Memoranda Soc. Fauna Flora Fennica 87: 95–101. 2011

Increased number of observations and notes of offspring production in the invasive orb-web spider *Argiope bruennichi* (Scopoli, 1772) (Araneae; Araneidae) in Finland

Juhani Terhivuo, Niclas R. Fritzén, Seppo Koponen & Timo Pajunen

Terhivuo, J., & Pajunen, T., Finnish Museum of Natural History, Zoological Museum, P.O. Box 17, FI-00014, University of Helsinki, Finland. E-mail: juhani.terhivuo@helsinki.fi and timo.pajunen@helsinki.fi
Fritzén, N.R,, Klemetsögatan 7 B7, 65100 Vasa, Finland. E-mail: nrfritzen@gmail.com
Koponen, S., Zoological Museum, University of Turku, FI-20014 Turku, Finland. E- mail: sepkopo@utu.fi

Prior to 2005, the orb-web spider *Argiope bruennichi* (Scopoli, 1772) was unknown in the Finnish spider fauna. In 2005–2010, four specimens in three localities were found by laymen. In 2011, 13 specimens were observed in various parts of southern Finland. The sample sites are separated by long distances suggesting that *A .bruennichi* specimens are spread by anemochory, i.e. by ballooning. All the individuals were females. Two cocoons (egg sacks) constructed by one of the two females reared in captivity and one cocoon constructed outdoors by another female yielded live offspring. Whether young *A. bruennichi* passed the winter in cocoons in Finland or arrived from abroad in spring 2011 prior to reaching maturity during summer of the same year is unknown. Here we compile the records of *A. bruennichi* gathered in Finland in 2005–2011. We document the arrival and reproduction of this alien spider at the northernmost edge of its range and discuss its dispersal in Northwest Europe and factors related to the establishment of permanent populations in general.

Introduction

The wasp spider *Argiope bruennichi* (Scopoli, 1772) is a spectacular member of the family Araneidae (Figs. 3, 4), with adult females measuring 11–14 mm in Britain (Locket & Millidge 1953) or as much as 14–17 mm in continental Europe (Bellmann 2001). The females are easily identified through their vivid coloration, i.e. dark horizontal stripes on the otherwise yellow dorsal part of the abdomen. The males are smaller in size (4–6 mm) and the striped pattern of their abdomen is blurred.

Spiders cannot fly but compensate for the lack of wings by ballooning. Usually, young spiders balloon by means of the gossamer threads they produced. The thread and the spider are carried by the wind and the spider may land far from the place of origin (e.g. Walter et al. 2005). If these spiders succeed in becoming mature, they may establish novel populations provided that the different sexes meet.

Argiope bruennichi was found for the first time in Finland in Vantaa near the city of Helsinki in 2005 (Koponen et al. 2007). Later in 2009, two females were found in Hirvensalmi and in 2010

a single female in Seinäjoki, in central Finland. In 2011, the number of observations increased in various areas of southern Finland. Here we focus on the recent dispersal and offspring production of the species observed, which may lead to the establishment of future permanent populations, and also discuss the modes of dispersal in the northward invasion of the species.

Material and methods

The dataset used comprised observations sent by local environmental observers to the university museums of Helsinki and Turku and published in the Internet and in local newspapers in 2005–2011. We included in the study material only records provided with photos (Table 1). In localities 2 and 14, the observers reported the presence of two females at the same site. Some of the females indicated in Table 1 were reared to observe their cocoon (egg sack) production and possible emergence of offspring.

Results

Observations of *A. bruennichi* up to 2011 are shown in Table 1. A notable increase in numbers of observations occurred in 2011 (Fig. 1). The corresponding locations of Table 1 in Finland and the observations are presented in chronological order according to the date of observation (Fig. 2). The material indicated above shows several noteworthy points:

1) Few records refer to the period of 2005–2010. Prior to this period, *A. bruennichi* was absent from the large arachnological collections preserved in the zoological museums of the universities of Helsinki and Turku and no records are likewise available. In 2011, a considerable increase in numbers of observations occurred (Fig. 1).

2) All the records in Table 1 were provided by laymen showing that this brightly coloured spider is easily recognizable.

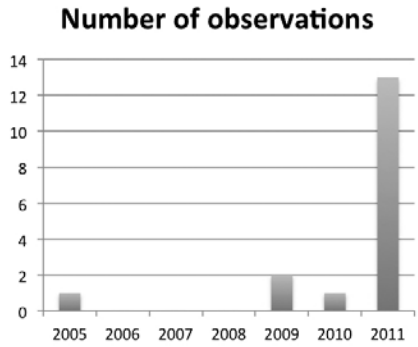

Fig. 1. Increase in numbers of observations of *A. bruennichi* in Finland in 2005–2011.

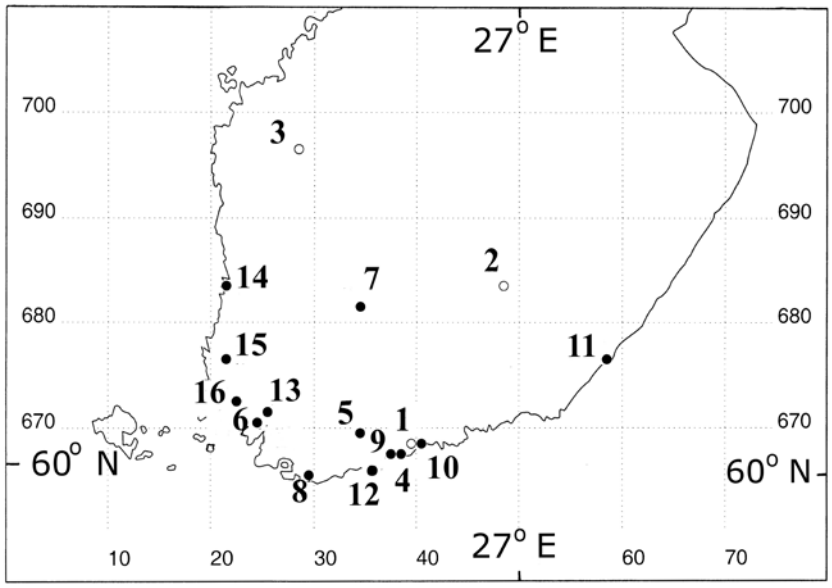

Fig. 2. Map of southern Finland provided with localities for *Argiope bruennichi* recorded in Finland. Open circles refer to records of the period 2005–2010, solid circles show those made in 2011.

Table 1. Records of *Argiope bruennichi* in Finland in 2005–2011. Serial numbers correspond to those in Fig. 1. All the records were provided with photos and they refer to females.

N:o	Commune & locality	Date	Observer(s)
1.	Vantaa, Kuninkaala	2005	Paula Piirainen
2.	Hirvensalmi	9.8.2009	Aila Haimilahti
3.	Seinäjoki, Huhtala	28.8.2010	Matti Anttila
4.	Helsinki	14.8.2011	Hailamäki (a)
5.	Lohja, Paksalo, Töyrytie 78	15.8.2011	Liisa Seppänen
6.**	Kaarina. Koristo, Kirvelikatu	21.8.2011	Charlotta Neffling & Emmi Virta
7.*	Kangasala, Heponiemi	22.8.2011	Anna-Maija Hautamäki & pupils of the Joonas school
8.	Raasepori, Skogby	23.8.2011	Eero Miettunen
9.	Espoo, Matinkylä, Koukkuniemi	30.8.2011	Erkki Peippo
10.	Sipoo, Söderkulla	25.8.2011	Tea Kettumäki
11.	Lappeenranta, Nuijamaa, Tulli	2.9.2011	Juha Väkevä
12.	Kirkkonummi, Porkkala	4.9.2011	Pertti Nupponen
13.	Lieto, Vaalantie 64	6.9.2011	Samuli Hakola
14.**	Pori, Yyteri	10.9.2011	Mari Rotkus
15.	Laitila, Valkojärvi	10.9.2011	Seppo Mäki
16.	Nousiainen, Ronkainen	16.9.2011	Simo Antola

* asterisks refer to females which produced one or more cocoons, ** = live spiderlings were found inside the cocoons. a = http://hyonteiset.net/foorumi/viewtopic.php?f=13&t=25809

3) The localities in Figure 2 are separated by long distances, indicating that this pattern can be the result of separate dispersal events.

4) All the observations refer to adult females (Table 1). No males have been recorded in Finland.

5) The dates of the observations refer to the period from the late summer to early autumn (Table 1). The observer in locality 4 stated on August 14, 2011 in a web site (Hyönteisfoorumi) that one *A. bruennichi* specimen had been there for about 2 months and that had become rather large.

6) The females from localities 6 and 14 (Table 1) produced cocoons (egg sacks) with live offspring. This shows that the species is able to produce offspring, i.e. the females have copulated and became fertilized, which is a prerequisite for the establishment of a population.

7) The female from locality 7 was sent by the collectors to the Zoological Museum of the University of Helsinki. The specimen was reared in a terrarium placed in the exhibition hall. It was fed with flies, spun an orb-web providing it with a stabilimentum. It also constructed three cocoons, one of which is shown in Figure 4. These cocoons did not result in any offspring and closer inspection showed that the eggs lacked embryos. This female, measuring 15 mm in body length, died in late October 2011. This may indicate that copulation is not a prerequisite for cocoon production. Another female found on her web in a wheat field

Fig. 3. Dorsal view of the adult *A. bruennichi* female (from locality 7) that constructed the cocoon shown in Fig. 5. Photo: J. Terhivuo.

in locality 6 was kept in a large glass jar at the Zoological Museum, University of Turku, since August 22. It was fed with tachinid flies and in late August produced a cocoon followed by another 2 weeks later, then the female died. The cocoons were kept at room temperature and checked on October 27, 2011. Both cocoons included a large number of live spiderlings. Another set of live spiderlings was found in a cocoon produced outdoors by the female of locality 14 but brought indoors for rearing. The two females kept in captivity did not moult, showing that they were adults and that at least one of them had copulated prior to being captured. The cocoon produced by the female of locality 14 was located about 3 m from the web.

Fig. 4. Ventral view of the adult female of Fig. 3. Photo: J. Terhivuo.

Fig. 5. One of the three cocoons constructed by *A. bruennichi* in Figures 3 and 4. Photo: J. Terhivuo.

Discussion

Dispersal

Argiope bruennichi is a widely distributed species in the southern parts of the Palearctic region. It has extended its range to China and Japan and is present in the Mediterranean basin, including North Africa (Wiehle 1931a, Heimer & Nentwig 1991). In Europe, it has rather recently widened its range to the Nordic countries. After the first record of it in Denmark in 1992, it later established itself there (Scharff & Langemark 1997). In Sweden, the species was recorded for the first time on the island of Gotland in 1989 (Jonsson & Wilander 1999). Jonsson (2004) reported the establishment of new populations and increases in numbers of specimens in southern Sweden. The northernmost published Swedish record refers to Nynäs, Södermanland near Stockholm (Landreus 2004), but currently the species is present in Stockholm and the northernmost records refer to Dalarna (L. Jonsson, pers. comm.). In Norway, *A. bruennichi* was recorded for the first time in 2004 (Bratli & Hansen 2004). The first observations of it in Estonia, Latvia and Lithuania refer to the period 2004–2006 (Biteniekyte 2005, Spuņģis 2005, cf. Koponen et al. 2007, accordingly). In Estonia, *Argiope bruennichi* was present at about 20 sites on Saaremaa Island and coastal areas of western Estonia in 2009, locally at remarkable densities (Talvi 2010). Later (in 2010 and 2011), a severe decline was observed both in inhabited sites and densities (T. Talvi, pers. comm.). In Sweden, there are likewise rather few records of *A. bruennichi* north of the permanently populated southernmost part;

single females were found at its northern limit, near Stockholm, at two localities in 2010 and at two in 2011 (L. Jonsson, pers. comm.). In Latvia, the species has been found widely, but not in high numbers during recent years, and with no peak in 2011 (I. Cera, pers. comm.). In Norway, no observations have been done after the first record by Bratli & Hansen (2004), despite active searching at suitable sites, including in 2011 (K. Åkra, pers. comm.). So, the invasion of *A. bruennichi* in Finland in 2011 differs clearly from the situation in nearby areas in the Baltic and Scandinavian countries. The species is also present in the St Petersburg area (Helsdingen 2004). Currently, the record in Seinäjoki (locality 3, Table 1) is the northernmost known locality for *A. bruennichi*. Undoubtedly, *A. bruennichi* is a newcomer to Scandinavia, the Baltic countries and Finland.

Figure 1 indicates an increasing rate of observations in Finland in 2011. In early spring 2011, winds blowing from the south and southwest carried several species of butterflies and moths not often recorded in Finland from Southern and Central Europe (J. Kullberg, pers.comm.). Such suitable winds may have also carried ballooning spiderlings of *A. bruennichi*. Another alternative is that the specimens observed in 2011 may have been the offspring of parent spiders that already arrived in Finland in 2010. If so, the specimens passed the winter as spiderlings inside cocoons produced during autumn 2010 and matured during 2011. We may note that winter 2010–2011 was very harsh in Finland, but the snow cover acting as an insulation layer was very thick. However, data indicating the survival of *A. bruennichi* offspring through the harsh winter are still lacking.

In some cases, the dispersal of *A. bruennichi* may be unconsciously aided by human agency. For instance, in locality 11 the spider was found behind a traffic sign in the customs station area of Nuijamaa where large numbers of vehicles annually cross the border between Russian and Finland.

Adult *A. bruennichi* females are large in size and remain in the middle of their webs, so that their ability to balloon is not likely. Seemingly, the increasing number of observations in Figure 1 may be based on the preceding ballooning of spiderlings, their source populations are unknown. Probably they are situated outside Finland, but we cannot reject the possibility that permanent populations already exist somewhere in Finland. On the other hand, awareness of the species has increased among people in Finland, especially in 2010 and 2011, when records of the species provided with photos were published on the Internet as well as in local newspapers. This may have contributed to the number of observations as well. In some reports, however, the observer asked the authors to identify the specimen they had found.

Argiope bruennichi is reported to live for only one year (Walter et. al 2005). If so, the establishment of a population is primarily dependent on the lucky coincidence of male and female specimens that arrive and mature at the same site. We believe that this is what occurred, as indicated by the fertile eggs and spiderlings produced by some of the females in Table 1. In any case, we assume that the number of ballooning young spiders must have been large. We are still attempting to determine when the species will establish permanent wild populations in Finland, where it would live at the northern edge of its range in Europe.

Reproduction

Wiehle (1931b) showed that copulation occurs in the middle of the web. Crome & Crome (1961) suggested that the males are usually consumed by the females or die the day after copulation. Several weeks after the copulation, the females produce cocoons. The spiderlings hatch after about 4 weeks, pass the winter in cocoons and mature the following year (Wiehle 1931b). Walter et al. (2005) collected cocoons in late April in Germany and the second instar spiderlings emerged in early May. Accordingly, the cocoons were constructed during summer or autumn of the preceding year, suggesting that ballooning usually occurs in spring. Our material shows that females kept in captivity and fed well may produce one or more cocoons that yield live offspring during late summer or early autumn (Table 1). If the latter offspring pass the winter successfully inside the cocoons, they would be ready to balloon next spring after emergence.

Despite the fact that *A. bruennichi* is reported to copulate and to reproduce in a normal sex-

ual way, the reason for the biased sex ratio observed among the specimens is still to be determined. Since the females in captivity (Table 1) did not moult, we suggest that they had copulated prior to being captured as adults.

Bratli & Hansen (2004), Almquist (2005), Biteniekyte (2005), Spuņģis (2005) and (cf. Koponen et al. 2007) showed that only females of *A. bruennichi* were recorded in areas where the species has not yet become permanently established. This accords with the data presented in Table 1. Does this mean that male spiderlings balloon less regularly than females or are the males usually left unnoticed? A plausible explanation for the lack of observations of males is that they are much smaller in size, have less conspicuous coloration of the abdomen and may also die soon after copulation or become eaten by the females.

Parthenogenesis is an uncommon method of reproduction among spiders, but the thelytokous mode of reproduction is known, e.g. in *Dysdera hungarica* (Dysderidae) (Gruber 1990) and *Triaeris stenaspis* (Oonopidae) (Korenko et al. 2009, see also Camacho 1994). Thelytokous females produce only female offspring. Thelytoky is, however, unknown in the Araneidae. Interestingly, in some spider species a biased sex ratio is produced by a parasite (Hurst & Vollrath 1992).

Prey and habitat occupation

Argiope bruennichi spins a vertical orb-web that is usually deposited some tens of centimetres above the soil surface, which explains why the prey mostly comprises insects flying or jumping rather close to the soil surface. In locality 4 the female captured a bumblebee and the female in locality 8 a grasshopper in its web. Since the spider waits for prey in the middle of the web, it is easily noticed there.

Argiope bruennichi occupies open habitats such as moist meadows, low bushes, gardens and walls of human settlements (Heimer & Nentwig 1991, Almquist 2005). The Finnish specimens were found on decorative plants in yards, cornfields, a sunny field by a forest road, as well as on the railing of a balcony, the wall of a garage and behind a traffic sign.

Acknowledgements. The authors extend their thanks to all those persons in Table 1 who sent their observations to the university museums in Helsinki and Turku as well as to those who reported their findings in the Net. We are thankful to the following for current information on nearby areas: Kjetil Åkra (Norway), Inese Cera (Latvia), Lars Jonsson (Sweden), Tönu Talvi (Estonia). Tomi Salin and Anssi Teräs kindly reared the females and cocoons in the zoological museums of the universities in Helsinki and Turku, respectively.

References

Almquist, S. 2005: Swedish Araneae, part 1 – families Atypidae to Hahniidae (Linyphiidae excluded). — Insect Systematics & Evolution, Supplement 62: 1–284.

Bellmann, H. 2001: Spinnentiere Europas. — Kosmos Atlas. Stuttgart, 344 pp.

Biteniekyte, M. 2005: Argiope bruennichi is a spreading spider species in Lithuania. — Abstracts, Conference "Research of insects: present and future", October 14–15, 2005, Vilnus. Leidykla. pp. 57–58 [In Lithuanian].

Bratli, H. & Hansen, L.O. 2004: The wasp spider Argiope bruennichi (Scopoli, 1772) Aranea, Araneidae) observed in Norway. — Norw. J. Entomol. 51: 183–185.

Camacho, J.P.M. 1994: Female-biased sex ratio in spiders caused by parthenogenesis? — Hereditas 120: 183–185.

Crome, W. & Crome, I. 1961: Die Paarung und Eiablage bei Argiope bruennichi (Scopoli) auf Grund von Freilandbeobachtungen an zwei Populationen in Spreewald / Mark Brandenburg (Araneaea: Araneidae). — Mitt. Zool. Mus. Berlin 37(2): 189–252.

Gruber, J. 1990. Fatherless spiders: — Br. Arachnol. Soc. Newsl. 58: 3.

Heimer, S. & Nentwig, W. 1991: Spinnen Mitteleuropas. — 543 pp. Verlag Paul Parey, Berlin und Hamburg.

Helsdingen, P.J. van 2004: Araneae. Fauna Europaea version 1.1. http://www.faunaeur.org

Hurst, L.D. & Vollrath, F. 1992: Sex-ratio adjustment in solitary and social spiders. — Trends Ecol. Evol. 7: 326–327.

Jonsson, L.J. 2004: Getingspindeln, Argiope bruennichi, etablerad och sprider sig norrut i Sverige. — Entomologisk Tidskrift 125 (3): 117–120.

Jonsson, L.J. & Wilander, P. 1999: Är getingspindeln, Argiope bruennichi, etablerad i Sverige? — Entomologisk Tidskrift 120: 17–21.

Koponen, S., Fritzén, N.R., Pajunen, T. & Piirainen, P. 2007: Two orb-weavers new to Finland. – Argiope bruennichi and Neoscona adianta (Araneae, Araneidae). — Memoranda Societatis pro Fauna et Flora Fennica 83: 20–21.

Korenko, S., Smerda, J. & Pekar, S. 2009: Life-history of the parthenogenetic oonopid spider, Triaeris stenaspis

(Araneae: Oonopidae). — Eur. J. Entomol. 2009, 106(2): 217–223.

Landreus, W. 2004: Getingspindeln Argiope bruennichi sprider sig norrut i Sverige. — Entomologisk Tidskrift 125: 54.

Locket, G.H. & Millidge, A.F. 1953: British spiders. vol. II. — 449 pp. Metchim & Son ltd, London.

Scarff, N. & Langemark, S. 1997: Hvepseedderkoppen, Argiope bruennichi (Scopoli) in Danmark. (Araneae, Araneidae). — Ent. Meddr. 65: 179–182.

Spuņģis, V. 2005: Wasp spider Argiope bruennichi (Scopili, 1772) (Aranea, Araneidae) in Latvia. — Latvijas Entomologs 42: 86.

Talvi, T. 2010: Spread and habitat preference of the wasp spider Argiope bruennichi (Araneae: Araneidae) in Estonia. — 28th Nordic-Baltic Congress of Entomology, Birtonas, Abstract Book: 73.

Walter, A., Bliss, P. & Moritz, R.F.A. 2005: The wasp spider Argiope bruennichi (Arachnida, Araneidae): Ballooning is not an obligate life history phase. — J. Arachnology 33: 516–522.

Wiehle, H. 1931a: 27. Familie Araneidae. — In: F. Dahl (ed.): Die Tierwelt Deutschlands und der angrenzenden Meeresteile. pp. 1–136. Verlag von Gustav Fischer, Jena.

Wiehle, H. 1931b: Neue Beiträge zur Kenntnis des Fanggewebe der Spinnen den Familien Argiopidae, Uloboridae und Theridiidae. — Z. Morph-Ökol. Tiere 22: 349–400.