exhibiting compliance to all structural characters and morphometric ratios.

Metasomal dorsal carinae statistics. Accompanying the thin metasoma of *P. kadleci* is a relatively high number of pointed spines comprising the dorsal carinae of segments I–IV, the highest in the genus. Table 2 compares average spine numbers across the six species of *Protoiurus*. Only the single specimen of *P. stathiae* Soleglad et al., 2012 exhibits spine numbers approaching those of *P. kadleci* showing minor overlap with the low portion of the range for *P. kadleci*. All other species

show no overlap with *P. kadleci*, including absolute ranges. *P. kraepelini* has the lowest number of spines on the dorsal carinae in the genus, with over a 55 % MVD from *P. kadleci*. See Fig. A2 for two views of the metasomal dorsal carinae.

Morphometric analysis. Kovařík et al. (2010: tab. 8; appendix C) presented morphometric ratio differences between *P. kadleci* and the other then described species of *Protoiurus* (i.e., *P. asiaticus* and *P. kraepelini*) as well as *Iurus dufourei* (Brullé, 1832) and *I. kinzelbachi* Kovařík et al., 2010. The morphometric analysis of *P. kadleci* presented in Kovařík et al. (2010) was based on three males and one female. The analysis showed that the metasoma, pedipalp chela, and the telson vesicle were thinner in *P. kadleci* than in other species, for both females and males. At the time, the three large *P. kadleci* males were considered to be adult although hemispermatochore had not been found in the specimens. The large holotype female was also considered to be an adult. However, results from our current study indicate that the three males analyzed by Kovařík et al. (2010) were not sexually mature (carapace lengths range from 11.10 to 12.30 mm). We now have morphometric data from three larger males (carapace lengths range from 12.00 to 12.90), from two of which hemispermatochore have been extracted and examined (see Fig. 5).

We show here that the sexually mature *P. kadleci* males are not as thin as previously reported in Kovařík et al. (2010), hypothesizing that the segments, in particular the telson vesicle, exhibit some degree of sexual dimorphism in the adults. Table 3 compares three adult *P. kadleci* males with the three subadult males studied in Kovařík et al. (2010). What is interesting from this comparison is that subadult males are thinner in all nine morphometrics originally considered as diagnostic in Kovařík et al. (2010). This is indicated by a larger mean value calculated for the subadult males. In particular, the telson vesicle is noticeably thinner in the subadults. Consequently, we see the value of the telson vesicle as a key diagnostic character is reduced in the male when adult males are used (i.e., a drop in the MVD when compared to other species). Similarly, the chelal palm is heavier in the adults, which also reduces its diagnostic value for the males of this species. The metasoma, though not as thin in the adult males, is still a good diagnostic character, exhibiting 18 to 55 % in MVD (see histograms in Fig. 6 showing comparison of all *Protoiurus* males). It is the only species in subfamily Iurinae (i.e., genera *Iurus* and *Protoiurus*) where all five metasomal segments are longer than wide.

Systematics

Order SCORPIONES C. L. Koch, 1850

Suborder Neoscorpiones Thorell et Lindström, 1885

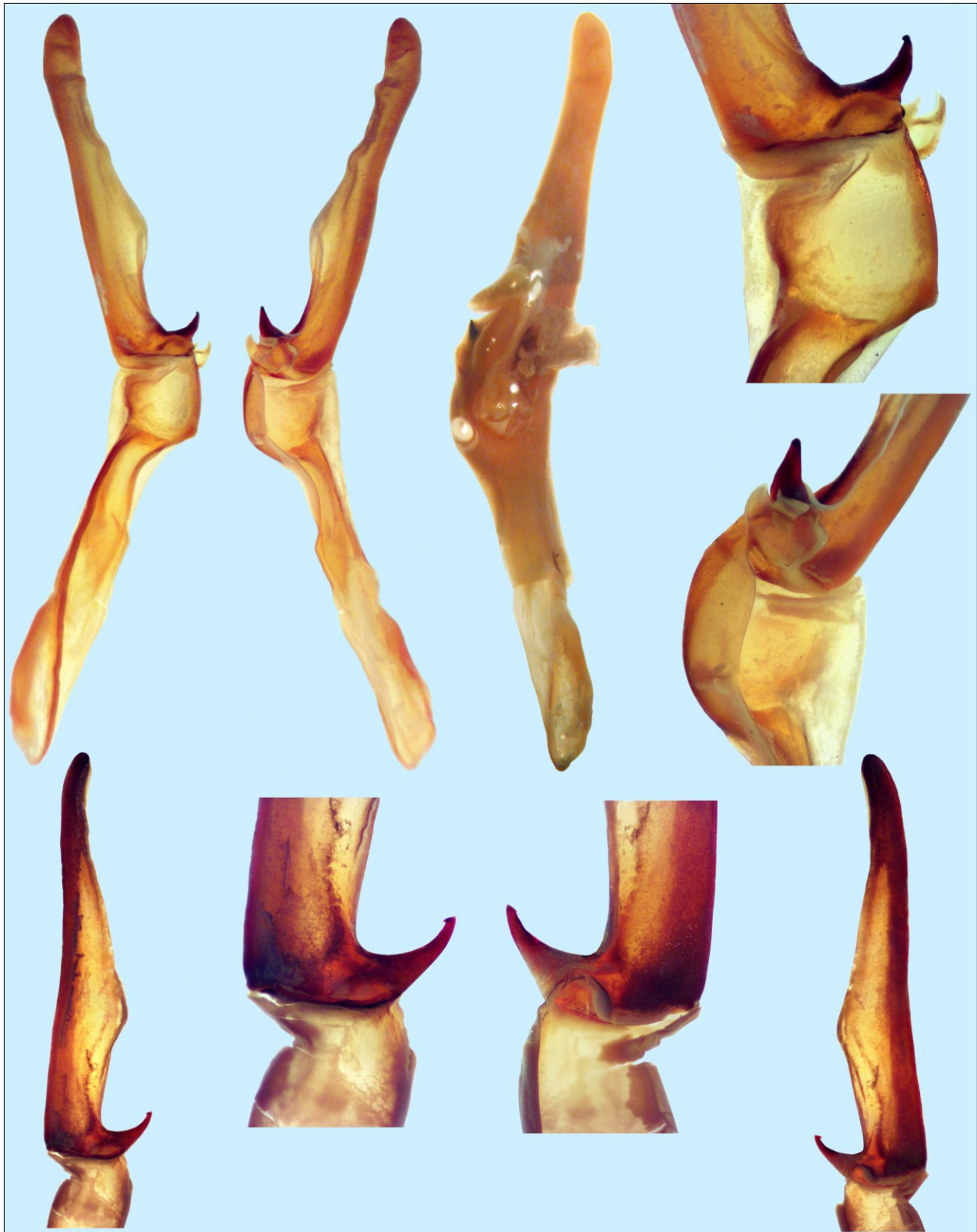


Figure 5: Hemispermatothore (submerged in alcohol) of *Protoiurus kadleci*, **Top.** İncekum Cave, Alanya, Antalya Province, Turkey. **Left:** Complete structure of right hemispermatothore, dorsal and ventral views. **Center:** Left hemispermatothore encased in membranous sack. **Right:** Closeup of median area of right hemispermatothore, dorsal (top) and interoventral (bottom) views. **Bottom.** Left hemispermatothore, Taşatan Plateau, Antalya Province. **Left:** Lamina and median area, dorsal view. **Center:** Closeup of median area, dorsal and ventral views. **Right:** Lamina and median area, ventral view.

<i>Protoiurus kadleci</i>				
	İncekum Cave, Alanya, Antalya Province, Turkey		Taşatan Plateau, Alanya, Antalya Province, Turkey	
	Male	Subadult Male	Male	Male
Total length	104.75	66.35	95.65	91.65
Carapace length	12.90	8.80	12.60	12.00
Mesosoma length	33.00	18.80	21.15	22.85
Metasoma length	43.25	27.75	45.00	41.30
Segment I length/width	5.80/5.40	3.90/3.90	5.90/5.50	5.50/5.05
Segment II length/width	6.95/4.95	4.50/3.40	7.20/5.10	6.60/4.80
Segment III length/width	7.45/4.60	4.85/3.25	7.80/5.00	7.10/4.55
Segment IV length/width	8.85/4.00	5.55/2.80	9.30/4.35	8.50/4.25
Segment V length/width	14.20/3.55	8.95/2.55	14.80/3.70	13.60/3.70
Telson length	15.60	11.00	16.90	15.50
Vesicle length	11.40	7.25	12.50	11.20
width/depth	4.30/3.80	2.80/2.55	4.35/4.20	3.85/3.80
Aculeus length	4.20	3.75	4.40	4.30
Pedipalp length	51.65	36.85	52.75	47.45
Femur length/width	12.90/4.10	9.65/3.20	13.70/4.50	12.20/3.90
Patella length/width* DPS height**	12.10/4.50 1.60	8.95/3.10 0.65	12.40/4.30 1.90	11.10/4.00 1.40
Chela length	26.65	18.25	26.65	24.15
Palm length	11.10	7.55	11.60	10.05
width/depth	6.95/8.10	4.10/4.75	7.00/8.60	6.55/7.80
Fixed finger length	12.70	9.80	13.10	11.10
Movable finger length	15.80	11.45	16.30	14.50
Sternum length/width	3.10/2.70	2.15/2.20	3.00/2.55	2.60/2.50
Pectines teeth middle lamellae	11-10 3+4	10-9 4-4	10-10 x-x	11-11 5-5+

Table 1: Morphometrics (mm) of *Protoiurus kadleci*. * Patella width is widest distance between the dorsointernal and extero-medial carinae. ** DPS height is from tip of spines to dorsointernal carina centered.

	Average Number of Spines on <i>Metasomal Dorsal Carinae</i> *	MVD % with <i>P. kadleci</i>
<i>P. kadleci</i>	10.50–13.88 (12.750) [8]	-
<i>P. asiaticus</i>	7.38–9.00 (8.175) [18]	56 %
<i>P. kraepelini</i>	6.00–9.12 (7.807) [62]	63.3 %
<i>P. kumlutasi</i>	7.50–10.00 (8.391) [23]	51.9 %
<i>P. rhodiensis</i>	9.63–9.63 (9.63) [1] **	32.4 %
<i>P. stathiae</i>	10.63–10.63 (10.63) [1] **	19.9 %

Table 2: Statistical data on the number of spines found on the metasomal dorsal carinae (segments I–IV) for *Protoiurus* species, based on 113 samples. This data clearly shows that *P. kadleci* has the largest number of spines on the dorsal carinae. * Counts are based on the average number of spines for segments I–IV, including both left and right carina (i.e., eight carinae are averaged). Statistical data group includes absolute range (mean) (\pm standard deviation) [number of samples]. MVD % = mean value difference percentage. ** Only the type specimen was tabulated.

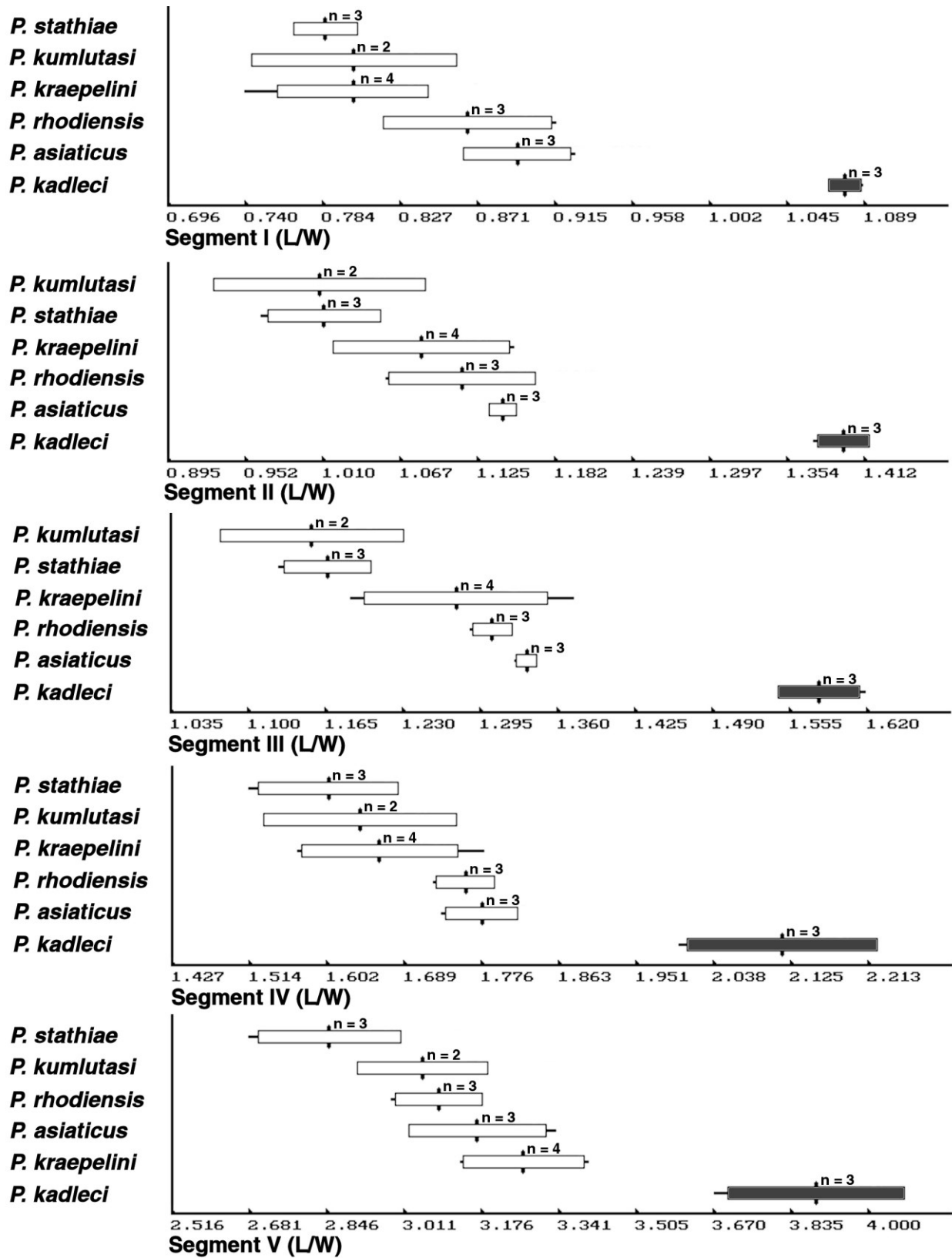


Figure 6: Histograms showing the relatively slender metasoma found on the *Protoiurus kadleci* male (dark bar). Note, all five segments are longer than wide. See Table 4 for more statistical data. The thin line represents the minimum and maximum range, the wide rectangle represents the plus-minus standard deviation range, and the vertical bar is the mean.

Morphometric Ratio	Statistical Comparison of Subadult Males to Adult Males	MVD (%)
Metasoma Segment I Length / Width	Subadult: 1.09 – 1.25 (1.193) (±0.090) [3] {1.10 – 1.28} → 0.075 Adult: 1.07 – 1.09 (1.079) (±0.009) [3] {1.07 – 1.09} → 0.008	10.6
Metasoma Segment II Length / Width	Subadult: 1.36 – 1.45 (1.400) (±0.047) [3] {1.35 – 1.45} → 0.034 Adult: 1.37 – 1.41 (1.397) (±0.019) [3] {1.38 – 1.42} → 0.014	0.2
Metasoma Segment III Length / Width	Subadult: 1.63 – 1.68 (1.663) (±0.025) [3] {1.64 – 1.69} → 0.015 Adult: 1.56 – 1.62 (1.580) (±0.034) [3] {1.55 – 1.61} → 0.022	5.2
Metasoma Segment IV Length / Width	Subadult: 2.05 – 2.25 (2.138) (±0.101) [3] {2.04 – 2.24} → 0.047 Adult: 2.00 – 2.21 (2.117) (±0.108) [3] {2.01 – 2.22} → 0.051	1.0
Metasoma Segment V Length / Width	Subadult: 3.76 – 4.24 (3.969) (±0.243) [3] {3.73 – 4.21} → 0.061 Adult: 3.68 – 4.00 (3.892) (±0.187) [3] {3.70 – 4.08} → 0.048	2.0
Chela Length / Width	Subadult: 3.91 – 4.38 (4.097) (±0.247) [3] {3.85 – 4.34} → 0.060 Adult: 3.69 – 3.83 (3.776) (±0.078) [3] {3.70 – 3.85} → 0.021	8.5
Chela Length / Depth	Subadult: 3.20 – 3.57 (3.403) (±0.187) [3] {3.22 – 3.59} → 0.055 Adult: 3.10 – 3.29 (3.162) (±0.111) [3] {3.05 – 3.27} → 0.035	7.6
Telson Length / Width	Subadult: 4.34 – 4.34 (4.343) (±0.000) [1] {4.34 – 4.34} → 0.000 Adult: 3.63 – 4.03 (3.846) (±0.202) [3] {3.64 – 4.05} → 0.052	12.9
Telson Length / Depth	Subadult: 4.61 – 4.61 (4.606) (±0.000) [1] {4.61 – 4.61} → 0.000 Adult: 4.02 – 4.11 (4.069) (±0.042) [3] {4.03 – 4.11} → 0.010	13.2

Table 3: Morphometric comparison of subadult and adult males of *Protoiurus kadleci*. In all nine morphometric ratio comparisons, the subadult males exhibited a larger mean value than the adult specimens, implying a relatively thinner metasoma, chelal palm, and telson vesicle. In particular, the telson vesicle is significantly thinner in the subadult males, exhibiting 13 % MVD. Reduction of MVD of 7 % or more are indicated in red. Statistical data group: minimum–maximum (mean) (±standard deviation) [number of samples] {standard deviation range} → coefficient of variability. MVD = mean value differences.

		<i>P. asiaticus</i> 3 ♂, 3 ♀	<i>P. kraepelini</i> 4 ♂, 4 ♀	<i>P. kumlutasi</i> 2 ♂, 1 ♀	<i>P. rhodiensis</i> 3 ♂, 3 ♀	<i>P. stathiae</i> 3 ♂, 3 ♀
Meta-I (L/W)	↑	21 %	35 %	35 %	25 %	37 %
	+	35 %	47 %	34 %	29 %	47 %
Meta-II (L/W)	↑	22 %	29 %	39 %	25 %	38 %
	+	45 %	47 %	47 %	43 %	55 %
Meta-III (L/W)	↑	18 %	24 %	37 %	21 %	35 %
	+	32 %	38 %	43 %	33 %	44 %
Meta-IV (L/W)	↑	19 %	27 %	29 %	20 %	32 %
	+	26 %	32 %	30 %	26 %	36 %
Meta-V (L/W)	↑	23 %	19 %	28 %	26 %	36 %
	+	28 %	22 %	33 %	30 %	37 %
Tel_L / Tel_W	↑	12 %	14 %	10 %	18 %	27 %
	+	25 %	28 %	16 %	32 %	35 %
Tel_L / Tel_D	↑	9 %	9 %	3 %	7 %	10 %
	+	23 %	18 %	12 %	20 %	17 %
Che_L / Che_D	↑	5 %	36 %	32 %	5 %	32 %
	+	8 %	25 %	28 %	14 %	24 %

Table 4: Morphometric ratio Mean Value Differences (MVD) between *Protoiurus kadleci* (based on 3 adult males and 1 female) and the other five species of *Protoiurus* (29 specimens). This data illustrates in general the relative slenderness of *P. kadleci* in metasomal segments (18–55 %), the telson (3–32 %), and the chela (5–36 %). However, the reduction of MVD's (indicated in red) based on the adult male is evident and therefore reduces the importance of the chela and telson as an overall general diagnostic character (indicated in red).

Infraorder Orthosterni Pocock, 1911
 Parvorder Iurida Soleglad et Fet, 2003
 Superfamily Iuroidea Thorell, 1876
 Family Iuridae Thorell, 1876
 Subfamily Iurinae Thorell, 1876
 Genus *Protoiurus* Soleglad, Fet, Kovařík et Yağmur,
 2012

Protoiurus kadleci (Kovařík, Fet, Soleglad &
 Yağmur, 2010)

Figures 1–6, A1–A6; Tables 1–4.

Iurus kadleci Kovařík et al., 2010: 123, figs. 7, 24, 35, 40, 52, 60, 73, 74, 181–197, tabs. 1, 7–9. Type locality: Turkey, *Antalya Province*: Akseki District, 10.5 km S Akseki, Geriş.

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Iurus dufourei: Soleglad et al., 2009: 2 (in part; Akseki).
Protoiurus kadleci: Soleglad et al., 2012: 2; Yağmur et al., 2015: 4.

Updated Diagnosis: Large species, 95 to 105 mm. Color variable, light red in juveniles and subadults, darker red to brown in adults, chelae darkened. Pectinal tooth counts 9–12 (10.643) [14] males, 10–11 (10.250) [4] females. Two chelal movable finger lobes and fixed finger proximal gaps found on both sexes. Chelal movable finger lobe in adults located on mid-finger or distally, lobe ratio 0.587–0.645 in males, 0.551 in females; conspicuous primary proximal gap of fixed finger present in both adult males and females; movable finger of adult males essentially straight, not highly curved; hemispermaphore of subtype *1a*; most slender species in the genus, as exhibited in the metasoma: metasomal segments thin, all longer than wide in both sexes, in subadults as well as adults; segment V length to width ratio, 3.68–4.00 in adult males, 3.88 in adult females; metasomal dorsal carinae (segments I–IV) with numerous pointed spines, their number averaging 10.50–13.88 (includes left and right carinae).

Distribution. Turkey: Antalya and Mersin Provinces. See map in Figure 3 for the five known localities, two of which are in caves.

Key to species of *Protoiurus*

1 – Chelal palm of mature male highly vaulted; movable finger curves abruptly, 28 to 31 degrees 2
 ■ – chelal palm of mature male not highly vaulted; movable finger curves subtly, 18 to 21 degrees 3

2 – Hemispermaphore (subtype *1a*) internal nodule conspicuously developed, terminus pointed; external edge of lamina straight. Turkey: Antalya Province, Hidirellez Cave *Protoiurus kumlutasi* Yağmur, Soleglad, Fet et Kovařík, 2015

■ – Hemispermaphore (subtype *1b*) internal nodule widely rounded; external edge of lamina curved. Widespread in southern Turkey: Antalya, Isparta, Konya, Karaman, Mersin, and Muğla Provinces; Greece: Megisti Island *Protoiurus kraepelini* (von Ubisch, 1922)

3 – Chelal movable finger of mature males with one lobe and fixed finger with one proximal gap; fixed finger of mature females without proximal gap; metasoma stocky, segment I wider than long in male and female, segment V L/W 2.68 to 3.34 in males, 2.71 to 3.13 in females

..... 4
 ■ – Chelal movable finger of mature males with two distinct lobes and fixed finger with two proximal gaps; fixed finger of mature females with conspicuous proximal gap; metasoma thin, all segments longer than wide in male and female, segment V L/W 3.68 to 4.00 in males, 3.88 in females. Turkey: Antalya and Mersin Provinces *Protoiurus kadleci* (Kovařík, Fet, Soleglad et Yağmur, 2010)

4 – Chelal fingers are relatively short, movable finger length / palm width = 1.75 to 1.99 in males, 1.90 to 2.08 in females; fixed finger length / palm width = 1.31 to 1.77 in males, 1.48 to 1.63 in females; chelal carinae dark reddish in color, in strong contrast to lighter palm

..... 5
 ■ – Chelal fingers are elongate, movable finger length / palm width = 2.26 to 2.33 (2.28) in males, 2.39 to 2.41 (2.40) in females; fixed finger length / palm width = 1.76 to 1.82 (1.79) in males, 1.63 to 1.91 (1.81) in females; chelal carinae color not noticeably darker than palm. South-central and eastern Turkey: Adana, Adıyaman, Kahramanmaraş, Mersin, and Niğde Provinces *Protoiurus asiaticus* (Birula, 1903)

5 – Chelal movable finger lobe in adult males situated on distal half of finger; proximal gap on fixed finger prominent in adult males; chelal palm quite robust, chela length / palm width = 2.86 to 3.15 (2.99) in males, 3.01 to 3.35 (3.19) in females; chela length / palm depth = 2.28 to 2.48 (2.40) in males, 2.52 to 2.76 (2.67) in females; pectinal tooth count standard error range 12–14 (12.93) for males and 10–12 (11.03) for females. Greece: Karpathos Island *Protoiurus stathiae* Soleglad, Fet, Kovařík et Yağmur, 2012.

■ – Chelal movable finger lobe in adult males situated on proximal half of finger; proximal gap on fixed finger very weak in adult males; chelal palm less robust, chela length / palm width = 3.14 to 3.63 (3.40) in males, 3.45 to 3.58 (3.53) in females; chela length / palm depth = 2.76 to 3.45 (3.01) in males, 2.88 to 2.99 (2.92) in females; pectinal tooth count standard error range 10–12 (11.28) for males and 9–10 (9.48) for females. Greece: Rhodes Island *Protoiurus rhodiensis* Soleglad, Fet, Kovařík et Yağmur, 2012.

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Appendix A

Structure Illustrations of an Adult Male *Protoiurus kadleci*

In this appendix we present photographs of the major structures of an adult male *P. kadleci* from Alanya Town, Antalya, Turkey. This includes detailed images of the pedipalp chelal fingers, three views of the metasoma and telson showing all carinae, setation and spination of the four legs, the chelicera, ventral and dorsal views, the complete trichobothrial pattern, the carapace and mesosoma, and the sternopectinal area. See Figure 5 for dorsal and ventral views of the hemispermatophore, completing the species description.



Figures A1–A4: *Protoiurus kadleci*, male, Taşatan Plateau, Antalya Province. **A1.** Chelal movable finger with a close-up of its distal aspect, and fixed finger. **A2.** Metasoma and telson showing the dorsal, ventral, and lateral views. **A3.** Right chelicera, ventral and dorsal views. **A4.** Ventral view of basitarsus and tarsus of all four legs, and a close-up of the tarsus of leg III.

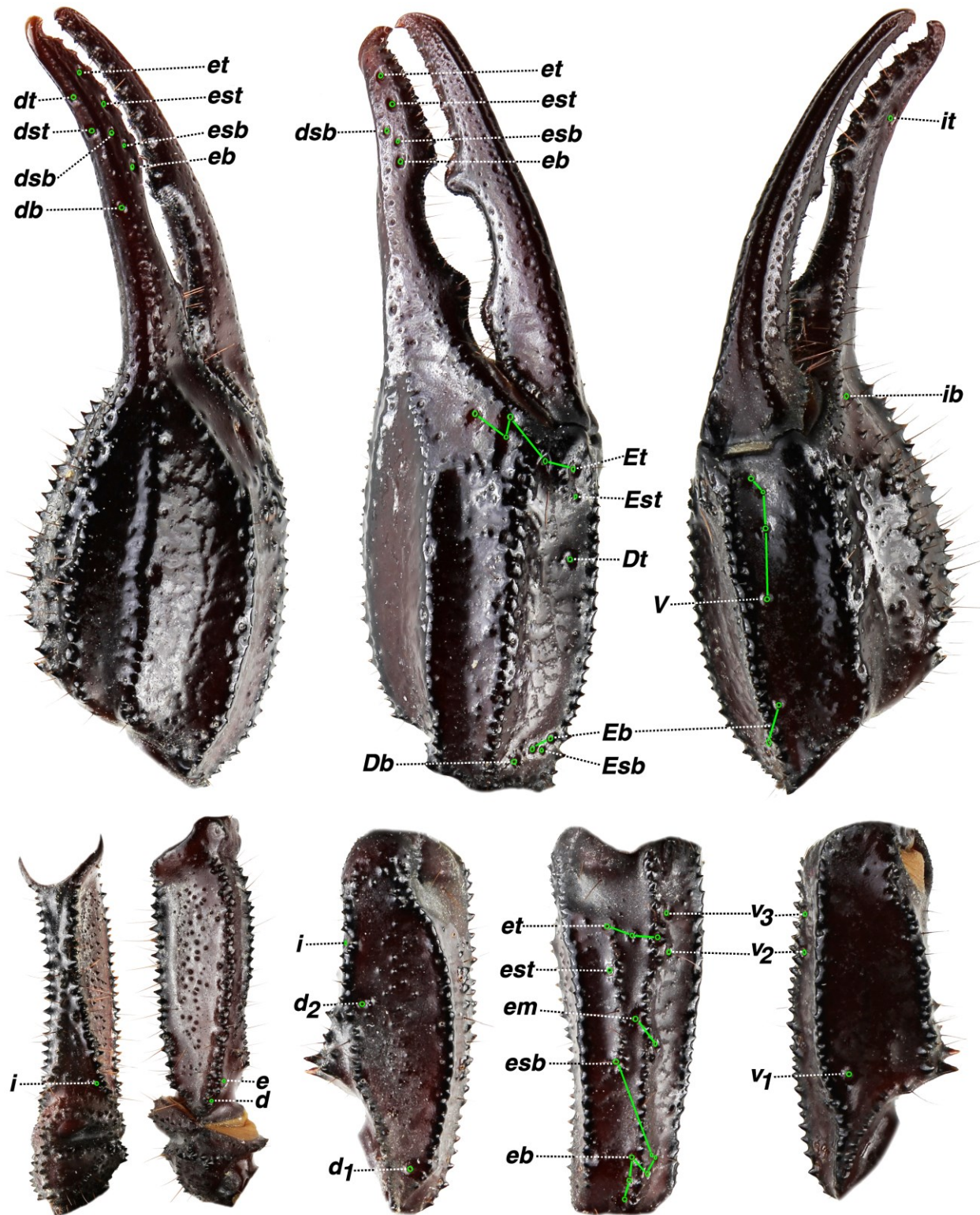


Figure A5: Trichobothrial pattern of *Protoiurus kadleci*, male, Taşatan Plateau, Antalya Province.



Figure A6: *Protoiurus kadleci*, male, Taşatan Plateau, Antalya Province. Dorsal view showing carapace and mesosoma, and ventral view showing sternoplectinal area.



Figure A7: Adult male *Protoiurus kadleci* photographed at Taşatan Plateau, Antalya Province.

Appendix B

Erratum to Kovařík et al. (2010)

It came to our attention that during our 2010 revisionary study of Turkish Iuridae (Kovařík et al., 2010), at the manuscript stage an incorrect specimen was indicated in print as a holotype of a new species. Two male type specimens of *Iurus kinzelbachi* Kovařík et al., 2010, both originating from the same locality (Aydın Province, Söke District, Dilek Peninsula National Park, Canyon), were published as a holotype and paratype. However, the holotype, described in detail and depicted by Kovařík et al. (2010, figs. 202–209, 211, table 10) (NMHW), in fact, was the adult male collected by E. A. Yağmur & V. Ülgezer on 13 August 2009 at 94 m asl, but *not* the subadult male collected by H. Koç on 18 June 2005 at 82 m asl as erroneously stated in Kovařík et al. (2010: 136). Two paratypes, 1 subadult ♂ and 1 ♀ (FKCP), listed in Kovařík et al. (2010: 151) as having the “same label as holotype” were also collected by E. A. Yağmur & V. Ülgezer on 13 August 2009 at 94 m asl. The current correction assigns the holotype status to the actual specimen used for description; this holotype is deposited in NMHW. The subadult male collected by H. Koç on 18 June 2005 (MTAS) belongs to the paratype series, which under the same label includes 5 subadult ♂, 9 adult ♀, and 1 subadult ♀ (Kovařík et al., 2010: 151).

We also correct here (and present on the map in Figure 3) the coordinates of type locality for *Protoiurus kadleci* (Kovařík et al., 2010) as: Turkey, Antalya Province, Akseki District, 10.5 km south of Akseki, Geriş, 36°58'37.27"N 31°43'18.12"E (36.9770°N, 31.7217°E), 847 m asl, 11–12 May 2006.