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THE SPIDERS OF RAPA NUI (EASTER ISLAND) REVISITED

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Cover image: The potentially endemic and undescribed *Tetragnatha* sp., believed restricted to the totora reeds lining the shores of Rano Raraku crater lake. Photo: Darko Cortoras.

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Spiders of Rapa Nui (Easter Island) Revisited. Cotoras *et al*. *Bishop Museum Occasional Papers* 120: 1–17 (2017)

The Spiders of Rapa Nui (Easter Island) Revisited

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Abstract. The spiders of Rapa Nui have not been assessed in over two decades. During this time, additional nonnative alien species introductions would be expected due to increased tourism visitation and the steady influx of commercial goods imported from mainland Chile. Prior to our work, only one endemic species (*Tetragnatha paschae* Berland, 1924) was known to occur on the island. We conducted multiple research trips (from 2008–2012) and examined 15 different study sites on Rapa Nui to search for both this species and other endemic ground-dwelling arthropod species including spiders. *Tetragnatha paschae* was not detected during our survey. We suggest this spider is probably extinct. Our sampling yielded 26 unique spider morphospecies (representing 15 families and at least 20 genera). Based on our research and previous work, we complied a list of 47 morphospecies known to Rapa Nui – including six new island records. Nearly half of these alien morphospecies (n = 23) have cosmopolitan or pantropical distributions. Importantly, we detected one potentially endemic and possibly undescribed spider, *Tetragnatha* sp., which is probably restricted to the native vegetation within one crater lake. The areas with highest spider diversity are likely due to high habitat heterogeneity. We also provide recommendations to expand the search for endemic spider species on Rapa Nui.

INTRODUCTION

Rapa Nui (or Easter Island) underwent a catastrophic ecological shift (Wynne *et al*. 2014) between Polynesian colonization (800–1200 CE; Martinsson-Wallin & Crockford 2001; Hunt & Lipo 2006; Shepardson *et al*. 2008; Wilmshurst *et al*. 2011) and European contact (1722; McCall 1990). The palm-dominated shrubland blanketing most of the island ultimately shifted to a grassland system. Geographic isolation, small island size, low topographic relief (Rolett & Diamond 2004), fire-intolerance (Mann *et al*. 2008) and limited colonization events of biota from South America and other Polynesian islands hastened this dramatic change. By the mid-nineteenth century, most of the island was converted to a century-long sheep-grazing operation (Fischer 2005), which exacerbated environmental degradation and biotic homogenization. In aggregate, these factors resulted in the loss of most stands of

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native vegetation and the extinction of all known land vertebrates (Wynne *et al*. 2014). Today, the terrestrial ecosystems of Rapa Nui is characterized by a preponderance of alien plant and vertebrate species.

The island arthropod community has been equally transformed. Of the nearly 400 arthropod species cataloged, only 31 species (~8%) are endemic or indigenous (Wynne *et al*. 2014); the remaining were intentionally or accidentally introduced (Wynne, unpublished data; CONAMA 2008). Ten of these species (one psocopteran, Mockford & Wynne 2013; seven collembolans, Jordana & Baquero 2008; Bernard *et al*. 2015; and, two isopods, Taiti & Wynne 2015) are endemic and believed restricted to caves (Wynne *et al*. 2014). Most of the remaining 21 endemic species have not been observed since their initial descriptions, and are either probably extinct or occur in such low numbers as to have evaded detection.

Rapa Nui spiders have not been examined in nearly two decades. The first documented arthropod study identified three spider morphospecies (Fuentes 1914). Later, Berland (1924) identified nine spider morphospecies including the discovery of the island's only known endemic spider, *Tetragnatha paschae* Berland 1924 (Berland 1924). Interestingly, this species has been observed only once since its initial discovery nearly a century ago. Using a combination of existing museum collections and field data, Baert *et al*. (1997) compiled a list of 36 spider morphospecies known to occur on the island, which included Berland's (1924) work. With the exception of two morphospecies identified by Baert *et al*. (1997), *T. paschae* and "Orchestininae gen. n., sp. n." (Family Oonopidae), all spiders likely represented nonnative alien species. This possible new genus and species was part of Lehtinen's (1988) unpublished collection and has yet to be formally described (P. Lehtinen, *in litt*.).

Our objectives were to rediscover *T. paschae*, identify additional endemic spider species on the island, and summarize the current knowledge of spiders on Rapa Nui. Specifically, we conducted an island-wide baseline survey including the first inventories of cave ecosystems and Motu Nui (a small islet off the southwestern coast of the island). We also developed an annotated list of spider species known to occur on Rapa Nui and outlined a strategy for future research and monitoring.

METHODS

Study Area. Located 3,512 km west of South American coast and 3,400 km south by southeast of the Pitcairn Islands, Rapa Nui, a Polynesian island under the administration of Chile, is approximately 164 km^2. Rapa Nui and its islets are volcanic and have a maritime subtropical climate. Today, the vegetation of Rapa Nui is primarily grassland with nonnative stands of *Eucalyptus* spp. trees with some native and indigenous vegetation primarily within and surrounding the three crater lakes.

We sampled 15 different locations across the island including both agrarian and undeveloped landscapes (Fig. 1). The Appendix provides study site place names, individual study site locations with their associated coordinates, and a description of the methods applied per study site. With the exception of Motu Nui and the Roiho lava tube caves, the general localities of our study areas overlap with Baert *et al*. (1997).

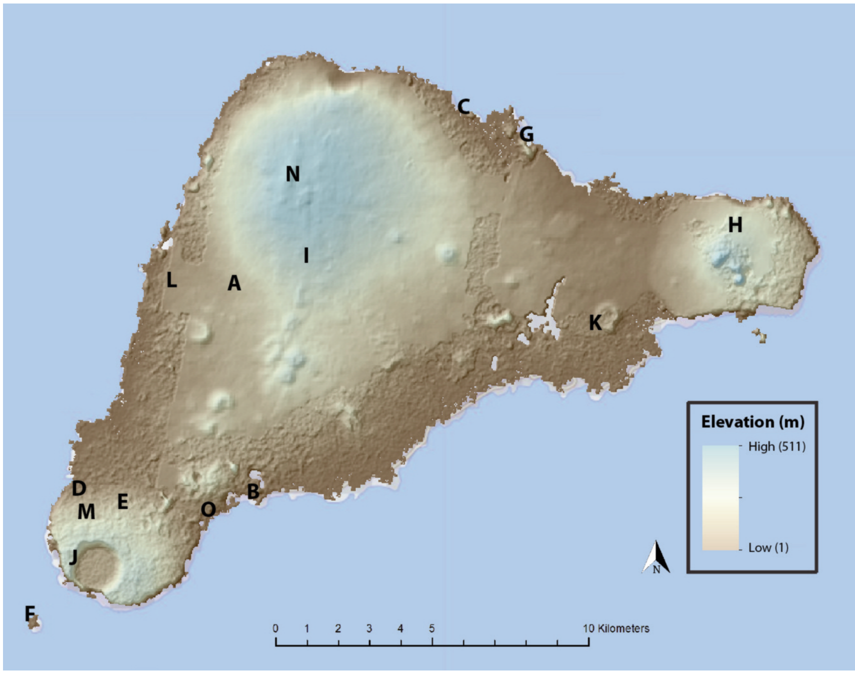

Figure 1. Fifteen study sites sampled across Rapa Nui from 2008 through 2012: Ahu Akivi [A], Akahanga [B], Anakena [C], Ava Ranga Uka [D], Greenhouse at CONAF [E], Motu Nui [F], Ovahe [G], Poike [H], Rano Aroi [I], Rano Kau [J], Rano Raraku [K], Roiho Lava Tube Caves [L], Te Ara O Te Ao [M], Terevaka [N], and Vinapu [O]. Base map is a NASA ASTER DEM, courtesy of Jeff Jenness.

Study Sites

Ahu Akivi: Two separate areas adjacent to Ahu Akivi were sampled. One (Aki 1) was within invasive guava trees and shrubs, while the second (Aki 2) was within a monoculture stand of *Eucalyptus* sp.

Akahanga: We sampled an open grassland area heavily grazed by horses and cattle.

Anakena: We sampled one area north of Anakena beach along the rocky coast. This grassland consisted primarily of invasive milkweed *Asclepias curassavica* L., was frequently used by humans, and appeared heavily grazed by horses and cattle.

Ava Ranga Uka (an intermittent stream): We searched for spiders in two areas along the banks of the small intermittent stream channel (Ava 1 and 2) and one area within the entrance of a cave (Ava 3). Standing water was present within the channel during our sampling effort. The banks of this intermittent stream were characterized with grasses including *Cyperus eragrostris* Lam. and *Melinis minutiflora* P. Beauv.

Greenhouse, Corporación Nacional Forestal (CONAF) Headquarters: We sampled one location near the greenhouse buildings of Oficina Provincial Parque Nacional Rapa Nui, CONAF. Within this area, there were several Polynesian endemic tree species (including *Hibiscus rosa-sinensis* L. and the functionally extinct *Sophora toromiro* (Philippi) Skottsberg) adjacent to a landscaped area of manicured grasses and ornamental plants.

Motu Nui: This islet is located off the southwestern coast of Rapa Nui. We randomly searched Motu Nui for spiders. Primary grassland association was *Paspalum fosterianum* Flüggé and *Cyperus polystachyos* Rottb. with other less dominant grass species including *Sporobolus indicus* (L.) R. Br., *Bromus catharticus* Vahl, *Cyperus eragrostris* Lam., *Portulaca oleracea* L., *Tetragonia tethragonoides* (Pallos) Kuntze, and *Chamaesyce serpens* Kunth (P. Lazo Hucke, in litt.).

Ovahe: We sampled two areas near Ovahe beach. One area (Ova 1) was along the rocky shoreline within both rocks and grassland, while the second area (Ova 2) occurred within grassland and shrubs heavily grazed by livestock.

Poike: Poike (370 m elevation) is the second highest mountain and demarcates the southeastern corner of the Rapa Nui island triangle. We collected within three areas. Two areas (Poike 1 and 2) were located within monoculture stands of *Eucalyptus* spp. adjacent to the highly eroded area in the southeastern most extent of Poike. Our third site (Poike 3) was located on the southern slopes of Maunga Vai a Heva, one of the three volcanic domes of Poike. Grassland vegetation around the base of Maunga Vai a Heva includes *Sporobolus indicus* (L.) R. Br.

Rano Aroi: We sampled one area within this crater. Vegetation was a *Schoenoplectus californicus* C.A. Mey. Steud. and *Persicaria acuminate* (Kunth) M. Gómez association.

Rano Kau: This volcano and its associated crater lake encompass the southwestern corner of the Rapa Nui island triangle. Rano Kau crater supports the highest diversity of island and Polynesian endemic plant species on the island (Dubois *et al*. 2012; Wynne 2016). This area is largely isolated from human use and livestock grazing (Skottsberg 1953; Wynne 2016), representing one of the most biologically important areas on the island (Wynne 2016). We sampled three sites (Rkau 1 through 3) along the western slope of the crater between the Rano Kau tourist overlook and the crater floor. Vegetation within these areas consisted of a closed canopy of miro tahiti (*Melia azedarach* L.) with a fern understory including *Microsorum parksii* Copel. and *Microlepia strigosa* (Thunb.) C. Presl.

Rano Raraku: We sampled two areas (Rrar 1 and 2) along the edge of the crater lake. Vegetation was primarily the indigenous reed (*S. californicus*) with the western boundary supporting a distinct *S. californicus – P. acuminate* association.

Roiho Lava Tube Caves: Ten caves were sampled ~5 km north of the village of Hanga Roa. The study area is characterized by gently rolling hills (i.e., extinct scoria cones) with coastal cliff faces flanking the western-most boundary. Vegetation was grassland and guava (*Psidium guajava* L.) shrub. Within the collapse pit and skylight entrances of most caves, several alien and Polynesian tree species were present including fig (*Ficus* sp.), avocado (*Persea americana* Mill.), apple banana (*Musa* ×*paradisiaca* L.), and roseapple (*Syzygium jambos* (L.) Alston). Additionally, fern-moss gardens, an important relict habitat (Wynne *et al*. 2014), occurred within several cave entrances and beneath cave skylights. This habitat is characterized by a presumed cave-restricted endemic fern (*Blechnum paschale*; DuBois *et al*. 2013) and several species of moss including at least one endemic species (*Fissidens pascuanus*; Ireland & Bellolio 2002). Wynne *et al*. (2014) suggests this habitat may have been somewhat insulated from intensive environmental changes that occurred on the surface.

Te Ara O Te Ao: We sampled one area along the Te Ara O Te O trail between CONAF headquarters and Rano Kau on the northern slope of the caldera. The site is situated within an area intensively grazed by horses and cattle. Vegetation includes various grass species and the invasive legume *Crotalaria grahamiana* Wight & Arn.

Terevaka: At 511 meters elevation, Terevaka is the highest mountain peak of the island, demarcating the northern corner of the Rapa Nui island triangle. Grassland vegetation included *Axonopus paschalis* (Stapf) Pilger, *Dichelachne micrantha* (Cav.) Domin, *Dichelachne crinita* (L.f.) Hook. f., and *Sporobolus indicus* (L.) R. Br.

Vinapu: We sampled an area within a forest patch north of the paved road leading to Ahu Vinapu trailhead. The forest patch consisted primarily of *Casuarina equisetifolia* L., *M. azedarach* and *P. guajava* with the latter two species as dominant.

Sampling

Surface Sampling: Surface collecting was conducted by DC, CV and LF between 12 August and 02 September 2012. Sampling techniques included beating sheet, sifting leaf litter, sticky paper traps, and opportunistic hand collecting. We used a 71 cm^2 canvas beating sheet (Bioquip Catalog #2840C) to extract spiders from plants. We held the beating sheet below selected trees and scrubs, and then hit the plant several times. As the spiders fell off the plant onto the sheet, they were collected. Leaf-litter was collected from selected trees and scrubs (regardless of whether the plants were native or alien). We extracted spiders and other insects from leaf litter using a Berlese funnel. At one study site, we deployed one Olson Products Inc.® yellow sticky strip (13 × 7.5 cm) for six days. The specific methods applied at each site are provided in the Appendix.

Cave Sampling: Three research teams (led by JW) systematically sampled 10 caves for all arthropods during three research trips (16–21 August 2008; 28 June–17 July 2009; and 01–07 August 2011). Four methods (pitfall traps, time-constrained searches, opportunistic collecting, and timed direct intuitive searches) were applied. Pitfall traps consisted of two 946-ml stacked plastic containers (13.5 cm high, 10.8-cm-diameter rim and 8.9-cm base). A teaspoon of peanut butter placed in the bottom of the exterior container was used as bait. The bottom of the interior container had several dozen holes to allow the bait to "breathe" to attract arthropods. Traps were deployed for three to four days. Although pitfall traps are not specifically designed to attract spiders, arachnids were occasionally attracted to other arthropods ensnared in the pitfall traps and were also collected.

Time-constrained searches involved estimating a one-meter radius around each pitfall trap sampling station and then conducting a timed search. Searches were conducted for one to three minutes (one minute if no arthropods were observed, three if arthropods were detected) before pitfall trap deployment and prior to trap removal.

Opportunistic collection involved collecting arthropods as encountered – while deploying and removing pitfall traps, and before and after timed searches. Personnel also searched the ground, walls and ceilings as they walked the length of each cave. In five caves (where all the collecting methodologies were applied), we also conducted timed direct intuitive searches (DIS) of fern-moss gardens by gently combing through the fern and moss and looking beneath rocks for 40 search-minutes per garden (two observers × 20 minutes per observer). In four additional caves, we limited sampling to DIS within fern-moss gardens only (two observers × 20 minutes per observer). In 2011, the deep zones of four caves were further sampled via bait sampling and DIS. Three types of baits were placed directly on the ground and within cracks and fissures on cave walls, ceilings and floors: sweet potato (*Ipomoea batatas*), chicken and fish entrails, and small branches of hibiscus (*Hibiscus rosa-sinensis*) and Ngaoho (*Caesalpinia major*) shrubs. Two to three stations of each bait type were deployed, for four to five days, within the deep zone(s) of each cave. At proximity to bait sampling arrays, we also conducted one DIS by searching the cave floor for 10 minutes within a $1m^2$ area.

Collection, Curation and Taxonomy

Spiders collected during the surface sampling effort were preserved in 95% ethanol. Specimens were identified to the lowest taxonomic level possible using Baert *et al*. (1997), Ubick *et al*. (2009), and Bradley (2012). Voucher specimens will be deposited at Museo Nacional de Historia Natural, Santiago, Chile.

Cave specimens were preserved in 75 to 95% ethanol. Cave-dwelling spiders were identified using a combination of voucher specimens from the Bishop Museum, Honolulu, HI and species' lists. Voucher specimens for most species are deposited at the Bishop Museum and Museo Antropológico P. Sebastian Englert on Rapa Nui.

We applied the following rules to summarize our results and develop an island-wide annotated species list. For our results, when comparing species and family richness across study sites, coarse level identifications (i.e., at family and genus level) were retained. For the annotated species list, coarse identifications (i.e., family and genus level) were included only if they represented a unique family or genus for the island. If the coarse identification within a given family or genus contained more than one species, it is possible the coarse level identification represents an existing species and was removed. However, if there was only one morphospecies identified within a given family or genus, the record was retained and presumed to be unique. The World Spider Catalog (WSC 2016) was used to confirm validity of taxonomy.

RESULTS

We detected 26 unique morphospecies (representing 15 families and at least 20 genera; Table 1) contributing to the total of 47 spider morphospecies known for Rapa Nui (Table 2). At least six new island records were identified including *Coras* sp. (Amaurobiidae), *Lepthyphantes* sp. (Linyphiidae), *Sanogasta maculatipes* (Keyserling, 1878), *Scytodes globula* Nicolet, 1849, *Scytodes fusca* Walckenaer, 1837, and *Steatoda* cf. *erigoniformis* (Pickard-Cambridge, 1872).

Table 1. Spider morphospecies detected during this study per study site.

Family	Morphospecies	Study Sites*														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
AGELENIDAE	*Tegenaria domestica* (Clerck, 1757)				X			X	X	X	X	X		X		
AMAUROBIIDAE	*Coras* sp.								X							
ANYPHAENIDAE	*Sanogasta maculatipes* (Keyserling, 1878)										X			X		
ARANEIDAE	Araneidae sp.													X		
CORINNIDAE	*Creugas gulosus* Thorell, 1878													X		
GNAPHOSIDAE	Gnaphosidae sp.		X									X				X
LINYPHIIDAE	*Lepthyphantes* sp.												X			
	Tenuiphantes tenuis (Blackwall, 1852)				X	X										
OECOBIIDAE	*Oecobius navus* Blackwall, 1859	X											X			
OONOPIDAE	Oonopidae sp.					X					X					X
PHOLCIDAE	*Holocnemus* cf. *piritarsis* Berland, 1942							X					X			
	Smeringopus pallidus Moenkhaus, 1898					X								X		
SALTICIDAE	Salticidae sp.							X								
	Habronattus coecatus (Hentz, 1846)		X													
	Hasarius adansoni (Audouin, 1827)			X							X	X	X	X		
	Opisthoncus cf. *mordax* Koch, 1880													X		
	Plexippus paykulli (Audouin, 1826)											X				
	Phidippus regius Koch, 1846				X										X	
SCYTODIDAE	*Scytodes fusca* Walckenaer, 1837										X					
	Scytodes globula Nicolet, 1849							X			X					
	Scytodes longipes Lucas, 1844						X				X		X			
TETRAGNATHIDAE	*Tetragnatha* sp.											X				
THERIDIIDAE	Thereidiidae sp.															X
	Latrodectus geometricus Koch, 1841	X					X	X	X		X		X		X	
	Parasteatoda tepidariorum (Koch, 1841)				X					X	X	X	X	X	X	
	Steatoda grossa (Koch, 1838)							X	X				X			
	Steatoda cf. *erigoniformis* (Pickard-Cambridge, 1872)												X			
TRACHELIDAE	*Meriola arcifera* (Simon, 1886)								X							

* Ahu Akivi [A], Akahanga [B], Anakena [C], Ava Ranga Uka [D], Headquarters at CONAF [E], Motu Nui [F], Ovahe [G], Poike [H], Rano Aroi [I], Rano Kau [J], Rano Raraku [K], Roiho Lava Tube Caves [L], Te Ara O Te Ao [M], Terevaka [N], and Vinapu [O]. An "X" corresponds to the presence of a morphospecies at a study site.

Table 2. Annotated list of spider morphospecies known from Rapa Nui.

Family, Genus species	Status	Distribution	Detections	Taxonomy
Agelenidae				
Tegenaria domestica (Clerck, 1757)	Alien	Cosmopolitan	2	
Amaurobiidae				
Coras sp.	Unk.	Unknown	4	
Anyphaenidae				
**Gayenna maculatipes* (Keyserling, 1878)	—		2	see *S. maculatipes*
Sanogasta maculatipes (Keyserling, 1878)	. Alien	Peru, Bolivia, Brazil, Uruguay, Argentina, Chile	4	
Araneidae				
Araneidae gen. sp.	Unk.	Unknown	3, 4	
Araneus sp.	Unk.	Unknown		
**Epeira* sp.	—		3	see *Araneus* sp.
Zygiella sp.?	Unk.	Unknown	2	
Corinnidae				
**Corinna cetrata* (Simon, 1888)	—		1	see *Creugas gulosus*
Creugas gulosus Thorell, 1878	Alien	Cosmopolitan	2, 4	
Gnaphosidae				
Drassodes sp.?	Unk.	Unknown	1	
Odontodrassus javanus (Kulczynski, 1911)	Alien	Myanmar to Japan, Seychelles, New Caledonia, Jamaica	2	
Urozelotes rusticus (Koch, 1872)	Alien	Cosmopolitan	2	
Linyphiidae				
Lepthyphantes sp.	Unk.	Unknown	2, 4	
Ostearius melanopygius (Pickard-Cambridge, 1879)	Alien	Cosmopolitan	2	
Tenuiphantes tenuis (Blackwall, 1852)	Alien	Palearctic (elsewhere, introduced)	2, 4	
Ochyroceratidae				
Theotima minutissima (Petrunkevitch, 1929)	Alien	Pantropical	2	
Oecobiidae				
Oecobius navus Blackwall, 1859	Alien	Cosmopolitan	2, 4	
Oonopidae				
**Gamasomorpha loricata* (Koch, 1873)	—		2	see *X. loricata*
Opopaea silhouettei (Benoit, 1979)	Alien	Seychelles	2	
Orchestininae sp.	End?	Rapa Nui?	2	
Xestaspis loricata (Koch, 1873)	Alien	China, Taiwan, Laos, Micronesia, Australian		
Pholcidae				
Pholcus phalangioides (Fuesslin, 1775)	Alien	Cosmopolitan	1, 2, 4	
Smeringopus pallidus Moenkhaus, 1898	Alien	Cosmopolitan	2, 4	
Holocneminus piritarsis Berland 1942	Unk.	Samoa, Austral Is., Henderson I., Marshall Is.	2, 4	

Table 2. (continued)

Family, Genus species	**Status**	**Distribution**	**Detections**	**Taxonomy**
Salticidae				
Dendryphantes mordax (Koch, 1846)	Unk.	Chile, Argentina, Uruguay	2	
Habronattus coecatus (Hentz, 1846)	Alien	USA, Mexico, Bermuda	2, 4	
Hasarius adansoni (Audouin, 1827)	Alien	Cosmopolitan	1, 2, 4	
Menemerus bivittatus (Dufour, 1831)	Alien	Pantropical	2	
Plexippus paykulli (Audouin, 1826)	Alien	Cosmopolitan	1, 2, 3, 4	
Phidippus regius Koch, 1846	Alien	USA, West Indies	2, 4	
Scytodidae				
Dictis striatipes Koch, 1872	Alien	China to Australia	2	
Scytodes fusca Walckenaer, 1837	Alien	Pantropical	4	
Scytodes globula Nicolet, 1849	Alien	Bolivia, Brazil, Argentina, Uruguay, Chile	4	
Scytodes longipes Lucas, 1844	Alien	Pantropical	2, 4	
Scytodes lugubris (Thorell, 1887)	Alien	Pantropical	1	
Sicariidae				
Loxosceles laeta (Nicolet, 1849)	Alien	America, Finland, Australia	2	
Tetragnathidae				
Tetragnatha sp.	End.?	Rapa Nui?	4	
Tetragnatha mandibulata Walckenaer, 1842	Alien	West Africa, India to Philippines, Australia	3	
Tetragnatha nitens (Audouin, 1825)	Alien	Pantropical	1, 2	
Tetragnatha paschae Berland, 1924	End.	Rapa Nui	1	
Theridiidae				
**Coleosoma adamsoni* Berland, 1934	—		2	see *P. mneon*
Coleosoma floridanum Banks, 1900	Alien	Pantropical	2	
Cryptachaea blattea (Urquhart, 1886)	Alien	Cosmopolitan		
Latrodectus geometricus Koch, 1841	Alien	Cosmopolitan	2, 4	
Nesticodes rufipes (Lucas, 1846)	Alien	Pantropical	2	
**Parasteatoda acoreensis* (Berland, 1932)?	—		2	see *C. blattea*
Parasteatoda tepidariorum (Koch, 1841)	Alien	Cosmopolitan	2, 4	
Platnickina mneon (Bösenberg & Strand, 1906)	Alien	Pantropical		
Steatoda grossa (Koch, 1838)	Alien	Cosmopolitan	4	
**Stearodea grossa* (Koch, 1838)	—		2	see *S. grossa*

Table 2. (continued)

Family, Genus species	**Status**	**Distribution**	**Detections**	**Taxonomy**
Theridiidae (continued)				
Steatoda cf. *erigoniformis* (Pickard-Cambridge, 1872)	Alien	Pantropical	4	
Theridion buxtoni Berland, 1929	Unk.	Samoa, Henderson Is., Tuamotu Arch.	2	
**Theridion tepidariorum* (Koch, 1841)	—		1	see *P. tepidariorum*
Trachelidae				
Meriola arcifera (Simon, 1886)	Unk.	Chile, Bolivia, Argentina, USA (introduced), Hawaii	2, 4	

Family- and genus-level identifications were included if they represented a unique detection for a given family or genus; if there were multiple species within a given family or genus, these records were removed. Status is endemic (End.), alien (Alien), or unknown (Unk.). "Endemic" is for morphospecies believed to occur only on Rapa Nui, while "alien" is used for species introduced to the island intentionally or accidentally by humans. We use "unknown" when there was not enough information to confidently place the morphospecies in one of the other two categories. Taxonomy was validated using WSC (2016). Taxonomy contains changes to the scientific names. When an asterisk (*) appears before a species name, go to the taxonomy column for direction to the valid taxonomic name. Distribution refers to the spider's known geographic distribution, and when available, we used distribution information from WSC (2016). Detections represent the studies during which the morphospecies was detected: [1] Berland, 1924; [2] Baert *et al*., 1997; [3] Fuentes, 1914; and, [4] this study. Baert *et al*. (1997) presented a list of morphospecies, which included those detected by Berland (1924); however, we listed species identified by Baert *et al*. (1997) and Berland (1924) independently. Specimens from Araneidae gen. sp. were identified by Fuentes (1914) and in this study; in keeping with our decision rules, we listed it as the same morphospecies. Baert *et al*. (1997) misspelled *Steatoda grossa* as "*Stearodea grossa*"; we made the correction in this list.

We did not find *Tetragnatha paschae* during our study. However, we did collect specimens of a potentially undescribed *Tetragnatha* species within the *S. californicus* reeds along the lake shore of Rano Raraku. This *Tetragnatha* sp. was not found in other study sites, nor was it reported in earlier studies. The *Tetragnatha* sp. specimens were morphologically distinct from *T. paschae* Berland, 1924, *T. nitens* (Audouin, 1826), and *T. mandibulata* Walckenaer, 1842. For the comparison with *T. paschae,* we used the original description and voucher specimens from the Natural History Museum of London. Our specimens did not represent any known Chilean *Tetragnatha* species (Nicolet 1849; Keyserling 1865), nor did they resemble *Tetragnatha* species described from other Pacific Islands (R. Gillespie, pers. comm. 2013).

Distributional patterns of Rapa Nui spider species included three likely endemic morphospecies with the remaining spider morphospecies introduced to the island from other parts of the world (Table 3). Nearly half of the spiders known to Rapa Nui have either a cosmopolitan or pantropical (13 and 10 species, respectively) distribution. Two species were identified as distributed across Polynesia and four species are known from South America.

Table 3. Number of morphospecies by geographic distribution based on the annotated list of known spider morphospecies of Rapa Nui.

	Distribution								
	Endemic*	Cosmopolitan	Pantropical	North America/ Caribbean	South America	Polynesia	Asia	Other	Unknown
Number of Morphospecies	3	13	10	2	4	2	2	5	6

*Both endemic and possible endemic species were considered "endemic" in this table.

There was one endemic species (*T. paschae*) and two potentially endemic species (Orchestininae sp. and *Tetragnatha* sp.), 33 morphospecies believed to represent alien species, and 11 morphospecies identified as "unknown". For six of these species (two species known from greater Polynesia and four species from South America), we were uncertain whether their occurrence represents recent human introductions or natural colonization events. If the former, these species would be considered alien, while if the latter they would be categorized as indigenous. The remaining five morphospecies with "unknown" distributions were placed in this category because they could not be identified beyond family or genus level. *Plexippus paykulli* (Audouin, 1826) was introduced over 100 years ago (Fuentes 1914) and represents a well-established alien species – as it has been documented in all subsequent spider studies (Berland 1924; Baert *et al*. 1997; this study).

Study sites with the highest species richness were Roiho lava tube caves (n = 10), Rano Kau (n = 9), and Poike (n = 7). Lowest richness was recorded at Akahanga and Anakena with one morphospecies each, while Ahu Akivi, Motu Nui, Rano Aroi, and Terevaka yielded two morphospecies each. Richness per study site at the species and family level is provided in Table 4. Images of select spider species are presented in Fig. 2.

We detected three spider species in nearly half of our study areas. One agelenid spider, *Tegenaria domestica* (Clerck, 1757) and two theridiid spiders, *Latrodectus geometricus* Koch, 1841 and *Parasteatoda tepidariorum* (Koch, 1841), were detected across seven study sites.

DISCUSSION

With the exception of three morphospecies (*Tetragnatha* sp., the potentially extinct *T. paschae*, and Orchestininae gen. n., sp. n.?), the remaining 47 morphospecies are probably alien species. Our work also yielded 14 species previously identified species by Baert *et al*. (1997) and contributed at least six new island records. The latter represents an important contribution for monitoring the influx of nonnative alien species, as well as providing a more complete picture of the island's arthropod community.

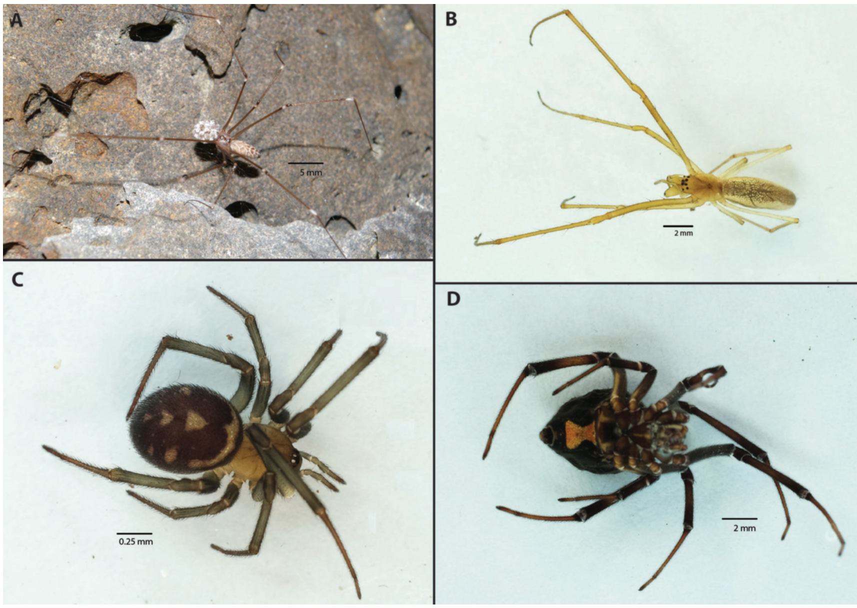

Figure 2. Examples of the spiders of Rapa Nui: [A] *Smeringopus pallidus* (♀) with egg sac from a cave in Roiho (alien species); [B] *Tetragnatha* sp. (♀; possibly an undescribed endemic species); [C] *Steatoda grossa* (♀; alien species); and, [D] ventral view of *Latrodectus geometricus* (♀; alien species). Specimens in B through D may be slightly discolored due to being curated in 70% isopropyl alcohol. Images courtesy Dan Ruby (A), Sebastian Yancovic Pakarati (B), and Byron Yeager (C, D).

Table 4. Number of spider families and morphospecies detected per study site.

	Study Sites*														
Taxonomic Groups	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**
Family	2	1	1	4	3	2	5	4	2	6	5	6	6	2	3
Morphospecies	2	1	1	4	3	2	6	6	2	9	6	10	7	2	3

*Ahu Akivi [A], Akahanga [B], Anakena [C], Ava Ranga Uka [D], Greenhouse at CONAF [E], Motu Nui [F], Ovahe [G], Poike [H], Rano Aroi [I], Rano Kau [J], Rano Raraku [K], Roiho Lava Tube Caves [L], Te Ara O Te Ao [M], Terevaka [N], and Vinapu [O].

The *Tetragnatha* sp. identified from Rano Raraku appears undescribed and may represent a new endemic species. Upon examination of Berland's (1924) description of *T. paschae* and specimens from the Natural History Museum of London, we found the *Tetragnatha* sp. specimens collected from Rano Raraku do not fit the morphological descriptions of *T. paschae* and is distinct from other known *Tetragnatha* species from Chile and other Pacific islands. Lehtinen (1995) identified Tetragnathidae as one of the first families to colonize Polynesia – originating from South America or Hawai'i. Gillespie (2002) found no phylogenetic evidence of an adaptive radiation event involving a single common ancestor diversifying across Polynesia. Additional taxonomic and genomic work will be required to describe this species, as well as to more fully address these biogeographical uncertainties.

The study sites with the highest spider diversity warrant further examination. Roiho lava tube caves (n = 10) exhibited the highest diversity across all study areas. We offer two possible explanations. Firstly, sampling intensity was much higher in Roiho than at all the other study sites. Thus, our conclusion that Roiho caves contained the highest diversity may be due to sampling intensity. However, it may also be a result of higher spatial heterogeneity when compared to our other study sites. Rapa Nui caves support numerous microhabitats including: fern-moss gardens within cave entrances and beneath cave skylights (Wynne *et al*. 2014); cracks, crevices and pore spaces within rock piles, cave walls and ceilings; mud covered floors; and, plant roots infiltrating the deepest portion of some cave passages. The occurrence of these microhabitats combined with the environmental zonal gradient common to the largest caves (i.e., photosynthetic zone to cave deep zone; Howarth 1980, 1982) results in a comparatively higher level of habitat heterogeneity. Because high habitat heterogeneity is an important variable driving high species richness of various arthropod groups (Gardner *et al*. 1995; Humphrey *et al*. 1999; Hansen 2000), we suggest, high spider diversity observed in Roiho caves may also be a product of high habitat heterogeneity at these sites.

Rano Kau (n = 9) supported the second highest spider diversity. This result may also be attributed to high habitat heterogeneity associated with higher habitat complexity and plant species diversity. Extending at least 172 m from the floor to rim, the crater walls receive varying degrees of insolation given aspect, time of day and season, and the interior is characterized by large boulder fields, vertical cliff faces, and dense vegetation ranging from thick grassland to forest with a *Schoenoplectus californicus – Persicaria acuminate* plant association within and surrounding the crater lake (Wynne 2016). Dubois *et al*. (2013) has listed at least 12 endemic or indigenous plants and at least five Polynesian-introduced plant species known to occur within Rano Kau. Vegetation in the other surface study sites were comparatively depauperate.

Three widely dispersed alien species on Rapa Nui, *T. domestica*, *L. geometricus*, and *P. tepidariorum* are associated with human activities and structures. Also, *T. domestica* and *L. geometricus* have cosmopolitan distributions globally, while *P. tepidariorum* is widely distributed across North America and Europe (WSC 2016). Thus, we are not surprised by the distributions of these species. Comparatively, *Steatoda grossa* (Koch, 1838) was detected in three of 14 study areas. This species has a cosmopolitan distribution (WSC 2016) and is also associated with human structures.

There are several environments that have been sampled minimally or remain unexamined. Wynne (2016) completed a baseline inventory of ground-dwelling arthropods on cliffs, caves, and crater lakes of Rapa Nui. Although the most extensive effort to date, only a fraction of these environments were sampled. Cliff habitats likely support one of the most important relict habitats on the island. As evidenced from other islands, these environments could be relictual sites for endemic plant (Wood 2012) and arthropod (Priddel *et al*. 2003) species. On Rapa Nui, cliffs remain largely inaccessible to humans, most livestock, and certain sections may be even inaccessible to rats. Regarding caves, only 30 of the at least 800 known caves have been sampled (Wynne *et al*. 2014; Wynne 2016). Thus, this work is far from complete. Additional surveys should be conducted in the crater lakes. Wynne (2016) suggests the interior of Rano Kau represents another high priority site for inventory, conservation and management of endemic arthropods. Finally, the neighboring islets of Rapa Nui may hold great promise for additional new endemic species discoveries (Wynne 2016). Motu Nui was not intensively sampled during this study, and the remaining islets have not been examined.

Additional work within these environments will be required to further guide conservation and management decisions, better define distributional ranges of target species, and provide critical monitoring information of arachnids likely predating upon endemic species. Data collected during such an effort will provide natural resource managers with some of the information required to develop management plans for protection and monitoring of endemic arthropod species' populations.

Additional research efforts will also serve to better define the distribution of *Tetragnatha* sp. as we suggest this spider may prove to be an important management species. Wynne *et al*. (2014) suggested the 10 endemic presumed cave-restricted species may be endangered due to a number of factors including an arthropod community dominated by alien species, and the subsequent predation and competition with alien species. Thus, further research may also serve to monitor alien arachnid species that may directly threatened Rapa Nui's limited endemic arthropods, as well as provide information on the distribution and autecology of the only possible extant endemic spider (*Tetragnatha* sp.). An intensive island-wide survey in the areas mentioned will likely reveal additional new endemic species including arachnids, and broaden our understanding of the natural history of the most isolated island in Polynesia.

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APPENDIX. **Study sites, sampling areas, coordinates, and methods applied during spider sampling conducted on Rapa Nui**.

Study Sites	Sampling Areas	Coordinates	Methods
Akahanga		27°09'58.26"S, 109°24'02.77"W	BS, OPP
Anakena		27°03'50.81"S, 109°20'36.12"W	OPP
Ahu Akivi	Aki 1	27°07'56.27"S, 109°24'09.95"W	BS, OPP
	Aki 2	27°07'24.37"S, 109°23'55.19"W	BS, OPP
Ava Ranga Uka	Ava 1	27°05'56.57"S, 109°22'15.45"W	OPP
	Ava 2	27°05'50.22"S, 109°22'21.64"W	OPP
	Ava 3	27°06'06.81"S, 109°22'13.09"W	OPP
Greenhouse, CONAF Hdqrtrs		27°09'55.98"S, 109°26'23.12"W	BS, OPP, LS
Motu Nui		27°12'00.79"S, 109°27'11.13"W	OPP
Poike	Poike 1	27°06'46.45"S, 109°14'20.62"W	BS, OPP
	Poike 2	27°06'49.66"S, 109°14'20.95"W	BS, OPP
	Poike 3	27°05'58.61"S, 109°15'09.02"W	BS, OPP
Ovahe	Ova 1	27°04'15.29"S, 109°18'57.17"W	OPP
	Ova 2	27°04'36.37"S, 109°19'07.21"W	BS, OPP
Rano Aroi	Raroi 1	27°05'35.52"S, 109°22'29.09"W	BS, OPP, LS
Rano Kau	Rkau 1	27°10'50.46"S, 109°26'21.29"W	BS, OPP
	Rkau 2	27°10'53.68"S, 109°26'16.56"W	BS, OPP
	Rkau 3	27°10'55.14"S, 109°26'16.35"W	BS, OPP
Rano Raraku	Rrar 1	27°07'23.80"S, 109°17'24.57"W	OPP, LS
	Rrar 2	27°07'15.47"S, 109°17'16.00"W	OPP, LS
Roiho Lava Tube Caves		27°6'25.81"S, 109°24'42.786"W	DIS, Bait, OPP, PT
Te Ara O Te Ao		27°10'26.30"S, 109°26'29.71"W	BS, OPP, SP
Teravaka		27°05'21.23"S, 109°22'26.89"W	OPP
Vinapu		27°10'10.27"S, 109°23'01.22"W	BS, OPP

We applied several techniques including beating sheets (BS), leaf litter sifting (LS), and sticky paper (SP) for surface environments; and bait sampling (Bait), pitfall trapping (PT), and direct intuitive searches (DIS) for caves. We opportunistically searched (OPP) at all study sites.