Life History and Distribution of the Arctic Pseudoscorpion, *Wyochernes asiaticus* (Chernetidae)

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The Pseudoscorpiones are a remarkable yet understudied order of arachnids. The northernmost species in North America, *Wyochernes asiaticus* (family Chernetidae), occurs under rocks beside rivers or creeks and can be found above the Arctic Circle in Canada. In North America, the species is limited to the northwest, although its global distribution includes parts of Asia. It is presumably a Beringian species with quite specialized habitat affinities. I report on some life history traits of this species, based on examination of nearly 600 specimens from 16 localities in the Yukon and Northwest Territories. All life stages were collected. Of the females, 17% were carrying brood sacs, with an average of 10.5 eggs per brood sac; larger females tended to have larger clutch sizes. Despite these data on the natural history and distribution of *W. asiaticus*, its phylogeographic history and how the species feeds, disperses, and recolonizes habitats after flooding remain largely unknown.

Key Words: *Wyochernes asiaticus*; Arachnida; natural history; biogeography; Pseudoscorpiones; Yukon Territory; Northwest Territory; Arctic

Introduction

According to Tschinkel and Wilson (2014: 442), "the story of any species chosen at random is an epic, filled with mysteries and surprises that will engage biologists for generations to come." In that essay, the authors argue for the value of knowing the natural history of species and how that knowledge is fundamental to progress in biology. Tewksbury *et al*. (2014) support this view and also argue that science and society's well-being is dependent on knowledge about natural history. That said, discovering, observing, and collecting data about "basic" life history is far from easy and seldom funded by major research grants. Furthermore, life-history data for arthropods are scarce in part because of their overwhelming diversity and relatively few specialists. This is apparent for the "neglected cousins" within the Arachnida (Harvey 2002), including the relatively small order Pseudoscorpiones.

There are over 3000 known Pseudoscorpiones species (Harvey 2002), but searching the literature for published accounts of their natural history and biology yields relatively few citations, and most describe tropical species (e.g., Zeh and Zeh 1992). One North American exception is the detailed account of *Microbisum confusum* by Nelson (1982), in which he counts, describes, and measures thousands of specimens and provides insights into the phenology and life history of the species. A text by Legg and Jones (1988) is also notable: this gem of a book lists the distribution and natural history of pseudoscorpions occurring in the United Kingdom. This information is far ahead of that for pseudoscorpions in any other region of the world.

Looking to northern North America, Canada is probably home to over 30 species of pseudoscorpions (Buddle 2010), but only a few species reach the northern boreal zone and beyond. *Microbisium brunneum* is a clear exception, as it has been recorded from sphagnum moss in relatively northern locations (Koponen and Sharkey 1988). In 1990, V. Behan-Pelletier collected a pseudoscorpion just north of the Arctic Circle (at 66.80°N, at Sheep Creek in the Yukon†), and Muchmore (1990) described the species as *Wyochernes arcticus*, new to science. Based on comparisons with Old World specimens, Muchmore (1996) later concluded that *W. arcticus* was the same as *W. asiaticus* (Redikorzev, 1922), which is found throughout central Asia through to Siberia. The type locality of *W. asiaticus* is in Tibet.

As part of other ongoing Arctic research (e.g., Bowden and Buddle 2012), I visited Sheep Creek in 2008 and found additional specimens of *W. asiaticus.* True to the description provided by Muchmore (1990), flipping rocks at the river's edge revealed dozens of specimens. Return trips to the Yukon in later years allowed for the collection of additional specimens from more localities in the Yukon and Northwest Territories.

Wyochernes asiaticus is a charming arachnid (Figure 1), occupying extreme environments in unusual habitats. The river beds where the species exists flood seasonally and are extremely remote. To my knowledge,

†The published locality (Muchmore 1990), 69.17°N, 140.30°W, is incorrect based on personal communication with the collector, V. Behan-Pelletier (March 2014); the actual location on the 1984 collections was approximately 66.80°N, 136.32°W, where the Dempster Highway crosses Sheep Creek, just north of the Arctic Circle.

FIGURE 1. Female pseudoscorpion, *Wyochernes asiaticus* (Chernetidae), showing a brood sac. Body length is approximately 2 mm. Photo: Crystal Ernst.

this species is the most northern member of this arachnid order in North America. The objective of this research was to collect life-history data for *W. asiaticus* along the Dempster Highway, which stretches from near Dawson City Yukon, north to Inuvik, Northwest Territories. I wanted to address the following questions: Where is *W. asiaticus* found? What are the sizes of the various life stages? Do larger females have larger clutch sizes? Does its size or fecundity vary along a latitudinal gradient in northwest North America? This work will hopefully open doors to more questions and contribute baseline data for these understudied and underappreciated arachnids.

Methods

Between 2008 and 2012, *W. asiaticus* was collected from under rocks near creeks and rivers at 16 locations along the Dempster Highway, from 64.28° to 67.18°N and 135.75° to 138.49°W (Figure 2). At each location, field teams (see acknowledgements) flipped rocks collected any and all life stages of *W. asiaticus* found underneath. The searches were between 30 minutes and 2 hours in duration, and we aimed for between 10 and 20 specimens. This variation was due to various issues that stopped us from collecting additional specimens (e.g., inclement weather, biting flies). Field teams also searched (unsuccessfully) for pseudoscorpions besides creeks from between approximately 64.0°N to 64.3°N along the Dempster Highway, and beside creeks and rivers between Whitehorse (Yukon) and Dawson City (Yukon). To the north, no other suitable habitats were found further north than 67.18°N.

Specimens were preserved in 70–90% ethanol and transported to the laboratory, where they were counted and measured using an SMZ 1500 dissecting microscope (Nikon Instruments, Inc., Melville, New York, USA), fitted with an ocular micrometer. Body length and carapace length were measured for all specimens. If females were carrying brood sacs (i.e., with individual eggs), the clutch size was determined.

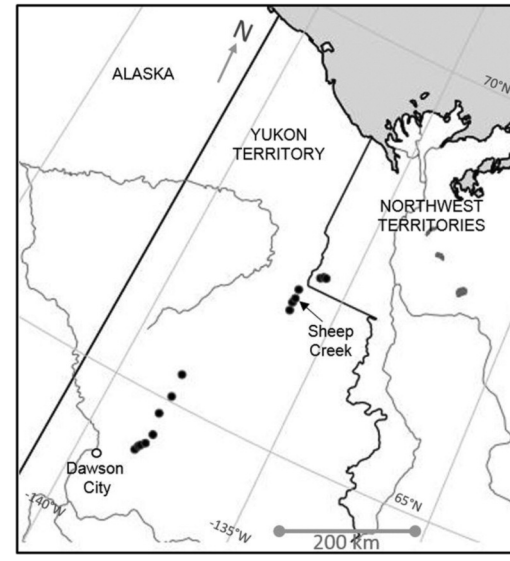

FIGURE 2. Collection localities (solid circles) of the pseudoscorpion, *Wyochernes asiaticus* (Chernetidae), in the Yukon and the Northwest Territories, Canada. Map created with SimpleMappr, http://www.simplemappr.net.

Data were analyzed using descriptive statistics. Correlations between size and latitude and between female size and fecundity were tested for significance. All specimens were deposited in the Lyman Entomological Museum (McGill University, Ste-Anne-de-Bellevue, Quebec, Canada).

Results and Discussion

Wyochernes asiaticus (Figure 2) was readily found at collection sites in the Yukon and Northwest Territories. The specimens found at an unnamed creek at 67.18°N and 135.75°W represent the northernmost record for the species in North America, expanding its

northern range by approximately 50 km (straight-line distance) from that established by V. Behan-Pelletier in the 1980s (Muchmore 1990). The habitat for *W. asiaticus* was always the same: individuals at all life stages were found under rocks beside rivers or creeks. Many rocks harboured no individuals, some revealed a few, and fewer rocks hid dozens of specimens (see video at https://www.youtube.com/watch?v=O_KISY4Zz_Y which depicts pseudoscorpion activity on the underside of a rock).

These arachnids seem to have a preferred "zone" beside creeks or rivers in areas that probably flood annually (i.e., during spring melt). In general, they were not found directly (i.e., 1-2 m) adjacent to flowing water, nor were they found in areas that appeared to flood only infrequently (i.e. higher up on banks, in regions where there was some soil development and permanent vegetation). There were found between these two regions, in habitats characterized as being well-drained, full of rocks, and a distinct lack of soil or permanent vegetation. This raises a curious question: what happens to *W. asiaticus* during times when the rivers flood? They may be swept away, hang on under rocks as water runs over them, retreat to their silken chambers, or move to higher ground. It would be most interesting to understand this aspect of their life history, but additional fieldwork would be required to do so.

Despite efforts to find *W. asiaticus* under rocks in riparian zones further south than 64.38°N, these searches turned up nothing. We, therefore, assume that there is a limit to the southern distribution of this species. I suspect the species can be found further north; however, our northernmost collection site was at the last accessible river with rocks and stones along its banks. I was able to collect the species near the headwaters of small streams heading up to mountain passes, e.g., from the car park at Windy Pass, near 65.06°N, 138.26°W (Figure 2). At this location, specimens were still found when the stream was only a trickle and less than 1 m wide. Although *W. asiaticus* can crawl, they do not move very quickly, which suggests that these arachnids have other means of reaching remote habitats. Phoresy (the act of "hitchhiking" on another species) is well known in pseudoscorpions and is particularly common in the Chernetidae (see, for example, Muchmore 1971). I suspect that *W. asiaticus* rides on other animals to disperse to new habitats along headwater streams or to recolonize habitats. The transporting species for this phoresy is unknown.

From a broader biogeographic perspective, I have seen specimens of *W. asiaticus* from central Alaska (courtesy of D. Sikes, University of Alaska, Fairbanks), and the species is known from several localities in Asia. In North America, its occurrence along the Dempster Highway strongly suggests that it is a Beringian species, minimally occupying what were mainly unglaciated regions of northwest North America during the last glacial maximum. Along with a suite of other interesting species, such as the holarctic Root Vole (*Microtus oeconomus*) (Brunhoff *et al*. 2003), North American *W. asiaticus* is truly a relict of the past, and occupies a unique habitat in a fascinating biogeographic region of the globe. Follow-up studies, using population genetics, would be extremely valuable in answering broader phylogeographic questions about the species. Unlike other groups that radiated from this unglaciated region (e.g., *Polyommatus* butterflies [Vila *et al*. 2011]), *W. asiaticus* appears to have remained relatively limited in its distribution in North America.

A total of 573 individual pseudoscorpions were collected and measured (Figure 3). The various life stages were easily recognized. Females predominated, possibly because their relatively large size and the presence, in some, of yellow brood sacs made them easier to find (Figure 1). Forty-eight of the 281 females had brood sacs, and the average (± standard error) clutch size was 10.5 ± 0.4 eggs/female (with a range of 5–15 eggs per brood). These measures of fecundity are aligned with some of the general estimates given by Weygoldt (1969). Although there was much variation, larger females, measured as carapace length or full body length, tended to have more eggs within their brood sac (Figure 4). This was expected, as other arachnids (e.g., spiders) show a similar pattern (e.g.,

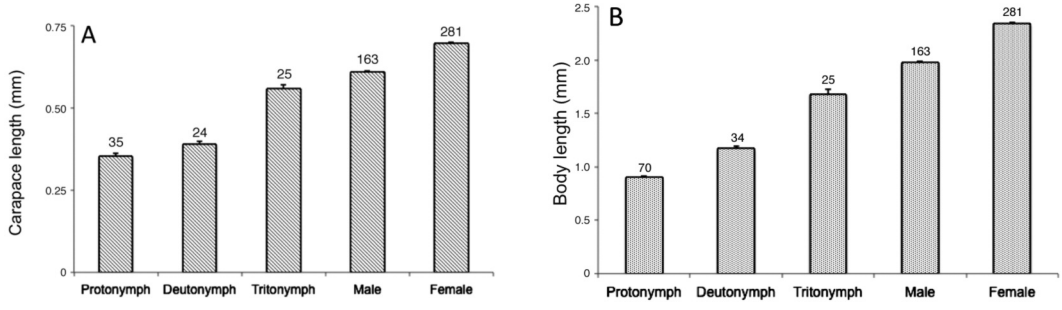

FIGURE 3. Average carapace (A) and body length (B) (+ standard error) of the pseudoscorpion, *Wyochernes asiaticus* (Chernetidae), by life stage: protonymph, deutonymph, tritonymph, and adult male and female. The number of specimens is indicated above each bar. The discrepancies in sample sizes of protonymphs and deutonymphs are a result of some specimens being too small to measure carapace length accurately.

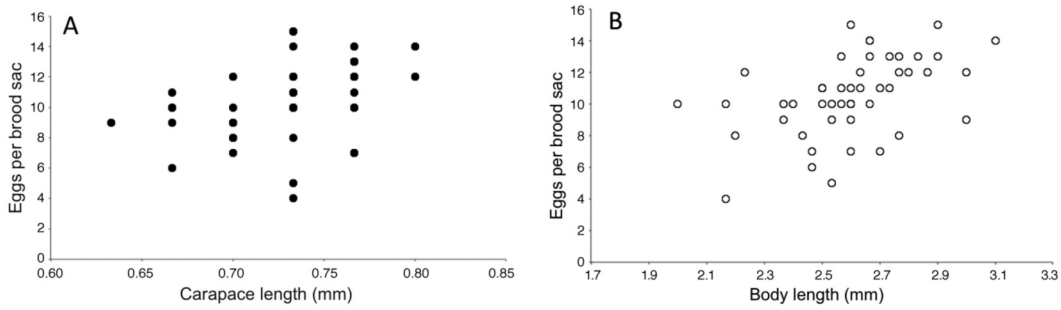

FIGURE 4. Number of eggs in brood sac of female pseudoscorpions, *Wyochernes asiaticus* (Chernetidae), as a function of carapace length (A, $r = 0.40$), and body length (B, $r = 0.47$). Symbols represent individual pseudoscorpions: Forty-eight females were used for both graphs, but some overlapping sizes occurred, hence the fewer symbols in (A).

Bowden and Buddle 2012) and also display high variation in this relation. It would be interesting to look more deeply into the relation between resource limitation and clutch size. Despite the time spent in the field and the collection of almost 600 individual *W. asiaticus*, its prey and feeding behaviour have yet to be observed.

All collections were made in July, and it is possible that collecting *W. asiaticus* at other times during the summer would yield different proportions of the life stages. Moulting likely occurs at times other than July, as specimens were not found in silken retreats. However, as all life stages were frequently found, these arachnids may take more than 1 year to reach maturity, and perhaps the adults are relatively long lived, a common feature of other Arctic arthropods (e.g., Danks 2004). There was no relation between latitude (as a proxy for temperature) and body size (data not shown), and thus there was no support for Bergmann's Rule (or the converse, which may better apply to ectotherms [see Mousseau 1997]), which predicts a size–latitude relation. As Shelomi (2012) argues, patterns of body size in relation to latitude, for arthropods, are largely idiosyncratic.

Conclusions

Although pseudoscorpions have been largely neglected, these findings may inspire more work on the natural history and biology of these fascinating arachnids. Despite significant collection efforts over many years, hours at the microscope, and hundreds of specimens, more questions have been raised by our work than have been answered. We now know that *W. asiaticus* is common in parts of northwest North America, likely as a relict that survived the last glaciation, and it can be found easily under rocks next to rivers and creeks, including small creeks in mountainous regions. All life stages can be collected and measured, and some benchmark measurements of clutch size are now available. Future research on the phylogeography, short-distance dispersal, and feeding behaviour of *W. asiaticus* would be most interesting. In conclusion, observing these marvelous animals in one of the most beautiful areas of the planet, was gratifying, awe-inspiring, and helped solidify a love of natural history. What has been learned is only the prologue to a truly astounding epic: many more discoveries await.

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