Ecology and taxonomy of the family Pholcidae in Israel:
Species richness, geographic distributions and taxonomical
revision of the genus *Artema* (Pholcidae, Araneae)

Thesis submitted in partial fulfillment of the requirements for the degree of
"Master of Science"

By: Shlomi Aharon

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Abstract

Israel is situated at a biogeographical crossroads, with a mixture of different biogeographical zones. Various geographical features together with diverse climatic conditions result in a unique composition of fauna. However, the diversity of many groups in this region, especially arthropods, remains unknown. The Pholcid spider family is the ninth species-rich family of spiders world-wide, however it has not been studied in Israel yet. According to the World Spider Catalog, only five pholcid species are reported from the Levant and only two from Israel thus far. This research examines the species richness and geographical distribution of the pholcid family in Israel, and specifically the taxonomy and the ecology of the genus Artema in Israel. I conducted a collections-based research followed by a taxonomical revision of the
genus *Artema* and an extensive survey of caves and diverse habitats and regions in Israel. The collections-based research, the taxonomical revision and the field survey revealed the existence of twelve pholcid species in Israel, including two troglobile species. The first, a species new to science, *Artema nephilit* sp. nov., is distributed mostly along the Rift Valley. The second species, *A. doriai*, previously known from Iran only, was found to be rare in the survey. Using GLM based on presence/absence data from the cave survey in combination with the physical attributes of the caves and environmental variables, I found that longitude and precipitation affect the distribution of *Artema nephilit* sp. nov. The importance of the environmental variables for the distribution of *Artema* species in Israel is discussed in a zoogeographical context.
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1. General Introduction

The Levant is a stretch of land about 150 km wide along the eastern shore of the Mediterranean, between the Mediterranean Sea in the west and the Syrian-Arabian desert in the east, and from the Taurus Mountain in the north to the Isthmus of Suez in the south (Por 1975). The Levant consists of four topographic elements, all oriented north to south: the coastal plain, the western mountain ridge, the rift valley and the eastern mountain ridge. For a relatively small biogeographical region, the Levant shows unusual heterogeneity and a highly dynamic faunal and floral history. This is due, in part, to the crossing of horizontal zonal climatic belts by these four topographic elements (Por 1975, Danin 1988). Four major geological events during the Miocene, Pliocene and early Pleistocene resulted in the present biogeographic zones of the Levant: 1. Separation of Tethys Sea into two parts and the establishment of the Eurasian-African land bridge, 2. Drying of the Old World subtropics and the appearance of the large desert belt of the Sahara and the Syrio-Arabian deserts, 3. Formation of the Red Sea as a branch of the Hindu-Pacific Ocean, and 4. Formation of the Afro-Syrian rift valley (Por 1975).

Israel is part of the Levant, situated in a biogeographical crossroads at the junction of three continents, and is composed of several climatic, phytogeographical and zoogeographical zones (Yom-Tov and Tchernov 1988). The phytogeographical and zoogeographical zones in Israel are not completely congruent. While it is common to divide Israel to five phytogeographical zones, only four zoogeographical regions are commonly used for terrestrial animals. The Palaearctic zoogeographical region, in the north and central areas of Israel mostly follows the Mediterranean phytogeographical zone, and is the most widespread element in the Levant. The
Ethiopian zoogeographical region stretches along the valley of the Dead Sea and the Jordan Rift valley and mostly follows the Sudanian phytogeographical zone. The Palaeoeremic zoogeographical region and the Saharo-Arabian phytogeographical zone reach Israel from the south into the Negev and the Judean Deserts and stretch up in two 'arms' along the coastal plain and the Rift Valley. Last, the Oriental zoogeographical elements, shows the least affinity to phytogeographical patterns and is scattered throughout the Levant. The Irano-Turanian and the Euro-Siberian phytogeographical zones are found mainly in high mountains such as the Hermon and the Negev Mountains (Por 1975, Yom-Tov and Tchernov 1988). While the zoogeography and taxonomy of the vertebrate species in these zones are well known, for some invertebrates, and spiders among them, this knowledge remains unknown.

Spiders (Arachnida, Araneae) include more than 45000 described species in 3,951 genera and 114 families worldwide (World Spider Catalog 2015). However, only thirteen out of 49 families known from Israel have been studied extensively by the late Gershom Levy (Lubin and Gavish-Regev 2009, Zonstein and Marusik 2013), and the taxonomy and zoogeography of many spider families was never studied thoroughly in Israel. Levy, in the three arachnid volumes of "Fauna Palaestina" and other taxonomic papers describes how the majority of the theridiid and thomisid spiders recorded from Israel are Palaearctic whilst some are Palaeoeremic and few are probably Ethiopian, found only along the Jordan Rift valley. Some are distributed worldwide by natural dispersal, while others are synanthropic spiders that are carried by man around the world (Levy 1985, 1998).

The daddy long-legs spiders (Pholcidae) are the ninth most species-rich family of spiders (World Spider Catalog 2015). Pholcids have a worldwide distribution, but
with their highest diversity in tropical and subtropical climates (Huber 2011a). Four of the five pholcid subfamilies are expected to be represented in Israel by indigenous and introduced species.

According to the world spider catalog (World Spider Catalog 2015), only five pholcid species are reported from Israel and its surroundings thus far. This low number of species is probably due to inadequate research of this family in the region. In addition, only taxonomical literature with species descriptions or genitalia drawings is included in the catalog, and species with broad distributions are not reported with their local distributions. I expect additional pholcid species to occur in Israel, including some indigenous and alien species (B. A. Huber, personal communication).

This research aims at studying the distribution and taxonomy of spiders in the family Pholcidae and especially in the genus *Artema*, in Israel. The research addresses these questions in three levels: the family level, the genus level and the species level. The first part of the thesis focuses on the species richness and geographic distribution of pholcids deposited in the national collections of Israel and collected in field surveys between the years 2012-2014. The second part focuses on the taxonomy of the genus *Artema* by performing a taxonomical revision of the whole genus. The last part studies the genus *Artema* in Israel, its geographical distribution and the various variables that affect this distribution, by means of a survey of caves and the use of previous records.
2. Synopsis of the family Pholcidae (Araneae) in Israel: 
Species richness and geographic distributions

2.1 Introduction
The daddy long-legs spiders (Pholcidae) are the ninth species-rich family of spiders world-wide, with 1430 described species in 79 genera (Huber 2014, World Spider Catalog 2015). Most pholcids have a dome-like sheet-web, but some species in the family build modified webs or do not seem to spin any webs (i.e. Pholcinae) (Huber 2011a). Although the family has a worldwide distribution, their highest diversity is in tropical and subtropical climates (Huber 2011a). In addition, pholcids are the second largest family of invasive alien spider species in Europe (Kobelt and Nentwig 2008, Nentwig and Kobelt 2010), with at least nine invasive species. The main lineages within the family are fairly well resolved, with a stable division into five superfamilies: Ninetinae, Arteminae, Modisiminae, Smeringopinae, and Pholcinae (Huber 2011b).
Based on their regional distributions, four of these superfamilies are expected to be represented in Israel by indigenous and introduced species (B. Huber, personal communication).

According to the world spider catalog (World Spider Catalog 2015), only two pholcid species are reported from Israel and four additional species reported from its surroundings thus far, representing three pholcid superfamilies. Pholcinae: Pehrforsskalia conopyga Deeleman-Reinhold and van Harten, 2001 (Israel) and Pholcus maronita Brignoli, 1977 (Lebanon); Smeringopinae: Hoplopholcus ceconini Kulczyński, 1908 (Israel), Holocnemus pluchei Scopoli, 1763 (Mediterranean), and Crossopriza semicaudata O. P. Cambridge, 1876 (Egypt); and Ninetinae: Nita elsayf
Huber and El-Hennawy, 2007 (Egypt). This low number of species is probably due to inadequate research of this family in the region. In addition, only taxonomical literature with species descriptions or genitalia drawings is included in the catalog, and species with broad distributions are not reported with their local distributions.

Bodenheimer reported two additional cosmopolitan pholcids from "Palestine" in 1935 and 1937: Pholcus phalangioides Fuesslin 1775 (Pholcinae), and Artema mauriciana Walckenaer 1837 from the additional subfamily Arteminae, while Zonstein and Marusik (2013), in their recent checklist of Israel spiders, report a total of five pholcid species from Israel (A. atlanta, H. pluchei, H. cecconii, P. conopyga, and P. phalangioides) and mention one additional species (Physocyclus globosus) as a misidentification.

In order to fill the gap in our knowledge on the pholcid family in Israel, I reviewed the pholcid species found in Israel by studying the material from past collections and from an extensive cave survey done throughout Israel.

I present here the outcome of collections-based research and field surveys: a checklist of the family Pholcidae in Israel together with geographic distribution maps for each of the 12 species found in Israel. I conducted surveys of diverse habitats including typical pholcid habitats such as caves and crevices from the south to the north of Israel. These surveys provide records of additional indigenous and alien species, which contribute to the knowledge of this diverse and ecologically important group.
2.2 Methods

All pholcid specimens that were deposited in the National Arachnid collection at the Hebrew University of Jerusalem and in the Arachnid collection, Steinhardt Museum of Natural History and National Research Center at Tel Aviv University, as well as additional material collected in recent field surveys were studied in 75% ethanol under Nikon ZM stereomicroscope and ZEISS SteREO Discovery V20 stereo-microscope to verify their identification. Female and male genitalia were compared to descriptions and illustrations from the literature. Digital microscope images were taken using an AxioVision imaging system digital camera mounted on a ZEISS SteREO Discovery V20 stereo-microscope (Zoologisches Forschungsmuseum Alexander Koenig, Bonn). All figures were edited using Adobe Photoshop ver. CS3 or GIMP ver. 2.6.10. Left structures (palps) are illustrated unless stated otherwise.

The field surveys were conducted in different habitats: 1. under stones, among rocks, hollows and crevices; 2. among vegetation, on the underside of leaves and in the leaf litter; 3. in caves. The first two habitats were surveyed during the cave surveys and on various occasions during 2013-2014 (see chapter 4 for full methodology and results). The cave surveys were conducted in different cave types (dry/humid, short/medium/long) throughout three seasons: autumn (September 2013), spring (March 2014) and summer (May-June 2014). The caves were surveyed in different regions in Israel: the Golan Heights, Galilee, Jordan Rift Valley, central Israel, the Judean Desert, the Negev Desert and the Arava. Four microhabitats were sampled in each cave to record non-cave species, non-obligatory cave dwelling species and obligatory cave dwelling species (troglobites): A. cave entrance; B. twilight zone, the intermediate part of the cave; C. dark zone, the depth of the cave; and D. outside the cave. The spiders were hand collected: adult spiders were placed in
70% alcohol and juveniles spiders were placed in 99% alcohol (for the purpose of future DNA sequencing). Some females with egg sacs were taken to the laboratory and were reared until their egg sacs hatched and the spiderlings reached adulthood.

Abbreviations used in the text:
HUJ – National Arachnid collection, The Hebrew University of Jerusalem, Israel
SMNHTAU – Arachnid collection, Zoological Museum at Steinhardt Museum of Natural History and National Research Center, Tel Aviv University, Israel
NHMW – Naturhistorisches Museum Wien, Vienna
MCZ – Museum of Comparative Zoology, Cambridge
ZFMK – Zoologisches Forschungsmuseum Alexander Koenig, Bonn

Locality names in Israel are transliterated following the “Israel Touring Map” (1:250,000) and “List of Settlements,” published by the Israel Survey, Ministry of Labour.

2.3 Results
Twelve species of pholcids belonging to nine genera and three subfamilies were found in this collection-based research and in the field surveys, all collected between the years 1932-2014. The species that were found in this work are: "Artema nephilit" sp. nov. (species description in preparation, see chapter 3); Artema doriai Thorell, 1881; Artema atlanta Walckenaer, 1837; Crossopriza lyoni Blackwall, 1867; Holocnemus pluchei Scopoli, 1763; Hoplopholcus cecconii Kulczyński, 1908; Micropholcus fauroti Simon 1887; Pehrforsskalia conopyga Deeleman-Reinhold and van Harten,
2001; *Pholcus* sp. (unidentified); *Pholcus phalangioides* Fuesslin, 1775; *Spermophora senoculata* Dugès, 1836; *Spermophorides* sp. (unidentified) (Table 1).

The HUJ collection included records of nine species, collected between the years 1932-1974, while the SMNHTAU collection included seven species, all collected recently, between the years 2011-2013. During the field surveys I successfully found all the species that were deposited in both collections. For *Spermophorides* sp. I succeeded in finding only juveniles in the surveys, while in the collections both males and females are deposited. The collections-based research and the field surveys yielded one species new to science (*Artema nephilit* sp. nov., see chapter 3) and two unidentified species, *Pholcus* sp. and *Spermophorides* sp., which might be new to science as well. The *Pholcus* sp. was collected during our surveys for the first time. The *Artema nephilit* sp. nov., was collected especially along the Jordan Rift Valley with two specimens, found in the collections, collected- one in Cyprus and the second in Greece. In addition, *Artema atlanta* and *Crossopriza lyioni*, both alien species and new records to the region were collected. All the material that was collected in the field survey will be deposited at HUJ.

Checklist of Pholcidae of Israel – Species are listed according to the current classification of subfamilies (Huber 2011b).

Subfamily Arteminae Simon, 1893: This subfamily is represented in Israel by one genus, with two in species.

*Artema Walckenaer, 1837.* Figure 1.
- Artema nephilit sp. nov., (in preparation). Plate 1, Fig. 1-16.

Distribution. Cyprus, Greece, Israel, Jordan.

Records. Israel: Found especially along the Jordan Rift Valley, from Elat to Metula; HaTanur Waterfall near Metula; Sussita (Hippos) National Park in bunker tunnel; Mount Berniki, south to Teverya, Berniki Caves; Mount Karmel, Oren Cave; Khirbet A-Samra, east of Na'ama in old mine; En Perat, Nahal Perat Caves and in a building; Ein ad-Duyuk, near Jericho; Qumeran Cave; Nahal Temarim among rocks; En Gedi, Nahal Dawid among rocks; Ma’ale Ya’ir under large rocks; Zavoa Cave south to Arad; Arubotaim Cave; Sedom Cave; Malham Cave; north west to 'En Tamar in crevices; Nahal Zin in crevices and in tube near road tunnel; Ramat Avedat near Sede Boqer, in cave; Kibbutz Samar in dumping ground and in houses; Elat Field School in basement.

Jordan: Petra, in rock-cut tombs and among rocks; Wadi Hasa; Wadi Mujib.

Cyprus: Nicosia.

Greece: without accurate location.

Note. Material collected between the years 1939-1970 in the Rift Valley was deposited at HUJ under the name Artema mauricia (misidentified). I conducted a revision on the genus Artema (see Chapter 3) and found that this species is new to science and the description is now in progress. Artema nephilit sp. nov., is the second most common pholcid in the Jordan Rift Valley, after the ubiquitous Holocnemus pluchei. The species was collected especially in caves but it was found also in crevices, cracks and holes between stones. Specimens from outside the Rift Valley (Ramat Avedat near Sede Boqer; Oren Cave, Mount Karmel; Petra, Jordan), and the specimens from...
Cyprus and Greece indicate that the species is probably widely distributed in the area.

- **Artema doriai** Thorell, 1881. Plate 1, Fig 3. Plate 9.

  Distribution. Afghanistan, Iran, Israel, Turkey.

  Records. Israel: This species has a sparse distribution along the Jordan Rift Valley and was collected also from the center of Israel. Ramot Naftali; Poriyya slope; Yavni‘el; Nahal Hagal near Kibbutz Gesher; Andartat Habik’a north-east to Peza‘el in cave; Modi’in; Jericho; Hazeva.

  Note. Israel is probably an edge population for this species, being the Western limit of its geographic range together with the population in Turkey. The species is relatively rare in this survey conducted in Israel. It was found in caves, crevices, cracks and holes between stones. The species was collected by pitfalls traps near Modi’in in 2012, far from its’ previously noted distribution in the Jordan Rift Valley. *Artema* specimens that were recorded and photographed from Tel-Aviv (19.XII.2014), Herzliya (2012) and Rosh-HaAyin, but were not collected and examined, might belong to this species.

- **Artema atlanta** Walckenaer, 1837. Plate 11.

  Distribution. Pantropical.

  Records. Israel: Haifa port.

  Note. Collected in Haifa port from a container arriving from Tuticorin, India. Its distribution ranges from north Africa (Egypt, Libya, Tunisia) to southern Arabia; It is apparently known from the whole of tropical Africa and the Oriental region, up to southern China. There are also records from a few
Pacific islands and Australia. In the Americas, the species has been recorded from the United States to Paraguay. It is not clear what the original distribution is, since this species is known to be introduced to many countries and has a wide distribution.

**Figure 1**: Distribution map of the genus *Artema* in Israel

![Distribution map of the genus *Artema* in Israel](image)

Subfamily Smeringopinae Simon, 1893: This subfamily is represented in Israel by three genera, with one species each.
**Crossopriza** Blackwall, 1867. Figure 4.

- *Crossopriza lyoni* Blackwall, 1867. Plate 2, Fig. 1-2.

  Distribution. Cosmopolitan.

  Records. Israel: Haifa port.

  Note. *Crossopriza lyoni* is a cosmopolitan species, originally described from India (Blackwall 1867). In Israel, it was found in a container arriving from Tuticorin, India at Haifa port. The related local species from Egypt *Crossopriza semicaudata* O. P. Cambridge, 1876, was observed "pretty frequently" among the ruins of the ancient temples in various parts of Egypt (Cambridge, 1876). However, it was not found in ruins in the Western Negev that resemble the original habitat in Egypt.

**Holocnemus** Simon, 1873.

- *Holocnemus pluchei* Scopoli, 1763. Plate 2, Fig. 3-4.


  Records. Israel: Throughout.

  Note. *H. pluchei* is a Mediterranean species that was introduced elsewhere in the world. It is found in great numbers all over Israel. According to our surveys and collection-based research, it is the most abundant pholcid in Israel, occupying natural habitats under rocks, bushes, caves and man-associated habitats such as buildings and basements.

**Hoplopholcus** Kulczyński, 1908. Figure 3.

- *Hoplopholcus cecconii* Kulczyński, 1908. Plate 2, Fig. 5-8.
Distribution. Israel, Lebanon, Turkey.

Records. Israel: Shetula Cave; Yir'on Cave; Ezba Cave; Giv'ot Zayd; Bet She'arim National Park in caves.

Note. Described in 1908 from "Palestine". Material was deposited in HUJ at 1945 from Giv'ot Zayd and was misidentified as *Physocyclus* sp. In a recent survey near its original location, Giv'ot Zayd, I found dozens of specimens of this species, males and females at Bet She'arim National Park in the Rock-cut tombs necropolis. This species prefers cold and humid caves and it was collected also from caves in Turkey and Lebanon (Brignoli 1979, World Spider Catalog 2015). Females carrying egg-sacs and males were recorded during September 2013.

Subfamily Pholcinae C.L. Koch, 1850: This subfamily is represented in Israel by six genera, with one species each, except *Pholcus* with two species.

*Micropholcus* Deeleman-Reinhold and Prinsen, 1987. Figure 4.

- *Micropholcus fauroti* Simon 1887. Plate 3, Fig. 3-4.

Distribution. Pantropical.

Records. Israel: Ra'anana; Tel-Aviv; Bat-Yam; Merkaz-Shapira; Retamim.

Note. This is a synanthropic species, with an original Pantropical distribution, but introduced elsewhere, probably also in Israel. Several specimens from different localities were found in both past and recent collections, all of them from man-associated habitats.

*Pehrforsskalia* Deeleman-Reinhold and van Harten, 2001. Figure 3.
Pehrforsskalia conopyga Deeleman-Reinhold and van Harten, 2001. Plate 3, Fig. 1-2.

Distribution. Africa, Israel, Madagascar and Yemen.

Records. Israel: Karei-Deshe; Degania Alef.

Note. A single specimen was found in HUJ collection under the name "Leptopholcus sp. n. sp.?". This specimen was collected by Ya'akov Palmoni in Kibbutz Degania Alef on an apple tree, 7 June 1942. I could not locate the apple orchard, but in our field survey during September 2013 I found juveniles, sub-adult males and females with egg sacs under fallen leaves in banana plantations. I collected a female with an egg sac in 16.IX.2013 and reared the spiderlings that hatched in 17.IX.2014 to adult stage. The female made a second egg sac and died on 15.X.2013. One juvenile molted in 3.X.2013, 2\textsuperscript{nd} in 15.X.2013 and had a final molt to adult male on 7.XI.2013. I verified the species identity with the adults I reared. The genus and the species were described only recently from Yemen by Deeleman-Reinhold and van Harten (2001).

Pholcus Walckenaer, 1805. Figure 2.

- Pholcus sp. Plate 4, Fig. 1,2,6.

Distribution. Unknown, in Israel it was found in three localities associated with the Jordan Rift Valley and one locality in central Israel.

Records. Mimlach Cave north west to Tiberias; Susita National Park, in cave; Bet Arif Cave near Shoham; Ro'im Cave in Nahal Perat.

Note. The identity of this species is under investigation. I found the species during the first and second field surveys in relatively humid caves. This species is quite distinct from other congeners (Bernhard A. Huber, personal
communication) and I am working on the identification of the species. I assume that it might be either a new species to science or a species that was described by Brignoli (1977) based only on two females collected in a cave in north Lebanon, without a male description.

- *Pholcus phalangioides* Fuesslin, 1775. Plate 4, Fig. 3-5.

Distribution. Cosmopolitan.

Records. Israel: Mount Karmel near Haifa University; Bet She'arim rock-cut tombs; Jerusalem; Bet Guvrin Caves; Susya (Southern Mount Hebron).

Note. The species is widely distributed in temperate and subtropical areas around the world (Huber, 2011). The species is not abundant in Israel and it was found in buildings and basements, under rocks and in caves. Only four specimens, all from buildings and basements in Jerusalem, were deposited in the collections. More specimens were recently found under rocks in Mount Karmel, Haifa University and in caves in Susya (Southern Mount Hebron) and Bet Guvrin.
Figure 2: Distribution map of the genus *Pholcus* in Israel

*Spermophora Hentz, 1841.* Figure 4.

- *Spermophora senoculata* Dugès, 1836. Plate 5, Fig. 1-2.

Distribution. Holarctic.

Records. Israel: Gadot; Hararit; Jerusalem; Modi'in.

Note. *S. senoculata* is a Holarctic species with records from the United States, southern Europe, northern Africa, and East Asia and it was introduced elsewhere (Huber 2002b, World Spider Catalog 2015). Only four specimens
were deposited in the collections, all from Jerusalem. I collected a few specimens during the field surveys in Gadot, Hararit and Modi'in. Males and females of this species were collected under stones and rocks and on stone walls.

*Spermophorides Wunderlich, 1992.* Figure 3.

- *Spermophorides* sp. Plate 5, Fig. 3-4.

Distribution. Unknown. In Israel it was found in three different locations.

Records. Israel: Karmel Mountain, Haifa University; Kinneret; Modi'in.

Note. This species belongs to a genus with very restricted Western Mediterranean distribution. As of today, only two species out of 34 species in this genus are known outside the Western Mediterranean, from Africa. This is the first record of this genus from Eastern Mediterranean (Bernhard A. Huber, personal communication; World Spider Catalog 2015). The specimen deposited in the collections was found in Northern Israel, and is not identified yet to the species level. Recently, another specimen from the same unknown species was found in a survey in Modi'in as well as a few juveniles that were observed under stones during our field survey in September 2013 from Karmiya Ridge, Mount Karmel.
Figure 3: Distribution map of the species *H. cecconii*, *P. conopyga* and *Spermophorides* sp.
2.4 Discussion

The collections-based research and field surveys yielded 12 species belonging to nine genera and three subfamilies, although only two pholcid species are reported in the World Spider Catalog (World Spider Catalog 2015) for Israel and six for the Levant. The reason for this difference may lie on the fact that there has not been any research
focusing on the Israeli pholcid fauna till now. The 12 species vary in their
distribution, habitats and abundance. The most abundant and widely distributed
pholcid is the Mediterranean species *Holocnemus pluchei*, occurring in both natural
and man-made habitats throughout Israel. Similarly, *Micropholcus fauroti*, a
pantropical synanthropic species, was found in various localities in Israel, all of them
inside houses and man associated habitats. Two other species, the cosmopolitan
*Pholcus phalangioides* and the Holarctic *Spermophora senoculata* were thought to be
rare or limited in their distribution in Israel according to the historical collection at
HUJ, but probably have wider distributions, as was found from recent surveys in both
natural habitats as caves and under stones as well as in man-made habitats. Still, they
are not very common. Two other species, *Artema atlanta* and *Crossopriza lyoni* are
alien cosmopolitan species that were caught inside containers that arrived at Haifa
harbor. I found no records of these species or any other evidence of their
establishment outside the containers. However, as these species are known to
establish populations outside their natural distribution areas, they have the potential to
become invasive species in Israel. *Hoplopholcus cecconii* was found in cold caves in
northern Israel, with distribution range from Lebanon, Turkey and Israel.

*Pehrforsskalia conopyga* may represent an Ethiopian zoogeographical distribution,
with an Afro-Arabian distribution and with records from the northern part of the Rift
Valley, around Lake Kinneret. The presence of *P. conopyga* in Kinneret Valley might
represent a relict of an African fauna from an ancient tropical climate or a native
population expansion from Africa through the Jordan Rift Valley, or an introduction
of the species in the early 20\(^{th}\) century arriving with banana or other plantation species
from Africa. The identity of *Spermophorides* sp. still needs to be investigated. This
genus shows high affinity and speciation in the western Mediterranean, with very few
representatives in Africa. This species, which was collected from the Mediterranean zone in Israel (Kinneret, Karmel Mountain and Modi'in), may be new to science or else a known species with a geographic distribution expansion. Another interesting species is the unrecognized *Pholcus* sp. that was never collected in Israel before the field survey. It is likely to be either a new, undescribed species or *Pholcus maronita* Brignoli, 1977 that was described from a cave in north Lebanon, based on two adult females without a male description. I found the species in relatively temperate humid caves without a clear pattern of a geographical region (Plate 4, Fig 1,2,6).

In the genus *Artema*, which is among the largest spiders in the pholcid family, I found in the collections three species. One, *Artema atlanta*, is an alien spider as mentioned above. Two other species were identified as part of the revision of the genus. One species is the Persian species *Artema doriai* Thorell, 1881. This species is widespread in Iran and occurs also in Afghanistan and Pakistan, while the populations in Israel and Turkey are probably the edge of the distribution, being at the western limit of the species geographic range. The second is *Artema nephilit* sp. nov., which was collected by A. Shulov, P. Amitai and others in the years 1939-1969 along the Jordan Rift Valley. I found this species to be present in few other localities outside of the Rift Valley as well as few specimens in Jordan, Greece and Cyprus. Those findings lead me to suggest that the original distribution of the species was wider than it seems today and maybe more abundant in the neighboring countries in the Levant. Climate change may have led to a reduction in the abundance of the species while the population in the Jordan Rift Valley was not affected by those changes, and some relict populations remained in suitable habitats outside the Jordan Rift Valley such as Oren Cave, Avedat Ruins, Petra in Jordan, Greece and Cyprus.
Artema doriai and Artema nephilit sp. nov. have an interesting geographical distribution pattern in Israel. They share the same geographical range along the Jordan Rift Valley but were never collected together from the same cave. These findings led me to conduct a revision of the genus (chapter 3) as well as a large ecological cave survey (chapter 4) in order to investigate the environmental variables affecting the distribution of each species.
<table>
<thead>
<tr>
<th>Species</th>
<th>Region</th>
<th>Zoogeographical zone</th>
<th>Found in collections/cave or field survey</th>
<th>Reported from Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Artema nephilit</em> sp. nov.</td>
<td>Upper Galilee, Lower Galilee, Southern Golan and Kinneret, , Jordan Valley, Dead Sea Area, Judean Desert, Central Negev, Southern Negev, 'Arava Valley.</td>
<td>Palaearctic</td>
<td>HUJ SMNHTAU Cave survey</td>
<td>Reported here for the first time</td>
</tr>
<tr>
<td><em>Artema doriai</em> Thorell, 1881</td>
<td>Upper Galilee, Lower Galilee, Foothills of</td>
<td>Palaearctic</td>
<td>HUJ SMNHTAU</td>
<td>Reported here for the first time</td>
</tr>
<tr>
<td><strong>Artema atlanta</strong> Walckenaer, 1837</td>
<td>Judea, Dead Sea Area, 'Arava Valley.</td>
<td>Cave survey</td>
<td>No evidence for population establishment, Collected in a container at sea-port, Northern Coastal Plain. Past report was misidentification.</td>
<td>Pantropical</td>
</tr>
<tr>
<td><strong>Crossoprisa lyoni</strong> Blackwall, 1867</td>
<td></td>
<td></td>
<td>No evidence for population establishment, Collected in a container at sea-port, Northern Coastal Plain.</td>
<td>Cosmopolitan</td>
</tr>
<tr>
<td><strong>Holocnemus pluchei</strong> Scopoli, 1763</td>
<td>Throughout Israel.</td>
<td>Mediterranean</td>
<td>HUJ</td>
<td>Reported,</td>
</tr>
<tr>
<td>Species</td>
<td>Location</td>
<td>Distribution</td>
<td>Collection</td>
<td>Survey</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
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<td>---------------------------------</td>
</tr>
<tr>
<td><strong>Hoplopholcus cecconii</strong> Kulczyński, 1908</td>
<td>Upper Galilee, Lower Galilee, Karmel Ridge.</td>
<td>Palaearctic</td>
<td>HUJ</td>
<td>Cave survey</td>
</tr>
<tr>
<td><strong>Micropholcus fauroti</strong> Simon 1887</td>
<td>Central Coastal Plain, Southern Coastal Plain, Judean Hills, Northern Negev.</td>
<td>Pantropical</td>
<td>HUJ</td>
<td>SMNHTAU field survey</td>
</tr>
<tr>
<td><strong>Pehrforsskalia conopyga</strong></td>
<td>Lower Galilee and Kinneret.</td>
<td>Ethiopian</td>
<td>HUJ</td>
<td>Field survey</td>
</tr>
<tr>
<td><strong>Pholcus sp. (unidentified)</strong></td>
<td>Lower Galilee, Southern Golan and Kinneret, Foothills of Judea, Judean</td>
<td>Unknown, probably Palaearctic.</td>
<td>Cave survey</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Location</td>
<td>Distribution</td>
<td>Collection</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Pholcus phalangioides Fuesslin, 1775</td>
<td>Northern Coastal Plain, Karmel Ridge, Foothills of Judea, Judean Hills.</td>
<td>Cosmopolitan</td>
<td>HUJ Cave and field survey</td>
<td>Reported here for the first time</td>
</tr>
<tr>
<td>Spermophora senoculata Dugès, 1836</td>
<td>Upper Galilee, Lower Galilee, Foothills of Judea, Judean Hills.</td>
<td>Palaearctic</td>
<td>HUJ SMNHTAU Cave and field survey</td>
<td>Reported here for the first time</td>
</tr>
<tr>
<td>Spermophorides sp.</td>
<td>Lower Galilee, Karmel Ridge, Foothills of Judea.</td>
<td>Unknown, probably Palaearctic.</td>
<td>HUJ SMNHTAU Field survey</td>
<td>Reported here for the first time</td>
</tr>
</tbody>
</table>
2.5 Appendix - Material examined

Subfamily Arteminae Simon 1893

1) *Artema nephilit* sp. nov.


**MCZ** – 1 specimen: near *Sede Boqer, Ramat Avedat* [30.8447°N, 34.7772°E], (MCZ 34068), I.1987 (V. and B. Roth), 1♀.

**NHMW** – 1 specimen: *Cyprus: Nicosia* [35.169°N, 33.361°E], 1♂ (NHMW 19.551), 1937 (F. Werner).


From the field survey – 65 specimens, all material will be deposited at HUJ:


2) *Artema doriai* Thorell, 1881

**HUJ – Poriyya slope** [32.7390°N, 35.5481°E], IV.1970 (Pener et al), 1♂.

**Yavni‘el** [32.7085°N, 35.5025°E], IX.1961 (collector is not mentioned), 2♂.

**Jericho** [31.8955°N, 35.4219°E], XII.1967,X.1969 (P. Amitai), 2♀; II.1968 (G. Tsabar), 1♀.

34.9715°E), pitfall trap in shrub habitat, IV. 2012 (I. Berenstein et al), 6♀.
Hazeva [30.7682°N, 35.2776°E], 17.VI.2010 (L. Friedman, C. Drees), 1♂.

**From the field survey** - *Andartat Habik'a, NE Peza'el* (32.0524°N, 35.4589°E) in cave, 10.III.2014 (S. Aharon, E. Gavish-Regev), 2♀.

3) **Artema atlanta** Walckenaer, 1837

**SMNHTAU** – 2 specimens: *Haifa Port* [32.8206°N, 35.0087°E], in a container arrived from Tuticorin, India, vi.2012 (E. Gavish-Regev), 1♀ 1 juv.

Subfamily Smeringopinae Simon, 1893

1) **Hoplopholcus ceconii** Kulczyński, 1908

**HUJ** – 4 specimens: *Giv'ot Zayd*, III.1945 (A. Shulov), 4♀.


2) **Crossopriza lyoni** Blackwall, 1867

**SMNHTAU** – 1 specimen: *Haifa Port* [32.8206°N, 35.0087°E], in a container arriving from Tuticorin, India, vi.2012 (E. Gavish-Regev), 2♀.
3) *Holocnemus pluchei* Scopoli, 1763

**HUJ** – ~ 120 specimens, all over Israel: from the desert in the south to the temperate zone of Northern Israel, 58♀ 24♂ 46 juv.

Subfamily Pholcinae C.L. Koch, 1850

1) *Spermophora senoculata* Dugès, 1836

**HUJ** – 4 specimens: Jerusalem [], XII. 1939 (collector is not mentioned), 1♀; XII. 1967 (S. Y. Kashi), 1♀; V. 1974 (P. Amitai), 2♀.


2) *Spermophorides* sp. Wunderlich, 1992


**TAU ZM** – 1 specimen: Modi’in [31.8935°N, 34.9715°E], pitfall trap in a herbaceous and stony habitat, IV. 2012 (I. Berenstein et al), 1♂.

**From the field survey** – 3 specimens: Karmiya Ridge, Mount Karmel [32.7185°N, 35.0065°E], under stones, 17.IX.2013 (S. Aharon, E. Gavish-Regev, B.A. Huber), 3 juveniles.

3) *Micropholcus fauroti* Simon 1887
HUJ – 6 specimens: *Yagur* [32.7418°N, 35.0771°E], 1934 (A. Shulov), 1♀.
*Kinneret* [32.7141°N, 35.5624°E], IV. 1967 (P. Amitai), 1 juv. *Ra’anana* [32.1850°N, 34.8714°E], VII. 1937 (A. Shulov), 1♀. *Tel-Aviv*, laboratory [32.1139°N, 34.8057°E], IX. 1950 (collector isn't mentioned), 1♀. *Alex. Le Cairo* (not from Israel), (collector and date are not mentioned), 1♀ 1♂.

TAU ZM – 4 specimens: *Tel-Aviv* [32.0722°N, 34.7784°E], in buildings, 2012 (A. Shlagman), 2♀ 3♂.


4) *Pehrforsskalia conopyga* Deeleman-Reinhold and van Harten, 2001

HUJ – 1 specimen, from the collection of Y. Palmoni, Bet Gordon, Deganya Alef [32.7070°N, 35.5752°E], on an apple tree, 7.VI.1942 (Y. Palmoni), 1♀.


5) *Pholcus phalangioides* Fuesslin, 1775


**From the field survey** –

6) Pholcus sp.

2.6 Plates

Plate 1: Subfamily Arteminae


(photograph: Akiva Topper).
Plate 2: Subfamily Smeringopinae

Plate 3: Subfamily Pholcinae

Plate 4: Subfamily Pholcinae

**Plate 5: Subfamily Pholcinae**


3.1 Introduction

The pholcid subfamily Arteminae Simon, 1893 is comprised of ninety five species in nine genera (Huber 2014, Valdez-Mondragon, 2014): the type genus of the subfamily, *Artema* Walckenaer 1837; *Wugigarra* Huber, 2001; *Chisosa* Huber, 2000; *Aucana* Huber, 2000 *Holocneminus* Berland, 1942; *Physocyclus* Simon, 1893; *Trichocyclus* Simon, 1908 and the monotypic genera *Tibetia* Zhang, Zhu and Song, 2006 and *Nita* Huber and El-Hennawy, 2007 (Huber 2011). *Physocyclus*, *Trichocyclus* and *Wugigarra* comprise the majority of species in the subfamily (Huber 2014, Valdez-Mondragon, 2014). The subfamily is characterized by two morphological synapomorphies, a pair of distinctive structures on the male procursus: 1. a dorsal apophysis and 2. a ventral pocket (Plate 7, Fig. 13) (Huber, 2011). Most of the species in the subfamily are relatively large spiders with large legs, high globose abdomen and often occur in dry regions, even deserts (Huber 2011).

*Artema* is easily distinguished from other pholcids by its large and heavy body with distinctive pattern on the globose and high abdomen, pointed ventrally. The male palpal organ, the bulbal processes and the shape of procursus, the special armature of chelicerae and the female epigynum plate (Huber and Kwapong 2013) are unique and easy to distinguish from other genera in the family.

According to the World Spider Catalog (2016), six *Artema* species are recognized. In this study I recognize eleven *Artema* species, four species are easily distinguished from other congener: *Artema atlanta* Walckenaer, 1837, the widespread type species; *A. kochi* Kulczyński, 1901 (revalidated) from Northeast
Africa; *A. bunkpurugu* Huber & Kwapong, 2013 from West Africa; and *A. nephilit* sp. nov. from the West Mediterranean and the Arabian Peninsula. All other species are considered problematic for varying reasons: species limits are unclear between *Artema doriai* Thorell, 1881 and *A. transcaspica* Spassky, 1934 from Central Asia and surrounding regions; Roewer’s Afghan species *A. magna* Roewer, 1960 and *A. ziaretana* (Roewer, 1960) are problematic because they are based on female and juvenile types respectively and little new material is available from Afghanistan. The material available suggests the existence of three further species.

The genus is represented worldwide by the type species *Artema atlanta* Walckenaer, 1837. This is a pantropical pholcid, the only species in the genus with a wide distribution, from the Americas through Africa, Europe and Asia to the Far East and Australia. Six additional species are distributed in the Old World, four species from Asia and the Middle East (including one species new to science that is described here): *Artema nephilit* sp. nov. from the Levant: Israel, Jordan, Greece and Cyprus, *A. doriai* Thorell, 1881 from Iran, *A. transcaspica* Spassky, 1934 from Central Asia (Turkmenistan-Uzbekistan region), *A. magna* Roewer, 1960 from Afghanistan and Pakistan and two species from Africa: *A. kochi* Kulezyński, 1901 (revalidated herein) from Sudan, Eritrea and Yemen and *A. bunkpurugu* Huber and Kwapong, 2013 from west Africa.

The genus *Artema*, like most of its family members, inhabits natural habitats as dark and shaded habitats especially caves, holes and crevices and under large rocks, as well as in man-made habitats like bunkers, buildings and basements and under concrete bridges (Huber and Kwapong, 2013). In a large cave survey I conducted along Israel, I found *Artema nephilit* sp. nov. in caves especially along the Jordan Rift Valley, in a very hot and arid zone. A few records of this species outside
the Jordan Rift Valley, in a more mesic habitat in Israel, also suggest that the species prefers the more xeric, hot and dry caves rather than humid caves nearby (see Chapter 4). A few species in the genus were collected in very dry regions and arid deserts with less than 50 mm of annual precipitation, as Huber (2011) mention about Arteminae subfamily in general. The web is irregular and non-sticky. Diets observed in remnants on webs were isopods, tenebrionid and carabid beetles, small scorpions and a few spiders. Females in Israel were observed to carry an egg sac during May, while nearby, the male was eaten and entangled in threads.

Here I revise the genus Artema and proposed six nominal species of Artema, in addition to the West African Artema bunkpurugu Huber and kwapong, 2013. I describe one new species Artema nephilit sp. nov. from the Levant, in addition to redescriptions of five Artema species: A. doriai Thorell, 1881; A. transcaspica Spassky, 1934; A. magna Roewer, 1960; A. kochi Kulczyński, 1901 and the pantropical species Artema atlanta Walckenaer, 1837.

### 3.2 Material and methods

This revision is based on material deposited in the following 26 collections: American Museum of Natural History, New York (AMNH); Natural History Museum, London (BMNH); California Academy of Sciences, San Francisco (CAS); Durban Natural Science Museum, Durban (DNSM); Museum of Comparative Zoology, Cambridge (MCZ); Muséum d'histoire naturelle, Genève (MHNG); Muséum national d'Histoire naturelle, Paris (MNHN); Musée royal de l'Afrique Centrale, Tervuren (MRAC); Museo Zoológico de “la Specola”, Firenze (MZF); Naturhistorisches Museum, Basel (NHMB); Naturhistorisches Museum Wien, Vienna (NHMW); Forschungsinstitut und
Naturmuseum Senckenberg, Frankfurt (SMF); Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK); Museum für Naturkunde, Berlin (ZMB); Zoologisches Institut und Zoologisches Museum, Hamburg (ZMH); Zoological Museum, University of Copenhagen, Copenhagen (ZMUC); The National Natural History Collections, The Hebrew University of Jerusalem (HUJ); Tel Aviv University Zoological Museum (SMNHTAU Ar); Sergei Zonstein personal Collection, Tel-Aviv (ZON); Zoological Museum of the Moscow University, Russia (ZMMU); Robert Bosmans personal collection (CRB); Yuri Marusik personal collection, Magadan, Russia (Marusik); Museo civico di Storia naturale di Genova (MCSNG:); Zoological Institute, Russian Academy of Sciences, St. Petersburg (ZIN); Naturhistoriska Museet, Göteborg, Sweden (NHMG); Collection of the Arachnological Museum of Kırıkkale University (KUAM)(Danisman).

Methods and terminology are as in Huber (2000, 2011b). Measurements are in mm unless otherwise noted. Eye measurements are ±5 μm. Cleared epigyna were stained with chlorazol black. Specimens were examined and measured using Nikon SMZ18 stereo-microscope. Digital microscope images were taken using AxioVision imaging system with AxioCamHR3 digital camera mounted on a ZEISS StéREO Discovery V20 stereo-microscopes (Zoologisches Forschungsmuseum Alexander Koenig, Bonn). Locality coordinates are in round brackets when copied from labels and original publications or when received directly from collectors, in square brackets when originating from some other source (such as online geographical database, Google Earth, etc.). Distribution maps were generated with Arc View GIS 3.2.

Further anatomical abbreviations are used in the text and the figures:
AEP, anterior epigynal projections; ALE, anterior lateral eye; ALS, anterior lateral spinneret; AME, anterior median eye; em, embolus; p, procursus; PME, posterior median eye; PMS, posterior median spinneret.

3.3 Results

Artema nephilit sp. nov.


“Artema mauricia” (misidentification): Dalmas 1920: 59 (Bodrum, Turkey) (record cited in Le Peru 2011 as "Artema atlanta"); see Notes below.

Diagnosis (all mentioned figures are in Plate 6, unless otherwise noted)

Males are easily distinguished from all known congeners by their bulbal apophyses:
apophysis c (Fig. 11) projecting prolaterally, apophysis d absent (Fig. 10); [A. magna: apophysis c robust, strongly curved prolaterally, apophysis d distinct inflated projection (no apophysis) on ventral side of bulb (Plate 10, Figs. 5-6); A. atlanta: apophysis c with sclerotized ridge projecting perpendicular to apophysis b with small teeth prolaterally; A. bunkpurugi: apophysis c partly membranous and directed towards apophysis b; A. kochi: apophysis b flattened, rectangular distally, apophyses c and d absent; A. doriai and A. transcaspica: apophysis d small, pointed towards ventrodistally] and by unique median projection on each male cheliceral apophysis (Figs. 13-14); [A. magna: median projection is not part of the main modified hairs apophysis ridge as in A. nephilit sp. nov., but situated (Plate 10, Figs. 9-10) separately and somewhat below the main apophysis ridge; absent in all other congeners].

Females differ from A. doriai and A. transcaspica by their wider epigynum (semi-
circular in *A. nephilit* sp. nov. rather than trapezoidal to square-shaped); from *A. atlanta* and *A. magna* by the straight posterior epigynal margin (strongly indented in *A. atlanta* and distinctively protruding in *A. magna*); from *A. bunkpurugu* by less prominent anterior epigynal projections (AEP in Fig. 16); from *A. kochi* by entirely different shapes of anterior epigynal projections and epigynal plate (cf. Plate 7, Fig 11).

**Etymology**

The species name, *nephilit*, derives from the biblical name "Nephilim", the giants who were seen by the twelve people sent by Moses to scout the Land of Canaan. Ten of those scouts were afraid of the giants they encountered: "And there we saw the Nephilim, the sons of Anak, who come of the Nephilim; and we were in our own sight as grasshoppers, and so we were in their sight (Numbers 13, 33)."

**Type material**

Holotype ♂, in HUJ (Israel-Jord 4)

**Type data**


**Other material examined**

ISRAEL: Northern District: 3♀, 1 juv. together with holotype, same data. 1♂ deep in cave in ZFMK (Isr-Jord 61), 1♀ in ZFMK (Isr-Jord 66), 1♀ in HUJ (Israel 4), 1
juv. in HUJ (Israel 14), same data; 1♀ in SMNHTAU, HaTanur Waterfall, near
Metula (33.269°N, 35.581°E), 15 Mar. 2011 (L. Friedman); 1♀ in HUJ (6.18), Ein

Judea and Samaria Distr.: 1♂ 1♀ 1 juv. in ZFMK (Isr-Jord 1, 68), En Perat, Nahal
Perat (31.833°N, 35.303°E), in caves and a building, 260-300 m a.s.l., 15 Sep. 2013
(B.A. Huber, S. Aharon, E. Gavish-Regev); 1♀ 1 juv. in pure ethanol in ZFMK (Isr-
Jord 51), same data; 8 juvs. in SMNHTAU (SMNHTAU 9), Qumeran Cave
(31.741°N, 35.459°E), 7 Nov. 2012 (L. Friedman); 1♀ in pure ethanol in ZFMK
(Isr/Jord 58), Nahal Dawid, En Gedi (31.470°N, 35.390°E) among rocks, -250 to
-300 m b.s.l., 10 Sep. 2013 (B.A. Huber, S. Aharon, E. Gavish-Regev); 1♀ in HUJ
(Israel 6) among rocks, same data; 1♂ 1♀ in HUJ (6.16-17), En Gedi (31.470°N,
35.390°E) 20 Sep. 1975 (B. Feldman); 1 juv. in HUJ (6.9), same locality, 29 May
1968 (P. Amitay).

Southern Distr.: 1♀ in pure ethanol in ZFMK (Isr-Jord 49), Ma’ale Ya’ir (31.215°N,
35.359°E), under large rocks, -370 m b.s.l., 9 Sep. 2013 (B.A. Huber, S. Aharon, E.
Gavish-Regev); 2♀ in HUJ (Israel 13), Nahal Temarim (31.640°N, 35.411°E),
under large rocks, 3 Sep. 2013 (S. Aharon), 2♀ 1 juv. in HUJ (6.10-12), Sedom
Cave (31.087°N, 35.395°E), -370 m b.s.l., 15 Aug. 1939 (A. Shulov); 1♀ in pure
ethanol in ZFMK (Isr-Jord 47), same locality, 10 Sep. 2013 (B.A. Huber, S. Aharon,
E. Gavish-Regev); 1♂ 1♀ in ZFMK (Isr-Jord 70, Israel 15), same data; 2♀ in
SMNHTAU (Zon 5), 30 Oct. 1941, same locality; 3 juvs. in HUJ (6.13-15), Sedom
Spring, 15 Aug 1957 (H. Ginsburg); 3♀ in ZFMK (Isr-Jord 22), Arubotaim Cave
(31.101°N, 35.390°E), -380 m b.s.l, 10 Sep. 2013 (B.A. Huber, S. Aharon, E. Gavish-
Regev); 1♀ 3 juvs. in pure ethanol in ZFMK (Israel 8, Isr-Jord 46), same data; 1♀ in
HUJ (Israel 7), Malham Cave (31.076°N, 35.397°E), -370 m b.s.l, 10 Sep. 2013
(B.A. Huber, S. Aharon, E. Gavish-Regev); 1♀ 1 juv. in pure ethanol in ZFMK (Israel 12, Isr-Jor 44), same data; 1♀ in HUJ (Israel 10), NW 'En Tamar, Nahal Zin (30.989°N, 35.346°E), in crevices, -340 m b.s.l, 9 Sep. 2013 (S. Aharon, E. Gavish-Regev, B.A. Huber); 1♂ in ZFMK (Isr-Jor 71), NW 'En Tamar, Nahal Zin (30.991°N, 35.347°E), in tube near road tunnel, -340 m b.s.l, 9 Sep. 2013 (B.A. Huber, S. Aharon, E. Gavish-Regev), moulted to adult: 30 Oct. 2013; 1♂ 1♀ in HUJ (Israel 9, Isr-Jord 31), Kibbutz Samar (29.831°N, 35.022°E), in dumping ground, 100 m a.s.l, 11 Sep. 2013 (S. Aharon, E. Gavish-Regev, B.A. Huber); 1♀ in pure ethanol in HUJ (Israel 17), same locality, 19 Oct. 2013 (E. Gavish-Regev); 1♂ 2♀ in HUJ (Israel 16), 80% ethanol, in houses, same data; 1♂ 1♀ in HUJ (Israel 1,2), Elat Field School buildings (29.509°N, 34.920°E), 12 Oct. 2013 (S. Aharon, E. Gavish-Regev); 2 juvs. in pure ethanol in HUJ (Israel 3), same data.

Haifa District: 2♂♂ 1♀ in ZFMK (Isr-Jord 6, 62), Oren Cave, Mount Karmel (32.714°N, 34.975°E), in cave, 70 m a.s.l., about 3 km from Mediterranean Sea, 17 Sep. 2013 (B.A. Huber, E. Gavish-Regev, S. Aharon).


JORDAN: Ma’an Province: 2♂♂ 2♀ in ZFMK (Isr-Jord 2), Petra (30.324°N, 35.447°E), rock-cut tombs, near theater, 900-950 m a.s.l., 13 Sep. 2013 (B.A. Huber); 1♀ 1 juv. in pure ethanol in ZFMK (Isr-Jord 36), same data; 1♂ in ZFMK (Isr-Jord 65), among rocks, same data.

Karak Province: 1♀ 1 juv. in ZFMK (Isr-Jord 19,72), Wadi Hasa (31.004°-31.014°N, 35.494-35.506°E), among rocks, -330 to -250 m b.s.l., 14 Sep. 2013 (B.A. Huber); 1♀ in pure ethanol in ZFMK (Isr-Jord 63), same data.


GREECE: exact locality is missing.

Material assigned tentatively (see Notes below)


Description

Male (holotype)

Measurements. Total body length 7.0, carapace width 3.1. Leg 1: 48.4 (11.9 + 1.4 + 13.9 + 18.3 + 2.9), tibia 2: 10.2, tibia 3: 8.0, tibia 4: 10.9; tibia 1 L/d: 35. Distance PME-PME 190 μm, diameter PME 170 μm, distance PME-ALE 90 μm, distance AME-AME 50 μm, diameter AME 190 μm.

Color. Carapace pale to light beige, with light gray median band; clypeus with wide light brown band; legs pale yellow to light ochre with dark rings on femora subdistally, patellae + tibiae proximally, and tibiae subdistally, tips of femora and tibiae whitish; sternum pale, with narrow light brown margins; abdomen light brown with white and dark dots forming stripes from dorsal to lateral side of abdomen.

Body. Ocular area slightly elevated; carapace with median pit and distinctive posterior furrow; clypeus unmodified; sternum wider than long (2.3/1.5); chelicerae as in Figs. 13-14, with frontal row of ~20 modified (cone-shaped) hairs on each side that splits distally, with outer branch ending at tip of apophysis, inner branch ending at tip of...
median projection; indistinct small field of stridulatory ridges laterally; gonopore with four epiandrous spigots.

Palps. Coxa unmodified; trochanter with short ventral projection; femur with short, somewhat pointed retrolateral process proximally; ventral membranous area proximally bordered on both sides by sclerotized ridges; femur-patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis, with weakly developed ventral pocket and distal dorsal notch on prolateral sclerotized margin (arrow in Fig. 11); bulb with two apophyses close to membranous embolus (apophyses a and b in Fig. 11), apophysis c (Fig. 11) strongly projecting prolaterally, and indistinct projection (no apophysis) on ventral side of bulb (Fig. 10).

Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 8%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible.

Variation. Tibia 1 in 14 other males: 9.2–20.6 (mean 14.4); color pattern on abdomen varies from distinctive stripes consisting of black and white dots on pale to brown-ochre background to pale without any pattern; leg color varies from light brown to ochre; ocular area usually light brown to ochre; median band on carapace sometimes reaches posterior margin of ocular area, forming short v-shaped mark; cheliceral modified hairs vary in numbers; gonopore with variable number of epiandrous spigots (4-6).

**Female**

In general similar to male; tibia 1 in 26 females: 8.0–16.5 (mean 12.5); several females with light brown margins of carapace and subtle brown stripes on ocular area; stridulatory files laterally on chelicerae present, more distinct than in males;
epigynum almost twice as wide as long, semi-circular, posterior margin almost straight, gently undulating; epigynal plate consisting of two sclerotized lateral areas that appear swollen posteriorly, pale median area, and dark median sclerite anteriorly (variably large and variably distinct); pair of projections anterior to epigynum (AEP) visible (Figs. 15-17) but not prominent as in A. bunkpurugu (cf. Figs. 49, 53-54 in Huber and Kwapon, 2013).

Natural history
The spiders were found both in natural habitats such as caves, deep crevices and under boulders, as well as in man-made habitats, such as buildings, under low culverts and artificial caves. In caves, the spiders built irregular webs (not clearly dome-shaped webs) near the ground, under stones, in crevices, and on the cave ceiling. The spiders seemed to avoid the deeper dark parts of the visited caves. The species occurs mainly in areas with only 50 mm mean annual precipitation and thus seems to be adapted to arid conditions.

In the more than 40 caves I examined, most of the inhabited caves were dry caves. The species was not found in wet caves, but there were a few collections in hot, humid caves. In the southern caves were food abundance was low, I couldn't observe prey items. In a cave situated in the Golan Heights where the annual precipitation is higher I recorded remnants of isopods, tenebrionid beetles, small scorpions and a spider. In two caves I observed remnants of adult males that were eaten probably by the female, while in another occasion I observed a predation of an adult male Artema nephilit sp. nov. by Holocnemus pluchei. A female in the Elat Field School basement was observed with an egg sac during mid-September. A few juveniles were collected in order to rear them in the lab. Juveniles that were reared in Bonn, Germany and
Sede Boqer, Israel, molted to adult almost simultaneously after an unusually long rearing period of 9-10 months, since September 2013 until July 2013 (4 males and one female molted in the lab in Sede-Boqer). This simultaneous timing suggests that it is not an artifact caused by the food regime or differences from natural condition but rather indicates an intrinsic growth and maturation period.

**Distribution**

*Artema nephilit* sp. nov. is the second most common pholcid in the Jordan Rift Valley, after the ubiquitous *Holocnemus pluchei*. It has been collected from Elat in the south to Nahal Ayun in the north. Specimens from outside the Rift Valley (Ramat Avedat near Sede Boqer; Oren Cave, Mount Karmel; Petra, Jordan), and the specimens from Cyprus and Greece indicate that the species is probably widely distributed in the area.

**Notes**

I have not seen the material identified by Bodenheimer (1937) as *A. mauriciana*. However, *A. mauriciana* (=*A. atlanta*) does not seem to occur in Israel and there is no evidence that it ever existed there. I consider it likely that Bodenheimer was dealing with this common species rather than with the much rarer *A. doriai*.

The same applies to the material from Bodrum, Turkey identified by Dalmas (1920) as *A. mauricia* (=*A. atlanta*). Since this locality is situated in between known localities of *Artema nephilit* sp. nov. in Cyprus and Greece and far from the most Western specimens of *A. doriai* that was collected in middle Turkey (Urfa and Gaziantep), I assume it as *A. nephilit* sp. nov.
The female from Yemen, “Yar Ju Am Iah” (“Yar Ju Amlah”?), has a very similar epigynum, but since no males from this locality are known, it is assigned tentatively.

**Plate 6: Artema nephilit**
1. male, habitus. 2. female, cephalothorax. 3. typical position. 4. male, habitus. 5-6. male chelicera, lateral (5), frontal (6). 7-9. male left pedipalp, prolateral (7), dorsal (8), retrolateral (9). 10-12. male left bulb, prolateral (10), dorsal (11), retrolateral (12). 13-14. male chelicera frontal, arrangement of the cone shaped hairs on the frontal apophysis. 15-17. female abdomen, epigynum (15), variation in epigynum sclerite of four females all from Berniki caves, ventral view (16), abdomen, dorsal and lateral view (17).

(a, b, c – apophyses, em – embolus, p – procursus, AEP – anterior epigynal projections).
**Artema kochi** Kulczyński, 1901 (revalidated)

_Artema kochii_ Kulczyński 1901: 19-20; pl. 1, fig. 14. [erroneously synonymized with “Artema mauriciana” by Simon (1908: 426-427)].

Misidentifications:


“*Artema mauricia*”: Simon 1890: 93.

**Diagnosis** (all mentioned figures are in Plate 7, unless otherwise noted)

Males are easily distinguished from known congeners by their bulbal apophysis b (Fig. 6; flattened, “band”-like, rectangular distally, rather than pointed or awl-shaped as in congeners); apophysis a slender and projecting towards retrolaterally (Fig. 6; in congeners more robust and not projecting towards retrolaterally); apophyses c and d absent (apophysis c present in all congeners, apophysis d absent in _A. nephilit_ sp. nov. and _A. bunkpurugu_, inflated in _A. atlanta_). Females differ from known congeners by entirely different shapes of anterior epigynal projections (AEP) and epigynal plate: anterior epigynal projections sclerotized and elongated (Fig. 11; in contrast to all congeners), not projecting (in contrast to _A. bunkpurugu_); epigynal plate sclerotized, wide rectangular, with triangular anterior projection between AEP, posterior border almost straight (Fig. 11) (epigynum of _A. doriai_ and _A. transcaspica_ rather trapezoidal to square-shaped; _A. atlanta_ with strongly indented posterior rim; _A. nephilit_ sp. nov. with semi-circular epigynal plate, _A. magna_ with distinctively protruding posterior epigynal margin, without triangular anterior projection between AEP).
Type material
Neotype ♂ (designated herein) in MCSNG (Genova 15), examined (see Notes below).

Type data

Other material examined
ERITREA: Massawa: 1♀ 7 juvs. together with neotype, same data.
Localities not clear: 1♂ in MZF (Firenze 13), “Urso 1283”, no date (Kovacs). 1♂ in MZF (Firenze 18), “Afrique Orientale, Gibdo” (Djibouti/Eritrea?), 10 May 1907 (Katona).

Description
Male (MNHN Ar 10169)
Measurements. Total body length 6.8, carapace width 3.5. Leg 1: 46.2 (12.1 + 1.6 + 13.4 + 16.2 + 2.9), tibia 2: 10.0, tibia 3: 7.6, tibia 4: 10.5; tibia 1 L/d: 34. Distance
PME-PME 190 μm, diameter PME 190 μm, distance PME-ALE 90 μm, distance AME-AME 40 μm, diameter AME 180 μm.

Color. Carapace ochre to light brown, with brown median band and narrow light brown margins; brown to light brown stripes radiate from margins to median pit; ocular area ochre to brown, clypeus with light brown band below AME, and dark brown rim; legs ochre to light brown, with reddish brown to ochre prolatetal marks on femora proximally, with brown rings on femora subdistally, patellae + tibiae proximally, and tibiae subdistally, tips of femora and tibiae not whitish; sternum ochre to light brown with narrow brown margins; abdomen beige to light brown with pale yellow and dark dots forming indistinct stripes from dorsal to lateral side of abdomen with large marks dorsally.

Body. Ocular area slightly elevated; carapace with distinct median pit and distinctive posterior furrow; clypeus unmodified; sternum wider than long (2.4/1.7); chelicerae as in Figs 8-10, with frontal row of 16-19 modified (cone-shaped) hairs on each side situated on proximally strongly projecting apophyses; with several cone-shaped, sclerotized processes situated frontally near median line (arrow in Fig. 8); without stridulatory ridges; gonopore with four epiandrous spigots.

Palps. Coxa unmodified, trochanter with short ventral projection, femur with distinct retrolateral process proximally, ventral membranous area proximally bordered on both sides by heavily sclerotized ridges, and small dorsal projection proximally; femur-patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis and weakly developed ventral pocket, and distal dorsal notch on retrolateral sclerotized margin; bulb with membranous embolus rising from base of apophysis a, apophysis an elongated, projecting towards retrolaterally with bifid tip; apophysis b flattened, band-like, rectangular (Fig. 6); apophyses c and d absent.
Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 8%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible.

Variation. Tibia 1 in 3 other males: 11.1–14.2 (mean 13.1); color pattern on abdomen varies from pale without any marks to light brown with dark and pale dots forming large dorsal marks and fine lateral stripes; leg color varies from light brown to ochre; elevated ocular area usually light brown; carapace pattern varies from narrow brown stripes to wide brown marks radiating from median pit to margin (Fig. 1, cf. fig. 1 in Koch, 1875)

Female

In general similar to male; tibia 1 in 2 females: 5.6, 9.8; stridulatory files laterally on chelicerae present; anterior epigynal projections (AEP) sclerotized, elongated (Fig. 11); epigynal plate sclerotized, wide rectangular (~3 x wider than long) projecting anteriorly between AEP, with almost straight posterior rim; some females with two dark dots at base of triangular anterior projection (Fig. 11).

Distribution

I examined specimens from Ethiopia, Eritrea and Yemen. Kulczyński’s (1901) original description was apparently based on specimens from Egypt (see Notes below).

Notes

The original description by Kulczyński (1901) is based on two female specimens, but it does not specify where these females were collected. I assume that Kulczyński
examine and illustrated the specimens from Egypt, near Cairo, that L. Koch (1875)
had misidentified as *Pholcus borbonicus* Vinson, 1863 (= *A. atlanta*). Kulczyński also
mentions specimens from “Massaua” (Eritrea, Massawa) that Thorell (1881) had
described in some detail but that he had equally misidentified as *Pholcus borbonicus.*
Since this material from Massawa contains males and females I conclude that it was
not available to Kulczyński. However, I chose to designate a neotype from the
material originating from Massawa for three reasons: (1) Kulczyński did not designate
type specimens; (2) I was not able to locate the specimens from Egypt (they are not in
ZMH and ZMB); (3) Kulczyński’s (1901) good illustration of the highly distinctive
epigynum of *A. kochi* leaves little doubt that the specimens available to him are in fact
conspecific with the specimens from Massawa.

Much less obvious is how Simon (1908), after having studied specimens of “*A.
mauriciana*” (= *A. atlanta*) from many localities, arrived at the conclusion that
Kulczyński’s drawings represented merely slight individual variation and that *A.
kochi* was a synonym of “*A. mauriciana*”. This is all the more mysterious because
Simon himself had collected *A. kochi* in Massawa and Aden (in 1889) and his own
material (in MNHN, examined) includes not only females but also the equally
distinctive males. I found both species that Simon collected from Massawa and Aden,
*A. atlanta* and *A. kochi*, deposited in the same vial, so I assume that Simon did not
examined all the material but only part of it and apparently it was *A. atlanta.*
Plate 7: Artema kochi
1. male habitus. 2-4. male left pedipalp. prolateral view (2), dorsal (3), retrolateral (4).

5-7. male left bulb. prolateral view (5), dorsal (6), retrolateral (7). 8-10. male chelicera. lateral view (8), frontal (9,10). 11. female epigynum sclerite and anterior epigynal projections (AEP). 12. female abdomen, lateral view. 13. ventral pocket (vp) and dorsal apophysis (da) on procursus.

Artema transcaspica Spassky, 1934

Artema transcaspica Spassky, 1934: 369-372; figs. 8-10; ♂♀ (Turkmenistan, Tajikistan).

**Diagnosis** (all mentioned figures are in Plate 8, unless otherwise noted)

Males are easily distinguished from other known congeners by their bulbal apophyses (Figs. 5-8): apophysis c triangular, sometimes curved and pointed prolaterally, situated near apophysis b and by small pointed ventral apophysis d distally; (A. atlanta): apophysis c with sclerotized ridge projecting perpendicular to apophysis b with small teeth prolaterally; A. bunkpurugu: apophysis c partly membranous and directed towards apophysis b; A. kochi: apophysis b flattened, rectangle distally; A. nephilit sp. nov.: apopysis c strongly projecting prolaterally, apophysis d absent; A. magna: apopysis c strongly curved prolaterally, apophysis d distinct inflated projection (no apophysis) on ventral side of bulb (Plate 10, Figs. 5-7)); females differ easily from other congeners by their rectangular to square-shaped epigynal plate (Fig. 1) (A. atlanta with strongly indented posterior rim; A. magna with ~2.5x wider epigynum than long with distinctively protruding posterior epigynal margin; A. nephilit sp. nov. with semi-circular epigynum plate; A. bunkpurugu with prominent anterior epigynal projections (cf. figs. 49, 53-54 in Huber and Kwapong, 2013) and semi-circular/triangular epigynum plate; A. kochi with anterior epigynal projections (AEP) sclerotized and elongated and epigynal plate sclerotized, wide rectangular, with triangular anterior projection between AEP.

Males are barely distinguished from A. doriai by their cheliceral proximal incline usually without ridge or small apophysis above modified hairs in lateral view which is
present in *A. doriai*. If present it is usually small gap or minor ridge, their bulbal apophyses seems to be very similar; females distinguished from *A. doriai* by their more rectangular to square-shaped epigynal plate rather than trapezoidal in *A. doriai* (in *A. doriai* anterior part of lateral sclerite plate is somewhat narrow than posterior part, forming more trapezoidal shape), by median sclerite line usually elongated to posterior margin and conjugating with the two lateral sclerite plates (in *A. doriai* the dark median sclerite is usually only about 0.5 length of epigynum, see Fig. 5) and by less distinct pale median area posteriorly (in *A. doriai* the pale median area is usually distinct posteriorly);

**Type material**

Lectotype ♂ (designated herein) in (ZIN 19), examined (see Notes below)

Paralectotype 4♂ 11♀ in (ZIN 19), examined (see Notes below)

Paralectotype 2♂ in (ZIN 17), examined (see Notes below)

Paralectotype 1♂ 2♀ in (Paris 170), examined (see Notes below)

**Type data**

UZBEKISTAN: 1♀ in (ZIN 19), Andizhan [=Andijan: 40.803935°N, 72.3051°E], in house, winter 1938 (Karpovich).

TURKMENISTAN: 3♂ 10♀ in (ZIN 19), Ashkhabad [=Ashgabat: 37.9333°N, 58.3666°E], spring 1933 (E. Mel'nikova); same locality, in room, 5.IX.1936 (collector: F?); 1♂ in (ZIN 19) (No 22, Acq no 1-1901), Krasnovodsk [=Türkmenbasy: 40.0166°N, 52.9666°E], summer 1900 (Ahnger); 1♀ in (ZIN 19) (No 22, Acq no 124-07), Repetek, "Transcaspian Provincei" [38.5666°N, 63.1833°E], 1907 (Dolgopolev).
TAJIKISTAN: 1♀ in (ZIN 19), Stalinabad [=Dushanbe: 38.5333°N, 68.7833°E], summer 1933 (A. Alparov).
Locality not clear: 1♂ in (ZIN 19) (No 22, no 87 [Acq?]), Akhalteke, 1896 (Ahnger);
1♂ 2♀ in MNHN 10178 (Paris 170), "Regio Transcaspica" may be specimens from ZIN 18?

Other material examined

UZBEKISTAN: 1♂ in (ZMMU 128), Navoi Area, Uchkuduk Distr.(41.859°N, 63.3068°E), Kyzylkum Desert, ca. 36.5 km SSW of Uchkuduk, ca. 6 km SWS of Tasbulak well, sands, 120m., 2.06.2003 (A.V. Gromov); 3♀ in (ZMMU129), Kafirnighan riv. valley, Ak-Mechat [38.0180°N, 68.2975°E], in house, 7.05.94 (S. Ovchinnikov); 3♂ in (ZMMU 130), transfer from (ZMMU 129), same data; 1♂ 5♀ numerous juv. in (ZMMU 136), 1-2 km SE Zaravshan Town [=Zarafshon: 41.5785°N, 64.2449°E], 20.IV.-19.VII. 1998 (A.V. Gromov); 1♂ numerous juv. in (ZMMU 144), same data; 1♀ numerous juv. in (ZMMU 151), Bukhara Area [39.5146°N,64.8413°E], 33 km SE Bukhara, 19-20.V.1994 (A.A. Zyuzin).

TURKMENISTAN: 8♂ 8♀ numerous juv. in (ZIN 18), Aschabad [=Ashgabat: 37.9333°N, 58.3666°E], summer and autumn 1933 (E. Mel'nikova), 16.IV.1934 (M.K. Laptev); 1♂ 1♀ in NHMW 13.677 (Wien 20), Badkhyz, Kushka [35.6800°N, 62.0000°E], 12.IV.1985 (S. Zonstein); 1♀ in (ZFMK 175), Kopetdag, Parkhai [28.4779°N, 56.2592°E], in house, X.2012 (V.I. Perepechaenko).

TAJIKISTAN: 1♂ in (ZMMU 122), Vaksh River Valley, "Tigrovaya Balka" State Res.[ 38.3579°N, 69.1888°E], Korolevskaya Dacha, 3.VIII.2006 (S.V. Ovchinnikov); in SMNHTAU (ZON 1), Kafirnigan river, 10-15 km NNE of Tartki,
(37.6905°N, 68.1598°E), inside a solitary abandoned farmer house near the riverbank, 12.VI.1989 (S. Zonstein).

Description

Male (ZIN 19)

Measurements. Total body length 5.7, carapace width 3.1. Leg 1: 39.1 (10.1 + 1.3 + 11.5 + 14.0 + 2.2), tibia 2: 9.0, tibia 3: 7.0, tibia 4: 9.3; tibia 1 L/d: 38. Distance PME-PME 150 μm, diameter PME 190 μm, distance PME-ALE 90 μm, distance AME-AME 60 μm, diameter AME 180 μm.

Color. Carapace light ochre with large brown radial marks, with brown median band that splits at posterior margin of ocular area; ocular area ochre to brown, clypeus with dark brown rim and light brown band below AME enlarged at base of clypeus to triangular shape; legs ochre yellow without dark rings on femora, patellae, and tibiae; sternum ochre to light brown with narrow brown margins; abdomen without distinct pattern.

Body. Ocular area slightly elevated; carapace with distinct posterior furrow and distinct median pit close to posterior margin of ocular area; clypeus unmodified; sternum wider than long (2.1/1.7); chelicerae as in Figs. 8-10, with frontal row of ~25 modified (cone-shaped) hairs on each side, situated on elevated apophysis; cheliceral proximal incline in lateral view without ridge, gap, or small apophysis above modified hairs but followed smoothly by first modified hair; without stridulatory ridges; gonopore with five epiandrous spigots.

Palps. Coxa unmodified, trochanter with short ventral projection, femur with distinct retrolateral process proximally, ventral membranous area proximally bordered on both sides by heavily sclerotized ridges, and small dorsal projection proximally; femur-
patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis, with weakly developed ventral pocket, and distal dorsal notch on prolateral sclerotized margin; bulb with membranous embolus rising from base of apophysis a; apophysis a with bifid tip; apophysis b narrow, elongated, and pointed; apophysis c triangular; apophysis d is a small ventral projection distally (arrows in Figs. 5-7).

Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 10%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible.

Variation.

Color pattern on abdomen varies from pale without any marks to light brown with lateral stripes; leg color varies from light brown to ochre; elevated ocular area usually light brown; carapace pattern varies from wide brown lateral marks to pale carapace with median band only; two brown bands at base of ocular area sometimes missing; clypeus dark rim and dark band sometimes absent; procursus distal dorsal notch on prolateral sclerotized margin usually slightly elevated and not a distinct indentation (Fig. 6; cf A. nephilit sp. nov. Plate 6, Fig.11); apophysis c sometimes curved pointing prolaterally; lateral stridulatory ridges either absent (as in lectotype) or very indistinct but sometimes present (Fig. 8); cheliceral proximal incline usually without ridge, gap, or small apophysis above modified hairs in lateral view; if present, then gap small and ridge indistinct.
**Female**

In general similar to male; stridulatory files laterally on chelicerae always present; epigynal plate rectangular (Fig. 1), consisting of two sclerotized lateral rectangular areas that are gently swollen posteriorly and depressed medially anteriorly, pale median area with long dark median sclerite, usually fused at posterior epigynal margin with lateral sclerotized plates, small median indentation in posterior rim; anterior epigynal projections oval, not prominent in lateral view.

**Distribution**

The species is distributed from Kopet Dag Mountain Range, situated at south of Turkmenistan, to Tajikistan in the East. The species is found also north of this range and was found in Uzbekistan. It is likely that *A. transcaspica* would be found also in Kyrgyzstan and Kazakhstan.

**Note**

The species is part of a complex of three related taxa which shows great similarity between them, *A. transcaspica, A. doriai* and specimens from Pakistan and Sudan tentatively assigned to *A. doriai*. Although the males of *A. doriai* and *A. transcaspica* shares very high similarity while the females differs in their epigynum structure, I decided conservatively not to synonymized *A. doriai* and *A. transcaspica*, while in this amount of knowledge, I have not separated the specimens from Sudan and Pakistan to an independent species.
Plate 8: *Artema transcaspica*

1. epigynum. 2-4. male left pedipalp. prolateral view (2), dorsal (3), retrolateral (4).

5-7. male left bulb. prolateral view (5), dorsal (6), retrolateral (7). 8-10. male chelicera. lateral view (8), frontal (9,10)  (a, b, c, d – apophyses, em – embolus, p – procursus, AEP – anterior epigynal projections).
Artema doriai Thorell, 1881


Denis 1958: 112 (Afghanistan); see notes below.

Diagnosis (all mentioned figures are in Plate 9, unless otherwise noted)

Males are barely distinguished from A. transcaspica by their cheliceral proximal incline usually with small ridge or apophysis above modified hairs in lateral view; A. transcaspica usually with smooth incline proximally of modified hairs, their bulbal apophyses seems to be very similar; A. doriai easily distinguished from other congeners by their modified hairs apophysis on cheliceral frontally, by bulbal apophysis c triangular, sometimes curved and pointed prolaterally, situated near apophysis b and by small pointed ventral apophysis d distally; (A. atlanta: apophysis c with sclerotized ridge projecting perpendicular to apophysis b with small teeth prolaterally, apophyses d and e (additional) inflated rather than small pointed apophysis; A. bunkpurugu: apophysis c partly membranous and directed towards apophysis b, apophysis d absent; A. kochi: apophysis b flattened, rectangle distally, apophyses c and d absent; A. nephilit: apophysis c strongly projecting prolaterally, apophysis d absent; A. magna: apophysis c strongly curved prolaterally, apophysis d distinct inflated projection (no apophysis) on ventral side of bulb); females distinguished from A. transcaspica by their more trapezoidal epigynal plate rather than rectangular to square-shaped in A. transcaspica (in A. doriai anterior part of
lateral sclerite plate is narrower than posterior part, forming more trapezoidal shape, in
*A. transcaspica* the lateral sclerite plates are not narrower anteriorly), by median
sclerite line usually only about 0.5 length of epigynum, (see Fig. 5) (in *A.
transcaspica* the dark median sclerite is usually elongated to posterior margin and
conjugating with the two lateral sclerite plates) and by more distinct and inflated pale
median area posteriorly (in *A. transcaspica* the pale median area is usually indistinct
posteriorly); females differs easily from other congeners by their trapezoidal epigynal
shape (*A. atlanta* with strongly indented posterior rim; *A. magna* with ~2.5x wider
epigynum than long with distinctively protruding posterior epigynal margin; *A.
nephilit* sp. nov. with semi-circular epigynum plate; *A. bunkpurugu* with prominent
anterior epigynal projections (cf. figs. 49, 53-54 in Huber and Kwapong, 2013) and
semi-circular/triangular epigynum plate; *A. kochi* with anterior epigynal projections
(AEP) sclerotized and elongated and epigynal plate sclerotized, wide rectangular, with
triangular anterior projection between AEP.

**Type material**

Syntypes 1♂ 1♀ in MCSNG (*Genova 6*), examined.

Syntypes 1♂ 1♀ in MNHN AR 10180 (397) (*Paris 173*), examined.

**Type data**

IRAN: Teheran [35.7086°N, 51.4215°E], 1862-1863 (G. Doria).
Other material examined

IRAN: 2♂ 2♀ 1 juv. in (HMNG 370), Lorestan, Ma'amulan (33.333°N, 47.9000°E), 6 August 1973 (A. Senglet); 2♂ in (HMNG 371), Esfahan (32.5666°N, 51.5166°E), 28 August 1973 (A. Senglet); 1♂ in (HMNG 373), Ganznameh / Hamedan (34.7333°N, 48.5000°E), 2100 m, 4 July 1974 (A. Senglet); 1♂ in (HMNG 374), Allabad (30.016°N, 53.0000°E), 9 June 1974 (A. Senglet); 1♂ 1♀ in (HMNG 376), Bishapur (29.7833°N, 51.5833°E), 28 May 1974 (A. Senglet); 1♂ in (HMNG 375), Kormansah, SE of Berendjan (34.5500°N, 47.0333°E), 12 September 1975 (A. Senglet); 1♀ in (SMF 232), Yazd Prov., 10 km NE Bafa (31.7000°N, 55.5344°E), 1260 m, 10 April 2004 (V. Vignoli and P. Crucitti); 2♂ in (SMF 279), Ahwaz (Khonsistan) [31.3100°N, 48.6800°E]

AFGHANISTAN: 1♂ in (HMNG 372), Herat (34.3333°N, 62.2166°E), 15 August 1975 (A. Senglet).

TURKEY: 2♀ in (HECO 3), Urfa [37.1044°N, 38.6416°E], 15 km Urfa – Gaziantep, webs under rocks on dry rocky hills, 12 September 1956 (Oxford).

ISRAEL: 1♀ in (SMNHTAU), Upper Galilee, Ramot Naftali (32.0522°N, 35.328°E), 15.V.2012, (S. Zonstein); 2♂ in (HUJ), Yavni'el [32.7085°N, 35.5025°E], IX.1961 (collector is not mentioned); 1♂ in (HUJ), Poriyya slope [32.7390°N, 35.5481°E], IV.1970 (Pener et al); 1♀ in (SMNHTAU), Nachal Chagal, north to Gesher (32.6341°N, 35.5340°E), 3.XII.2010 (L. friedman, C. Drees); 2♀ in (HUJ), Andartat Habik'a, NE Peza'el (32.0524°N, 35.4589°E) in cave, 10.III.2014 (S. Aharon, E. Gavish-Regev, B.A. Huber), 2♀ in (HUJ), Jericho [31.8955°N, 35.4219°E], XII.1967,X.1969 (P. Amitai), 2♀ in (HUJ), II.1968 (G. Tsabar); 6♀ in (SMNHTAU), Modi'in (31.8935°N, 34.9715°E), pitfall trap in shrub habitat, 2012 (I. Berenstein et al); 1♂ in (SMNHTAU), Hazeva [30.7682°N, 35.2776°E],
17.VI.2010 (L. Friedman, C. Drees); 1♀ in (HUJ), Near Hazeva [30.7682°N, 35.2776°E], 11 VIII 2014 (Akiva Topper).

**Material assigned tentatively** (see Notes below)

INDIA: 1♂ in (SMF 423), Rajasthan, Durjana (29.0038°N, 74.8217°E), 181m in steppe with sparse vegetation and single trees, at wall, 10 March 2011 (P. Yager); 1♀ in (CAS 418), Rajasthan [25.7373°N, 73.3418°E], hill S Pali, 275 m, 8 I 1962 (Ross and Cavagnaro).

PAKISTAN: 2♀ in (ZMMU 172), Baluchistan, Muslimabagh village (30.7833°N, 67.7666°E), 7 IX 2005 (S. V. Ovchinnikov); 1♂ in (ZMMU 132), Baluchistan, Quetta Town [30.2081°N, 67.0178°E], (missing details).

SUDAN: 8♂ in (MRAC SM 239, 240, 241, 243) (121706, 121718, 169130, 127506), Khartum [15.5458°N, 32.5341°E], I/II 1962 (J. S. Cloudsley-Thompson); 2♀ in (AMNH AF 39), arrived in NY in engine parts from Sudan, VI 1995 (K. Devage).

**Description**

**Male** (MNHN AR 10180)

Measurements. Total body length 8.5, carapace width 4.1. Leg 1: 60.8 (16.0 + 1.9 + 18.2 + 21.2 + 3.5), tibia 2: 14.2, tibia 3: 10.0, tibia 4: 13.8; tibia 1 L/d: 36. Distance PME-PME 220 μm, diameter PME 200 μm, distance PME-ALE 140 μm, distance AME-AME 50 μm, diameter AME 200 μm.

Color. Carapace ochre with light brown median band; ocular area light brown, clypeus with subtle brown rim and light brown band below AME enlarged at base of clypeus to triangular shape; legs ochre yellow to ochre without dark rings on femora subdistally but with light brown rings on patellae + tibiae proximally, and tibiae
subdistally, tips of femora and tibiae not whitish; sternum ochre with narrow brown margins; abdomen beige with indistinct pale stripes from dorsal to posterior of abdomen with several marks dorsally.

Body. Ocular area slightly elevated; carapace with distinct posterior furrow and distinct median pit; clypeus unmodified; sternum wider than long (3.0/2.2); chelicerae as in Figs. 9-13, with frontal row of ~20-25 modified (cone-shaped) hairs on each side, situated on elevated apophysis; cheliceral proximal incline in lateral view with distinct small apophysis above modified hairs (see Figs. 12-13); with stridulatory ridges laterally; gonopore with four epiandrous spigots.

Palps. Coxa unmodified, trochanter with short ventral projection, femur with distinct retrolateral process proximally, ventral membranous area proximally bordered on both sides by heavily sclerotized ridges, and small dorsal projection proximally; femur-patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis and weakly developed ventral pocket, and distal dorsal notch on prolateral sclerotized margin (Fig. 7); bulb with membranous embolus rising from base of apophyses a and b; apophysis a with bifid tip; apophysis b narrow, elongated, and pointed; apophysis c small, triangular; apophysis d is a small ventral projection distally (arrows in Figs. 6-8).

Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 8%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible.

Variation. Tibia 1 in 19 other males: 8.0-22.2 (mean 14.5); color pattern on abdomen varies from pale without any marks to beige with lateral stripes and large marks dorsally; leg color varies from light brown to ochre; elevated ocular area usually light brown; carapace pattern varies from sub-marginal brown marks to pale carapace with
median band only; clypeus sometimes without dark band; apophysis c varies in length, sometimes curved pointing prolaterally; lateral stridulatory ridges usually present and easy to notice, sometimes invisible (Fig. 12-13); cheliceral proximal incline usually with ridge forming a gap or small apophysis above modified hairs in lateral view, sometimes absent or indistinct.

Female

In general similar to male; stridulatory files laterally on chelicerae present, more distinct than in males; epigynal plate trapezoidal, consisting of two sclerotized lateral areas that are wider posteriorly, gently swollen posteriorly, and depressed medially anteriorly, pale median area inflated posteriorly with dark median sclerite 1/2-1/3 the length of epigynal plate, dark median sclerite not fused at posterior epigynal margin with lateral sclerotized plates, epigynal posterior margin usually straight, sometimes with small median indentation; anterior epigynal projections oval, not prominent in lateral view.

Distribution

This species is widespread in Iran and occurs also in Afghanistan and Pakistan, while the populations in Israel and Turkey are probably the edge of the distribution, being at the western limit of the species geographic range. see notes about eastern specimens from Pakistan and southern population from Sudan.

Notes

A group of eastern specimens, 1♂ 1♀ from Rajastan, India, 1♂ 2♀ from Baluchistan, Pakistan and 8♂ 2♀ from Khartoum, Sudan shares some characters with A. doriai.
Male: distinct stridulatory ridge, presence of apophysis above modified hairs in lateral view, bulbal apophyses, female: presence of pale median area on epigynal plate; The specimens differ in other characters, male: cheliceral apophysis forming finger-like shape in frontal view rather than S shape, distinctive inflated ridge or apophysis in front of proximal incline above modified hairs in lateral view, apophysis c more robust, long and usually not curved prolaterally, female: epigynum much wider than long ~1.8 x (mean of 5♀♀, range of 1.73-1.9 rather than ~1.53-1.54 x in A. doriai and A. transcaspica, distinctive pale median area of epigynal plate very inflated and prominent, dark median sclerite varies from very dark sclerite half the length of epigynal plate to brown band all the length of epigynal plate to totally absent. It is therefore assigned tentatively to A. doriai.

I have not seen the material identified by Denis (1958) as A. transcaspica (Pirzada, Afghanistan). However, although Denis mention that this species seems fairly widespread in the Trans Caspian region, I assume that he was dealing with the very close species A. transcaspica, which is more likely according to the species distribution (I examined one male of A. doriai that was collected from Herat, Afghanistan).
**Plate 9: Artema doriai**

1. female, habitus. 2-4. male left pedipalp, prolateral (2), dorsal (3), retrolateral (4). 5. female epigynum. 6-8. male left bulb, prolateral (6), dorsal (7), retrolateral (8). 9-13. male chelicera. frontal view, arrangement of the cone shaped hairs on the frontal apophysis (9,10), lateral view (11). small projection proximally on frontal apophysis, marked in an arrow. specimen from Iran (12) and Israel (13).

(a, b, c, d – apophyses, em – embolus, p – procurus, AEP – anterior epigynal projections)
Artema magna Roewer, 1960

Artema magna Roewer, 1960: 43-45, figs 14a-h (♀, Afghanistan).

**Diagnosis** (all mentioned figures are in Plate 10, unless otherwise noted)

The putative males of this species are easily distinguished from all known congeners by the combination of bulbal apophyses and male cheliceral armature: bulbal apophysis c (Fig. 6) strongly curved prolaterally, apophysis d distinct inflated projection (no apophysis) on ventral side of bulb (Fig. 5); [A. atlanta: apophysis c with sclerotized ridge projecting perpendicular to apophysis b with small teeth prolaterally; A. bunkpurugu: apophysis c partly membranous and directed towards apophysis b; A. kochi: apophysis b flattened, rectangle distally, apophyses c and d absent; A. doriai and A. transcaspica: apophysis d small pointed ventral distally] each male cheliceral apophysis with unique median projection (Fig. 10), which is not part of the main modified hairs apophysis ridge as in A. nephilit sp. nov., but situated separately and somewhat below it; absent in all other congeners. Females differ from A. doriai and A. transcaspica by their wider epigynum (~2.5x wider than long, rather than trapezoidal to square-shaped); from A. atlanta by the median protruding posterior epigynal margin (strongly indented in A. atlanta); from A. bunkpurugu by less prominent anterior epigynal projections (AEP in Figs. 12-13) and wider epigynum; from A. kochi by entirely different shapes of anterior epigynal projections and epigynal plate (cf. Plate 7, Fig. 11).
Type material

Holotype ♀, in NHMG (A 196) (Göteborg), examined.

Type data


Material assigned tentatively (see Notes below)


Description

Male (assigned tentatively)

Measurements. Total body length 9.3, carapace width 4.3. Leg 1: 54.8 (14.0 + 1.8 + 15.8 + 20.3 + 2.9), tibia 2: 11.8, tibia 3: 9.0, tibia 4: 12.0; tibia 1 L/d: 39. Distance PME-PME 210 μm, diameter PME 230 μm, distance PME-ALE 100 μm, distance AME-AME 30 μm, diameter AME 210 μm.

Color. Carapace light ochre to beige with small brown spots laterally forming few small lines near median pit, with light brown median band that splits at posterior margin of ocular area to brown lines following base of ocular area and light brown band medially on ocular area; clypeus with wide ochre brown band below AME that fades towards dark brown edge of clypeus; legs ochre to light brown with dark rings on femora subdistally, patellae + tibiae proximally, and tibiae subdistally, tips of femora and tibiae pale ochre; sternum ochre, with brown margins and median light brown dots forming cross-like pattern; abdomen beige without pattern.
Body. Ocular area slightly elevated; carapace with median pit and distinct posterior furrow; clypeus unmodified; sternum wider than long (3.0/2.1); chelicerae as in Figs. 8-10, with frontal row of ~17 modified (cone-shaped) hairs on each side with unique median projection (Fig. 10), which is not part of the main modified hairs apophysis ridge but situated separately and somewhat below it, ending with 2 modified hairs; without stridulatory ridges; gonopore with four epiandrous spigots.

Palps. Coxa unmodified; trochanter with short ventral projection; femur with short, somewhat pointed retrolateral process proximally; ventral large membranous area proximally bordered on both sides by sclerotized ridges; femur-patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis with weakly developed ventral pocket and three distal dorsal fine notches on prolateral sclerotized margin (Fig. 6); bulb with membranous embolus rising from base of apophyses a and b, apophysis a slightly spiraling with pointed tip; apophysis b elongated and pointed, apophysis c robust strongly curved prolaterally (Fig. 6), and distinct inflated projection (no apophysis) on ventral side of bulb (Fig. 5).

Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 10%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible.

Female

In general similar to male; tibia 1: 17.8; abdomen beige with lateral gray stripes with large marks dorsally; stridulatory files laterally on chelicerae present; epigynum ~2.5 times wider than long, median posterior margin protruding distally; epigynal plate consisting of two swollen sclerotized lateral areas, pale median area, and dark median
anterior sclerite; pair of projections anterior to epigynum (AEP) oval, not prominent; sternum with light brown dots forming cross-like pattern more distinct than in male.

**Natural history**

The male was collected inside a house together with a male assigned tentatively to *A. doriai* (ZMMU 132). The female was collected from a cave. The synonymized *Pholciella ziaretana* (Roewer, 1960) that was also collected under stones on hill near Jalalabad and was identified by Huber (2009) as a juvenile in the genus *Artema*, might be a juvenile of *A. magna*.

**Distribution**

The type locality of the female that Rower collected was near Nurgal, not far from Jalalabad. The putative male was collected in Quetta town, Baluchistan Province, Pakistan. Only two localities are not enough to draw a distribution, but it might be that the species distribution lies along the mountain ridge from North East Afghanistan to South West Pakistan.

**Notes**

The male of *A. magna* was not described, but since the female of *A. magna* show similarity to *A. nephilit* sp. nov., and since this male also shows related and unique characters to *A. nephilit* sp. nov. and similar geographic region as *A. magna*, it is therefore assigned tentatively to this species. The male from Pakistan shares some characters with *A. nephilit* sp. nov. (inner projection on cheliceral apophysis; cheliceral lateral shape) but differs in others (bulb apophysis c spur like as in *A. doriai*)
and *A. transcaspica* but more robust, apophysis d inflated and more distinct, see Figs. 5-6);

The specimen that was collected near Jalalabad and established as a new genus by Rower (1960) as *Pholciella ziaretana* was identified by Huber (2009) as a juvenile in the genus *Artema*, might be a juvenile of *A. magna*.

**Plate 10: Artema magna**
1. cephalothorax, female. 2-4. male left pedipalp. prolateral view (2), dorsal (3), retrolateral (4). 5-7. male left bulb. prolateral view (5), dorsal (6), retrolateral (7). 8-10. male chelicera. lateral view (8), frontal (9, 10). 11. female abdomen, lateral and dorsal view. 12-13. female epigynum sclerite and anterior epigynal projections (AEP), lateral view (12) and ventral view (13).

(a, b, c, d – apophyses, em – embolus, p – procursus, AEP – anterior epigynal projections).
Artema atlanta Walckenaer, 1837

2012: 3, fig.1 (Kenya, Uganda, Somalia, Tanzania). Huber and Kwapong 2013: 7 (Guinea, Togo, Benin).


Misidentifications:

“Artema atlanta”: Dalmas 1920 (see A. nephilit sp. nov. Feng 1990: 45 (misidentification of Physocyclus globosus).

“Artema mauriciana”: Bodenheimer 1937: 238 (see A. nephilit sp. nov.). Millot 1941: 3-5, figs 1A-I (except fig. 1F; misidentification of A. bunkpurugu; see Huber and Kwapong 2013).

“Pholcus borbonicus”: L. Koch 1875: 25-26; Simon 1882 (see A. kochi).

“Tibiosa coreana”: Gonzalez-Sponga 2006: pl, 3, figs 8-9 only.

**Diagnosis** (all mentioned figures are in Plate 11, unless otherwise noted)

Males are easily distinguished from all known congeners by their bulbal apophyses: apophysis c (Fig. 6) with sclerotized ridge projecting prolaterally perpendicular to apophysis b with small teeth prolaterally on round end of the apophysis, apophyses d and e (additional) inflated rather than small pointed apophysis (as in A. doriai and A. transcaspica). A. nephilit sp. nov.: apophysis c strongly projecting prolaterally, apophysis d absent; A. bunkpurugu: apophysis c partly membranous and directed towards apophysis b; A. kochi: apophysis b flattened, rectangular distally, apophyses c and d absent; A. doriai and A. transcaspica: apophysis d small pointed ventral
distally; *A. magna*: only one distinct inflated projection (no apophysis) on ventral side of bulb) and by different arrangement of modified hairs on cheliceral apophysis (Figs. 5, 10). Males differ also by two deep dorsal notches on distal margin of procursus. Females differ from other congeners by strongly indented posterior epigynal margin (additional differences: *A. doriai* and *A. transcaspica* with trapezoidal to square-shaped epigynum; *A. bunkpurugu* with prominent anterior epigynal projections; *A. kochi* with entirely different shapes of anterior epigynal projections and epigynal plate (cf. Plate 7, Fig. 11); *A. magna* with much wider epiganum (~2.5x wider than long) and distinctively protruding posterior epigynal margin.

**Type material and data**

*A. atlanta* Walckenaer, 1837: Syntypes ♂ ♂ probably lost; BRAZIL: (no further data) [9.7956°S, 55.3710°W].

*A. mauriciana* Walckenaer 1837: Syntypes ♂ ♀ probably lost; MAURITIUS: (no further data) [20.2776°S, 57.5848°E].


*A. convexa* Blackwall 1858: Syntypes ♂ ♀, probably lost; BRAZIL: Pernambuco [8.000°S, 35.000°W].
*Pholcus borbonicus* Vinson 1863: Syntypes ♂ ♀ probably lost; REUNION: (no further data) [21.1267°S, 55.5276°E].

*Pholcus rotundatus* Karsch 1879: Syntypes ♀♀, probably lost; COLOMBIA: Santa Marta [11.2419°N, 74.2052°W].

*Crossopriza sexsignata* Franganillo 1926a: Syntypes ♂ ♀ probably lost; CUBA: Habana, Luyanó [23.1050°N, 82.3480°W].

**Other material examined**

USA: 1♂ 1♀ in AMNH (*ref coll*), Arizona, Tucson [-32.2°N, -110.9°W], July-Aug. 1935 (P. Steckler); 3♀♂ in AMNH (*ref coll*), same data; 3♂ 4♀ in NMB (*Basel 11*), same locality, July 1937 (collector not given).

VIRGIN ISLANDS: 1 juv. in (*Hamburg 30*), St. Thomas [18.3333°N, 64.9167°W], 28 March 1898 (L.D. Calwood).


PARAGUAY: 2♀ in ZMH (*Hamburg 27*), [-23.584°S, 58.128°W], without additional data, (Wiengreen).

Togo: 1♂ 1♀ 2 juvs. in ZMH (Hamburg 20), "Anecho" [=Aneho] [6.228°N, 1.578°E], 27 Jan. 1910 (Günther); see also Huber and Kwapong (2013).

Guinea-Bissau ("Portuguese Guinea"): 1♂ 2♀ 1 juv. in ZMH (Hamburg 26), Bissao [11.860°N, 15.601°W], 4 Oct. 1898 (H. Eberhardt); 1 juv. in ZMH (Hamburg 41), same data.

Guinea and Benin: see Huber and Kwapong (2013).

São Tomé: 1♀ in (Hamburg 18) no. 31, "S. Thomé" (=São Tomé) [0.3408°N, 6.7309°E], 1879 (R. Greef).

Tchad: 3♂ 2♀, numerous juvs. in MRAC (132893) (MRAC sm 236), between Bongor and Fort Lamy ("Lancy?") [= N'Djamena; ~11.102°N, 15.232°E], Nov.-Dec. 1965 (Y. Brandlly).

Tunisia: 7♂ 2♀, numerous juvs. in MNHN (AR 10170) (Paris 174), Djerba [33.808°N, 10.885°E], (Vibert).

Libya: 1♂ in MZF (Firenze 3), Gialo [=Jalu] [29.025°N, 21.540°E]; 1♀ in MZF (Firenze 9), same locality, Jan. 1934 (Di Caporiacco); 1♂ in MCSNG (Genova 7), "Gialo", 4-5 May 1931(?), collector not given; 1♂ in MCSNG (Genova 9), same locality ("Oajo di Gialo"), Aug. 1931(?), collector not given; 1♀ in MCSNG (Genova 10), same locality ("Gialo"), 1931(?), collector not given; 1♂ 1♀ in MCSNG (Genova 12), same locality ("Gialo"), 1931, collector not given; 6♀ 6 juvs. in MCSNG (Genova 13), "Giarabub" [=Al Jaghbub; 29.740°N, 24.515°E], June 1926-March 1927 (Confalonieri); 1♀ in MZF (Firenze 21), with two locality labels: "Giarabub", June 1926-March 1927, and "Porto Bardia" [=Bardiyah; 31.758°N, 25.080°E], March 1927; 1♀ in ZMH (Hamburg 17), Tripoli [32.861°N, 13.174°E], 1906 (Klaptocz).

EGYPT: 1♂ 1♀ 1 juv. in ZFMK (ref coll), Sohag, Maragha [26.698°N, 31.603°E], 26 Feb. 2002 (H. El-Hennawy); 1♂ 7♀, numerous juvs. in MNHN (AR 10155 392) (Paris 172), Alexandria [31.194°N, 29.915°E], and Suez [29.964°N, 32.548°E], (E. Simon); 2♀ in NMB (1041a, 1402b) (NMB Basel 10), near Cairo [~30.0°N, 31.2°E], 1911 (E. Graeter); 3♂ in ZMUC (cop 397), Mansurah [31.040°N, 31.378°E], (Sorensen).

ISRAEL: 1♀ 1 juv. in SMNHTAU (AR 50186) (SMNHTAU 8), Haifa port [32.827°N, 34.992°E], imported in a container arrived from Tuticorin, India [8.764°N, 78.130°E], 5 June 2012 (E. Gavish-Regev).

YEMEN-ERITREA: 1♂ 2♀ 1 juv. in MNHN (AR 10169 part) (paris 171), Aden [12.865°N, 44.989°E], and Massawa [15.610°N, 39.450°E] [1889, E. Simon, “393” part].

YEMEN: 1♀ 5 ju-vs. in (Genova 11), Aden [12.865°N, 44.989°E], 1880 (Doriai and Beccari).

SUDAN: 1♂ in MRAC (120764) (MRAC sm 242), Khartoum [15.545°N, 32.534°E], 1960-1961 (J.S. Cloudsley-Thompson); 1♂ in MRAC (120766) (MRAC sm 244), same data; 1♂ 1♀ 2 juv. in NHMW (356) (Wien 25), [South] Kordofan, Talodi [10.633°N, 30.381°E], 15 Oct. 1938 (Werner); 1♂ 2♀ 7 juvs. in ZMH (Hamburg 25), El-Obeid [13.181°N, 30.223°E], March 1914 (D.G. Mainhof).

BURUNDI: 1 juv. in MRAC (29993) (MRAC sm 252), "Usumbura" [=Bujumbura] (3.368°S, 29.366°E), Jan. 1926 (H. Schenuden); 2♂ 1♀ in MRAC (57974-77) (MRAC sm 255), same locality, 1948 (A. Lestrede); 1♀ 1 juv. in MRAC (24696) (MRAC sm 254), Rumonge [3.971°S, 29.438°E], 1934 (A. Lestrede).
UGANDA: 1♀ 1 juv. in MRAC (134815) (MRAC sm 253), Jinja [0.436°N, 33.204°E], Apr. 1968 (E. Vertriest); see also Huber and Warui (2012)

SOMALIA: 1♀ 1 juv. in MZF (Firenze 22), locality unknown (“339.76”, “Mag. no. 866”), 1924 (Stefanini and Puccioni); 2♀ in MZF (Firenze 29), locality unknown (“1140 20”), 1924 (Stefanini and Puccioni); 1♀ in MRAC (177.415) (MRAC sm 251), Kismayo [0.358°S, 42.548°E], under stones, 16 Apr. 1993 (Vercammen Gino).

KENYA: 1♀ in CAS (CAS 358), Rift Valley, Lodwar, along Turkwell River (3.1166°N, 35.595°E), 10-12 June 1999 (W.J. Pulawski and J.S. Schweikert); 1♂ in CAS (CAS 359), Gabraland, Marsabit area [2.335°N, 37.987°E], 17 Jan. 1978 (from artifact in CAS anthropology collection); 1♂ in NHMW (355) (Wien 22), "Ostafrika Waboniland" [2.078°S, 40.704°E], 15 Oct. 1938 (Haeseler); see also Huber and Warui (2012).


MOZAMBIQUE: 1♂, numerous juvs. in ZMH (Hamburg 32), Cucuta ("Cucuta/brasilien") [11.8361° S, 40.2411°E], 29 Sep. 1887 (W. Bösenberg).

ZAMBIA: 1♂ in SMF (SMF 65), Mpalungu [8.7637°S; see also Huber and Warui (2012)

CONGO DR: 3♀, numerous juvs. in MRAC (119889) (MRAC Sm 245), Kivu, Uvira between. Kolundu and Kavimvira [3.3485°S, 29.1549°E], June 1961 (R. Kiss); 2 juvs. in MRAC (119917) (MRAC sm 247), same data; 1♀ in MRAC (76923) (MRAC sm 246), "Mutelemko" Uvira [-3.4065°S, 29.1286°E], 1954 (J. Bouillon).

ZIMBABWE: 1♂ in CAS (CAS 360), Victoria Falls (17.933°S, 25.833°E).


MADAGASCAR: 1♀ in ZMH (7791) (Hamburg 15), Tamatave [18.151°S, 49.401°E], 12 May 1885 (A. O'Swald). 1♀ in ZMH (12832) (Hamburg 14), Nosy Be, Lokobe [13.301°S, 48.262°E], 5 Nov. 1885 (A. O'Swald); 1♀ in ZMH (Hamburg 29), Nosy Be, 13 March 1908.

INDIA: 3♀ 2 juvs. in MCSNG (Genova 17), Bombay, Elephanta [=Gharapuri] [18.960°N, 72.930°E], 18 Sep. 1877 (Beccari and E. D'Albertis); 2♂ 9♀ in ZMUC (COP 401), Vellore [12.930°N, 79.133°E], without date (Miss Löwenthal).

MYANMAR: 3♂ 14♀ in ZMUC (COP 402) "fra Rangoohn" [Rangoon; 16.840°N, 96.149°E] [see also label of COP 399 for comparison] (Löwenthal).

CHINA: 1♀ in ZMH (Hamburg 38), Canton [22.674°N, 113.609°E], 8 Aug. 1904 (W. Helms).

TAIWAN: 1♀ 2 juvs. in ZMH (Hamburg 28), "Takao, Formosa" [=Kaohsiung] [22.771°N, 120.429°E], 1 Nov. 1908 (W. Schwinghammer).

PHILIPPINES: 1♂ in CAS (CAS 422), Manila [14.613°N, 121.046°E], 10 June 1945 (T. Aarons).

INDONESIA: 1♂ in SMF (SMF 219), Flores, Labuan Bajo (8.490°S, 119.878°E), 22 Nov. 2009 (S. Huber); 2♂ 4♀ 4 juvs. in NHMW (WIEN 29), Sumatra, Medan [3.614°N, 98.673°E], 15 Oct. 1938 (Fulmek).
Locations not clear: 1♂ in SMF (SMF 413), "Ferokee, Malebar", no further data; 2♀ in MCSNG (Firenze 11), "El Buz", "Mag. no. 1220", 15 Aug. 1968 ("SBS", "977"); 1♂ 1 juv. in BMNH (29) (BMNH 49), "Museat, Jayakan". 1♀ 1 juv. in ZMH (Hamburg 37), “Westindien”, 3 Sep. 1906 (C. Gazgo).

AUSTRALIA.

Description

Male (Rangoon, ZMUC)

Measurements. Total body length 9.6, carapace width 4.0. Leg 1: 48.4 (16.0 + 1.6 + 16.6 + 22.5 + 2.6), tibia 2: 12.6, tibia 3: 9.5, tibia 4: 13.0; tibia 1 L/d: 42. Distance PME-PME 210 μm, diameter PME 210 μm, distance PME-ALE 110 μm, distance AME-AME 60 μm, diameter AME 180 μm.

Color. Carapace ochre beige, with light brown median band and small dots laterally; ocular area light brown; clypeus with light brown band fading towards edge, with brown rim; legs light ochre with large ochre ventral mark on patella 1 proximally; with dark rings on femora subdistally, patellae + tibiae proximally, and tibiae subdistally; sternum light ochre with two small light brown marks posteriorly, with narrow light brown margins; abdomen pale ochre with pale and dark dots forming large marks dorsally and stripes laterally.

Body. Ocular area slightly elevated; carapace with median pit and distinct posterior furrow; clypeus unmodified; sternum wider than long (2.5/2.2); chelicerae as in Figs. 8-9, with frontal row of ~20 modified (cone-shaped; cf. Figs. 12-13 in Huber 2000) hairs on each side in s-shape pattern that splits proximally, with four parallel inner modified hairs (Fig. 10); stridulatory ridges absent (Fig. 8); gonopore with four epiandrous spigots (cf. Fig. 121 in Huber 2000). ALS with several cylindrical spigots
in addition to widened and pointed spigot (cf. Fig. 169 in Huber 2000); PMS with two pointed spigots each (cf. fig. 195 in Huber 2000).

Palps. Coxa unmodified; trochanter with short ventral projection; femur with short, somewhat pointed retrolateral process proximally; ventral membranous area proximally bordered on both sides by sclerotized ridges and small dorsal projection proximally; femur-patella hinges close together dorsally; patella very short; procursus with proximal dorsal apophysis with weakly developed ventral pocket and two distal dorsal notches on sclerotized margin (arrows in Fig. 6); bulb with membranous embolus rising from base of apophysces a and b (cf. fig. 56 in Huber 2000), apophysis a long, somewhat inflated distally; apophysis b elongated and pointed, apophysis c (Figs. 5-6) with sclerotized ridge projecting prolaterally perpendicular to apophysis b, with small teeth prolaterally on round end of apophysis (cf fig. 57 in Huber 2000), apophyses d and e (additional) inflated rather than small pointed apophysis (Fig. 6).

Legs. Without spines; with long curved hairs, especially on tibiae and metatarsi; retrolateral trichobothrium on tibia 1 at 9%; prolateral trichobothrium present on all tibiae; pseudosegmentation not visible (cf fig. 99 in Huber 2000).

Variation. Tibia 1 in 19 other males: 12.0–19.0 (mean 15.4); color pattern on abdomen varies from distinct stripes consisting of dark and pale dots on pale to brown-ochre background to pale without any pattern; leg color varies from pale to ochre, prolateral ochre mark on patella 1 proximally sometimes absent; ocular area light brown to ochre; lateral dots on carapace vary from round radiating pattern to small indistinct marks; cheliceral modified hairs vary in numbers (~17-20), sometimes sclerotized ridge very dark and pattern of modified hairs hard to distinguish, one male with small apophysis medial of sclerotized ridge (♂ from Khartoum, MRAC 120766); brown marks posteriorly on sternum variable; one male
with procursus notches almost fused to one large notch without sclerotized line between them (MNHN AR 10166). No variation observed in numbers of epiandrous spigots.

**Female**

In general similar to male; tibia 1 in 20 females: 9.2–17.2 (mean 13.2); stridulatory files laterally on chelicerae present; epigynum plate trapezoidal (posteriorly larger) with deep median indentation on posterior margin; epigynal plate consisting of two sclerotized lateral areas that appear swollen posteriorly, usually light brown, sometimes very pale at lateral posterior edge, light brown to pale median area, and dark sclerite anteriorly (variably large and variably distinct), posterior rim sometimes slightly sclerotized; pair of projections anterior to epigynum (AEP) ovoid, sometimes with variable light brown marks anteriorly.

**Natural history**

As other species in the genus, *A. atlanta* is inhabiting caves as well as buildings and basements.

**Distribution**

*Artema atlanta* is the only species in this small genus that is Pantropical: it is found in the tropical Americas to Africa and throughout the Mediterranean basin to India and the Far East and Australia. It can be assumed from the genus distribution that *A. atlanta* was originally also an Old World pholcid, like the other species in the genus, which expanded its distribution and became invasive (Brignoli, 1981).

**Notes**
*A. atlanta*, due to its large distribution, was repeatedly described as a new species even by Walckenaer who described the genus. The intraspecific variations in males and females characters are minor despite the large distribution and the many synonymies.

**Plate 11: Artema atlanta**
1. epigynum. 2-4. male left pedipalp. prolateral view (2), dorsal (3), retrolateral (4).  
5-7. male left bulb. prolateral view (5), dorsal (6), retrolateral (7). 8-10. male chelicera. lateral view (8), frontal (9,10). (a, b, c, d, e – apophyses, em – embolus, p – procursus).

3.4 Discussion

This genus overall seems to have an Old World distribution, specifically in central Asia, the Middle-East and Africa (Iran, Afghanistan, Uzbekistan, Turkmenistan, Tajikistan, Pakistan, India, Israel, Jordan, Greece, Cyprus, Turkey, Sudan, Yemen, Ethiopia, Eritrea, Ghana and Togo. Artema atlanta is the only species in this small genus that is Pantropical: it is found in the Americas and many Pacific islands, in tropical Africa, the Mediterranean basin the Oriental region to Australia. It can be assumed from the genus distribution that A. atlanta was originally also an Old World pholcid, like the other species in the genus, which expanded its distribution and became invasive (Brignoli 1981). Bodenheimer (1935) mentions A. mauriciana (=A. atlanta) in his publications as present in the fauna of Palestine. I have not seen the material identified by Bodenheimer (1937) as A. mauriciana. However, based on the revision I have conducted on the genus, A. mauriciana (=A. atlanta) does not seem to occur in Israel and there is no evidence that it ever existed in Israel until the recent findings in the imported container from India. I consider it likely that Bodenheimer was dealing with the common species in the area A. nephilit sp. nov. rather than with the much rarer A. doriai.

I observed three closely related taxa, from Central Asia and the Middle East, resembled in a very similar male palpal organs and cheliceral apophyses and with a
square to trapezoidal shape of epigynum: *Artema transcaspica, Artema doriai* and a close population distributed in Baluchistan, Pakistan; Rajasthan, India and from Khartoum, Sudan. This population is assigned tentatively to *Artema doriai* but shows slight differences in the shape of the male palpal organs and cheliceral apophyses and with more obvious difference in the female epigynal sclerite. All the males of these three different taxa shows high resemblance in the males palpal organs and the arrangement of the cone-shape apophyses on chelicera while the females shows fairly large differences in their epigynum plate structure.

Females from four species, *Artema nephilit* sp. nov., *Artema bunkpurugu*, *Artema atlanta* and *Artema magna* show relatively similar general shape of more elongated epigynum plate rather than rectangular. One female from Yemen (assign tentatively to *A. nephilit* sp. nov.) also shows similar shape of epigynum while an undescribed female from Oman shows a very simple rectangular shape of epigynum plate. From the last species mentioned, only the males of *A. nephilit* sp. nov. from Israel and *A. magna* from Afghanistan shows similar shape and structure of male palpal organs and cheliceral apophyses. I examined one male of undescribed species from Algeria but I did not describe it due to lack in a female. The most different species in the genus is *A. Kochi*, showing very different shape of palpal organs and cheliceral apophyses and with unique epigynum plate and shape of the pair of projections anterior to epigynum (AEP).

I have not included in the revision the doubtful species *Artema ziaretana* Roewer, 1960 as it is a juvenile specimen of *Artema* (Huber 2009) and might be one of at least two species.
Artema nephilit sp. nov. is the only species from the genus Artema, with a Levantine distribution, lies from Elat in southern Israel along the Jordan Rift Valley up to Metula in Lebanon's border. The species may occur also in Sinai and Egypt, as well as in Syria and Lebanon, this is due to the presence of the species near the borders of those countries with the presence in the Jordanian side of the Jordan Rift Valley. I assume that the species is present in Bodrum, western Turkey, based on a collection of Artema specimens there, which I did not examine, but it is situated nearby Greece and Cyprus, two localities that I identified the new species Artema nephilit sp. nov. from two females that have been collected there. In this revision, I recorded one additional new species based on a male collected in Algeria, but it has not been described yet due to lack in a female.
4. Ecology and Distribution of the Genus *Artema* in Israel

4.1 Introduction

The distribution of a species depends on ecological and biogeographic processes occurring in both a local and a regional scale. The factors that may play a role in the local scale are, among others, predation, parasitism, competition, dispersal and dispersal limitations, stochastic processes and abiotic factors (e.g. temperature, precipitation, solar radiation, wind regimes and soil type). At the regional scale speciation, historical biogeography, long-distance dispersal, wide-spread extinction and invasions can affect species distribution and regional species pool (Pulliam, 2000).

Species' historical biogeography can be explained by two contrasting hypotheses - vicariance and dispersal. Vicariance is the fragmentation of widespread ancestors by isolating events, creating non-continuous (disjunct) distributions, relicts or even allopatric speciation (Sanmartin, 2003). Nevertheless, long-distance dispersal among regions can overcome these fragmentations and is responsible, for example, for the successful colonization of remote islands (Gillespie et al., 2011). Climatic changes may lead to extreme changes in distribution due to extinctions and invasions. Species from a variety of taxonomic groups were shown to shift their distributions as a result of climatic change and invade open niches, however not all species respond quickly enough and are likely to become extinct (Thomas, 2011).

The species pool is determined by large scale and small scale processes. These act as filters determining the actual species that are present in a community. (Zobel, 1997). The filters can be either biotic or abiotic factors. Biotic factors such as interspecific competition and predation influence species range (Gaston, 2003; Holt,
Species coexistence is a possible positive outcome of these interactions, provided that species do not coincide in their ecological demands. However, species can out-compete one another and cause the exclusion of the less suited species from the habitat, or may prey one another and affect the local presence of a species. Abiotic conditions filter species that can adapt to certain abiotic conditions and exclude species that fail to adapt and suffer from low fitness. When species richness is high, such as in low latitudes, it is suggested that biotic interactions are more important than abiotic factors in filtering species (Zobel, 1997). However, the significance of adaptation to abiotic conditions becomes greater in harsh habitats where mainly abiotic factors act as extremely strong filters of species (Romero, 2009).

Caves are a unique, often harsh, underground ecosystem isolated from the outside world and home to many exceptional organisms that have adapted to life in the dark. The specific spatial distribution and organization of various biotic a abiotic elements in caves interact with a species’ way of dispersing, which, in turn, affect its abundance and distribution (Campbell Grant et al., 2007) and result in high rates of endemism (Romero, 2009). Limitation of space, light and resources may act as filters and both limit the number of species in caves and select for adapted species. For example, species that are less mobile are expected to have special adaptations to caves (i.e. troglomorphism) while it would be disadvantageous for highly mobile species to show troglomorphism (Romero, 2009). However, although the study of the evolution and ecology of organisms that live in caves has great potential, there is little knowledge regarding many animal groups, especially invertebrates.

Arachnids are one of the most important groups of invertebrates inhabiting subterranean (hypogean) environments. Of the 11 orders of Arachnida, nine have hypogean representatives. Cave dwelling species can be classified into three groups,
according to their affinity to life in caves: troglobites, troglophiles and trogloxenes (Schiner, 1854). The first are obligated to life in caves and among the characteristics of many troglobite arachnid species are the reduction or complete loss of vision and pigmentation, elongation of appendages, presence of sensory setae etc. Troglophiles are organisms that have strong affinity to caves but can also have populations outside caves. Trogloxenes are organisms that live in caves but are required to leave the subterranean habitat for various needs (Culver and White, 2005). Spiders (Araneae) include nearly 1,000 true troglobite species, and many more species are troglophiles and can be found at the entrances of caves (Romero, 2009).

No specific survey of spiders in caves has yet been done in Israel. However, findings from the collection-based study (chapter two in this work) suggested that caves and rock crevices are important habitats for the family Pholcidae. *Hoplopholcus cecconii* Kulczyński, 1908, was described from 'Palestine' but its specific location was unknown. A few females collected in 1945, probably in a cave near Bet-She'arim, were identified from the HUJ collection as *H. cecconii*. Moreover, from a recent collection from Susita Cave, a *Pholcus* sp. was identified as a new species to Israel or possibly even to science. Species of this genus tend to live in caves and crevices. One of the most interesting findings was of specimens of two *Artema* species found in caves and crevices in different sites throughout Israel.

The taxonomic revision I conducted as part of this research (chapter three in this work) on the genus *Artema* sheds new light on the global distribution of the genus, and particularly its distribution in Israel. The genus shows an overall Old World distribution, specifically in Central Asia, the Middle-East, Turkestan and Africa. *Artema atlanta* is the only species in this small genus that is Pantropical (Brignoli 1981). Based on the genus distribution it is assumed that *A. atlanta*
originally had an Old World distribution similar to other species in the genus, and then expanded its distribution and became invasive (Brignoli 1981). The revision I conducted revealed the existence of two *Artema* species in Israel: *A. doriai* found along the Jordan Rift Valley and in central Israel, and a species new to science, *A. nephilit* sp. nov., found only along the Jordan Rift Valley. The local distribution of *Artema* species in Israel was largely unknown, and their habitat preferences were completely unknown.

The little information available on the biogeography of the genus *Artema* in Israel leads to the questions: are both *Artema* species restricted to caves, do the species share similar habitat preferences, and what factors influence their distribution?

This study aims at revealing the various factors determining the distribution of two cave dwelling spiders of the genus *Artema* (Pholcidae) in Israel. In order to study the geographical distribution of the two *Artema* species, and to investigate what are the ecological and environmental variables that affect their distribution, I conducted a large ecological cave survey. I hypothesized that the two species of *Artema* found in Israel differ in their geographical distribution and that the presence of each species in a cave is associated with the specific climatic and geographic attributes in the local environment of the cave.

### 4.2 Methods

**Cave Survey and Sampling Sites**

The survey was conducted in large, medium and small caves. The size of the cave was determined as a function of the cave length and the presence of a twilight zone (transition zone) and a dark zone. Large caves were caves longer than twenty meters
including a twilight zone and a dark zone. Medium caves were ten to twenty meters with a twilight zone in the end of the cave. Small caves were with length of maximum 10 meters, lacking a twilight zone and a dark zone.

The caves were surveyed in two seasons: spring (March-April 2014) and summer (May-June 2014). Thirty three caves were chosen in order to represent various physical and ecological characteristics based on preliminary data. These preliminary data come from three different sources: the location data of the specimens from the collections, preliminary cave sampling I conducted in September 2013, and information from the Cave Research Unit (המרכז לחקר מערות- מלח"ם) of the Hebrew University of Jerusalem, a group that studies the caves and karst formations of Israel.

The studied caves (sites) represent different regions in Israel (Table 2 and Figure 5, the abbreviations of the regions are in parentheses): the Golan Heights (GH), Galilee (GL), Jordan Rift Valley (RV), central Israel (C), Judean Desert (JD) and the Negev Desert (ND).

<table>
<thead>
<tr>
<th>Northern Israel</th>
<th>Large caves</th>
<th>Medium caves</th>
<th>Small caves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yir'on Large</td>
<td>Oren</td>
<td>Yir'on Small</td>
<td></td>
</tr>
<tr>
<td>Shetula</td>
<td>Yonim</td>
<td>Pelekh</td>
<td></td>
</tr>
<tr>
<td>Berniki Large</td>
<td>Berniki Medium</td>
<td>Berniki Small</td>
<td></td>
</tr>
<tr>
<td>Ezba</td>
<td>Susita Cave</td>
<td>Horvat Rakit</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:** list of the 33 caves sampled in the field survey, arranged by size and geographic region.
<table>
<thead>
<tr>
<th>Central Israel</th>
<th>Haruva</th>
<th>Perat Inbal</th>
<th>Perat Small</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bet A'rif (Shoham)</td>
<td>Perat Roa'im</td>
<td>Perat Southern Slope</td>
</tr>
<tr>
<td></td>
<td>Sali’it</td>
<td></td>
<td>Oah</td>
</tr>
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<td></td>
<td>Te’omim</td>
<td></td>
<td>Tinshemet</td>
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<tr>
<td>Southern Israel</td>
<td>Ashalim</td>
<td>Telalim</td>
<td>Avedat</td>
</tr>
<tr>
<td></td>
<td>Malcham</td>
<td>Arubotaim</td>
<td>Nezirim- Ne’ot HaKikkar</td>
</tr>
<tr>
<td></td>
<td>Amude Amram Large</td>
<td>Qumeran</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zavoa Cave</td>
<td>Nahal Ha’Besor</td>
<td>Amude Amram Small</td>
</tr>
</tbody>
</table>

**Variables Recorded**

In each of the 33 chosen caves specific local measurements of environmental variables were recorded, both inside and outside the caves (Table 3). Inside the cave, three microhabitats were sampled (depending on the cave size) in order to determine the preferred niche for the spiders: 1) Cave entrance – illuminated area; 2) Transition zone – twilight zone (in medium and large caves); and 3) Depth of cave – dark zone (in large caves). Temperature and light measurements were recorded in the three microhabitats where I sampled the spiders. Temperature measurements were taken using PicoLite 16-K, a Single-trip USB Temperature Logger (FOURTEC), measuring the temperature once an hour, for 74-77 days. Illumination was recorded at the time of sampling using an ExTech 401025 Lux Light Meter and transformed to a standardized scale: from 1-9 lux – level 1, from 10-99 lux – level 2, and from 100-450 lux – level 3. Elevation, precipitation, and geological data were provided by the GIS (Geographic Information System) center, Hebrew University of Jerusalem (see table 8 in appendix 4.5).
**Table 3**: Environmental variables recorded

<table>
<thead>
<tr>
<th>Cave variables</th>
<th>Environmental variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cave size</td>
<td>Elevation</td>
</tr>
<tr>
<td>Opening size</td>
<td>Precipitation</td>
</tr>
<tr>
<td>Cave humidity: dry, humid and wet</td>
<td>Latitude and Longitude</td>
</tr>
<tr>
<td>Temperature: maximum, minimum and</td>
<td>Geology: soil type</td>
</tr>
<tr>
<td>average</td>
<td></td>
</tr>
<tr>
<td>Illumination</td>
<td>Outside cave temperature: maximum,</td>
</tr>
<tr>
<td></td>
<td>minimum and average</td>
</tr>
<tr>
<td></td>
<td>Slope</td>
</tr>
</tbody>
</table>
**Figure 5:** Geographic representation of the surveyed sites. Caves with specific local measurements (33) presented by yellow triangles. Additional sites (from past and occasional collections) with general local measurements (28) represented by purple triangles.
Collecting Methods

Each site and microhabitat was sampled with two methods: 1) Hand collection; 2) wet, salt-water (dissolved NaCl) pitfall traps. Each cave was searched, with help of flashlights and UV light, for twenty minutes in each microhabitat. Minimum search time in a cave was 20 minutes (small caves) while maximum search time was one hour (large caves), depending on the cave size. Each microhabitat was sampled with one pitfall trap. Minimum number of pitfall traps inside each cave was one (small caves) and maximum of three (large caves). One pitfall trap was placed outside of each of the caves. All pitfall traps were collected after 74-77 days.

Spider Preservation and Identification

Adult specimens were collected and preserved in 75% ethyl alcohol. In caves where I found only juvenile Artema, I collected them alive and reared them in the laboratory (25°C, 45% humidity, 12 hours of light a day) until they molted to adults, then I identified them under a dissecting microscope and preserved them in 75% ethyl alcohol.

Statistical Analysis

Two models were used in order to determine which ecological and geographical variables affect the distribution of the two Artema species. One model analyzed presence and absence data of the ecological survey of 33 caves, including environmental measurements taken both inside and outside the caves (see Table 2 and Figure 5, yellow triangles). The second model, a more general data analysis, was based on a larger presence and absence data set, including the designated cave survey, the records from past collections and other occasional observations. The second model included only local environmental data (latitude, longitude, precipitation,
elevation). This analysis included a total of 61 sites (Figure 5, yellow and purple triangles). Details of the 61 sites are in Chapter 3, under *Artema nephilit* sp. nov. description, other material examined.

The presence-absence data were analyzed with a generalized linear model (GLM) with a binomial distribution and logit link using IBM SPSS Statistics 21. Spatial and geographical data were determined using Arc GIS ArcMap 10.2.2 program.

### 4.3 Results

I found *Artema nephilit* sp. nov. in 18 out of 33 surveyed caves and in 16 additional sites from past and occasional collections (Figure 6a). Most of the sites were associated with the Jordan Rift Valley. *Artema doriai* was found in only one site during the cave survey and in 7 additional sites from past and occasional collections (Figure 6b). Therefore I used only *A. nephilit* sp. nov. for the statistical models. All the specimens collected during the cave survey were caught by hand. The pitfall traps inside the caves were found to be unsuccessful for trapping *Artema*, either because the cups were too small for these large spiders, or due to environmental conditions (the saline solution dried up in the extreme hot caves). In contrast, several *Artema* specimens were caught in pitfall traps placed in open areas in Modi'in Hills (collected by Berenstein and Gavish-Regev, 2014).
Figure 6a: Presence (red) and absence (black) of *A. nephilit* sp. nov. in 61 sites, including the cave survey (full circles), occasional collections (caves in empty circles, crevices, under stones and man-made habitats in empty square) and past collections (caves in grid circles, unspecified habitats in grid square)
**Figure 6b:** Presence data of *A. doriai* in 9 sites, including the cave survey (full circles), occasional collections (crevices, under stones and man-made habitats in empty square) and past collections (outside caves in X marked in a square, unspecified habitats in grid square)
**4.3.1 The Cave Survey: Effect of Environmental Variables**

Of the continuous variables I recorded, the four temperature variables were significantly correlated with each other (minimum and maximum temperature inside and outside the cave) (Pearson correlation, p<0.05), as well as with elevation, precipitation and latitude (Pearson correlation, p<0.05). Moreover, latitude was significantly correlated with precipitation and longitude (Pearson correlation, p<0.05), but not with elevation (Pearson correlation, p>0.05), while longitude was correlated with all temperature variables and with elevation (Pearson correlation, p<0.05) but not with precipitation (Pearson correlation, p>0.05). Precipitation was not correlated with elevation (Pearson correlation, p>0.05). Therefore I used only two continuous variables that were not correlated for the models: longitude, representing the geographic location of the cave, and precipitation, representing the climatic conditions at the cave location.

Of the categorical variables recorded, the opening size of the cave was significantly correlated with the illumination (Pearson correlation, p<0.05) while cave size was not significantly correlated with any variable. Therefore, the cave size and the illumination were tested separately using chi-square tests of independence.

The overall GLM model with precipitation and longitude as main effects and the interaction between the two variables was significant (p<0.0001); however, each of the main effects and the interaction were not significant (precipitation, p=0.103; longitude, p=0.06; interaction, p=0.102) (Table 4). I then tested the two main effects without the interaction. The GLM with only the main effects was significant for both precipitation and longitude (p=0.004, p=0.03 respectively, overall model significance:
p<0.0001) (Table 5). *Artema nephilit* sp. nov. was more abundant in caves with low precipitation (Figure 7 and Figure 8), and in caves located in the east (Figure 6a).

**Table 4:** cave survey GLM analysis of the effects of longitude, precipitation and their interaction on the presence/absence of *A. nephilit* sp. nov.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>Hypothesis Test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wald $\chi^2$ (df)</td>
<td>Sig.</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>809.711</td>
<td>440.5547</td>
<td>3.378 (1)</td>
<td>.066</td>
</tr>
<tr>
<td>longitude</td>
<td>-23.264</td>
<td>12.6502</td>
<td>3.382 (1)</td>
<td>.066</td>
</tr>
<tr>
<td>precipitation</td>
<td>-1.746</td>
<td>1.0717</td>
<td>2.653 (1)</td>
<td>.103</td>
</tr>
<tr>
<td>longitude * precipitation</td>
<td>.050</td>
<td>.0307</td>
<td>2.667 (1)</td>
<td>.102</td>
</tr>
</tbody>
</table>

**Table 5:** cave survey GLM analysis of the effects of longitude and precipitation on the presence/absence of *A. nephilit* sp. nov. (main effects only).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>Hypothesis Test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wald $\chi^2$ (df)</td>
<td>Sig.</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>142.286</td>
<td>66.1686</td>
<td>4.624 (1)</td>
<td>.032</td>
</tr>
<tr>
<td>longitude</td>
<td>-4.120</td>
<td>1.8956</td>
<td>4.725 (1)</td>
<td>.030</td>
</tr>
<tr>
<td>precipitation</td>
<td>.008</td>
<td>.0027</td>
<td>8.508 (1)</td>
<td>.004</td>
</tr>
</tbody>
</table>
**Figure 7:** *Artema nephilit* sp. nov. presence (red) and absence (black) data along a precipitation gradient from the cave survey. *A. nephilit* sp. nov. is more abundant where precipitation is low, while in high precipitation it is almost absent. The numbers above the bars represent the number of caves in each category.
Figure 8: *Artema nephilit* sp. nov. presence (red) and absence (black) data along a precipitation gradient from the cave survey. *A. nephilit* sp. nov. is more abundant where precipitation is low, while in high precipitation it is almost absent.
The illumination level overall had a significant effect on the presence of *A. nephilit* sp. nov. ($\chi^2=13.013$, df=2, $p=0.001$). *A. nephilit* sp. nov. was present in the higher levels of light (levels 2, 3) to the same degree ($\chi^2=0.0094$, df=1, $p=0.92$), but its occurrence in lower light level (level 1) is significantly lower than in levels 2 and 3 ($\chi^2=10.22$, df=1, $p=0.001$, $\chi^2=7.89$, df=1, $p=0.004$, respectively) (Figure 9). The size of the cave did not affect the presence or the absence of *A. nephilit* sp. nov. in caves ($\chi^2=0.6823$, df=2, $p=0.710941$) (Figure 10).

**Figure 9:** *Artema nephilit* sp. nov. presence/absence (red/black, respectively) data in different illumination level categories. *A. nephilit* sp. nov. is present at the higher light levels in comparison to the lower light level. ***** - represent significance level of $p<0.001$; the numbers above the bars represent the number of caves in each category.
Figure 10: *Artema nephilit* sp. nov. presence/absence (red/black, respectively) data in different cave sizes. *A. nephilit* sp. nov. does not show a preference for cave size. The numbers above the bars represent the number of caves in each category.

4.3.2 All Sites Model

This GLM included 54 caves and non-cave sites from the cave survey and occasional collections, in addition to seven records from past collections.

The overall GLM model with precipitation and longitude as main effects and the interaction between the two variables was significant (p<0.0001), as well as longitude (p=0.018); Precipitation and the interaction were not significant (precipitation, p=0.778; interaction, p=0.801) (Table 6). I then tested the two main effects without the interaction.

The GLM with only the main effects was significant for both precipitation (p<0.0001) and longitude (p<0.0001) and the overall significance of the model was
p<0.0001 (Table 7). *A. nephilit* sp. nov. was more abundant in sites with low precipitation (Figure 11 and Figure 12), and in sites located in the east (Figure 6a).

**Table 6**: all sites GLM analysis of the effects of longitude, precipitation and their interaction on the presence/absence of *A. nephilit* sp. nov.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>Hypothesis Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wald $\chi^2$ (df)</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>192.322</td>
<td>82.2826</td>
<td>5.463 (1)</td>
</tr>
<tr>
<td>longitude</td>
<td>-5.541</td>
<td>2.3502</td>
<td>5.559 (1)</td>
</tr>
<tr>
<td>precipitation</td>
<td>.064</td>
<td>.2273</td>
<td>.080 (1)</td>
</tr>
<tr>
<td>longitude * precipitation</td>
<td>-.002</td>
<td>.0065</td>
<td>.064 (1)</td>
</tr>
</tbody>
</table>

**Table 7**: all sites GLM analysis of the effect of longitude and precipitation on the presence/absence of *A. nephilit* sp. nov. (main effects only).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>Hypothesis Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wald $\chi^2$ (df)</td>
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<tr>
<td>(Intercept)</td>
<td>208.552</td>
<td>53.3508</td>
<td>15.281 (1)</td>
</tr>
<tr>
<td>long</td>
<td>-6.004</td>
<td>1.5282</td>
<td>15.435 (1)</td>
</tr>
<tr>
<td>precipitation</td>
<td>.007</td>
<td>.0018</td>
<td>14.399 (1)</td>
</tr>
</tbody>
</table>
Figure 11: *Artema nephilit* sp. nov. presence/absence (red/black respectively) data along a precipitation gradient from all sites. *A. nephilit* sp. nov. is more abundant where precipitation is low, while in high precipitation it is almost absent. The numbers above the bars represent the number of caves in each category.
Figure 12: *Artema nephilit* sp. nov. presence/absence (red/black respectively) data along a precipitation gradient from all sites (61 sites). *A. nephilit* sp. nov. is more abundant where precipitation is low, while in high precipitation it is almost absent.

4.4 Discussion
There are two indigenous species of *Artema* in Israel, the new species, *Artema nephilit* sp. nov., and the Persian species, *Artema doriai*. The two species have partially overlapping distributions along the Jordan Rift Valley. *Artema nephilit* sp. nov. shows a significant preference for dry habitats and locations east of the major watershed, while *A. doriai* in Israel is at its westernmost edge geographically, and shows a wider, fragmented distribution without a clear habitat preference in this region. Moreover, it seems to be less abundant than *A. nephilit* sp. nov. Interestingly, although the two species share an overlapping distribution in the Jordan Rift Valley, I never observed them in the same site or cave. Both species were found in caves, but they are not restricted to them and were found also in man-made habitats such as buildings, basements, water tunnels and natural habitats as crevices and under large stones.

In this study, *Artema doriai* was rare, as it was found only in one site during the cave survey (Andartat Habik’a). However, it may be more abundant in other habitats that were not surveyed. In addition to this site, I identified eight specimens that were collected in the past along the Rift Valley, as well as recent collections of *A. doriai* from a Mediterranean shrubland (“batha”) near Modi’in. This indicates that the species may have established a stable population in the Modi'in area. Observation of these *A. doriai* specimens, and photographs sent to me in the past two years from Dan Metropolitan Area (Rosh-Ha'ain, Herzlia, Tel-Aviv), may support the assumption that it is established in central Israel, although the specimens were not collected and I did not examine them.

Observations I made during the cave survey indicate that *Artema nephilit* sp. nov. prefers hot and relatively dry caves, rather than cold and humid caves that are the preferred habitat of other cave-dwelling pholcids found in this survey. In areas where
the two cave types were present, I found *Artema* inhabiting the hot dry caves and *Hoplopholcus cecconi* or an unidentified *Pholcus* inhabiting the cold humid caves.

*Artema nephilit* sp. nov. was found in 34 sites out of the 61 sites, 20 of them were caves while seven sites were under large boulders, crevices and man-made habitats as buildings and water tunnels. Seven additional sites were from past collection, without any indication of the specific habitat (cave or any other habitat). Most of the sites were associated with the Rift Valley, while two sites were outside of the Rift Valley: a cave in Avedat ruins and Oren cave in Mt. Karmel. These two sites may be in fact associated with the Rift Valley: Avedat is connected to the Rift Valley via Zin Wadi and Oren cave is connected via the Jezreel Valley which connects the Rift Valley to Mt. Karmel.

The preference of *A. nephilit* sp. nov. for dry and eastern sites in this cave survey, the association with the Rift Valley and the presence of the species in Oren Cave, Avedat, and outside of Israel in Jordan, Cyprus and Greece, led me to raise two different hypotheses about the species’ distribution in the Mediterranean basin. The first hypothesis is that this species originated in the Jordan Rift Valley, later expanding its distribution to suitable habitats and other geographical regions using ecological corridors: from the Rift Valley to Jezreel Valley and Zin Wadi from there expanding the distribution across the sea to the west, and to the east to Moab and Edom canyons. Juvenile specimens of *Artema* were collected in 1964 from Bet Alfa, in eastern Jezreel Valley, from examining the specimens I suggest to identified them as *A. nephilit* sp. nov.. These finding support my hypothesis that the species originated in the Jordan Rift Valley and expanded its distribution to the west. Specific survey of caves along the two suggested corridors, and a molecular analysis testing relatedness of specimens from different regions may help to test this hypothesis.
The second hypothesis is that *A. nephilit* sp. nov. had a wide Mediterranean distribution during a warmer climatic period, and following historical climate changes, the species’ distribution decreased and narrowed to suitable habitats within its preferred hot and dry climate. This resulted in isolated populations within its original distribution area and relicts in appropriate habitats. This hypothesis of a climatic-relict distribution is common in explaining the colonization of the hypogean environment. However, most examples are of the creation of relicts in cool, humid habitats such as many caves as a result of the retreat of the glaciers, and not of relicts in dry warm caves (Romero 2009).

To summarize, the two *Artema* species in Israel overlap in their distribution, but may represent two different faunal elements. The first, *Artema doriai*, represents a Central Asian element that originated in Iran and widespread to the west to Turkey and Israel. The second species is the new species *Artema nepilit* sp. nov. The interesting distribution of this species, especially along the Jordan Rift Valley, at first led me to assume that it is a classic Ethiopian zoogeographical element. However, the presence of this species in Greece and Cyprus and its absence from African regions (where *A. kochi* and *A. bunkpurugu* are abundant), indicates that *A. nephilit* sp. nov. is a local East Mediterranean species.
4.5 Appendix

**Table 8:** Geographical location and environmental data of 33 surveyed caves.

<table>
<thead>
<tr>
<th>Cave name</th>
<th>A. nephilit sp. nov. presence</th>
<th>Geographical location (WGS84)</th>
<th>Elevation (m above sea level)</th>
<th>Precipitation (mm/ year)</th>
<th>Minimum temperature in cave (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yir'on large</td>
<td>0</td>
<td>33.0679N° 35.4665E°</td>
<td>528</td>
<td>750</td>
<td>13</td>
</tr>
<tr>
<td>Yir'on small</td>
<td>0</td>
<td>33.0672N° 35.4672E°</td>
<td>541</td>
<td>750</td>
<td>8</td>
</tr>
<tr>
<td>Shetula</td>
<td>0</td>
<td>33.0873N° 35.3169E°</td>
<td>690</td>
<td>850</td>
<td>11.5</td>
</tr>
<tr>
<td>Oren</td>
<td>1</td>
<td>32.7144N° 34.9749E°</td>
<td>73</td>
<td>650</td>
<td>15.5</td>
</tr>
<tr>
<td>Ezba</td>
<td>0</td>
<td>32.7118N° 34.9747E°</td>
<td>120</td>
<td>650</td>
<td>14.5</td>
</tr>
<tr>
<td>Pelekh</td>
<td>0</td>
<td>32.9324N° 35.238E°</td>
<td>488</td>
<td>750</td>
<td>12.5</td>
</tr>
<tr>
<td>Yonim</td>
<td>0</td>
<td>32.9236N° 35.2168E°</td>
<td>216</td>
<td>700</td>
<td>12.5</td>
</tr>
<tr>
<td>Horvat Rakit</td>
<td>0</td>
<td>32.7128N° 35.0123E°</td>
<td>355</td>
<td>750</td>
<td>14.5</td>
</tr>
<tr>
<td>Susita cave</td>
<td>0</td>
<td>32.7793N° 35.6577E°</td>
<td>70</td>
<td>450</td>
<td>21</td>
</tr>
<tr>
<td>Berniki large</td>
<td>1</td>
<td>32.7775N° -102</td>
<td>-102</td>
<td>450</td>
<td>17</td>
</tr>
<tr>
<td>Location</td>
<td>Type</td>
<td>Lat.</td>
<td>Long.</td>
<td>Depth</td>
<td>Area</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------</td>
<td>----------</td>
<td>-----------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Berniki</td>
<td>medium</td>
<td>32.7768N°</td>
<td>35.5413E°</td>
<td>-166</td>
<td>450</td>
</tr>
<tr>
<td>Berniki small</td>
<td></td>
<td>32.7775N°</td>
<td>35.5401E°</td>
<td>-102</td>
<td>450</td>
</tr>
<tr>
<td>Perat inbal</td>
<td></td>
<td>31.8332N°</td>
<td>35.3019E°</td>
<td>314</td>
<td>400</td>
</tr>
<tr>
<td>Perat southern slope</td>
<td></td>
<td>31.8334N°</td>
<td>35.3054E°</td>
<td>295</td>
<td>400</td>
</tr>
<tr>
<td>Perat roa'im</td>
<td></td>
<td>31.8325N°</td>
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<td>238</td>
<td>400</td>
</tr>
<tr>
<td>Perat small</td>
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<td>31.8321N°</td>
<td>35.3083E°</td>
<td>268</td>
<td>400</td>
</tr>
<tr>
<td>Bet a'rif (Shoham)</td>
<td></td>
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<td>34.9642E°</td>
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<td>550</td>
</tr>
<tr>
<td>Oah</td>
<td></td>
<td>32.0053N°</td>
<td>34.9722E°</td>
<td>140</td>
<td>550</td>
</tr>
<tr>
<td>Tinshemet</td>
<td></td>
<td>31.9994N°</td>
<td>34.9681E°</td>
<td>99</td>
<td>550</td>
</tr>
<tr>
<td>Haruva</td>
<td></td>
<td>31.9133N°</td>
<td>34.9607E°</td>
<td>180</td>
<td>500</td>
</tr>
<tr>
<td>Sali'it</td>
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<td>32.2454N°</td>
<td>35.0456E°</td>
<td>254</td>
<td>650</td>
</tr>
<tr>
<td>Te'omim</td>
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<td>31.7262N°</td>
<td>35.0217E°</td>
<td>405</td>
<td>550</td>
</tr>
<tr>
<td>Location</td>
<td>Type</td>
<td>Latitude</td>
<td>Longitude</td>
<td>Depth</td>
<td>Size</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>Arubotaim</td>
<td>1</td>
<td>31.1016N°</td>
<td>35.3900E°</td>
<td>-348</td>
<td>100</td>
</tr>
<tr>
<td>Malcham</td>
<td>1</td>
<td>31.0765N°</td>
<td>35.3971E°</td>
<td>-380</td>
<td>100</td>
</tr>
<tr>
<td>Ne'ot HaKikkar</td>
<td>1</td>
<td>30.9911N°</td>
<td>35.3465E°</td>
<td>-333</td>
<td>100</td>
</tr>
<tr>
<td>Qumeran</td>
<td>1</td>
<td>31.7556N°</td>
<td>35.459E°</td>
<td>-308</td>
<td>150</td>
</tr>
<tr>
<td>Telalim</td>
<td>0</td>
<td>30.9734N°</td>
<td>34.7929E°</td>
<td>482</td>
<td>150</td>
</tr>
<tr>
<td>Ashalim</td>
<td>0</td>
<td>30.9434N°</td>
<td>34.7391E°</td>
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<td>100</td>
</tr>
<tr>
<td>Nahal HaBesor</td>
<td>0</td>
<td>30.9415N°</td>
<td>34.6961E°</td>
<td>356</td>
<td>100</td>
</tr>
<tr>
<td>Avedat</td>
<td>1</td>
<td>30.7941N°</td>
<td>34.772E°</td>
<td>601</td>
<td>100</td>
</tr>
<tr>
<td>Zavoa</td>
<td>1</td>
<td>31.2086N°</td>
<td>35.2311E°</td>
<td>470</td>
<td>100</td>
</tr>
<tr>
<td>Amude Amram</td>
<td>1</td>
<td>29.6515N°</td>
<td>34.9336E°</td>
<td>293</td>
<td>50</td>
</tr>
<tr>
<td>Amude Amram small</td>
<td>1</td>
<td>29.6518N°</td>
<td>34.9337E°</td>
<td>288</td>
<td>50</td>
</tr>
</tbody>
</table>
5. General Discussion

Twelve species of pholcids which represents different biogeographical elements were found during this research. Seven species are indigenous species while the five other species have a worldwide distribution, are invasive or are synanthropic species.

Four of the seven local species are restricted to the Mediterranean region: 1. *Artema nephilit* sp. nov., a Levantine species, which is mostly abundant in the arid Jordan Rift Valley and in Jordan, Greece and Cyprus, inhabiting especially hot and dry caves. 2. *Hoplopholcus cecconi* belongs to a Mediterranean genus inhabiting cold caves. 3. *Pholcus* sp., an unidentified species that may be the undescribed male of *Pholcus maronita*, a species that was described from karst caves at northern Lebanon. 4. A tiny pholcid, *Spermophorides* sp., most likely an undescribed species, that unlike the first species occurs under stones in the Mediterranean region in Israel.

Two other species constitute edge populations of their species: the first, *Artema doriai* representing a Middle East element with Israel being the western limit of its geographic range, inhabits both caves and man-made habitats. The second species is the African species *Pehrforsskalia conopyga*, known from Yemen, Madagascar and throughout Africa, occurs in leaf litter in banana plantations. One additional species is the most widespread species in Israel, the Mediterranean *Holocnemus pluchei* which shows very wide habitat tolerance and can be found from the more xeric zone to the most temperate zone in various habitats from caves, man-made habitats and in shrubs and under stones.

The other five species are among the most widespread pholcids in the world, including the cosmopolitan synanthropic species *Pholcus phalangioides*, *Spermophora senoculata*, *Micropholcus fauroti*, *Crossopriza lyoni*, and *Artema atlanta*. The origin of last three species is not known but it is likely to be in the Middle East (Huber and Kwapong, 2013).

The number of indigenous species known now from Israel is not extremely high, but the composition of the species origins and mixture of the biogeographic
zones of the different species and genera are remarkably diverse. This is particularly true for the number of species relative to the small area surveyed. In comparison, in West Africa, in an area of 1,403,506 km$^2$, 38 species in 14 genera are present (Huber and Kwapong, 2013). In contrast, in East Africa, in area of 1,822,873 km$^2$, 87 species in 15 genera were found (Huber and Warui, 2012). These large differences between the geographically and ecologically different regions, is explained by the presence of complex geographical and climatic conditions in East Africa (Huber and Warui, 2012; Linder *et al.*, 2012). There seems to be a relatively high number of pholcid species in Israel compared to its size, 22,072 km$^2$. The mixture of different biogeographical zones together with different suitable habitats as caves, crevices, under large leaves and in litter had probably led to regional representatives of various genera and species in Israel relative to its small area.

The genus *Artema*, which is represented in Israel by two local and one recently introduced species, is comprised of an interesting distribution of seven nominal species. Three species origin in the Middle East (*A. doriai*, *A. transcaspica* and *A. magna*), one species from the Levant (*Artema nephilit* sp. nov.), three species from Africa (*A. bunkpurugu*, *A. kochi* and an undescribed species from Algeria) and one pantropical species (*A. atlanta*). The overall distribution of the genus is Old World, with a speciation center that seems to be in the Middle East. Some of the species are partially overlapping in their distributions. Thus, it might be that there was sympatric speciation or else allopatric speciation followed later by a distribution expansion of one species.

Interestingly, the morphological characters of the species show relationships between the species and there is still more to reveal. *A. doriai* from Iran and *A. transcaspica* from Tajikistan and Uzbekistan show great similarity in the male palpal organ with subtle differences in male chelicera. The female epigynum of both species share a similar general structure. The edge populations of *A. doriai* found in Israel and Turkey shows male cheliceral character of *A. transcaspica*, but the female epigynum is rather similar to *A. doriai*. There are two edge populations from Sudan and Pakistan that show great similarity among them, while showing great morphological distance from *A. doriai* and *A. transcaspica*. These specimens are tententively
assigned to *A. doriai* since I lack both sufficient collections and molecular and statistical analysis needed to separate it.

The relationship between the species is not geographically continuous: while the eastern species in the genus, *A. magna*, shares some similarities in male and female characters with *A. nephilit* from Israel, *A. nephilit* itself has a clear resemblance in epigynum shape to the West African species *A. bunkpurugu*. *A. kochi*, which is sympatric with *A. doriai* in Sudan and geographically could be related to *A. nephilit* from the Jordan Rift Valley, is the most morphologically isolated species and shares the least similarity with other species in the genus. More data on the species of the genus *Artema* and the relationships between them may be gained by a molecular analysis and phylogenetic work on the genus. Other interesting specimens, some perhaps new species, are from Algeria, Oman, Yemen and Sudan and Pakistan.

The cave survey revealed the existence of two *Artema* species in Israel. Both sharing their distribution in Jordan Rift Valley region, but never located in the same locality or cave. From analyzing the physical and environmental condition of inside and outside the cave, I concluded that *A. nephilit* prefers the most arid zone in Israel, situated in the East of the country, in the hot, dry and low rainfall region. Some collections of this species outside the Rift Valley indicate that the species might use ecological corridors to expand its distribution to suitable ecological habitats. During the cave survey I found that *A. doriai* was not abundant as *A. nephilit* in the caves and regions I sampled, hence, I did not analyzed the habitat preferences of *A. doriai*.

In order to draw a clear understanding of the two *Artema* species in Israel, and in order to predict their potential distribution pattern, I would suggest conducting a comprehensive species abundance survey together with records of environmental and spatial characteristics. Using statistical tools and species distribution models I can reveal new potentially suiting habitats and can strengthen the GLM I presented. This may serve a revised general model for a larger presence absence data set.

Conducting this research I synthesized different disciplines of taxonomy, ecology and biogeography, trying to draw a picture of the species richness at the family level in a specific region and through a revision of the genus *Artema*. This enabled me to work at the species level and to study its habitat preferences and relationships with congener.
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