

The first Australasian species of the halophilic pseudoscorpion genus *Paraliochthonius* (Pseudoscorpiones: Chthoniidae)

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Abstract – The widespread halophilic genus *Paraliochthonius* Beier is recorded from Australasia for the first time, and two new species are recorded: *P. darwini* from tropical northern Australia and *P. vachoni* from New Caledonia. *Paraliochthonius darwini* is based upon several adults and a tritonymph, whilst *P. vachoni* is based on a male and a tritonymph. A key to the species of *Paraliochthonius* is presented, and the taxonomic status of *P. insulae* Hoff (from Jamaica), *P. puertoricensis* Muchmore (from Puerto Rico), *P. johnstoni* (Chamberlin) (from Mexico) and *P. mexicanus* Muchmore (from Mexico) is assessed, with *Paraliochthonius mexicanus* being removed from synonymy with *P. johnstoni* and regarded as a distinct species. New terms are proposed for two morphologies of the chelal teeth: diastemodentate for teeth in which a gap is present between adjacent teeth, and juxtadentate for teeth that are abutting each other.

Keywords: new species, morphology, taxonomy, Australia, New Caledonia

INTRODUCTION

Representatives of several pseudoscorpion genera occur exclusively in halophilic habitats. The genera *Paraliochthonius* Beier, 1956 (Vachon 1960; Beier 1963; Hoff 1963; Muchmore 1972; Lee 1979; Muchmore 1984b; 1994) (Chthoniidae), *Garypus* L. Koch, 1873 (Wagenaar-Hummelinck 1948; Beier 1963; Lee 1979) (Garypidae), *Anagarypus* Chamberlin, 1930 (Muchmore 1982) (Garypidae), *Halobisium* Chamberlin, 1930 (Schulte 1976) (Neobisiidae), *Parahya* Beier, 1957 (Harvey 1991b; Harvey *et al.* 2007) (Parahyidae), *Nipponogarypus* Morikawa, 1955 (Morikawa 1955) (Olpiidae), *Nannochelifer* Beier, 1967 (Beier 1967c; Harvey 1984) (Cheliferidae), *Epactiochernes* Muchmore, 1974 (Muchmore 1974) and *Mucrochernes* Muchmore, 1973 (Muchmore 1973, 1984a) are either totally or mostly restricted to sea-shore environments. In addition, individual species of other genera are endemic to intertidal habitats, including species of *Chthonius* C.L. Koch, 1843 (Hadži 1933) (Chthoniidae), *Neobisium* Chamberlin, 1930 (Gabbutt 1962, 1965, 1966) (Neobisiidae), *Pachyolpium* Beier, 1931 (Mahnert and Schuster 1981) (Olpiidae), *Serianus* Chamberlin, 1930 (Lee 1979) (Garypinidae), *Mexachernes* Hoff, 1947 (Lee 1979), *Parachernes* Chamberlin (Muchmore

and Alteri 1969) and *Pselaphochernes* Beier, 1932 (Beier 1956) (Chernetidae). The biological traits of littoral pseudoscorpions have been rarely studied, but notable studies include investigations into the ecology of *Neobisium maritimum* (Leach, 1817) by Gabbutt (1962, 1966) and of *Pachyolpium atlanticum* Mahnert and Schuster, 1981 by Mahnert and Schuster (1981), and a taxonomic and ecological review of the littoral pseudoscorpions of Baja California, Mexico (Lee 1979).

Recent collecting in intertidal habitats in tropical Australasia has revealed the first populations of the chthoniid genus *Paraliochthonius*, one on an off-shore island near the Kimberley coast in northern Western Australia, another at Darwin, Northern Territory, and a third on the south-western Pacific island of New Caledonia. These species, the first of the genus to be found in the Australasian region, are described in this contribution.

This paper is dedicated to Charles Robert Darwin (1809–1882) in recognition of his contributions to science.

MATERIAL AND METHODS

The specimens used in this study are lodged in

the American Museum of Natural History, New York (AMNH), the Museum and Art Gallery of the Northern Territory, Darwin (MAGNT), Muséum d'Histoire Naturelle, Geneva (MHNG), Muséum National d'Histoire Naturelle, Paris (MNHN) and the Western Australian Museum, Perth (WAM). The specimens were studied using temporary slide mounts prepared by immersion of specimens in lactic acid at room temperature for several days, and mounting them on microscope slides with 10 or 12 mm coverslips supported by small sections of 0.25, 0.35 or 0.50 mm diameter nylon fishing line. After study the specimens were returned to 75% ethanol with the dissected portions placed in 12 x 3 mm glass genitalia microvials (BioQuip Products, Inc.). Specimens were studied using a Leica MZ-16A dissecting microscope and Olympus BH-2 and Leica DM2500 compound microscope, the latter fitted with interference contrast, and illustrated with the aid of a drawing tube attached to the compound microscopes. Measurements were taken at the highest possible magnification using an ocular graticule. Terminology and mensuration mostly follow Chamberlin (1931), with the exception of the nomenclature of the pedipalps, legs and with some minor modifications to the terminology of the trichobothria (Harvey 1992).

The maps were produced with the computer program ArcMap 9.1 (ESRI, <http://www.esri.com>) after the relevant locality data were stored in an Access (Microsoft) database.

SYSTEMATICS

Family Chthoniidae Daday, 1888

Subfamily Chthoniinae Daday, 1888

Tribe Tyrannochthoniini Chamberlin, 1962

Tyrannochthoniini Chamberlin, 1962: 310; Muchmore, 1972: 249; Judson 2007: 57; Harvey 2009 [unpaginated].

Remarks

First proposed by Chamberlin (1962), the tribe Tyrannochthoniini was recently relimited and diagnosed by Judson (2007) to include six genera, *Lagynochthonius* Beier, 1951, *Maorichthonius* Chamberlin, 1925, *Paraliochthonius* Beier, 1956, *Troglochthonius* Beier, 1939, *Tyrannochthonius* Chamberlin, 1929 and *Vulcanochthonius* Muchmore, 2000, and was thoroughly diagnosed on a series of features including the presence of one or two rows of chemosensory setae on the dorsal surface of the chelal hand, coxal spines only present on coxae II; intercoxal tubercle absent; cuticle of anterior part of carapace very thin; submedian setae of anterior row

of carapace lost; lamina superior broad and strongly fimbriate; spinneret of movable finger of chelicera absent or a low tubercle; trichobothria *ib* and *isb* situated slightly proximad of middle of chelal palm; sensilla *p1* and *p2* of movable chelal finger separate (not contiguous); male sternite III elongate medially, with very long notch; epigeal species often with strong olive pigmentation. Many of these features are not found exclusively in the Tyrannochthoniini, and occur in other chthonioid pseudoscorpions.

Whilst based on only three species – *Tyrannochthonius* sp. from Colombia, *Lagynochthonius johni* (Redikorzev, 1922) from Indonesia, and a species of *Paraliochthonius* from north-western Australia, named in this paper as *P. darwini* – the molecular analysis by Muriene *et al.* (2008) found small support for a monophyletic Tyrannochthoniini. The best support for a clade containing these three species was found with a combined analysis using all three genes (CO1, 18S and 28S) and with the nuclear genes alone (18S and 28S), but not with the CO1 analysis. In the combined analysis and the analysis using the nuclear genes, the Tyrannochthoniini formed the sister-group to *Austrochthonius* + *Drepanochthonius*. *Paraliochthonius* formed the sister-group to *Tyrannochthonius* + *Lagynochthonius* in the combined analysis, but the nuclear genes analysis found *Paraliochthonius* grouping with *Lagynochthonius*, with *Tyrannochthonius* as the sister-group to these.

Chelal teeth morphology

Chthonioid pseudoscorpions have long been recognized as having differing tooth morphologies, which have been utilized at both specific and generic levels to distinguish between taxa. The terms homodentate, for teeth that are approximately equal sized throughout the length of the tooth row, or heterodentate, for teeth that have alternating sizes throughout the length of the tooth row, have been in use since Chamberlin (1929). There are also differences in the spacing of the chelal teeth, in which the teeth are either widely spaced such that a gap is present between most teeth, or in which the teeth are contiguous such that the teeth abut against each other. The terms 'diastemodentate' (*diastema*, Greek, space between, interval, and *dentatus*, Latin, tooth), and 'juxtadentate' (*juxta*, Greek, near, close, next to, nigh, and *dentatus*) (Greek and Latin translations from Brown 1956), are here proposed for these variant tooth morphologies.

Genus *Paraliochthonius* Beier, 1956

Paraliochthonius Beier, 1956: 58–59; Beier 1963: 76; Hoff 1963: 23; Muchmore 1972: 250–252; Murthy and Ananthakrishnan 1977: 12–13; Muchmore 1984: 121; Harvey 1991: 193; Gardini 1994: 1;

Harvey 2009 [unpaginated].

Morikawia Chamberlin, 1962: 311–312 (synonymised by Muchmore 1972: 250).

Stygiochthonius Carabajal Márquez, García Carrillo and Rodríguez Fernández, 2001: 8–9 (synonymised by Judson 2007: 58).

Type species

Paraliochthonius: *Chthonius singularis* Menozzi, 1924, by original designation.

Morikawia: *Chthonius johnstoni* Chamberlin, 1923, by original designation.

Stygiochthonius: *Stygiochthonius barrancoi* Carabajal Márquez, García Carrillo and Rodríguez Fernández, 2001, by original designation.

Diagnosis

Species of *Paraliochthonius* differ from other tyran-

nochthoniine chthoniids by the following combination of characters: antero-median seta of carapace not close to epistome (Figures 8, 20); internal margin of chelal hand with at least one, and usually two or more, enlarged spine-like setae which are not situated on greatly enlarged bases (Figures 12, 24).

Remarks

Eighteen species of *Paraliochthonius* are currently named (Harvey 2009; Table 1), and evidence is here provided for the recognition of two new species from Australasia, and for removing *P. mexicanus* Muchmore, 1972 from the synonymy of *P. johnstoni*, thus bringing the total to 21 species. A further 16 species have in the past been attributed to *Paraliochthonius* or its junior synonym *Morikawia* (Beier 1964, 1965, 1966, 1967a, 1967b, 1969, 1974b, 1974a, 1976, 1977), but these species

Table 1 List of named species of *Paraliochthonius*, and their distributions and habitat.

| Species | Distribution | Habitat |
|--|--|-------------|
| Europe (Figure 4) | | |
| <i>Paraliochthonius barrancoi</i> (Carabajal Márquez, García Carrillo and Rodríguez Fernández, 2001) | Spain (Andalucía) | Troglobitic |
| <i>Paraliochthonius singularis</i> (Menozzi, 1924) | Croatia, France (mainland), Greece, Italy (mainland, Sardinia, Sicily), Turkey | Epigean |
| Macaronesian Islands (Figure 5) | | |
| <i>Paraliochthonius canariensis</i> Vachon, 1961 | Spain (Canary Islands) | Epigean |
| <i>Paraliochthonius cavalensis</i> Zaragoza, 2004 | Portugal (Madeira) | Troglobitic |
| <i>Paraliochthonius curvidigitatus</i> (Mahnert, 1997) | Spain (Canary Islands) | Troglobitic |
| <i>Paraliochthonius hoestlandti</i> Vachon, 1960 | Portugal (Madeira) | Epigean |
| <i>Paraliochthonius martini</i> Mahnert, 1989 | Spain (Canary Islands) | Troglobitic |
| <i>Paraliochthonius mirus</i> Mahnert, 2002 | Spain (Canary Islands) | Troglobitic |
| <i>Paraliochthonius setiger</i> (Mahnert, 1997) | Spain (Canary Islands) | Troglobitic |
| <i>Paraliochthonius superstes</i> (Mahnert, 1986) | Spain (Canary Islands) | Troglobitic |
| <i>Paraliochthonius tenebrarum</i> Mahnert, 1989 | Spain (Canary Islands) | Troglobitic |
| Africa (Figure 2) | | |
| <i>Paraliochthonius azanius</i> Mahnert, 1986 | Kenya | Epigean |
| Caribbean, Mexico (Figure 3) | | |
| <i>Paraliochthonius carpenteri</i> Muchmore, 1984 | The Bahamas | Epigean |
| <i>Paraliochthonius insulae</i> Hoff, 1963 | Jamaica | Epigean |
| <i>Paraliochthonius johnstoni</i> (Chamberlin, 1923) | Mexico (Baja California Sur) | Epigean |
| <i>Paraliochthonius mexicanus</i> Muchmore, 1972 | Mexico (Jalisco) | Epigean |
| <i>Paraliochthonius puertoricensis</i> Muchmore, 1967 | Puerto Rico | Epigean |
| <i>Paraliochthonius weygoldti</i> Muchmore, 1967 | U.S.A. (Florida) | Epigean |
| Australasia (Figure 6) | | |
| <i>Paraliochthonius darwini</i> , sp. nov. | Australia (Northern Territory, Western Australia) | Epigean |
| <i>Paraliochthonius takashimai</i> (Morikawa, 1958) | Japan | Epigean |
| <i>Paraliochthonius vachoni</i> , sp. nov. | New Caledonia | Epigean |



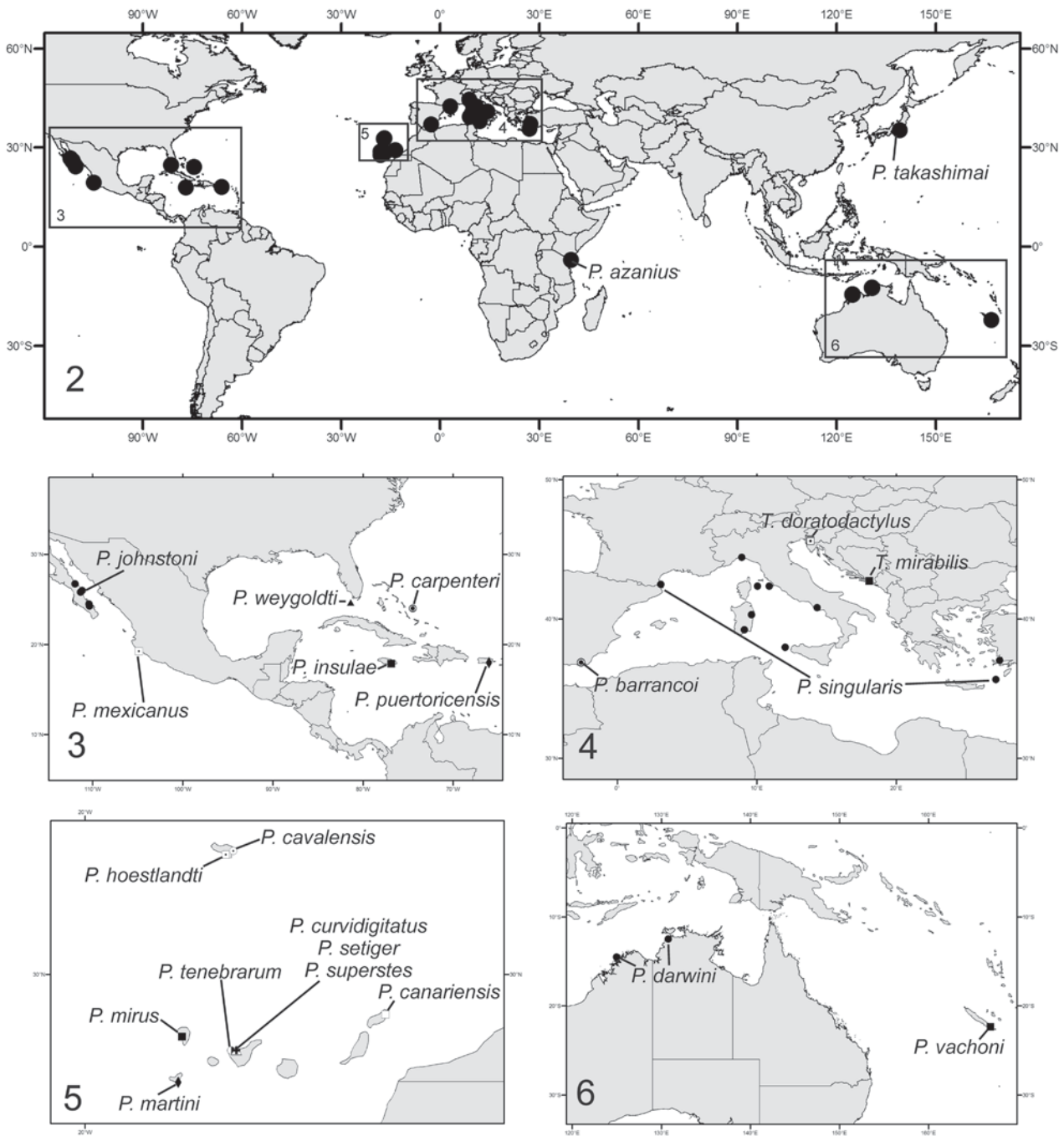
Figure 1 *Paraliochthonius darwini*, sp. nov., dorsal aspect of paratype male from Berthier Island, Western Australia (WAM T85186).

were subsequently transferred to *Tyrannochthonius* by Muchmore (1984b), Mahnert (1986) and Harvey (1989). Whilst our knowledge of the species included within *Paraliochthonius* is now sufficient that it can be readily distinguished from *Tyrannochthonius*, *Lagynochthonius*, *Vulcanochthonius* and *Maorichthonius* (Muchmore 1972, 1984b, 2000; Judson 2007), it has yet to be adequately distinguished from *Troglochthonius* which is known from two troglobitic species, the type species *T. mirabilis* Beier, 1939 from Bosnia-Herzegovina and Croatia, and *T. doratodactylus* Helversen, 1968 from Croatia and Italy (Figure 4). Helversen (1968), Muchmore (1972) and Judson (2007) noted the great resemblance between species of *Paraliochthonius* and *Troglochthonius*, with Muchmore (1972) even stating "It would seem preferable to consider *Troglochthonius* as a polyphyletic group (subgenus) of the genus *Paraliochthonius*...". This suggestion has not since been adopted and, in any case, *Troglochthonius* predates *Paraliochthonius* by 17 years so any form of synonymy would result in the priority of *Troglochthonius* over *Paraliochthonius* (Judson 2007). The similarity of the carapacal setation, especially with the anterior-median setae not being situated adjacent to the epistome, and the presence of large spines on the internal margin of the chelal hand suggests that they are very similar, if not synonymous. There appear to be very few

characters that distinguish the two genera (Judson 2007). Species of *Paraliochthonius* have homodontate chelal teeth, whereas species of *Troglochthonius* have heterodontate teeth. Tooth morphology is variable within other chthoniid genera which comprise both homodontate and heterodontate species, e.g. species of *Chthonius* (e.g. Beier 1963), *Lagynochthonius* (e.g. Harvey 1988) and *Tyrannochthonius* (e.g. Beier 1976; Edward and Harvey 2008). The first four tergites of *Paraliochthonius* usually have a setal formula of 4 (or very occasionally 3): 4: 4–6: 4–7, whereas both species of *Troglochthonius* have only 2 setae on each of tergite I–IV. This feature is also highly variable within other chthoniid genera, and is likely to represent a poor feature to define genera. The epistome of *Paraliochthonius* is usually prominent and triangular, being about twice as long as broad, whereas the epistome of *Troglochthonius* is either absent (Helversen 1968) or small (Beier 1939). A complete redescription of the type species of *Troglochthonius* is necessary before any such synonymy can be proposed.

The status of *Paraliochthonius mexicanus*

Paraliochthonius mexicanus was described by Muchmore (1972) from a single female collected at La Manzanilla, Bahía Tenacatita (19°17'N, 104°50'W), Jalisco, Mexico. It was compared with *P. johnstoni*, described from a single female from Puerto Escondido, Baja California Sur, Mexico (25°49'N, 111°19'W) by Chamberlin (1923) and later redescribed by Chamberlin (1962). Muchmore (1972) found *P. mexicanus* to be somewhat larger than *P. johnstoni*; for example, the chela length of the female holotype of *P. mexicanus* was reported as 1.08 mm (Muchmore 1972), whereas the female holotype of *P. johnstoni* was given as 0.761 mm (Chamberlin 1962). He also found differences in the size of the chelal hand, the more slender legs, and differences in the numbers of setae on tergites V–IX: 7: 7: 8: 7: 7 in *P. mexicanus* and 6: 6: 6: 6: 6 in *P. johnstoni*. Lee (1979) examined the holotype of *P. johnstoni* and found the chaetotaxy of tergites V–IX to be 7: 7: 7: 7: 7, thus diminishing some of the differences between these two species. Additional female specimens of *P. johnstoni* from Baja California were found to have 7–8: 8–10: 7–8: 7–8: 2P(1–2)P2 setae on tergites V–IX, and a chela length of 0.58–0.63 mm. Lee (1979) then synonymized *P. mexicanus* with *P. johnstoni*, claiming that the diagnostic features of *P. mexicanus* simply represented intraspecific variation. Despite the lack of any distinct differences in the tergal setal patterns of *P. johnstoni* and *P. mexicanus*, there seems to be sufficient evidence that the specimen from Jalisco represents a different species to that from Baja California. The lengths of the female pedipalpal chela, 1.08 mm in *P. mexicanus* and 0.58–0.76 mm in *P. johnstoni*, are sufficiently distinct from each other to suggest species differentiation. This



Figures 2–6 Maps showing known distribution of species of *Paraliochthonius* and *Trogllochthonius*: 2, World map showing *P. azanius* Mahnert and *P. takashimai* (Morikawa); 3, Central America showing *P. carpenteri* Muchmore, *P. insulae* Hoff, *P. johnstoni* (Chamberlin), *P. mexicanus* Muchmore, *P. puertoricensis* Muchmore and *P. weygoldti* Muchmore; 4, Mediterranean region showing *P. barrancoi* (Carabajal Márquez, García Carrillo and Rodríguez Fernández) and *P. singularis* (Menozzi); 5, Macaronesian Islands showing *P. canariensis* Vachon, *P. cavalensis* Zaragoza, *P. curvidigitatus* (Mahnert), *P. hoestlandti* Vachon, *P. martini* Mahnert, *P. mirus* Mahnert, *P. setiger* (Mahnert), *P. superstes* (Mahnert) and *P. tenebrarum* Mahnert; 6, Australasia showing *Paraliochthonius darwini*, sp. nov. and *P. vachoni*, sp. nov.

size difference is also accordance with differences reported between other species of *Paraliochthonius*. Therefore, I hereby remove *P. mexicanus* from the synonymy of *P. johnstoni*, and recognize it as a distinct species. Whilst *P. mexicanus* is ostensibly distinct from *P. johnstoni*, it is similar to several

other named species of the genus. For example, the chela length of 1.08 mm is similar to *P. carpenteri* Muchmore, 1984 (♀, 1.125–1.21 mm) from the Bahamas, *P. canariensis* Vachon, 1961 (♂, 0.94 mm) from the Canary Islands, *P. insulae* Hoff, 1963 (♀, 0.95 mm) from Jamaica and *P. puertoricensis*

Muchmore, 1967 (♂, 1.07–1.09 mm, ♀, 1.11 mm) from Puerto Rico. However, the presence of three thick spines on the internal margin of the chelal hand in *P. carpenteri* and *P. canariensis*, four thick spines in *P. insulae* and *P. puertoricensis*, and only two thick spines in *P. johnstoni* and *P. mexicanus* suggests that *P. mexicanus* is distinct from these taxa.

The status of *Paraliochthonius puertoricensis*

Paraliochthonius insulae was described from a single female from Jamaica (Hoff 1963) and *P. puertoricensis* from two males, a female and a tritonymph from Puerto Rico (Muchmore 1967), some 1,000 km apart. I have examined all four adult specimens (lodged in AMNH) and found that in most morphological features *P. insulae* and *P. puertoricensis* are virtually identical. The arrangement of the chelal spines on the internal margin of the chelal hand is the same, with 2 large spines basally, one near the base of the chelal fingers and another slightly more distally, even though the illustrations provided by Hoff (1963) and Muchmore (1967) do not adequately show these spines. The anterior eye of both species is large, with the posterior eye reduced (Hoff 1963; Muchmore 1967). The dorsum of the chelal hand and fixed chelal finger bears 22 chemosensory setae in all four adults. The only noticeable differences are in the shape of the chelal teeth, where every second tooth is smaller and medially offset in *P. puertoricensis*, and are not smaller or offset in *P. insulae*, and in the slightly larger size of *P. puertoricensis* [e.g. chela length 1.07–1.09 (♂), 1.11 (♀) mm] than *P. insulae* (e.g. chela length 0.95 (♀) mm). Further specimens of *Paraliochthonius* are required from the Caribbean region to assess whether these slight differences are adequate to support the recognition of two separate species.

KEY TO SPECIES OF *PARALIOCHTHONIUS*

1. Two pairs of eyes present, with at least the anterior eye represented by a distinct cornea..... 2
 Eyes absent, or with only 1 or 2 pairs of faint eye-spots; eyes never corneate 14
2. Internal margin of chelal hand with four thickened, anteriorly directed setae..... 3
 Internal margin of chelal hand with two or three thickened, anteriorly directed setae..... 4
3. Chela 1.07–1.09 (♂), 1.11 (♀) mm in length; chelal teeth of distal half of fixed finger with every second tooth smaller and offset to the medial side of the finger..... *P. puertoricensis* Muchmore, 1967 (Puerto Rico)

- Chela 0.95 (♀) mm in length; chelal teeth of distal half of fixed finger all equal sized.....
 *P. insulae* Hoff, 1963 (Jamaica)
4. Internal margin of chelal hand with three enlarged, thickened, anteriorly directed setae 5
 Internal margin of chelal hand with two enlarged, thickened, anteriorly directed setae 11
 5. Trichobothrium *sb* midway between *b* (formerly *st*) and *st* (formerly *b*); trichobothrium *ist* slightly basal to level of *eb* and *esb*
 *P. azanius* Mahnert, 1986 (Kenya)
 Trichobothrium *sb* closer to *b* (formerly *st*) than to *st* (formerly *b*); trichobothrium *ist* level with, or slightly distal to level of *eb* and *esb*... 6
 6. The three thickened, anteriorly directed chelal setae equidistant from one another 7
 The three thickened, anteriorly directed chelal setae with basal seta slightly further separated from others 8
 7. Posterior pair of eyes reduced to eye-spots.....
 *P. singularis* (Menozi, 1924) (Mediterranean region)
 Posterior pair of eyes corneate..... *P. carpenteri* Muchmore, 1984 (The Bahamas)
 8. Smaller species, e.g. movable chelal finger length 0.33 (♂), 0.35–0.38 (♀) mm
 *P. weygoldti* Muchmore, 1967 (Florida)
 Larger species, e.g. movable chelal finger length greater than 0.45 mm..... 9
 9. Teeth of both cheliceral fingers low and vestigial; smaller species, e.g. movable chelal finger length ca. 0.47 mm.....
 *P. darwini* sp. nov. (Australia)
 Teeth of both cheliceral fingers distinct; larger species, e.g. movable chelal finger length greater than 0.60 mm..... 10
 10. Chelal teeth closely spaced, with gaps between teeth smaller than width of tooth base.....
 *P. canariensis* Vachon, 1961 (Canary Islands)
 Chelal teeth widely spaced, with gaps between teeth greater than width of tooth base
 *P. mexicanus* Muchmore, 1972 (Mexico)
 11. Larger species, e.g. chela length greater than 1.00 mm and movable chelal finger length greater than 0.80 mm; chelal fingers with 34 (♂, ♀) teeth on fixed finger and 36 (♂, ♀) teeth on

- movable finger.....
 *P. hoestlandti* Vachon, 1960 (Madeira)
- Smaller species, e.g. chela length less than 0.95 mm and movable chelal finger length less than 0.75 mm; chelal fingers with fewer than 31 (♂, ♀) teeth on fixed finger and fewer than 30 (♂, ♀) teeth on movable finger..... **12**
12. Cheliceral palm with 4 setae [see Remarks on page 000].....
 *P. takashimai* (Morikawa, 1958) (Japan)
- Cheliceral palm with 5 setae..... **13**
13. Smaller species, e.g. chela length 0.58–0.76 (♀) mm in length; teeth of movable chelal finger erect and triangular; anterior setal row of carapace with 6 setae, including 1 pair of anterior-lateral setae
 *P. johnstoni* (Chamberlin, 1923) (Mexico)
- Larger species, e.g. chela length 0.91 (♂) mm in length; teeth of movable chelal finger low and retrorse; anterior setal row of carapace with 8 setae, including 2 pairs of anterior-lateral setae (Figure 20)
 *P. vachoni* sp. nov. (New Caledonia)
14. Both chelal fingers strongly curved mesally in dorsal view; base of movable chelal finger with strongly sclerotized apodeme; internal margin of chelal fingers with 1 small thickened seta.....
 ... *P. curvidigitatus* (Mahnert, 1997) (Canary Islands)
- Chelal fingers not strongly curved mesally in dorsal view; base of movable chelal finger without strongly sclerotized apodeme; internal margin of chelal fingers with 2 or more thickened setae..... **15**
15. Cheliceral palm with 5 setae..... **16**
- Cheliceral palm with 6 or 7 setae..... **20**
16. Larger species, e.g. movable chelal finger length greater than 1.30 mm in length..... **17**
- Smaller species, e.g. movable chelal finger length less than 1.20 mm in length..... **19**
17. Every second tooth of the fixed chelal finger smaller than other teeth and medially offset **18**
- Every second tooth of the fixed chelal finger not smaller than other teeth and not medially offset
 *P. mirus* Mahnert, 2002 (Canary Islands)
18. Larger species, e.g. chela ca. 2.7 (♂), 2.9–3.0 (♀) mm in length..... *P. barrancoi* (Carabajal

Márquez, Garcia Carrillo and Rodríguez Fernández, 2001) (Spain)

Smaller species, e.g. chela ca. 2.1–2.3 (♂), 2.3–2.6 (♀) in length *P. superstes* (Mahnert, 1986) (Canary Islands)

19. Larger species, e.g. movable chelal finger length 1.06 (♂) mm in length; chelal fingers with 42 (♂) teeth on fixed finger and 44 (♂) teeth on movable finger
 ... *P. martini* Mahnert, 1989 (Canary Islands)

Larger species, e.g. movable chelal finger length 0.88 (♂) mm in length; chelal fingers with 35 (♂) teeth on fixed finger and 37 (♂) teeth on movable finger *P. tenebrarum* Mahnert, 1989 (Canary Islands)

20. Chelal teeth homodontate; larger species, e.g. movable chelal finger length 1.41–1.49 (♀) mm in length; chelal fingers with 44–49 (♀) teeth on fixed finger and 45–47 (♀) teeth on movable finger
 .. *P. setiger* (Mahnert, 1997) (Canary Islands)

Chelal teeth heterodontate; smaller species, e.g. movable chelal finger length 0.89–0.99 (♀) mm in length; chelal fingers with 34 (♀) teeth on fixed finger and 35 (♀) teeth on movable finger
 *P. cavalensis* Zaragoza, 2004 (Madeira)

Paraliochthonius darwini sp. nov.
 Figures 1, 6–18

Paraliochthonius sp.: Murienne *et al.* 2008: 174.

Material examined

Holotype

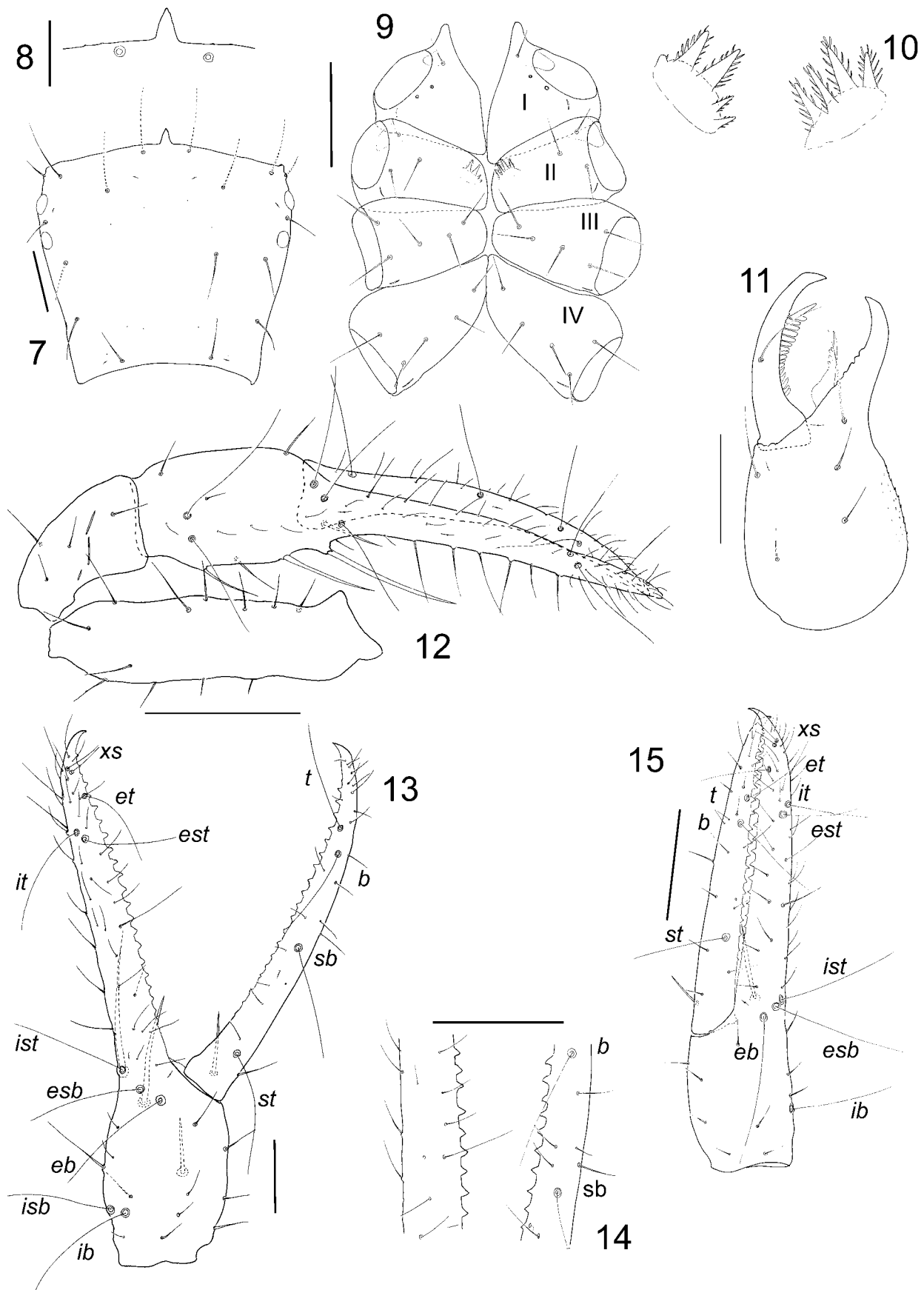
Australia: Western Australia: ♂, Berthier Island, 14°31'14.0"S, 124°59'08.8"E, 25 March 2007, under intertidal basaltic rocks, J.M. Waldock and K. Edward (WAM T66747).

Paratypes

Australia: Western Australia: 3 ♂, 2 ♀, collected with holotype (WAM T85182, T85183, T85186). **Northern Territory:** 1 ♂, 4 ♀, Plater Beach, west side of Darwin Harbour, 12°29.25'S, 130°46.55'E, 21 April 1999, J.K. Webber (MAGNT); 1 ♂, 3 ♀, 1 tritonymph, Doctors Gully, Darwin, 12°27'35"S, 130°49'57"E, 10 April 2007, under rocks in intertidal zone, M.S. Harvey (WAM T85184, T85185); 1 ♂, 1 ♀, same data (MNHN); 1 ♂, 1 ♀, same data (MHNG).

Diagnosis

Paraliochthonius darwini most closely resembles



Figures 7–15 *Paraliiochthonius darwini* sp. nov., paratype male (WAM T85182) unless stated otherwise: 7, carapace, dorsal aspect; 8, epistome, dorsal aspect; 9, coxae, ventral aspect; 10, coxal spines, ventral aspect; 11, left chelicera, dorsal aspect; 12, left pedipalp, dorsal aspect; 13, right chela, lateral aspect; 14, detail of chelal teeth; 15, left chela, lateral aspect, paratype tritonymph (WAM T85185). Scale lines = 0.05 mm (Figure 8), 0.1 mm (Figures 7, 9, 11, 13–15), 0.2 mm (12).

P. canariensis, *P. mexicanus* and *P. weygoldti* in the possession of two pairs of corneate eyes (Figure 7), three enlarged thickened, anteriorly directed setae on the internal margin of the chelal hand, of which the two distal setae are situated closer to each other than to the basal seta (Figures 12, 13), and trichobothrium *sb* closer to *b* (formerly *st*) than to *st* (formerly *b*) (Figure 13). It is larger than *P. weygoldti* (e.g. movable chelal finger length ca. 0.47 mm in *P. darwini* and less than 0.40 mm in *P. weygoldti*), but smaller than *P. canariensis* (e.g. movable chelal finger length 0.61 mm) and *P. mexicanus* (0.705 mm).

Description

Adults

Colour: uniformly light yellow brown (Figure 1).

Chelicera: 5 setae on hand, all setae acuminate (Figure 11); movable finger with 1 medial seta; fixed finger with 3 large teeth followed by 3 small teeth basally, movable finger without obvious teeth but with a row of small hyaline undulations; with 2 dorsal and 1 ventral lyrifissures; galea absent; rallum consisting of 8 blades, anterior blade long and finely denticulate, other blades bipinnate; scaly projections present on lateral edges of hand (Figure 11).

Pedipalp: all setae acuminate (Figure 12); trochanter 1.89 (♂), 1.71 (♀), femur 3.82 (♂), 3.87 (♀), patella 1.72 (♂), 1.89 (♀), chela 4.86 (♂), 4.85 (♀), hand 0.202 (♂), 1.24 (♀) × longer than broad; moveable finger 2.31 (♂), 2.69 (♀) × longer than hand, without large basal apodeme. Femur without tactile setae. Patella with three mediodorsal lyrifissures. Fixed chelal finger and hand with 8 trichobothria, movable chelal finger with 4 trichobothria (Figure 13): *ib* and *isb* situated close together, sub-medially on dorsum of chelal hand; *eb*, *esb* and *ist* forming an oblique row sub-laterally at base of fixed chelal finger; *it* and *est* situated sub-distally about one areolar diameter apart, *it* distal to *est*; *et* near tip of fixed finger, close to chelal teeth; *xs* situated distal to *et*, each seta shorter than those of other trichobothria; dorsum of chelal hand and fixed finger with a row of microsetae (chemosensory setae); trichobothrium *st* of movable finger situated sub-basally; *sb* situated slightly closer to *st* than to *b*; *b* and *t* situated sub-distally, *t* situated at same level as *est*; *b* situated basal to *est*. Internal margin of hand with 2 large and 1 smaller acuminate spine-like setae, 1 situated at level of *esb*, the second slightly posterior, and the third, which is smallest, situated medially on hand; inner margin of movable chelal finger with three small spines, largest basally. Single small sensillum situated proximal to *sb* (Figure 14). Venom apparatus absent. Chelal teeth homodontate and diastemodontate: fixed finger with 21 (♂), 22 (♀) acute teeth;

movable finger with 23 (♂), 24 (♀) acute, strongly diastemodontate; accessory teeth absent (Figure 14). External and internal chelal condyles small and rounded.

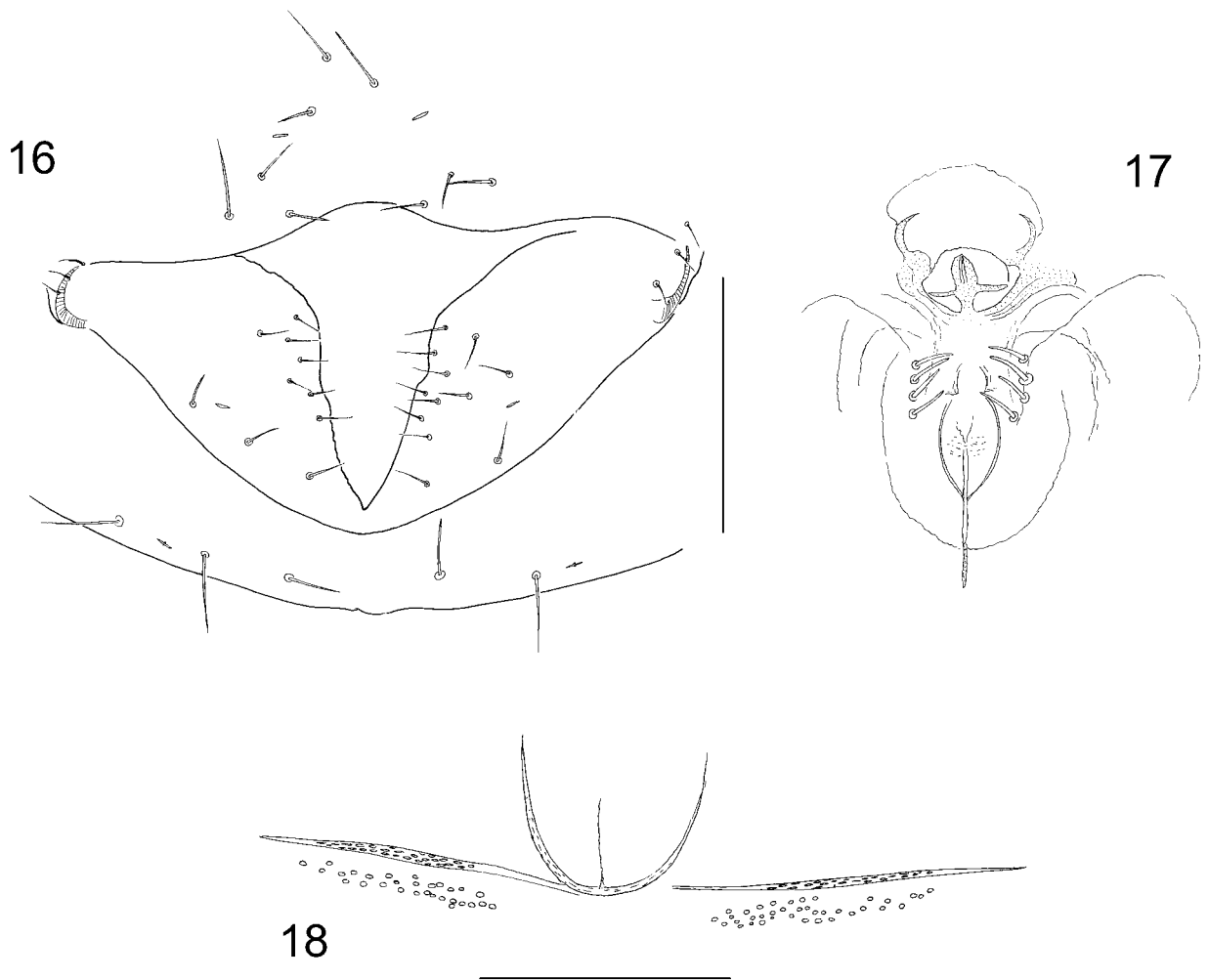
Cephalothorax: carapace 0.85 (♂), 0.82 (♀) × longer than broad; lateral margins constricted posteriorly; with four small corneate eyes (Figure 7); triangular epistome present, slightly longer than wide (Figure 8); with 18 or, occasionally 17, setae arranged 6: 4: 3–4: 2: 2; with very shallow furrow situated near posterior margin; the pre-ocular seta about 50% length of other setae in anterior row; antero-median seta not situated at base of epistome (Figure 7); with 3 pairs of small lyrifissures, first and second pairs situated in ocular row, third pair situated lateral to setae of posterior row. Chaetotaxy of coxae: 2+3: 3: 3: 5: 5 (Figure 9); manducatory process with 2 acuminate distal setae, anterior seta about 2/3 length of medial seta; pedipalpal coxa without dorsal setae; coxae II with 4 coxal spines on each side, set in oblique row (Figure 10), each spine with multiple incisions extending to base of spine; intercoxal tubercle absent (Figure 9); without sub-oral seta; coxa I with large, rounded apical projection (Figure 9); setae on coxa I situated near trochanteral foramen (Figure 9).

Abdomen: pleural membrane papillostriate. Tergites and sternites undivided; setae uniseriate and acuminate. Tergal chaetotaxy: holotype ♂, 4: 4: 4: 10: 10: 11: 11: 11: 10: 4: 4: 0; paratype ♀, 4: 4: 4: 10: 12: 11: 12: 11: 10: 4: T2T: 0. Sternal chaetotaxy: holotype ♂, 10: (3) 24 [4+4] (3): (3) 6 (3): 12: 12: 12: 13: 13: 9: –: 2; paratype ♀, 5: (3) 7 (3): (3) 6 (3): 12: 14: 15: 14: 14: 11: –: 2.

Genitalia: male genitalia with small ejaculatory atrium, lateral apodeme meeting in midline (Figure 17); glandular genital setae in 2 parallel rows of 4; sternite III with V-shaped opening (Figure 16). Female genitalia with incomplete lateral apodeme frame, lateral diverticulum densely cribrate (Figure 18).

Legs: femora I and II longer than patellae I and II; femora I and II with 1 small transverse lyrifissure situated sub-basally; femur + patella of leg IV 2.98 (♂), 2.67 (♀) × longer than broad; tibiae III and IV with 1 medial tactile seta; metatarsi III and IV with 2 seta longer than others; heterotarsate; subterminal tarsal setae not distally serrate; arolium same length as claws, not divided; claws simple.

Dimensions (mm): male holotype WAM T66747: Body length ca. 1.31. Pedipalps: trochanter 0.200/0.106, femur 0.416/0.109, patella 0.205/0.119, chela 0.685/0.141, hand length 0.202, movable finger length 0.466. Chelicera 0.366/0.179, movable finger length 0.200. Carapace 0.339/0.397. Anterior eye diameter 0.035, posterior eye diameter 0.027. Leg I: femur 0.494/0.048, patella 0.115/0.051, tibia 0.130/0.044, tarsus 0.250/0.037. Leg IV: femur +



Figures 16–18 *Paraliochthonius darwini* sp. nov.: 16, sternites II and III, ventral aspect, paratype male (WAM T85182); 17, genitalia, ventral aspect, paratype male (WAM T85182); 18, genitalia, ventral aspect, paratype female (WAM T85183). Scale lines = 0.1 mm (Figures. 16, 17), 0.2 mm (Figure 18).

patella 0.429/0.144, tibia 0.273/0.068, metatarsus 0.114/0.050, tarsus 0.248/0.040.

Dimensions (mm): female paratype WAM T85183: Body length 1.50. Pedipalps: trochanter 0.197/0.115, femur 0.426/0.110, patella 0.220/0.116, chela 0.688/0.142, hand length 0.176, movable finger length 0.474. Chelicera 0.378/0.190, movable finger length 0.206. Carapace 0.352/0.428. Anterior eye diameter 0.032, posterior eye diameter 0.035. Leg I: femur 0.311/0.059, patella 0.116/0.052, tibia 0.136/0.045, tarsus 0.248/0.037. Leg IV: femur + patella 0.379/0.142, tibia 0.278/0.071, metatarsus 0.112/0.055, tarsus 0.250/0.040.

Tritonymph

Colour: generally pale yellow orange, chelicera slightly darker.

Chelicera: 5 setae on hand, all setae acuminate; movable finger with 1 medial seta; galea represented by a slight bulge near sub-distal end of movable finger.

Pedipalp: femur 3.58, patella 1.73, chela 4.71, hand 1.39 x longer than broad; moveable finger 2.26 x longer than hand, without large basal apodeme. Fixed chelal finger and hand with 7 trichobothria, movable chelal finger with 3 trichobothria (Figure 15): *isb* and *sb* absent, *ib* situated sub-medially on dorso-lateral section of chelal hand; *eb*, *esb* and *ist* situated close together in an oblique row, sub-laterally at base of chelal fingers; *it* situated slightly distal to *est*, about one areolar diameter apart; *et* situated basal to *xs*, close to chelal teeth; *xs* situated sub-distally, each seta shorter than those of other trichobothria; row of microsetae (chemosensory setae) present on dorsum of hand and fixed finger; trichobothrium *st* of movable finger situated sub-basally; *b* situated sub-distally near *t*, ca. 4 areolar diameters apart; *t* at level of *it*. Hand with 2 large, medial acuminate spine-like setae at level of *eb* and *esb*. Venom apparatus absent. Chelal teeth homodontate and diastemodontate: fixed finger with 22 large, well-spaced, erect teeth; movable

finger with 18 well-spaced, slightly retrorse teeth; accessory teeth absent.

Cephalothorax: carapace 0.72 x longer than broad; lateral margins slightly constricted posteriorly; anterior eye corneate, posterior eye lens low; epistome triangular but small; with 18 setae arranged 6: 4: 4: 2: 2. Chaetotaxy of coxae: 2+3: 3: 3: 4: 4; coxae II with 3–4 coxal spines on each side, set in oblique row, each spine with multiple incisions extending to base of spine.

Abdomen: pleural membrane papillostriae. Tergites and sternites undivided; setae uniseriate and acuminate. Tergal chaetotaxy: 4: 4: 4: 7: 9: 10: 9: 9: 9: 2T2T2: 1T2T1: 0.

Dimensions (mm): tritonymph WAM T85184: Body length ca. 0.95. Pedipalps: femur 0.301/0.084, patella 0.163/0.094, chela 0.499/0.106, hand length 0.147, movable finger length 0.333. Carapace 0.283/0.181.

Remarks

Paraliochthonius darwini has been collected from two locations in northern Australia, one situated on Berthier Island, Western Australia, and the other in Darwin, Northern Territory. They were found under stones deeply embedded in the beach sand between the low and high tide marks. They began walking quickly on the wet rocks once exposed to light and air, seeking a place to find refuge. One specimen collected in Darwin was found with a small purple collembolan gripped by its chelicerae, which presumably represented a food item. The collembolan is too macerated for identification.

Specimens of *Paraliochthonius darwini* were utilized in the molecular analysis of Murienne *et al.* (2008).

Etymology

The specific epithet honours the great English naturalist Charles Robert Darwin (1809–1882) in honour of the 150th anniversary of the publication of the “The Origin of Species by Means of Natural Selection” (Darwin 1859) and the 200th anniversary of his birth. The species is also known from the city of Darwin, which was named for the naturalist by his former shipmate John Wickham.

Paraliochthonius vachoni sp. nov.

Figures 6, 19–30

Material examined

Holotype

New Caledonia: Province Sud: ♂, Port Boisé, 22°21'S, 166°58'E, 8 February 1993, under stones on beach, M.S. Harvey, N.I. Platnick, R.J. Raven (MNHN).

Paratypes

New Caledonia: Province Sud: 1 tritonymph, collected with holotype (MNHN).

Diagnosis

Paraliochthonius vachoni differs from all other species of the genus by the number of setae in the anterior setal row of the carapace, in which there are two pairs of lateral setae slightly anterior to the eyes (Figure 19). In addition, the eyes are large and prominent (Figure 19), and separated by less than the eye diameter.

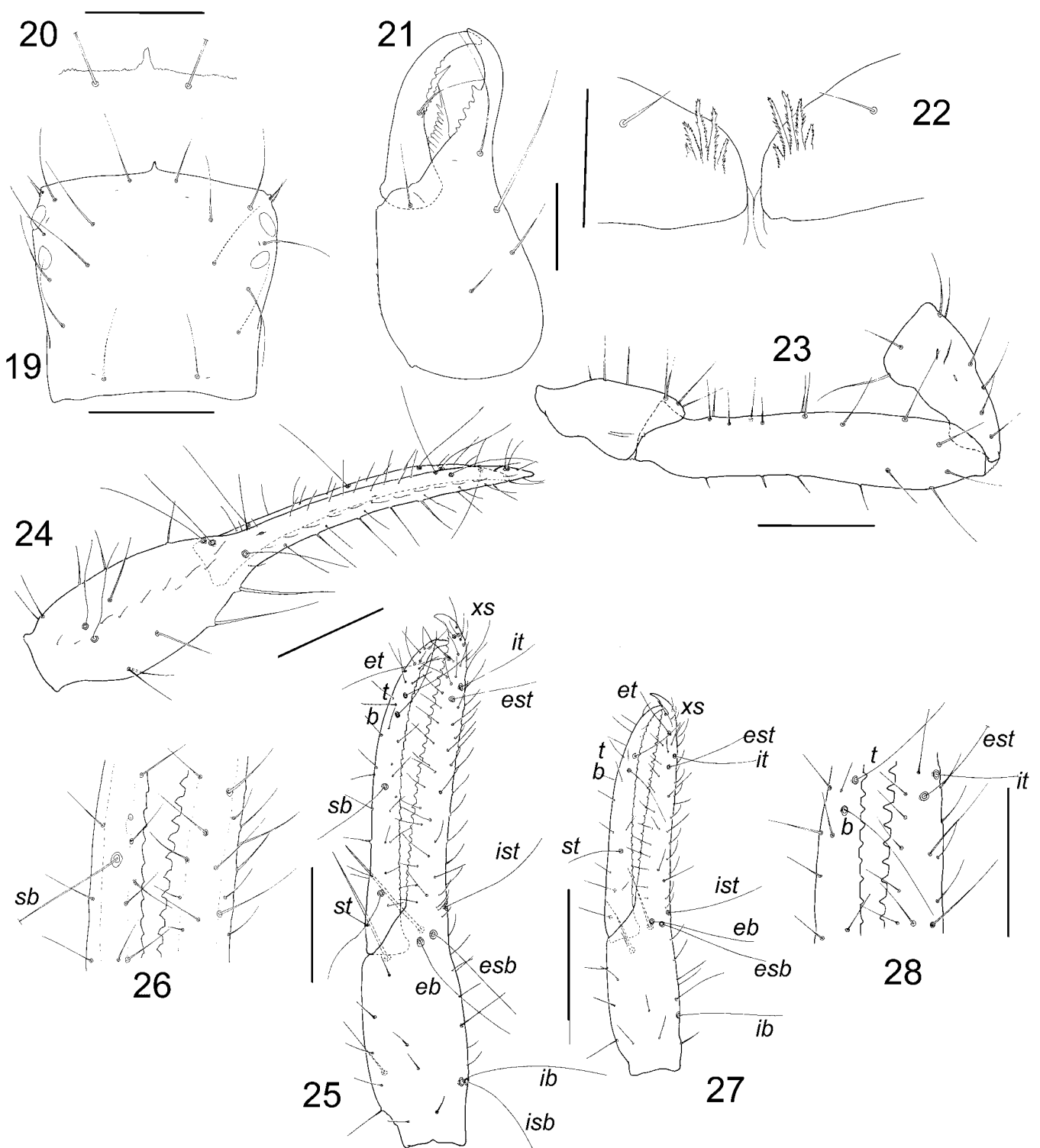
Description

Adult (male)

Colour: uniformly light yellow brown.

Chelicera: 5 setae on hand, all setae acuminate (Figure 21); movable finger with 1 medial seta; fixed finger with 6 teeth plus a small microdenticle at base, movable finger with 9 teeth; with 2 dorsal and 1 ventral lyrifissures; galea absent; rallum consisting of 7 blades, anterior blade long and finely denticulate, other blades bipinnate; scaly projections present on lateral edges of hand (Figure 21).

Pedipalp: all setae acuminate (Figures 23, 24); trochanter 1.95, femur 4.82, patella 2.11, chela 5.04, hand 1.88 x longer than broad; moveable finger 1.60 x longer than hand, without large basal apodeme. Femur without tactile setae. Patella with three mediodorsal lyrifissures. Fixed chelal finger and hand with 8 trichobothria, movable chelal finger with 4 trichobothria (Figure 25): *ib* and *isb* situated close together, sub-medially on dorsum of chelal hand; *eb*, *esb* and *ist* forming an oblique row sub-laterally at base of fixed chelal finger; *it* and *est* situated sub-distally about 2 areolar diameters apart, *it* distal to *est*; *et* near tip of fixed finger, close to chelal teeth; *xs* situated distal to *et*, each seta shorter than those of other trichobothria; 7 microsetae (chemosensory setae) present in longitudinal row on dorsum of chelal hand; trichobothrium *st* of movable finger situated sub-basally; *sb* situated slightly closer to *st* than to *b*; *b* and *t* situated sub-distally, *t* situated at same level as *est*. Internal margin of hand with 2 large and 2–3 smaller acuminate spine-like setae, 1 situated at level of *esb*, the second slightly posterior, and the others, which are smallest, situated medially on hand; inner margin of movable chelal finger with three small spines, largest basally. Single small sensillum situated distal to *sb* (Figure 26). Venom apparatus absent. Chelal teeth homodontate and diastemodontate (Figure 26): fixed finger with 31 erect, triangular teeth; movable finger with 29 mainly low retrorse teeth; accessory teeth absent. External and internal chelal condyles small and rounded.



Figures 19–28 *Paraliichthonius vachoni* sp. nov., holotype male unless stated otherwise: 19, carapace, dorsal aspect; 20, epistome, dorsal aspect; 21, left chelicera, dorsal aspect; 22, coxae II showing coxal spines, ventral aspect; 23, right pedipalpal trochanter, femur and patella, dorsal aspect; 24, left chela, dorsal aspect; 25, left chela, lateral; 26, detail of chelal fingers, lateral; 27, left chela, lateral, paratype tritonymph; 28, detail of chelal fingers, lateral, paratype tritonymph. Scale lines = 0.1 mm (20–22, 26, 28), 0.2 mm (Figures 23–25), 0.25 mm (Figures 19, 27).

Cephalothorax: carapace 0.88 x longer than broad; lateral margins slightly constricted posteriorly; with four large corneate eyes (Figure 19); triangular epistome present, longer than wide and with small teeth (Figure 20); with 20 setae arranged 8: 4: 4: 2: 2; with very shallow furrow situated near posterior margin; the pre-ocular seta about 50% length of other setae in anterior row; antero-median seta not situated at base of epistome; with 3 pairs of small lyrifissures, first and second pairs situated in ocular row, third pair situated lateral to setae of posterior row. Chaetotaxy of coxae: 2+3: 3: 3: 5: 5; manducatory process with 2 acuminate distal setae, anterior seta about 2/3 length of medial seta; pedipalpal coxa without dorsal setae; coxae II with 4 coxal spines on right coxa, 5 on left coxa, set in oblique rows (Figure 22), each spine long, with multiple incisions extending to base of spine (Figure 22); intercoxal tubercle absent; without sub-oral seta; coxa I with large, rounded apical projection; setae on coxa I situated near trochanteral foramen.

Abdomen: pleural membrane papillostriate. Tergites and sternites undivided; setae uniseriate and acuminate. Tergal chaetotaxy: 4: 4: 6: 7: 8: 8: 8: 8: 8: 4: T2T: 0. Sternal chaetotaxy: 9: (4) 22 [4+4] (4): (4) 6 (4): 10: 10: 10: 12: 12: 2T1T2: -: 2.

Genitalia: male genitalia with small ejaculatory

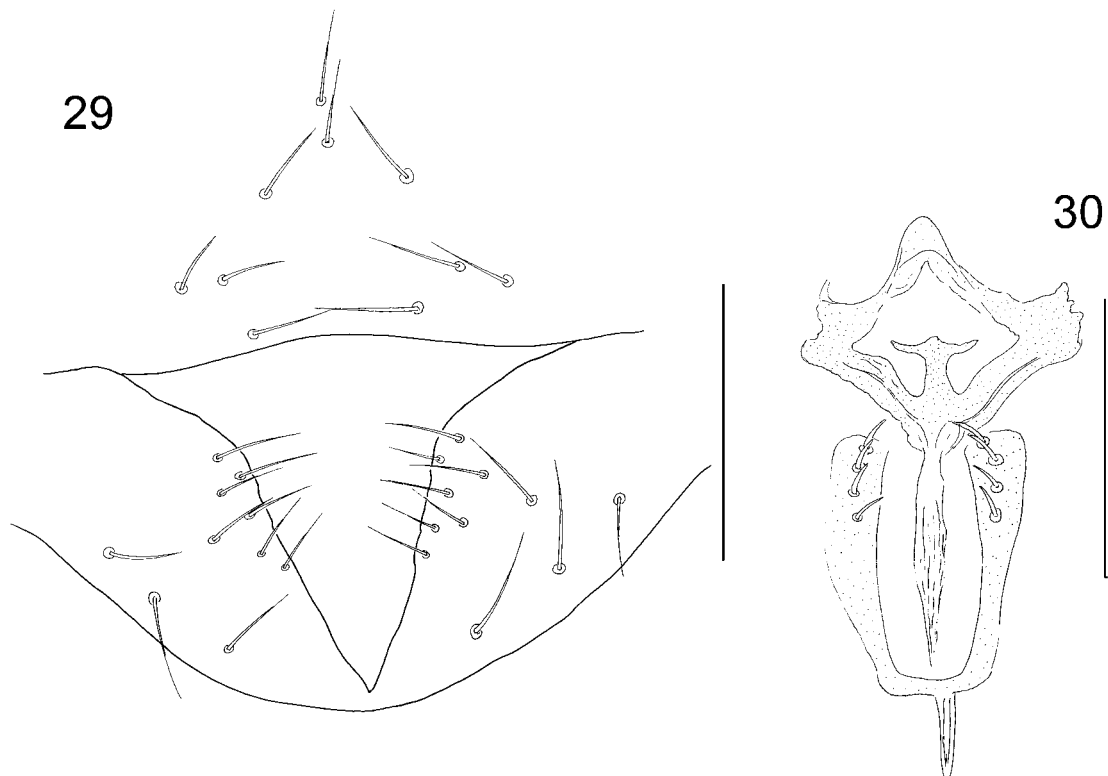
atrium, lateral apodeme meeting in midline (Figure 30); glandular genital setae in 2 parallel rows of 4 (Figure 30); sternite III with broad V-shaped opening, extending to posterior margin of sternite (Figure 29).

Legs: femora I and II longer than patellae I and II; femora I and II with 1 small transverse lyrifissure situated sub-distally; femur + patella of leg IV 2.92 x longer than broad; tibiae III and IV with 1 medial tactile seta; metatarsi III and IV with 2 setae longer than others; heterotarsate; subterminal tarsal setae not distally serrate; arolium same length as claws, not divided; claws simple.

Dimensions (mm): male holotype (MNHN): Body length 1.62. Pedipalps: trochanter 0.250/0.128, femur 0.602/0.125, patella 0.291/0.138, chela 0.907/0.180, hand length 0.339, movable finger length 0.544. Chelicera 0.458/0.207, movable finger length 0.243. Carapace 0.429/0.486. Anterior eye diameter 0.506, posterior eye diameter 0.464. Leg I: femur 0.355/0.070, patella 0.180/0.065, tibia 0.179/0.054, tarsus 0.347/0.045. Leg IV: femur + patella 0.589/0.202, tibia 0.397/0.086, metatarsus 0.140/0.067, tarsus 0.397/0.034.

Tritonymph

Colour: generally pale brown and yellow, chelicera slightly darker.



Figures 29–30 *Paraliochthonius vachoni* sp. nov., holotype male: 29, sternites II and III, ventral aspect; 30, genitalia, ventral aspect. Scale lines = 0.1 mm.

Chelicera: 5 setae on hand, all setae acuminate; movable finger with 1 medial seta; galea absent.

Pedipalp: femur 4.41, patella 2.03, chela 5.33, hand 1.78 x longer than broad; moveable finger 1.88 x longer than hand, without large basal apodeme. Fixed chelal finger and hand with 7 trichobothria, movable chelal finger with 3 trichobothria (Figure 27): *isb* and *sb* absent, *ib* situated sub-medially on dorso-lateral section of chelal hand; *eb*, *esb* and *ist* situated close together in an oblique row, sub-laterally at base of chelal fingers; *it* situated slightly distal to *est*, about one areolar diameter apart; *et* situated basal to *xs*, close to chelal teeth; *xs* situated sub-distally, each seta shorter than those of other trichobothria; a row of microsetae (chemosensory setae) present on dorsum of chelal hand; trichobothrium *st* of movable finger situated sub-basally; *b* situated sub-distally near *t*, ca. 4 areolar diameters apart; *t* at level of *it*. Hand with 2 large, medial acuminate spine-like setae. Venom apparatus absent. Chelal teeth mainly homodentate, and always diastemodentate (Figure 28): fixed finger with 19 large, well-spaced, erect teeth, plus several small denticles basally; movable finger with 20 well-spaced, retrorse teeth; accessory teeth absent.

Cephalothorax: carapace 0.87 x longer than broad; lateral margins slightly constricted posteriorly; with 2 large eyes; epistome triangular; with 20 setae arranged 8: 4: 4: 2: 2. Chaetotaxy of coxae: 2+3: 3: 3: 4: 4; coxae II with 4 coxal spines on each side, set in oblique row, each spine with multiple incisions extending to base of spine.

Abdomen: pleural membrane papillostriate. Tergites and sternites undivided; setae uniseriate and acuminate. Tergal chaetotaxy: 4: 4: 5: 7: 7: 8: 8: 8: 8: 4: T2T: 0.

Dimensions (mm): tritonymph paratype: Body length ca. 1.18. Pedipalps: femur 0.397/0.090, patella 0.211/0.104, chela 0.613/0.115, hand length 0.205, movable finger length 0.385. Chelicera length 0.339/0.162; movable finger 0.192. Carapace 0.329/0.378.

Remarks

The two specimens of *Paraliochthonius vachoni* described here were collected under a rock on the beach at Port Boisé, situated near the southern tip of New Caledonia. It appears to be most similar to *P. johnstoni* from western Mexico, and *P. takashimai* from Japan, as all three species have two pairs of eyes, two enlarged, thickened, anteriorly directed setae on the internal margin of the chelal hand, chela less than 0.95 mm in length and movable chelal finger length less than 0.75 mm, and the chelal fingers with fewer than 31 (♂, ♀) teeth on the fixed finger and fewer than 30 (♂, ♀) teeth on the movable finger. It is larger than *P. johnstoni*

[e.g. chela 0.91 (♂) mm in length, versus 0.58–0.76 (♀) mm], the teeth of the movable chelal finger are low and retrorse (versus erect and triangular in *P. johnstoni*), and the anterior setal row of carapace has eight setae, including two pairs of anterior-lateral setae, rather than just six setae in *P. johnstoni*. The cheliceral palm of most tyrannochthoniine pseudoscorpions bears five setae, but Morikawa (1958) reported just four setae, and reaffirmed this number of setae in a letter to Dr J.C. Chamberlin (see Chamberlin 1962). It is highly unlikely that this setal number is correct, and that Dr Morikawa may have misinterpreted the setal pattern (Dr M. Judson, in litt.). If this is the case, then Couplet 12 of the key presented in this paper may not work properly. A more detailed description of *P. takashimai* is required to establish how it differs from other species of the genus.

Etymology

The specific epithet honours Professor Max Vachon (1908–1991) for his outstanding contributions to the study of arachnids, including significant studies on the genus *Paraliochthonius* (Vachon 1960, 1961).

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