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An anomalous spermathecae resolved after moulting events in a female of *Hapalopus* Ausserer, 1875 with a review of spermathecal anomalies in theraphosid spiders (Araneae: Theraphosidae)

Danniella Sherwood[1]*, Ray Gabriel[1], Sylvia M. Lucas[2] & Antonio D. Brescovit[2]

[1] Arachnology Research Association, United Kingdom.
[2] Laboratório de Coleções Zoológicas, Instituto Butantan, Av. Vital Brasil, 1500, São Paulo, Brazil.
* Corresponding author: danni.sherwood@hotmail.com

Abstract: A theraphosid spider of the genus *Hapalopus* Ausserer, 1875 previously regarded as having a conjoined spermatheca was re-examined after death and found to actually have a typical spermatheca. This interesting finding is discussed within the constraints of the currently scanty knowledge of anomalies in theraphosid spiders, and a review of prior cases of anomalous spermathecae reported in the literature is presented.
Key words: Araneae, Theraphosidae, morphology, anomalies, conjoining, injury, healing.

Una espermateca anómala explicada tras la muda en una hembra de *Hapalopus* Ausserer, 1875, y revisión de las anomalías en las espermatecas de arañas terafósidas (Araneae: Theraphosidae)
Resumen: Una araña terafósida del genero *Hapalopus* Ausserer, 1875 que primeramente se consideró que tenía una espermateca con un lóbulo supernumerario fusionado fue reexaminada después de su muerte y se encontró que en realidad tenía una espermateca típica. Se discute este interesante hallazgo dentro de las limitaciones del escaso conocimiento actual de las anomalías en los terafósidos, y se presenta una revisión de todos los casos previos de espermatecas anómalas reportados en la literatura.
Palabras clave: Araneae, Theraphosidae, morfología, anomalías, conjunción, lesión, cicatrización.

Introduction

Gabriel & Sherwood (2020a) presented two cases of spermathecal conjoining in theraphosid spiders, building on previous works (Lucas *et al*., 2009; Gabriel, 2011a, 2011b). One of the specimens reported in this work was a (at the time of the previous work, alive) female specimen of the genus *Hapalopus* Ausserer, 1875 which was a stowaway imported into the United Kingdom in a shipment of bananas from Colombia. On its initial arrival to the United Kingdom in 2013, the specimen was drab yellow and black in colouration (Fig. 1) but soon underwent ecdysis (Fig. 2) and its colour brightened (Fig. 3) showing that colouration is variable during the ecdysial cycle. At this stage, the exuvia was examined and the spermathecae found to be anomalous, this subsequently being reported in Gabriel & Sherwood (2020a).

After its first ecdysis in captivity, the specimen had then undergone ecdysis annually thereafter. The second, third, fourth and fifth exuviae (discarded by the specimen in 2014, 2015, 2016 and 2017 respectively) also showed the anomaly but two later exuviae (in 2018 and 2019, the latter being the final ecdysis undergone by the specimen before death) were not interpretable due to both having been partially eaten and thus the opisthosomal skin and associated structures destroyed.

On 15/05/2020 the specimen was found deceased in its enclosure by DS and RG. Given that this specimen was adult when it was discovered as a stowaway in the UK, it is likely the specimen was in excess of 10 years old at the time of its death. However, its exact age cannot be determined with the available data. Nonetheless, the death of the specimen presented the opportunity for the spermathecae to be dissected and compared against previous findings.

In this work, we report the results of examination of the specimen after death and review prior cases of spermathecal anomaly reported in theraphosid spiders in the published literature.

Material and methods

Photographs of the newly non-anomalous spermathecae of *Hapalopus* sp. were made using a Canon EOS 6D Mark II attached to a Leica MZ12.5 stereomicroscope, with images stacked using Helicon Focus software. The spermathecae was dissected from the specimen using a micro scalpel and immersed in 70% EtOH for observation and imaging. All other photographs of spermathecae in this work were extracted from the original files used in the corresponding original articles and were adapted herein. The photograph of the spermathecae of *N. tripartitus* (Fig. 16) is reproduced here with permission from Peter Jäger (SMF). Specimens indicated without a museum acronym or accession number in their corresponding captions are specimens currently deposited in the private collection of RG. Abbreviations: MCZ = Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, United States; MCN = Museu de Ciencias Naturais, Secretaria do Meio Ambiente e Infraestrutura, Rio Grande do Sul; SMF = Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany. Due to a lack of knowledge of its true wild locality, and the general homogeneity that is found interspecifically in many *Hapalopus* spermathecae, the specimen discussed herein cannot be definitively determined at the species level at present.

Results

Following dissection of the specimen of *Hapalopus* sp. postmortem, the spermathecae was now found to be non-anomalous in its morphology (Figs 4–5) and unlike the initial anomaly observed on the bottom left of the spermathecal receptacle in several prior exuviae (e.g. Figs. 6–7; Gabriel & Sherwood, 2020a: 28, figs. 2–3). The incongruence between the anomalous spermathecae in the earlier exuviae and the non-anomalous spermathecae in the specimen at death could be a result of the healing process, which may have begun gradually following the discarding of subsequent exuviae (hence not being noticeable in the second to fifth exuviae). However, this explanation cannot be proven definitively at present due to examination of only a limited amount of material derived from a single specimen, and therefore we present it merely as a hypothesis for future consideration. Nonetheless, we are unaware of any prior reports in the literature of a theraphosid specimen with anomalous spermathecae subsequently undergoing ecdysis on multiple occasions and then no longer presenting the anomaly at death. Therefore, we report this herein so that this information is available to future workers.



Figs. 1–7: Stowaway *Hapalopus* sp. adult female imported with bananas from Colombia, **1–3** habitus in vivo, 2013, **1** prior to ecdysis, **2** immediately following ecdysis, **3** several days following ecdysis, **4–5** spermathecae of specimen dissected postmortem, 2021, **4** dorsal view, **5** apical view, **6–7** spermathecae of specimen dissected from discarded exuvia, 2013, **6** dorsal view (area of receptacle anomaly indicated by arrow), **7** apical view (area of receptacle anomaly indicated by arrow). Scale bars (4–7) = 1mm.

Discussion

Lucas, Brescovit & Paula (2009) were the first authors to recognise and report an anomalous theraphosid spermathecae in the literature. In their work, they illustrated two anomalous duplicated receptacles in a female of *Acanthoscurria suina* Pocock, 1903 (now *Acanthoscurria cordubensis* Thorell, 1894) in addition to anomalies in the size and shape of the typical receptacles. A few years later, Gabriel (2011a) reported two anomalous spermathecae in the theraphosid species *Acanthoscurria sternalis* Pocock, 1903 (now *Acanthoscurria musculosa* Simon, 1892) and *Grammostola rosea* (Walckenaer, 1837) respectively, each possessing an anomalous duplicated receptacle on the left-hand side of the spermathecae. In the *A. musculosa* specimen the left-hand typical receptacle is shorter than the right-hand typical receptacle, and the apical lobe of the left-hand typical receptacle is abnormal in shape. Therefore, the *A. musculosa* specimen reported by Gabriel (2011a) and the *A. cordubensis* specimen reported by Lucas, Brescovit & Paula (2009) exemplify that in addition to the anomalous duplicated receptacle(s), additional anomalies can also be present in the typical receptacles of the spermathecae in some specimens.

Gabriel (2011b) presented a photograph of the ventral aspect of the spermathecae of the previously reported female of *G. rosea* from his previous work of that year (Gabriel, 2011a) and a photograph (taken by Peter Jäger) of the spermathecae of the holotype female exuvia of *Nhandu tripartitus* Schmidt, 1997. The holotype of *N. tripartitus* has an anomalous duplicated receptacle on the left-hand side of the spermathecae. Günter Schmidt had failed to recognise the spermathecae was anomalous and had instead described the specimen as a new species, defined based on the presence of three spermathecal receptacles (ultimately, Gabriel (2011b) concluded that *N. tripartitus* was a junior synonym of *Nhandu carapoensis* Lucas, 1983). At the time of Schmidt's work, no known cases of spermathecal anomaly in theraphosid spiders appear to have been published in the literature and had Schmidt noticed that this specimen was anomalous, he could have likely contributed the first published report of this. The spermathecae is present on a microscope slide in the SMF collections but because the opisthosomal skin from the ventral aspect of the spermathecae has been dissected, it is very difficult to determine whether the photograph was taken from a true dorsal or ventral aspect. Removal of the ventral skin behind the spermathecae of theraphosids during dissection is unnecessary as there is a method to view the ventral spermathecae without fully dissecting it from the ventral skin (see Sherwood & Gabriel, 2020). Furthermore, removal of the ventral skin can make orientation of a spermathecae difficult to interpret (unless orientation is known at time of dissection or some remnants of the ventral skin remain attached after dissection), potentially not allowing for consistent interpretation and measurement of morphometric characters in taxa where the structures of the dorsal and ventral spermathecae may be very similar.

Gabriel & Sherwood (2020a) reported several new anomalies within theraphosid spiders including anomalous spermathecae in *Davus ruficeps* (Simon, 1891) and an undetermined species of

Table I. A summary of all prior-reported cases of spermathecal anomalies in theraphosid spiders

Name of taxon at time of original work	Current name of taxon	Original work reporting anomaly	Classification of anomaly	Notes
Acanthoscurria suina Pocock, 1903	*Acanthoscurria cordubensis* Thorell, 1894	Lucas *et al*. (2009)	Two anomalous duplicated receptacles and further anomaly in the size and shape of both typical receptacles.	
Acanthoscurria sternalis Pocock, 1903	*Acanthoscurria musculosa* Simon, 1892	Gabriel (2011a)	Single anomalous duplicated receptacle and further anomaly in the size and shape of the left-hand typical receptacle.	Figure caption in Gabriel (2011a) erroneously reads "*Acanthoscurria suina*" but the main body of text correctly uses *A. sternalis*.
Grammostola rosea (Walckenaer, 1837)	Unchanged	Gabriel (2011a, 2011b)	Single anomalous duplicated receptacle	Dorsal view presented in Gabriel (2011a), ventral view presented in Gabriel (2011b) although erroneously listed as "dorsal view" in figure caption of Gabriel (2011b).
Nhandu tripartitus Schmidt, 1997	*Nhandu carapoensis* Lucas, 1983	Gabriel (2011b)	Single anomalous duplicated receptacle	
Davus ruficeps (Simon, 1891)	Unchanged	Gabriel & Sherwood (2020a)	Anomalous area on typical receptacle	
Hapalopus sp.	Unchanged	Gabriel & Sherwood (2020a)	Anomalous area on typical receptacle	Novel discussion relating to this specimen is reported in the main text of this work.
Psalmopoeus copanensis Gabriel & Sherwood, 2020	Unchanged	Gabriel & Sherwood (2020b)	Single anomalous duplicated receptacle	

Hapalopus Ausserer, 1875 (= the specimen revisited in this work). In both taxa, the normal character state is a single, fused, receptacle but in both anomalous spermathecae there was an abnormal growth emergent from one part of the receptacle, giving the appearance of a malformed second receptacle. In the same year, Gabriel & Sherwood (2020b) described several new psalmopoine species, including *Psalmopoeus copanensis* Gabriel & Sherwood, 2020 from Honduras. *P. copanensis* was described based on a holotype female from Copán, Honduras held in the MCZ collections, and this specimen has an anomalous duplicated receptacle on the right-hand side of the spermathecae. However, it is important to note the taxonomic features used to delineate this species from congeners were interpreted from the left-hand (typical) receptacle of the spermathecae, which is non-anomalous. A summary of all prior-reported cases of spermathecal anomalies in theraphosid spiders is summarised in Table I.

In the present contribution, it was demonstrable that the anomaly previously present in the spermathecae of *Hapalopus* sp. resolved after several subsequent ecdyses. It is probable that the case of *D. ruficeps* (Fig. 18) may represent a similar anomaly (consisting of an abnormal area of growth on the receptacle). However, as the *D. ruficeps* specimen is already preserved in ethanol it is of course impossible to see if this anomaly would resolve over time.

Gabriel & Sherwood (2020a) postulated that injuries during mating may contribute to some instances of spermathecal anomaly. We cannot eliminate the possibility that the specimen could have copulated in the wild with a male, sustaining an injury that resulted in the spermathecal anomaly later observed during its life in captivity. However, this is purely speculative and we cannot state it with certainty.

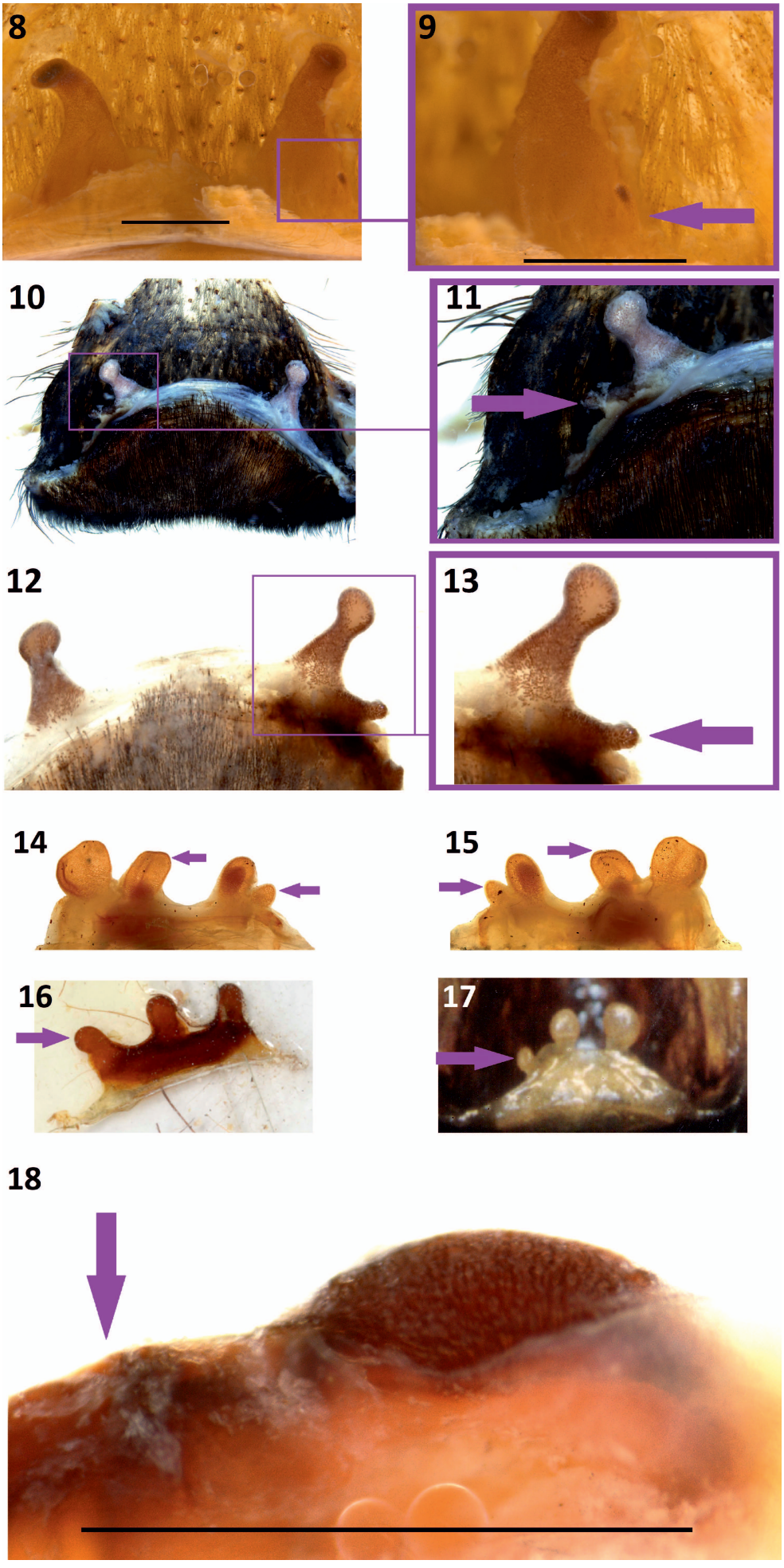
It is thus clear that whilst research within the last decade has advanced our knowledge of anomalies in theraphosid spermathecae, much is still to be discovered, especially in regards to definitively establishing any particular causes or mechanisms. It is our hope that this work will encourage more research contributions in this area by future workers. Finally, we stress the importance of recognising anomalies in theraphosid spiders and mitigating the likelihood of the inadvertent use of anomalous anatomic features in the diagnoses and delineation of specimens.

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► **Figs. 8–13:** Examples of anomalous spermathecae in theraphosid spiders, adapted from the published literature, **8–9** *Psalmopoeus copanensis* Gabriel & Sherwood, 2020 holotype female (MCZ 746617), **8** spermathecae dorsal view, **9** inset, close up of anomalous duplicated receptacle (indicated by arrow), **10–13** *Grammostola rosea* (Walckenaer, 1837) non-type female, **10** spermathecae dorsal view, **11** inset, close up of anomalous duplicated receptacle (indicated by arrow), **12** spermathecae ventral view, **13** inset, close up of anomalous duplicated receptacle (indicated by arrow). Scale bars (8–9) = 1mm.

► **Figs. 14–18:** Further examples of anomalous spermathecae in theraphosid spiders, adapted from the published literature, **14** *Acanthoscurria cordubensis* Thorell, 1894 (as *Acanthoscurria suina* Pocock, 1903 in original report by Lucas, Brescovit & Paula, 2009) non-type female (MCN 0981) spermathecae dorsal view (anomalous duplicated receptacles indicated by arrows), **15** *Acanthoscurria cordubensis* Thorell, 1894 (as *Acanthoscurria suina* Pocock, 1903 in original report by Lucas, Brescovit & Paula, 2009) non-type female (MCN 0981) spermathecae ventral view (anomalous duplicated receptacles indicated by arrows), **16** *Nhandu tripartitus* Schmidt, 1997 (= *Nhandu carapoensis* Lucas, 1983) holotype female exuvia (SMF 57970-84) slide containing dissected spermathecae (anomalous duplicated receptacle indicated by arrow; photo courtesy of Peter Jäger), **17** *Acanthoscurria musculosa* Simon, 1892 (as *Acanthoscurria sternalis* Pocock, 1903 in original report by Gabriel, 2011b) non-type female, spermathecae dorsal view (anomalous duplicated receptacle indicated by arrow), **18** *Davus ruficeps* (Simon, 1891) non-type female, spermathecae dorsal view (area of receptacle anomaly indicated by arrow). Scale bar (18) = 1mm.


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