A REVIEW ON THE SPIDER GENUS ARGIOPE AUDOUIN 1826 WITH SPECIAL EMPHASIS ON BROKEN EMBOLI IN FEMALE EPIGYNES (ARANEAE: ARANEIDAE: ARGIOPINAE).

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„While a published monograph may appear to provide definite solutions, and readers infer that the author is certain of his findings, more likely the work only identifies and illuminates tantalizing problems. Especially to those with no experience with taxonomic problems, a published monograph has an unfortunate aura of authority.“ Herbert Levi (1983: 256)

Abstract: Argiope species are revised with special emphasis on broken male emboli in female epigynes. Broken emboli proved suitable for matching conspecifics and recognising cryptic species in species swarms with similar females. Material of 47 species from 63 countries was included in this study: 92 males, 834 females and 316 broken emboli were examined. Broken emboli are documented for 32 species, those of 27 species are illustrated for the first time, those of 8 species have been known and illustrated before. 19 species are illustrated by means of in situ emboli, 9 of them are not recorded as broken emboli. In total, emboli of 41 species are illustrated. The male of A. luzona could be confirmed by means of broken emboli stuck in the epigyne. One new species is described: Argiope hinderlichi spec. nov. (female; Laos, Lak Sao, Nong Khiao). The male of Argiope jinghongensis Yin, Peng & Wang 1994 is redescribed and the female is described for the first time. Argiope doleschalli Thorell 1873 and Argiope bivittigera Strand 1911 are removed from the synonymy of A. reinwardti Doleschall 1859. A. crenulata pictula Strand 1911 is removed from the synonymy of A. modesta Thorell 1881 and raised to species rank. A. boetonica Strand 1915 is removed from the synonymy of A. appensa (Walckenaer 1841) and considered a junior synonym of...
A. pictula. A. squalllica Strand 1915 is removed from the synonymy of A. brunnescentia Strand 1911. Argiope submaronica Strand 1916 is removed from the synonymy of A. argentata (Fabricius 1775), and A. savignyi Levi 1968 is recognised as junior synonym of A. submaronica. Further, the following synonymies are proposed: Argiope bruen-nichi nigrofasciata Franganillo 1910 and Argiope acuminata Franganillo 1920 as junior synonyms of A. bruenichi (Scopoli 1772), Argiope lobata retracta Franganillo 1918 as junior synonym of A. lobata Pallas 1772, Argiope papuana Workman 1900 as junior synonym of A. picta L. Koch 1871. Argiope avara angulicosta Strand 1911, A. a. ocel-ligera Strand 1911, A. a. tristipes Strand 1911, A. aetherea tangana Strand 1911 and A. lihirica Strand 1913 are removed from the synonymy of A. aetherea and placed in the synonymy of A. brunnescentia Strand 1911. Argiope aetherea keyensis Strand 1911 is removed from the synonymy of A. aetherea and placed into synonymy of A. modesta Thorell 1881. Argiope maja Bösenberg & Strand 1906 is misplaced, transferred to the genus Nephila Leach 1815 and proposed as junior synonym of Nephila clavata L. Koch 1878. Argiope thai Levi 1983 was misplaced and is transferred to the genus Cyrtophora Simon 1864 and proposed as junior synonym of C. moluccensis (Doleschall 1857).

In most cases distribution ranges of species were confirmed by the material included in this study. Argiope chloreis Thorell 1877 is recorded as first record for Laos and northernmost record for the species, A. jinghongensis from Thailand and Laos for the first time. A. comorica Bjørn 1997 is recorded the second time in general and the first time from the Island Mayotte, a female close to A. tapinolobata Bjørn 1997 is recorded from Namibia. The record of A. pulchella from Sumbawa extends its range farther east.

A map is provided with records of the new species, new Asian country records and Asian species previously not included in large revisions. Habitus photos of 41 species are provided in the Senckenberg online database, 9 of which are included in this paper.

Key words: Taxonomy, new species, first description, first record, Southeast Asia, Indochina, Greater Mekong Region, Africa, Americas, Europe

INTRODUCTION

Argiope species are famous for their colourful opisthosomal patterns of the showy females and the strong sexual size and colour dimorphism (Levy 1983). Argiope species are also known for their sexual cannibalism: in Argiope bruenichi (Scopoli 1772) no male survived a second insertion (Schneider et al. 2006), and in A. aurantia Lucas 1833 the heart beat of the male stopped when the second palp was inserted resulting in a whole-body-plug of the male (Foellmer & Faibairn 2003). Ghione & Costa (2011) found in experiments with Argiope argentata (Fabricius 1775) that male emboli break without a female attack. During the copulation process emboli break usually on a predetermined breaking point (crack) and emboli or parts of them plug copulatory openings. Bjørn (1997) suggested that the breaking off may be an active process as haemato-
dochal zones were involved. Whether broken emboli are a real barrier for a potential second male in all species was not clear, as in some openings several emboli were found (Bjørn 1997, present study). Nessler et al. (2006) and Uhl et al. (2007) showed in macerated female copulatory organs, that the very distal embolic tip is plugging the copulatory duct in Argiope bruennichi. Similarly plugging was found by Grasshoff (1970a: fig. 8c; 1970b: fig. 8c; 1984: figs 18, 21, 25, 27) for Kilima conspersa Grasshoff 1970, Larinia chloris (Audouin 1826) and species of the genus Caerostris Thorell 1868 respectively. Paternity success in Argiope bruennichi was increased by plugging the female’s insemination duct (Nessler et al. 2006, 2007). Moreover, Nessler et al. (2007) showed that the spur of the median apophysis promotes the breakage of the embolus tip. For a review on mating plugs (also including broken emboli) in spiders in general see Uhl et al. (2010).

No matter whether or in which way emboli represent an effective barrier for a subsequent successful insertion of a male or not, broken emboli provide a good taxonomic help to identify a female spider when its colouration has faded (Levi 2004) or when it belongs to a group with similar females and only weak diagnostic characters. An excellent example is the American species pair Argiope blanda O. Pickard-Cambridge 1898 and A. argentata (Fabricius 1775), whose males are clearly identified by the absence or presence of an embolic pendant (Figs 115, 119, 123, 126, 131, 152–153, 157). Broken emboli can also help matching conspecifics when male and female are not found together in one web or in copula (Levi 1983, Bjørn 1997, present study). They provide in most cases good evidence whereas colour and size dimorphism makes it difficult to match male and female of the same species (Strand 1915: 217). Additionally, broken emboli can be illustrated in the case the male sex is not known which again can help in future identification of the male. In one case of the literature investigated male and female were matched together (Yin et al. 1997: figs 19a–i, sub Argiope versicolor), but the broken embolus illustrated betrayed that the broken embolus and the embolus in situ were different and thus the assumed matching was wrong. Broken emboli were already used by Grasshoff (1984: 729) to match male and females in the genus Caerostris.

(Doleschall 1859) from Laos. Recently, Cheng et al. (2010) published a first molecular approach on few Argiope species focusing on evolution of web decoration. In the present paper, initially Argiope specimens collected by the author from Laos and Thailand were reviewed. Additionally, the collection deposited in the Senckenberg Research Institute, including unidentified and identified material, was examined. One new species is recognised and described. Species are commented and illustrated especially by means of broken emboli. New country records for species are listed. A marginal aspect of this paper is to stress the importance of Natural History collections for systematic studies. Therefore an evaluation of the material examined is provided in the results chapter. Scientific collections received in the near past less and less attention in political terms, i.e. financial support. This paper demonstrates the necessity of not only maintaining these but actively working on this material and reviewing it after main revisions of taxa have been done.

According to Levi’s (1983: 256) warning and advice (see leitmotif above) some taxonomic problems may be solved in this paper, but some problems can be just indicated. Future work must continue finding answers to open questions.

Material and Methods

Adult spiders were considered with only few exceptions, i.e., when immature spiders could be unambiguously identified. Spiders are preserved in 70% denatured ethanol. Female copulatory organs were dissected and observed in 96% lactic acid, if necessary, i.e. if an illustration of a new species was made or to investigate whether broken tips of emboli were present. Broken emboli were removed from epigynes using ultra-thin pins fixed to wooden sticks. They were drawn in a Boveri dish with white artificial sand to choose the best orientation. Usually the embolus was drawn in a mesal view as in an intact palp. Sometimes it was necessary to shift the embolus slightly to show important details. To allow a better comparison especially with illustrations in Levi (1983, 2004) and Bjørn (1997) as well as within the present paper all right emboli were mirrored and all emboli are shown to the same scale. In some cases the tip of the broken embolus is shown in detail and with a higher magnification to allow unambiguous identification with particular details. In few cases emboli could only be removed by damaging the epigyne. This was the case in species with a long scapus (e.g., A. aurantia, A. protensa) or when only a very small part of the embolus was left behind (e.g., A. aemula). These procedures were made exclusively with non-type material. Only entire broken emboli were recognised as such. It was not searched for broken tips in every epigyne (cf. Uhl et al. 2007), which would have exceeded the scope of the study and which have not been possible in every case.

Style of description follows Jäger & Praxaysombath (2009: Argiope dang), terminology Levi (1983) and Bjørn (1997). Eye measurements are according to Bjørn (1997: fig. 3). Localities in the material lists are ordered according to continents, countries and in some cases to provinces or similar entities. Numbers behind the SMF collection number (Lxx) referring to Laotian localities and to the numbering in Jäger (2007: L1–L36) and Jäger & Praxaysombath (2009: L37–L78; 2011: L79–L103). Collection
numbers are SMF numbers, belonging to the regular Senckenberg collection. In some taxa, among these in Argiopinae, the Roewer collection was not included in the regular Senckenberg collections, but placed separately. These series are indicated as RIIxxxxx and will appear in the online database of Senckenberg (http://sesam.senckenberg.de) as 99xxxxxx. Totals of material examined for each species is given in parentheses in the beginning of the material list. Material was generally identified by the author. Exceptions are either listed (e.g., Roewer det., Strand rev.) or self-explanatory, for instance in cases of original type material. Photos could not provided in the manuscript for all species and are therefore uploaded to the online database of Senckenberg (http://sesam.senckenberg.de). Particular specimens are marked behind the collection numbers with “www”. Photos are displayed in the database under “General Data” (“Allgemeine Daten”).

In general, Senckenberg material was examined. In some cases material from other collections was included. In the case of A. comorica and A. ranomafanensis the material from Tervuren Museum was on loan by Manfred Grasshoff and therefore included in this review. Type material of the difficult aetherea-group from Chinese collections was borrowed to check details in a direct comparison of specimens.

Abbreviations:
ALE — anterior lateral eyes
AME — anterior median eyes
AW — anterior width of dorsal shield of prosoma
OL — opisthosoma length
OW — opisthosoma width
PL — prosoma length
PLE — posterior lateral eyes
PME — posterior median eyes
PW — prosoma width
I–IV/XII — legs I–IV / months I–XII

Museum collections:
HNU — Hunan Normal University, Changsha, China (X.J. Peng)
MHBU — Museum of Hebei University, Baoding, China (F. Zhang)
NMID — National Museum of Ireland, Dublin, Ireland (N. Monaghan, M. Nolan)
NMNH — National Museum of Natural History, Leiden, Netherlands (J. Miller, K. van Dorp)
RMCA — Royal Museum for Central Africa, Tervuren, Belgium (R. Jocqué)
SKU — Songkhla University, Hat Yai, Thailand (B. Ponksee)
SMF — Senckenberg Research Institute, Frankfurt, Germany (P. Jäger)
Results

In the arachnological collections of the Senckenberg Research Institute 41 *Argiope* species in more than 400 series were available, additional 6 species were examined from other collections. Ninety-two males, 834 females, and 316 broken emboli have been examined which originate from 63 countries. Thus, approximately 50% of the described *Argiope* species worldwide (Platnick 2011) are found in the SMF collection. Ninety-two series (<25%) of the catalogued part of the SMF collection had to be newly determined, i.e. either specimens were misidentified or the nomenclature had to be updated. Additionally, three species represented only by immatures (*A. florida*, *A. doboensis*, *A. ericae*) and several species from original literature and descriptions were included in this study. The oldest record of the Senckenberg collections concerning the genus *Argiope* has been collected in 1872 (Karl von Fritsch & Rein leg. in Casablanca, Morocco, *A. bruennichi*). The arachnological collections in Senckenberg have been established in 1834 (Wider’s collection from Germany, Odenwald including type material).

Table 1: Species treated in this paper with number of adult males and females, broken emboli and list of countries (Note: doubtful records are not included in the country list, immatures are listed in parentheses only when these were the only specimens examined; Islands such as Canary Islands are listed as zoogeographically independent entities from their political countries). *epiygnes of only few specimens were investigated for broken emboli.

<table>
<thead>
<tr>
<th>Species</th>
<th>males</th>
<th>females</th>
<th>emboli</th>
<th>countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Argiope manila</em></td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>Philippines.</td>
</tr>
<tr>
<td><em>Argiope catenulata</em></td>
<td>1</td>
<td>13</td>
<td>-</td>
<td>Laos. Indonesia: Sumatra, Sulawesi, West Nusa Tenggara, Papua Province.</td>
</tr>
<tr>
<td><em>Argiope bivittigera</em></td>
<td>-</td>
<td>6</td>
<td>8</td>
<td>Indonesia: Maluku Islands.</td>
</tr>
<tr>
<td><em>Argiope reinwardti</em></td>
<td>-</td>
<td>5</td>
<td>6</td>
<td>Indonesia: Java.</td>
</tr>
<tr>
<td><em>Argiope doleschalli</em></td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>Indonesia: Maluku Islands.</td>
</tr>
<tr>
<td><em>Argiope sp.</em></td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>Indonesia: Maluku Islands.</td>
</tr>
<tr>
<td><em>Argiope boesenbergi</em></td>
<td>-</td>
<td>5</td>
<td>2</td>
<td>Japan.</td>
</tr>
<tr>
<td><em>Argiope amoena</em></td>
<td>1</td>
<td>18</td>
<td>23</td>
<td>Japan.</td>
</tr>
<tr>
<td><em>Argiope magnifica</em></td>
<td>-</td>
<td>6</td>
<td>5</td>
<td>Papua New Guinea.</td>
</tr>
<tr>
<td>Species</td>
<td>males</td>
<td>females</td>
<td>emboli</td>
<td>countries</td>
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</tr>
<tr>
<td>Argiope aurantia*</td>
<td>1</td>
<td>37</td>
<td>4</td>
<td>USA. Mexico. El Salvador.</td>
</tr>
<tr>
<td>Argiope sp. cf. tapinolobata</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>Namibia.</td>
</tr>
<tr>
<td>Argiope coquereli</td>
<td>-</td>
<td>7</td>
<td>6</td>
<td>Madagascar.</td>
</tr>
<tr>
<td>Argiope ranomafanensis</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>Madagascar.</td>
</tr>
<tr>
<td>Argiope protensa</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>Australia.</td>
</tr>
<tr>
<td>Argiope florida</td>
<td>-</td>
<td>- (1)</td>
<td>-</td>
<td>USA.</td>
</tr>
<tr>
<td>Argiope doboensis</td>
<td>-</td>
<td>- (1)</td>
<td>-</td>
<td>Indonesia. Maluku Islands.</td>
</tr>
<tr>
<td>Argiope chloreis</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>Laos.</td>
</tr>
<tr>
<td>Argiope blanda</td>
<td>-</td>
<td>9</td>
<td>12</td>
<td>Mexico. El Salvador.</td>
</tr>
<tr>
<td>Argiope submaronica</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>Brazil.</td>
</tr>
<tr>
<td>Argiope ericae</td>
<td>-</td>
<td>- (2)</td>
<td>-</td>
<td>Brazil.</td>
</tr>
<tr>
<td>Argiope anasuja</td>
<td>8</td>
<td>54</td>
<td>-</td>
<td>India. Maldives.</td>
</tr>
<tr>
<td>Argiope minuta</td>
<td>1</td>
<td>10</td>
<td>-</td>
<td>Japan.</td>
</tr>
<tr>
<td>Argiope hinderlichi spec. nov.</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>Laos.</td>
</tr>
<tr>
<td>Argiope aetheroides</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>China.</td>
</tr>
</tbody>
</table>
Females of *A. bruennichi* and *A. aurantia* were investigated for emboli only in few cases due to their hidden epigynal openings. Therefore these cannot be compared with others statistically. However, species with females exhibiting openly accessible epigynal depressions are generally comparable in terms of presence or absence of broken emboli. There are striking differences between species. Apart from the fact that broken embolus tips were difficult to detect, the presence of longer emboli is comparable. Females of species close to *A. aetherea* (with embolic pendant situated distant from embolus tip: *A. modesta, A. pictula, A. appensa, A. brunnescentia, bogainvilla, Aetherea, A. picta*), for instance, had only rarely broken emboli in their epigynes (7 in 203 females). The same is true for *A. anasuja* and *A. minuta* with no embolus found in 64 females. In some species, e.g. *A. argentata or A. pulchella* in almost all females at least one embolus were found.

41 species have been examined with adult females, 26 species with adult males. Seven species have been found without broken emboli in epigynes. In 13 species, where no males were available, broken emboli were found. Considering single identification

<table>
<thead>
<tr>
<th>Species</th>
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<th>females</th>
<th>emboli</th>
<th>countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Argiope luzona</em></td>
<td>1</td>
<td>7</td>
<td>8</td>
<td>Philippines.</td>
</tr>
<tr>
<td><em>Argiope pulchelloides</em></td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>China.</td>
</tr>
<tr>
<td><em>Argiope dang</em></td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>Laos.</td>
</tr>
<tr>
<td><em>Argiope cameloides</em></td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>China.</td>
</tr>
<tr>
<td><em>Argiope modesta</em></td>
<td>-</td>
<td>13</td>
<td>2</td>
<td>Indonesia: Java, West Nusa Tenggara, Maluku Islands.</td>
</tr>
<tr>
<td><em>Argiope pictula</em></td>
<td>1</td>
<td>11</td>
<td>2</td>
<td>Indonesia: Sulawesi.</td>
</tr>
<tr>
<td><em>Argiope brunnescentia</em></td>
<td>-</td>
<td>37</td>
<td>1</td>
<td>Papua New Guinea.</td>
</tr>
<tr>
<td><em>Argiope squallica</em></td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>Papua New Guinea.</td>
</tr>
<tr>
<td><em>Argiope bougainvillea</em></td>
<td>-</td>
<td>25</td>
<td>-</td>
<td>Papua New Guinea.</td>
</tr>
<tr>
<td><em>Argiope picta</em></td>
<td>7</td>
<td>85</td>
<td>1</td>
<td>Indonesia: Maluku Islands, Papua Province. Papua New Guinea. Australia.</td>
</tr>
<tr>
<td><em>Argiope comorica</em></td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>Comores.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>92</td>
<td>834</td>
<td>316</td>
<td>63</td>
</tr>
</tbody>
</table>
events, the percentage with females found without males in the same series but with broken emboli present was similarly high: in 103 series with exclusively females available broken emboli could be found (ca. 25 %). All this stresses the usefulness of emboli for identification purposes.

TAXONOMY

ARANEIDAE Simon 1895

Argiope Audouin 1826

Species are listed in an order following Levi (1983, 2004) and Bjørn (1997). It seems that males offer better features to group species systematically, whereas female epigynes are in many cases similar between groups and the opisthosomal pattern and shape seem to vary within groups.

Levi (1983: 259) grouped the following species with A. ocula Fox 1938 and A. macrochoera Thorell 1891. But he presumed that similar structures (scape) in the female epigyne are convergently developed. Males are necessary to make statements of the systematic position of A. manila and A. macrochoera. For the first description of a broken embolus in A. manila see below.

Argiope manila Levi 1983 (Figs 1–2)


A broken embolus is illustrated for the first time (Figs 1–2). Broken emboli were recognisable by their long sperm ducts (SD in Fig. 2) extending beyond the broken embolus tip (not to be confused with tiny bristles!) or by a black sclerotised portion of the embolus tip visible best in the posterior view. Special and probably diagnostic feature is the prominent bulge (B in Fig. 2; present in all three emboli investigated) situated distally to
the opening of the sperm duct, which latter is situated on a small apophysis (A in Fig. 2). Another smaller outgrowth (O in Fig. 2) is situated on the proximal side of the opening. Placement of this species is doubtful. A comparison of male emboli of this and other species may give hints for its relationship. Most similar conformation of the embolus tip is that of *A. jinghongensis*.

*Argiope aemula* (Walckenaer 1841) (Figs 3–7)


**Note.** This synonymy was not included in Platnick (2011).


**1 female** (SMF), Ban Na Deua (= Ban Nadua), L88, northern slopes of Phou Samkeng, 7.9 air km WSW of Lak Sao, N 18°11'9.00" E 104°53'55.00", 520 m altitude, limestone forest, vegetation at forest margin, rice fields, by hand, by night, P. Jäger & S. Bayer leg. 8.XI.2009. INDONESIA: SUMATRA. **1 female** (SMF 61152, ex RII 827), Roewer det. 1931 sub A. reinwardti (1 female = A. pulchella). **2 females, 6 juvenile females** (SMF 31434), Fort de Kock (=Bukkittinggi), Jacobson leg. 1924, Levi det. 1981. **3 females [1 female without emboli, 1 female: 3 emboli, 1 female: 2 emboli]** (SMF 31433), W Sumatra, Schütz leg. 14.IV.1914, Levi det. 1981. **1 male** (SMF 61152), without data. JAVA. **3 females [2 emboli]** (SMF, RII 4477), Roewer det. 1934. **1 female** (SMF 31601), Levi det. 1981. **1 female [2 right emboli]** (SMF 3477), Java?, Strubell leg. 1908, Strand det. WEST NUSA TENGGARA. **2 females** (SMF 3476), Soembawa [Sumbawa], Wawó [Wawu], B. Rensch leg. 1927. SULAWESI. **1 female** (SMF 3459), SE-Celebes, Elbert leg. 1909. ARU ISLANDS. **1 female** (SMF 3478, www), Terangan, Popjetur, H. Merton leg. 1908. PHILIPPINES. **1 male** (SMF 61155, www), Laguna, Luzon, Mt. Maquiling, Baker leg. PAPUA NEW GUINEA. **1 female** (SMF 3457), New Ireland, Marrahat [not found; there is Mahagat on Tatau Island N of New Ireland], E. Wolf leg. 3.V.1909, sub A. aemula nigripes.

Only a tiny and very distal tip of the male embolus has been shown to break in this species (Figs 4–7, cf. intact embolus in Fig. 3). One female from Mumbai (SMF 31457, www) showed a pattern in the posterior part of the dorsal opisthosoma which resembles *A. bougainvilla*, whereas the other female showed the typical pattern, but with trans-
versal bands rather than the characteristic lines. However, both females are faded and pattern is not clearly recognisable. Levi (1983: fig. 31) illustrated for these specimens an epigyne with striking differences in comparison with material from other part of the distribution range. Jäger & Praxaysombath (2011) recorded the species for the first time from Laos. The male from Vientiane had an extensive black patch in the posterior two third of the dorsal opisthosoma as well as a distinct irregular lateral pattern.

**Argiope catenulata** (Doleschall 1859) (Figs 8–9)


No broken emboli have been found in this study. Yin et al. (1997: fig. 4h) illustrated one embolus, which is, however, not indicated as broken embolus (Li, in litt.). For an embolus in situ see Fig. 8. The spermathecae of this species are uniquely bent laterad (Fig. 9). Jäger & Praxaysombath (2011) recorded the species for the first time from Laos.

The following four species (*A. bivittigera, A. reinwardti, A. doleschalli, Argiope sp.*) exhibit a similar opisthosomal pattern (three transversal dorsal bright patches; Photos 1–20) and epignyes having a broad median septum in posterior view (MS in Fig. 22). Levi (1983: 259) suggested that all members of this group may belong to the same species, “since they are allopatric”. In another paragraph he suggests for *A. reinwardti* that different forms may be species on its own or subspecies (Levi 1983: 278). He illustrated two male palps of *A. reinwardti*. These show a distinctly different shape of embolus as well as of the median apophysis. An investigation of broken emboli revealed strong differences between embolus forms corresponding with characters in females (colouration, shape of epigyne, sternal protuberances). Considering the diversity of other SE Asian *Argiope* (e.g., *aetherea* group, see below) and on the other hand the low variability of copulatory organs of widespread species such as *A. aurantia* and *A. bruennichi* over their entire range, all these forms are considered having species status, according to the distinct and consistent differences in copulatory organs, size and colouration. However, due to limited material available, especially males and fresh material in larger amounts, not in all cases final conclusions can be drawn. Two additional species within this group which were not examined are *A. buehleri* Schenkel 1944 and *A. niasensis* Strand 1907. The latter is transferred to this group tentatively according to its broad epigynal septum, the pentagonal shape of the opisthosoma and the characteristic opisthosomal pattern.
illustrated by Strand (1907: fig. 3). Levi (1983) designated a neotype with indistinct opisthosomal pattern (“washed out”) and placed it incertae sedis. A similar case of an island speciation and allopatric distribution pattern is known from Herennia in SE Asia (Kuntner 2005) and Nephilengys in the Indian Ocean (Kuntner & Agnarsson 2011).

Argiope bivittigera Strand 1911 (Figs 10–14, Photos 1–5)

Material examined (6 females, 8 emboli). INDONESIA: MALUKU ISLANDS. 1 female syntype (SMF 3539, www), Kai Islands, between Elat and Ohilim, H. Merton leg. 8.VI.1908, Strand det. sub A. doleschalli b. 2 female syntypes [1 female: 2 emboli] (SMF 3538, www), Kai Islands, Dula, H. Merton leg. V.1908, Strand det. sub A. doleschalli b. 1 subadult female syntype (SMF 3537), Kai Islands, Elat, H. Merton lag. 2.VI.1908, Strand det. sub A. doleschalli b. 2 females [each 2 emboli] (SMF 3535), Kai Islands, between Elat and Ohilim, H. Merton leg. 2.VI.1908, Strand det. sub A. doleschalli. 1 female [2 emboli] (SMF 3536), Kai Islands, Elat, H. Merton leg. 2.VI.1908, Strand det. sub A. doleschalli.

Levi (1983: figs 50–51) illustrated an adult female of this species rather than a penultimate instar of A. reinwardti, as he suggested. Epigynes of both species can be clearly distinguished by their shape in posterior view with narrower atrial holes in A. bivittigera, from which it was extremely difficult to remove the broken emboli. Moreover the posterior epigynal margin is slightly bilobate in ventral view (Fig. 12). Note that the additional material of the present species identified by Strand as A. doleschalli was collected by Merton at the same day and at the same place as the syntypes of A. bivittigera (cf. Jäger 2010 on a similar case from the family Pisauridae indicating Strand’s attitude to determine different species if not genera from the same locality and from material belonging in fact to the same species)! Size ranges for the species are: PL 6.4–7.9, PW 5.4–7.0, AW 2.8–3.5, OL 10.1–10.8, OW 8.5–10.1. Colouration as in Photos 1–5. Spermathecae rather spherical in lateral view (arrow in Fig. 14; elongate in A. reinwardti, cf. Fig. 23).

Argiope reinwardti (Doleschall 1859) (Figs 15–28, Photos 6–14)

Male emboli exhibit a distinctly longer straight part than in *A. bivittigera*. In 3 broken emboli the distal tip was broken (Figs 15–16, 18). The females from the Senckenberg collection exhibit slightly longer broken emboli than the type material (15–18; cf. 19–20). Further diagnostic characters could be the seven only slightly humped protuberances on the sternum and the almost entirely yellow sternum (Photos 7, 10, 13). Moreover, the second (middle) transversal bar on the dorsal opisthosoma has a convex anterior margin (Photos 9, 12), whereas in *A. bivittigera*, *A. doleschalli* and *Argiope* sp. it is straight (Photos 1, 15) or indistinct (Photo 19). However, one female (Photo 6) of *A. reinwardti* shows an intermediate state.

*Argiope doleschalli* Thorell 1873 (Figs 29–31, Photos 15–18)

Material examined (1 female, 1 embolus). INDONESIA: MALUKU ISLANDS. Female holotype [1 left embolus], Ambon, Doleschall described as *Epeira* (*Argyropes*) *trifasciata*, NMNH). Name preoccupied: *A. trifasciata* Forsskål 1775. *Argiope doleschalli* Thorell 1873: 520 (new name).

The species was synonymised by Levi (1983: 276) with *A. reinwardti*. The broken embolus found in the epigyne of the female holotype is distinctly different from all other emboli known in this group: It is shorter and stout with a small and straight distal tip (Fig. 29). The female is best recognised by 4 distinct sternal protuberances (Photo 17–18). The sternal median stripe is restricted to a narrow zone (Photo 16). Moreover the opisthosoma and parts of the dorsal shield of the prosoma (especially posterior margins) are littered with small dark-brown wart-like structures (Photo 15).

*Argiope sp.* (Fig. 32, Photos 19–21)


PL 4.5, PW 3.7, AW 2.1, OL 6.3, OW 5.0. According to the smaller size, the distinctly smaller and differently shaped embolus (Fig. 32) it is considered a species on its own. Since there are potential names available (*A. concinna* Thorell 1881, *A. barbipoda* Strand 191), whose type material could not be checked, no identification can be provided. Examination of types (and searching for broken emboli in adult females) of above listed species as well as others listed as synonyms within this species group, e.g., *A. celebesiana* Merian 1911 or *A. reinwardti sumatranaa* (Hasselt 1882), could discover more species.
Argiope boesenbergi Levi 1983 (Fig. 33)


Both emboli exhibit the same sharp bend of their tip (Fig. 33). Protruding sperm ducts were well visible in epigynal cavities, emboli were difficult to get out.

Argiope amoena L. Koch 1878 (Figs 34–35)

Material examined (1 male, 18 females, 23 emboli). JAPAN. 1 male [without palps], 12 females [17 emboli], 2 subadult males, 12 immature females (SMF 3481, www), Saga, Kompira [Daimon, Kinryu-machi, Saga-shi], W. Dönitz leg. 1882. 3 females [1 female: 1 left embolus, 2 females: 1 embolus on each side], 1 subadult female (SMF 31417), Yokohama, B. Schmacker leg. 1889, Levi det. 1981. 3 females [with emboli] (SMF 61142), Gifu, Kitagata, Yokohama, G. & B. Lehmacker leg. 1889.

Broken emboli are distinctly larger than those of A. boesenbergi and A. magnifica (Figs 34–35) and are similar to those of A. sector in having no appendage or modification. Colour pattern of male and female immatures as well as adults is similar (SMF 3481, www).

Argiope magnifica L. Koch 1871 (Fig. 36)


Broken emboli had very long and well reconisable sperm ducts extending into the epigynal depression. Emboli are small (Fig. 36) and were hard to remove.
Argiope bruennichi (Scopoli 1772) (Figs 37–41)

Argiope bruennichi nigrofasciata Franganillo 1910: 7, figs 1–2 [fig. 2 depict the characteristic egg-sac of A. bruennichi] (description of female, type material not examined).

Syn. nov.

Argiope acuminata Franganillo 1920: 138 (description of male and female; type material not examined). Syn. nov.

Note. The type material of Franganillo is either dried or lost, in any case not available (Cardoso & Morano 2010, in litt.). In the Iberian Peninsula three species are recorded: A. bruennichi, A. lobata and in the South A. trifasciata (Cardoso & Morano 2010). From the description as well as from the illustration of A. b. nigrofasciata it is clear that this name is a synonym of A. bruennichi, whose dorsal opisthosomal pattern of transversal black, white and yellow lines is variable according to strength of single elements but characteristic among the three species in question. The Latin description of A. acuminata points also to conspecificity with A. bruennichi, especially the two parallel longitudinal lines on the ventral opisthosoma and the median longitudinal sternal line mentioned. I guess that Frangaillo examined a juvenile female, whose opisthosoma is in fact much more distinctly acuminate and extending beyond the spinnerets.

Material examined (5 males, 102 females, 3 emboli). GERMANY. 1 female [without embolus] (SMF 61402), Rösrath, Nature Reserve Wahner Heide, Geisterbusch, by sweep-net, P. Jäger leg. 7.VIII.1994. 1 subadult male, 1 subadult female (SMF 61403), with same data as for SMF 61402, but 10.VII.1994. 1 male, 2 subadult males (SMF 61404), Troisdorf, Nature Reserve Wahner Heide, Tongrube, by sweep-net, P. Jäger leg. 10.VII.1994. 2 subadult males (SMF 61401), Mainz, Draisberghof, P. Jäger leg. 11.VII.1997. 1 female (SMF, RII 4387), near Berlin, Roewer det. 1934. 2 females (SMF 3506), Frankfurt am Main, K. Koch leg. 1883, Strand rev. 4 females (SMF 3508), Frankfurt am Main, F. Römer leg. 1902, Strand rev. 1 female (SMF 3514), Frankfurt am Main, Fechenheim, Mainkur, F. Römer leg. 1901, Strand det. 1 subadult female (SMF 3516), Frankfurt am Main, C. v. Heyden leg., Strand det. 4 females, few juveniles (SMF 3515), Schwanheim, A. Knoblauch leg. VIII.1901, Strand det. 3 females (SMF 3522), Offenbach, Luhwald, A. Zilch leg. VIII.1935. 1 female (SMF 3513), between Darmstadt and Messeler Park, Ernst-Ludwigs pond, F. Haas leg. 9.IX.1934. SWITZERLAND. 3 females (SMF 3512), Lugano, L. Edinger leg. 1904, Strand det. FRANCE. 1 subadult female (SMF, RII 1900), Riviera, near Nice, Roewer det. 1940. 4 females (SMF, RII 8992), Marseille, Roewer det. 1943. 1 female (SMF 3517), S France, A. Knoblauch leg., Strand det. SPAIN. 4 females (SMF, RII 1796), E-Pyrenees, Roewer det. 1942. 13 females (SMF 3507), Girona, La Fosca de Palamós, F. Haas leg. 1914. 2 females (SMF 3510), Prov. Tarragona, Flix, F. Haas leg. 1915. 2 females (SMF 3511), Cataluna, Province Lerida, Podla de Segur, F. Haas leg. VII–IX.1918. 1 male [right palp missing, left embolus broken, but hanging on sperm duct at bulb], 1 female [without emboli] (SMF 34474), Ibiza, Wunderlich det. + ded. 1983. ITALY. 2 females (SMF, RII 5658), Florence, Roewer det. 1940. 30 females (SMF, RII 1794), Sardinia, Roewer det. 1938. HUNGARY. 1 female (SMF, RII 1366), Simontornya, Roewer det. 1928. CROATIA. 1 male (SMF 10481, www), Istria, Rovinj, Braun leg. VIII.1956, Braun det. XII.1957. MACEDONIA. 2 females (SMF, RII 9009), Ostrowo lake, meadow, Grell leg.,
Roewer det. 1943. GREECE. 3 females [1 female: 2 emboli + amorphous plugs] (SMF, RII 815), Crete, Meskia, Roewer leg. VII.1926, det. 1927. AZORES. 1 subadult female [with epigyne fully developed under cuticle] (SMF 36772), Faial, Horta, hotel garden, G. Schmidt leg. 3.VIII.1987, G. Schmidt det. 1986. MOROCCO. 4 females (SMF 3521), Casablanca, Karl von Fritsch & Rein leg. 1872, E. Strand det. sub A. b. africana. LEBANON. 1 male (SMF 61135, RII 12636), no further data. IRAN. 1 female (SMF, RII 10724), Maharlu Lake, Schiras, Löffler leg., Roewer det. 1953. 1 female (SMF, RII 10729), Maharlu Lake, Schiras, Löffler leg., Roewer det. 1953. JAPAN. 2 males, 1 additional right palp, 8 females, 19 immatures (SMF 3509), Nagasaki and Kompira [Daimon, Kinryu-machi, Saga-shi], W. Dönitz leg. 1882. 1 female, 1 subadult female (SMF 31418), Yokohama, Kanagawa, B. Schmacker leg. 1889, Levi det. 1981.

DOUBTFUL LOCALITIES. Holotype female of Argiope bruennichi orientalis Strand 1907 [with 1 left embolis] (SMF 31604, www), Indonesia, Java, Strand det., Levi rev. 1982. 1 female (SMF 61118), Mexico, Guerrero, Acapulco, E. Seele leg. 10.XI.1966 [label wrong, see below]. In the Senckenberg collection 102 further series of this species are registered, which have not been examined for this study.

Only few females were investigated for broken emboli, since the epigyne would be damaged in old material, when bending it in a ventro-anterior direction. Exclusively historical records, samples from the border of the distribution range or specimens newly identified in the course of this study are listed above. The holotype female of A. b. orientalis had one left broken embolus in its epigyne. This exhibited a typical embolus in comparison with those from other males. The locality data (Java) were already questioned by Levi (1983). Preliminary investigations on DNA-sequences showed evidences that it is actually from Western Europe (Krehenwinkel, personal communication). The same is true for the female from Mexico. Most likely the locality data has been confused, since both show the western European haplotype in Krehenwinkel’s COI-gene analysis. Similar wrong labeling could be true for A. lobata records from Indonesia, Australia and New Caledonia (Levi 1983: map 3) considering the distribution range of the majority of the records. One female of A. bruennichi had a shorter scapus (Figs 40–41) which is considered intraspecific variation. Uhl et al. (2007, 2010) showed photos of broken emboli in a female epigyne and indicated two areas in male palps where the embolus can break during copulation. Moreover, a tip of embolus is shown in a macerated epigyne plugging effectively the insemination duct (Nessler et al. 2006, 2007, Uhl et al. 2007).

Argiope aurantia Lucas 1833 (Figs 42–43)

Material examined (1 male, 37 females, 4 emboli). USA. 4 females (SMF 10581, www), West Virginia, Wheeling Ohio County, K.W. Haller leg. VIII.-X.1947, Gertsch ded., Coll. O. Kraus, VIII. 1958. 1 male (SMF 10559, www), Maryland, Kensington, J.M. Davis leg. 30.VIII.1945, Gertsch ded., Coll. O. Kraus, VIII. 1958. 1 female [4 emboli, 2 on each side], 1 subadult female (SMF 61099, www), Texas. 1 female (SMF 61136), Tennessee, Sparta, E. Franz leg. 25.IX.1956. MEXICO. 1 female (SMF 61105), Guerrero, Acapulco, H. Wagner leg. 12.IX.1933. EL SALVADOR. 3 females (SMF 7811),
Dept. La Union, road Zacatecoluca-Marcos Lampa, km 17 E Zacatecoluca, 100 m altitude, A. Zilch leg. 11.VIII.1951. **3 females** (SMF 7812), Dept. La Union, km 198 of road La Union-Pasoquina, A. Zilch leg. 29.VIII.1951. **13 females** (SMF 7809), Dept. Sonsonate, E of Acajutla, small forest above rock at the beach, A. Zilch leg. 21.X.1951. **3 females** (SMF, RII 10946), Roewer det. 1953. DOUBTFUL LOCALITIES. **3 females** (SMF 31603), Levi det. 1981. **4 females** (SMF 31602), Levi det. 1982. **1 female** (SMF 61113), Santa Catharina [Brazil?]. Further four series are deposited in the Wiehle collection.

Epigynal scapus was strongly truncated in females from El Salvador (SMF 7811) in comparison with illustrations in Levi (2004: fig. 9). In this species it was not searched routinely for broken emboli, as openings are hidden and scapus had to be deformed in every single specimen. Therefore no statements on the frequency of broken emboli in this species can be made. Uhl *et al.* (2010: fig. 1B) showed a photograph of several emboli in a macerated epigyne. Emboli found in this study exhibited a deep V-shaped indentation at the base of the broken embolus (Fig. 42), in one case secretion(?) stuck to the broken embolus (Fig. 43). In *A. bruennichi* the basal indentation is distinctly smaller (Figs 37–38).

Levi (1983: 260) stated that “*A. lobata*, with males known, is not close to any [Asian] group”. Bjørn (1997: 205), in his revision of African species, grouped *A. australis*, *A. coquereli*, *A. lobata*, *A. sector* and *A. tapinolobata* together due to the “possession of bluntly rounded lateral abdominal lobes and of a thorn at the concave side of the proximal part of the embolus” and proposed a further subdivision. Due to congruence in characters listed above this group should also include *A. ahngeri* from Central Asia.

**Argiope lobata** Pallas 1772 (Figs 44–48)

*Argiope lobata retracta* Franganillo 1918: 122 (description of female; type material not examined). **Syn. nov.**

**Note.** The type material of Franganillo is either dried or lost, in any case not available (Cardoso & Morano 2010, in litt.). In the Iberian Peninsula three species are recorded: *A. bruennichi*, *A. lobata* and in the South *A. trifasciata* (Cardoso & Morano 2010). From the description of *A. l. retracta* it is clear that this name is a synonym of *A. lobata*. No other species at the Iberian Peninsula has such distinct lateral lobes. The shape of lobes and opisthosoma in general can vary strongly (Levi 1983, Bjørn 1997, present study).

**Material examined (2 males, 56 females, 7 emboli).** France. **1 female** (SMF, RII 8993), Marseilles, Roewer det. 1943. Italy. **1 female** [1 right embolus] (SMF 61146), Isola dei Conigli, 1.X.1969. Portugal. **1 male** [with both emboli intact after copu-

Emboli were easy to remove from epigynes. The variability of basal embolic thorns (T in Figs 44, 46–47) was smaller than in A. australis (T in Figs 49–50). However, in one female two emboli of A. australis were found and, vice versa, in females of A. australis two emboli of A. lobata (e.g., SMF 31849) were observed. Another female (SMF 61145) showed considerable variation when compared with illustrations by Levi (1983: figs 87–91).

Nessler et al. (2009) showed for A. lobata that males which were cannibalised during their first copulation damaged their pedipalps with a higher probability (74%) than those which escaped. Only a low plugging rate was observed in females (14 %), which can be confirmed from the present study for preserved specimens (12.7 %). Nessler et al. (2009: figs 2 A–D) show photos of differently damaged pedipalps (entire embolus or tip of embolus broken).

Note. The distribution shown in Levi (1983: map 3, Indonesia, Australia, New Caledonia) may be affected by wrong labels (see note in A. bruennichi on localities in Java and Mexico).
Argiope australis (Walckenaer 1805) (Figs 49–53)


Emboli were easy to remove from epigynes. In most cases the long embolic apophysis was visible in the epigynal depression and made a removal unnecessary. There was a great variability especially of the basal thorn (H in Figs 49–50; see also Bjørn 1997). There was also a strong variation in epigyne shape (Figs 51–53; partly covered by illustrations in Bjørn 1997). See also comments for A. lobata above and in the discussion.

Argiope sector (Forsskål 1775) (Figs 54–58)


The male embolus of this species can be deformed in different ways, when stuck in an epigyne, i.e. the tip can be bent more or less strongly (Figs 56–58; cf. Fig. 54 for an embolus in situ), in some cases it was coiled 3-dimensionally (Fig. 56). The embolus in situ (Fig. 54: SMF 31853, 31854, 31880) showed no basal thorn in spiders from Cape Verde Islands as illustrated and proposed as diagnostic by Bjørn (1997: 225, fig. 67). Probably this character is also variable as in other species of this group.

**Argiope ahngeri** Spassky 1932

No material was found in the Senckenberg collection. Judging from illustrations in the original publication and from illustrations made by Marusik (unpubl.), the species belongs clearly to the *lobata*-group, and is most similar to *A. sector*. Beside the three female syntypes from the type locality Akhal-Teke [old name of an oasis in S Turkmenistan: N foothills of Kopetdagh [=Kopetdag] Mts., environments of Geok-Tepe [=Gök-depe], c. 38°09’N, 57°57’E] (Spassky 1932), the species was recorded from Kyrgyzstan (Bakhvalov 1974), Tajikistan (Andreeva 1976) and Uzbekistan (KaraUL-Bazar: Marusik 1989) (Mikhailov, in litt.).

**Argiope sp. cf. tapinolobata** Bjørn 1997 (Figs 59–60, Photos 22–24)

**Material examined (1 female, 1 embolus).** NAMIBIA. 1 female [1 embolus] (SMF 61122, RII 5953, www), Khomas, Windhoek.

The female from Namibia shows distinctly stronger lateral opisthosomal lobes (Photos 22–23) than the holotype of *A. tapinolobata* illustrated by Bjørn (1997: fig. 80). Moreo-
over, the Namibian specimen exhibits thinner black transversal lines. The broken embo-
lus (Fig. 59) and the posterior view of the epigyne (Fig. 60) showed distinct differences
in comparison with Bjørn (1997: figs 83, 85). It might represent a new species, but more
material and males are necessary to finalise a species diagnosis.

Argiope coquereli (Vinson 1863) (Figs 61, Photos 25–27)

Material examined (7 females, 6 emboli): MADAGASCAR. 2 females [1 female:
2 emboli, one on each side] (SMF 3526), Nossi Bé, A. Stumpf leg. 18.XII.1885, Strand
det. 2 females [1 female: 2 emboli, one on each side; 1 female: 1 right embolus],
1 subadult female, 1 juvenile female (SMF 3524), Nossi Bé, A. Stumpf leg. 1881,
Strand rev. 2 females (SMF 3525, www), Nossi Bé, A. Stumpf leg. 1883, Strand det.
1 female [1 right embolus] (SMF 3523), C. Ebenau leg. 1875, Strand det.

The broken embolus has a distinctly broader base than the preceding species. Moreo-
ver it is armed with strong and numerous proximad teeth (Fig. 61). In comparison, the
embolus shown in Bjørn (1997: fig. 48) exhibits less teeth. The median sternal band is
narrower in one female (SMF 3525: Photo 26) than that illustrated by Bjørn (1997: fig.
44). All females could be unambiguously identified as A. coquereli by the broad bright
epigynal rim and the lateral depressions as well the opisthosomal colour pattern (Pho-
tos 25–27).

Representatives of the following species (A. flavipalpis, A. ranomafanensis) are char-
acterised by a rather short and only slightly curved embolus without basal apophysis or
distal pendant in males and the epigynal roof wider than long and sub-triangular. Ad-
ditional species: Argiope levii Bjørn 1997 from Kenya and Tanzania, Argiope aurocincta
Pocock 1898 from Central, East, and Southern Africa.

Argiope flavipalpis (Lucas 1858) (Figs 62–64, Photos 28–33)

Material examined (1 male, 34 females, 3 emboli). IVORY COAST. 3 females [1 fe-
male: 1 left embolus] (SMF 61132), Comoé National Park, Research Station University
of Würzburg, S. Otto leg. VII–IX.2002. 3 females (SMF 58820, www), Northeast
30.VIII.2002. 1 female, 1 subadult female (SMF 61108), Abidjan, D. Sattler leg. CAM-
EROON. 1 female (SMF 61082, RII 12863), Centre, Yaounde. 1 female (SMF 61079,
RII 1842), Sud, Bipindi. 7 females (SMF 61077, RII 7258), no further data. 7 females
In contrast to the embolus in situ (Fig. 62; Bjørn 1997: fig. 53) the embolus tip might be regularly bent strongly in broken emboli (Fig. 64). Male and female are illustrated by means of photos for the first time (Photos 28–33).

\textit{Argiope ranomafanensis} Bjørn 1997 (Photos 34–37)


Since only the male and female type was known from the literature, the present series were included from the RMCA collections. Variation in colour pattern is recognisable from Photos 34–37. No broken emboli could be found in the epigynes, although it cannot be excluded that as in other species another more distal breaking zone exists and only a distal tiny tip breaks in this species which is not visible in the epigynal depression without maceration (cf. \textit{A. bruennichi}).

The ten species listed below were grouped by Levi (1983) as trifasciata-group. One additional South American species, \textit{Argiope legionis} Motta & Levi 2009 from Brazil, is close to \textit{A. ericae} Levi 2004, but distinguished by characters of copulatory organs and colouration pattern (Motta & Levi 2009). Further (Australian) species assigned by Levi (1983: 260) to this group: \textit{A. probata} Rainbow 1916 from Queensland, \textit{A. bullocki} Rainbow 1908 from New South Wales, \textit{A. ocyaloideas} L. Koch 1871 from Queensland, and \textit{A. dietrichae} Levi 1983 from Western Australia and Northern Territory. \textit{A. katherina} Levi 1983 from Northern Territory, Australia was placed here provisionally (Levi 1983: 260), but was compared also with \textit{A. minuta} to which latter it was placed within the \textit{anasuja} group (Levi 1983: 300).
Argiope protensa L. Koch 1872 (Figs 65–67)

Material examined (1 male, 8 females, 6 emboli): AUSTRALIA. 1 female [3 emboli, 2 right] (SMF, RII 4411), Queensland, Roewer det. 1933. 2 females [1 female: 1 right embolus, 1 female: 1 embolus on each side] (SMF 3587), Central Australia, von Leonhardi leg. 10.IX.1909, E. Strand det. 1 male, 4 females [raised, without emboli] (SMF 38009, www), Victoria, G. Schmidt leg. + det. 1993 sub A. syrmatica. 1 female [with 2 egg-sacs] (SMF 38027, www), G. Schmidt leg. + det. 1993 sub A. syrmatica.

Broken emboli are smooth and strongly bent (> 180°) (Figs 66–67), whereas the embolus in situ (Fig. 65) shows a broad U-shaped course. The embolus base is characterized by a distinct V-shaped incision with differently long arms.

Argiope trifasciata (Forsskål 1775) (Fig. 68)

Material examined (14 males, 21 females, 2 emboli). USA. 1 male (SMF 10549), West Virginia, Tomlinson Run State pk, 3 miles to New Cumberland, K.W. Haller leg. 4.IX.1948, Gertsch det. + ded. 1958, Coll. O. Kraus, VIII. 1958. 1 female (SMF 10553, www), Texas, Nueces County, Corpus Christi, K.W. Haller leg. 7.XII.1954, Gertsch det. 1958, Coll. O. Kraus, VIII. 1958. 2 females (SMF 61120), USA, Texas. EL SALVADOR. 1 female (SMF 8718), Dept. Cuscatlan, Cerro de Las Paras, 1000 m altitude, O. Schuster leg. 27.VIII.1952, sub A. aurantia. VENEZUELA. 1 female, 1 subadult female (SMF, RII 1777), Roewer det. 1934. PERU. 3 males, 1 female, 2 subadult females (SMF 61415), Pisac (nr. Cusco) [S 13°25'21.30", W 71°51’10.39"], grass, VIII., ex. Coll Wunderlich. BRAZIL. 1 female (SMF 61121), Pernambuco, Rio Branco. ARGENTINA. 1 female (SMF, RII 5464), Buenos Aires, Roewer det. 1940. HAITI. 2 females [1 female: 2 emboli, not removable] (SMF, RII 1090), Roewer det. 1928. BALKANS. 1 female (SMF 16576), former Jugoslavia [?], Grasshoff det. 1964, Zoo Berlin ded. 1958. AZORES. 2 males (SMF 61089), Madeira, Montanha, E. Schindler leg. 12.07.1960. 2 males, 1 female (SMF 34845, www), Madeira, Grasshoff leg. 25.III.1986, Wunderlich det. 1986. CANARY ISLANDS. 1 female (SMF 25213), Gran Canaria, Maspalomas, Oasis, G. Schmidt leg., det. + ded. 1970. 1 male (SMF 25668), Gran Canaria, Maspalomas, G. Schmidt leg., det. + ded. 1971. 1 female, 4 juvenile females (SMF 61130), Gran Canaria, 27°44.169’N, 15°35.905’E, Faro, 5 m altitude, P. Jäger leg. 3.XII.2003. 1 female (SMF 61076, RII 2577), Tenerife. 1 female (SMF 25847), Tenerife, Puerto de la Cruz, G. Schmidt leg. 1961, det. + ded. 1972. 1 male, 1 female (SMF 40195), Tenerife, Adeje Municipality, Barranco del Infierno, 28°8’N, 16°42.05’W, 450–650 m altitude, P. Jäger leg. 9.VIII.1993, P. Jäger det. 1 male (SMF 40196), Tenerife, Teno Alto, 28°20.5’N, 16°52.433’W, 750–800 m altitude, P. Jäger leg. 3.VIII.1993. SENEGAL. 1 male (SMF 61080, RII 13385). EGYPT. 1 female (SMF, RII 5664), Gizeh, Roewer det. 1940 sub A. bruennichi. 1 juvenile female (SMF 61075, RII 4377), Quahirah, Kairo. RUANDA. 1 female (SMF 61074, RII 7890). TANZANIA. 1 male (SMF 61090), Pwani,

Platnick (2011) lists “Cosmopolitan except for Europe” as distribution range of this species. In fact it is found in the South Iberian peninsula and in the Balearic Islands (Cardoso & Morano 2010). Populations are considered native, i.e. by expansion to the North and not introduced (Cardoso in litt.). It is not clear whether the single female (SMF 16576) is from former Jugoslavia (Southern Europe) or not. The only broken emboli sticking in the epigyne of one female (RII 1090) could not be removed without probably destroying the specimens. Therefore an embolus in situ is illustrated (Fig. 68). This is coiled three-dimensionally.

**Argiope florida** Chamberlin & Ivie 1944


Although immature, the present specimen could be identified by its colouration and locality data.

**Argiope madang** Levi 1984

No material examined. According to Levi (1984) the male palp with the twisted embolus is close to *A. trifasciata*, the embolus has a hooked tip (Levi 1984: fig. 7). The epigyne is unique in having wing-shaped rims (Levi 1984: 250). Dorsal opisthosomal colour pattern is similar to that of *A. manila*, but the only found broken embolus of the latter species (Figs 4–5) does not suggest a closer phylogenetic relationship.

**Argiope doboensis** Strand 1911

**Material examined:** INDONESIA. MALUKU ISLANDS. **Holotype juvenile** (SMF 3534, www), Aru Islands, Pulau Warmar, in forest between Dobo and Wangil, H. Merton leg. 30.I.1908, Strand det.
The female illustrated by Levi (1983) does not show the distinct indentations of the median folium as in the holotype (SMF 3534, www). It may occur that this difference is due to ontogenetic development.

**Argiope chloreis** Thorell 1877 (Figs 69–72)

**Material examined (1 female).** LAOS. 1 female, 1 subadult female (SMF 61143, www), Champasak Province, Xe Pian National Protected Area, Tha Hou (L103), 14°46.16’N, 105°59.575´E, 132 m altitude, rock extending above wetland forests, vegetation, by day, by hand, P. Jäger & S. Bayer leg. 22.XI.2009.

Epigyne differed from that illustrated by Levi (1983) by the considerably wider posterior part of median septum and the concave septum in lateral view (Figs 69–72). Size matches exactly the same as illustrated by Levi (1983; fig. 146, female from Western New Guinea): PL 2.9, PW 2.55, AW 1.15, OL 4.8, OW 3.1. Colouration differed by the dark ventral opisthosoma with white patches (SMF 61143, www). In the live female this dark stripe was dark-green (SMF 61143, www), which appeared in the preserved specimen black (SMF 61143, www). The web was decorated with ca. five circular stabilimenta and an inner plate of seven zigzag-bands (SMF 61143, www). The spiders represent the first record for Laos. So far, this species was known from Sumatra to New Guinea (Platnick 2011), thus the present specimens represent the northernmost record for this species (Fig. 167: 10).

**Argiope argentata** (Fabricius 1775) (Figs 73–79)

**Material examined (14 males, 73 females, 109 emboli).** USA. 1 female [2 emboli, 1 on each side] (SMF 10593), Florida, Key Largo, Gertsch and R.R. Forster leg. 1.IV.1957, Gertsch det. + ded. 1958, Coll. O. Kraus 1958. MEXICO. 4 females [all: at least 1 embolus] (SMF 10579), Tamaulipas, Padilla, Cazier, Gertsch & Schrammel leg. 17.V.1952, Gertsch ded., Coll. O. Kraus VIII.1958. PANAMA. 1 male (SMF 10588), Barro Colorado Island, S.J. Hook Bishop leg. 3.VII.1933, Gertsch det. + ded. 1958, Coll. O. Kraus VIII.1958. CUBA. 1 female [2 emboli, 1 on each side], 1 juvenile female (SMF 10574), Pinar del Rio, San Vicente, C. + P. Vaurie leg. 26.VII.1956, Gertsch det. + ded. 1958, Coll. O. Kraus VIII.1958. LESSER ANTILLES. 1 male, 1 female [at least 1 left embolus] (SMF 34058, www), Aruba, Zindler leg. 1983, H.-G. Müller det. 1984. ECUADOR. 1 male, 2 females [1 female: 2 emboli, 1 on each side; 1 female: 3 emboli, 2 left, 1 right] (SMF 61412), Banos, VIII., ex. Coll. Wunderlich. 1 female [2 emboli, one on each side] (SMF 61411), Galapagos, Santa Cruz, North Coast, VIII. 1 female [5 right emboli, 1 left embolus] (SMF 31446), Galapagos, James, Jamesbay,

The embolus of this species exhibits a distinct apophysis. This is even recognisable, when the broken embolus is still sticking in the epigyne. Therefore a removal of the embolus is usually not necessary to distinguish between the related A. blanda. This species holds the record with five emboli sticking in one half of an epigyne. It appears to be slightly larger and more robust than A. blanda. However, small females are mentioned by Levi (1983: 58) as having the dorsal opisthosomal pattern of A. florida, being coloured like an immature and having broken emboli in the epigyne, which clearly are A. argentata. This can be confirmed from one female (SMF 31448, www) with a body length of 8.2. In some of the females examined the two longitudinal anteriorly converging lines between the epigastric furrow and the transverse white bar were absent. Four males (SMF 35482) showed considerable size variation, one very large and differently
coloured male had as all three others an embolic apophysis (Figs 73–79). The tip of the left palp in the three smaller males has been broken, distal hooks were in general much more pronounced than in *A. blanda*. Colouration of males can be more distinct and darker than shown in SMF 34058 (www).

**Argiope blanda O. Pickard-Cambridge 1898** (Figs 80–82)

**Material examined (9 females, 12 emboli). MEXICO.** 1 female [2 right emboli] (SMF 61094, RII 1792), Tamaulipas, Vera Cruz. 1 female [1 right embolus] (SMF 61106), H. Wagner leg. EL SALVADOR. 1 female [1 left embolus], 1 juvenile female (SMF 7871), Dept. Cabañas, Sensuntepeque, 760 m altitude, A. Zilch leg. 17.X.1951, sub *A. argentata*. 2 females [1 female: 1 left embolus, 1 female: 2 emboli on each side] (SMF 7876, www), Dept. Santa Ana, Metapan, Laguna, Hacienda Santa Rosa, 450 m altitude, A. Zilch leg. 29.VIII.1951, sub *A. argentata*. 1 female, 1 juvenile female (SMF 7874), Dept. La Libertad, Santa Tecla (=Nueva San Salvador), Finca El Paraiso, 900 m altitude, A. Zilch leg. 8.XI.1951, sub *A. argentata*. 1 female [1 embolus on each side] (SMF 7873), Dept. Morazán, Osicala, Cacaguatique (Cordillera Cacahuatique), Finca San Pedro, 1200 m altitude, A. Zilch leg. 13.IX.1951, sub *A. argentata*. 1 female [epigyne missing] (SMF 7877), Dept. La Union, 200 m before La Union, A. Zilch leg. 11.IX.1951, sub *A. argentata*. 1 female [1 right embolus] (SMF 7875), Dept. San Vincente, volcano San Vincente, Finca El Carmen, 1300 m altitude, A. Zilch leg. 11–16.VI.1951, sub *A. argentata*.

Broken emboli are rather small, usually breaking at the main breaking point, although sometimes tip broke, too (Figs 80–82). In one female (SMF 7876) the embolus broke at a secondary position and exhibited a sperm duct extending beyond the breaking point distally. Some of the material was misidentified as *A. argentata*, in many cases because it was considered immature (original labels!) due to the generally smaller size of *A. blanda*. Beside the broad transversal band the narrow epigynal septum was also good as a differentiating feature (Levi 2004).

**Argiope submaronica Strand 1916** (Fig. 83)

**Material examined (2 females, 2 emboli). BRAZIL.** Holotype female (SMF 3590), Santa Catarina, Joinville, W. Ehrhardt leg. 1906. 1 female [2 emboli] (SMF 61117, www), Amazonas, km 26 road from Manaus to Itacoatiara, Reserva “Adolfo Ducke”, leg. 2.XII.1964, sub *A. savignyi*. 
Argiope submaronica Strand 1916 is removed from the synonymy of A. argentata (proposed by Bonnet (1955: 673), and A. savignyi Levi 1968 syn. nov. is placed in the synonymy of A. submaronica. The female holotype conforms to all details described in Levi (2004). The broken embolus was consisting of a small tip and long sperm duct (Fig. 83).

Argiope ericae Levi 2004

Material examined. BRAZIL. 2 juveniles (SMF 61114, www), Pernambuco.

The two specimens represent the first record for Pernambuco and the northernmost for this species. They have been identified by the black colouration of legs (legs ringed black and white in A. legionis) and their colouration pattern especially the distinct longitudinal band on the ventral sternum (SMF 61114, www; margins of that band diffuse in A. legionis, Motta & Levi 2009: figs 2, 8; cf. Levi 2004: figs 67, 70).


Argiope anasuja Thorell 1887 (Figs 84–87)


No embolus has been found in epigynes, although checking carefully and dissecting one vulva. The filamentous structure protruding from the spermathecae is considered from its consistency hardened secretion rather than a sperm duct (Figs 86–87). The embolus in situ illustrated (Fig. 84) is shorter and stouter than that drawn by Levi (1983: fig. 172).

**Argiope minuta** Karsch 1879 (Fig. 88)


The embolus in situ is spirally coiled, the tip is drawn to facilitate comparison to other (broken) emboli (Fig. 88). Some females were considerably smaller (SMF 3551, www).

The following species may be close to *A. vietnamensis* Ono 2010 (Fig. 167: 11). It has a similar colour pattern and shape of opisthosoma, body size and epigynal shape, especially the extending rim in lateral view (see also diagnosis of *A. hinderlichi* spec. nov.). The embolus without any modification resembles more that of males from the *reinwardti*-group, colour pattern of *A. hinderlichi* females also similar to *reinwardti*-group.

**Argiope hinderlichi** spec. nov. (Figs 89–92, 167: 7, Photos 38–45)

Type material (2 females, 3 emboli): LAOS. Holotype female [2 emboli] (SMF), Luang Prabang Province, NE Luang Prabang, Nam Ou, Nong Khiao, Tham Pathok, L7, N 20°33.082’, E 102°37.925’, 373 m altitude, in front of limestone rock, vegetation, by hand, by day, P. Jäger & S. Bayer leg. 16.XI.2009. Paratype. LAOS. 1 female [1 right embolus], Bolikhamsay Province, S of Sayphou Loyang, Ban Na Deua (= Ban Nadua), northern slopes of Phou Samkeng, 7.9 air km WSW of Lak Sao, L88, N 18°11’9.00” E 104°53’55.00”, 520 m altitude, limestone forest, vegetation at forest margin, small caves, by hand, by sweepnet, P. Jäger & S. Bayer leg. 8.XI.2009.
**Etymology.** The species is named in honour of Jürgen Hinderlich (Solidaritätsdienst International, SODI e.V., Lak Sao), who cleared bombs in Laos which have been dropped in the so-called “secret war”, and who supported field work of the author in Bolikhamsay Province; name in genitive case.

**Diagnosis.** Males of *A. hinderlichi* spec. nov. are only known from the two broken emboli. Potentially diagnostic features are 1. Embolus without pendant, 2. Embolus tip sharply pointed, smooth (Fig. 89). Females of *Argiope hinderlichi* spec. nov. similar to *A. vietnamensis* Ono 2010 in having a similar body size and epigyne, but can be distinguished by 1. Colouration of dorsal opisthosoma and legs (distinct transversal bands and uniformly dark legs in *A. hinderlichi* spec. nov., Photos 38, 41, 44; without distinct bands and with tibiae I–II with white patch in *A. vietnamensis*: Ono 2010: fig. 10), 2. Epigyne elongate, extending posteriorly distinctly beyond epigastric furrow (Figs 90–92; not elongate, extending slightly beyond epigastric furrow in *A. vietnamensis*, Ono 2010: fig. 26).

**Description.** Female (holotype). PL 8.4, PW 7.3, AW 3.7, OL 12.4, OW 10.3. Eye diametres: AME 0.43, ALE 0.21, PME 0.45, PLE 0.45. Eye interdistances: AME–AME 0.32, AME–ALE 0.68, PME–PME 0.50, PME–PLE 1.02, AME–PME 0.85, ALE–PLE 0.02, clypeus AME 0.35, clypeus ALE 0.32. Leg and pedipalpus measurements: pedipalpus 10.5 (3.6, 1.6, 2.1, -, 3.2); leg I 43.3 (12.5, 3.8, 10.6, 13.5, 2.9), II 42.2 (12.5, 3.9, 9.9, 13.4, 2.5); leg III 25.3 (8.7, 2.7, 5.3, 6.6, 2.0); leg IV 40.1 (13.4, 3.8, 8.7, 12.2, 2.0). Leg formula. 1243.

Cheliceral furrow with 10–15 tiny and partly very indistinct denticles and 4 anterior and 3 posterior teeth. Palpal claw with 7 teeth.

Copulatory organ as in diagnosis. Epigynal field with elongate patch anteriorly and two slit sense organs anterolaterally (SS in Fig. 90). Spermathecae elongate oval, anteriorly concave (Fig. 92). Rim forming small bulge in lateral view. Flange strongly developed. Septum gradually diverging anteriorly (Fig. 91).

Colour in ethanol (Photos 38–43). Dark brown with bright pattern. Dorsal prosoma with reticulate pattern consisting of white hairs and bright and dark cuticular parts. Sternum with pale orange pentalobal patch and one pair of lateral patches at coxae II. Labium and gnathocoxae dark with distal pale orange lip. Ventral coxae II–IV black with one yellow patch each, larger patches posteriorly. Frontal chelicerae with inner parts orange. Palps with irregular pattern. Legs almost uniformly dark brown. Dorsal opisthosoma with three transversal, clearly delimited bands, muscle sigilla reddish brown, dark parts darker posteriorly. Lateral opisthosoma spotted anteriorly, becoming darker posteriorly. Ventral opisthosoma with two white parallel stripes with median extension and three pairs of bright median patches connected to first three pairs of four muscle sigilla pairs. Spinnerets orange. For colouration of live specimen see Figs 298–299. All bright parts of preserved specimens are shiny yellow in live spiders (Photos 44–45).

Male. Unknown (except for embolus; see diagnosis and Fig. 89).

**Variation.** Female paratype with PL 7.5, PW 6.9, AW 3.1, OL 13.2, OW 10.3; cheliceral furrow with c. 15 indistinct denticles. Broken embolus of right half of paratype’s epigyne with pointed tip broken. Left tarsus of holotype has a extraordinary branch, most likely results from a malformation during individual development.

**Distribution.** Known from Laos (Luang Prabang Province: Nong Khiao; Bolikhamsay Province: Lak Sao) (Fig. 167: 7).
The following three species (A. jinghongensis, A. aethereoides, A. luzona) have an embolus with blunt and widened tip, which is well hidden in the conductor in resting position.

**Argiope jinghongensis** Yin, Peng & Wang 1994 (Figs 93–107, 167: 4, 7–9, 12–13)

**Material examined (3 males, 4 females, 2 emboli)**: CHINA. Holotype male (HNU), Yunnan Province, Jinghong, J.F. Wang leg. 21.-23.X.1987. LAOS. 1 female (SMF 61735), Bolikhamsay Province, S of Sayphou Loyang, Ban Na Deua (= Ban Nadua), L88, northern slopes of Phou Samkeng, 7.9 air km WSW of Lak Sao, N 18°11'9.00" E 104°53'55.00", 520 m altitude, limestone forest, vegetation at forest margin, small caves, by hand, by sweepnet, P. Jäger & S. Bayer leg. 10.XI.2009. 1 female [without emboli] (SMF 56331), Khammouan Province, 8.7 air km (9.5 car km) NE Thakek, N 17°26.936', E 104°52.499', 159 m altitude, foot caves and surroundings, by hand, sweeping, P. Jäger & V. Vedel leg. 30.X.2004. 1 female [2 emboli] (SMF 61734), Champasak Province, Muang Bachiang (=Ban Bachieng), That Paxuam (L92), 22 air km NNE of Pakse, N 15°16'35.50", E 105°55'22.00", 190 m altitude, secondary forest, vegetation, by hand, by day, P. Jäger & S. Bayer leg. 25.XI.2009. THAILAND. 1 male, 1 female (SMF 61733, www), Trat Province, Ko Chang, Kheeri Phet waterfall, N 12°00'27.6", E 102°21'09.2", 50–150 m altitude, secondary forest, waterfall, by hand, by day, P. Jäger & S. Bayer leg. 02.XI.2009. PSUZC-EN-AR 09-94.

**Diagnosis.** Males can be distinguished by 1. Embolus distally widened with two distinct triangular protrusions, hidden by conductor in resting position (Fig. 94), best observed in broken embolus (PT in Fig. 98), 2. Median apophysis toothed and with sabre-toothed spur (95–97). Females of *A. jinghongensis* similar to species of the *aetherea* group in having a similar colouration, but can be distinguished from those of *A. taprobancia*, *A. luzona*, *A. pulchella*, *A. modesta*, *A. aethereoides* and *A. aetherea* by 1. Median septum with parallel margins (M) and abrupt widening to posterior plate (PP) (Figs 100, 103, 106), 2. Long convex anterior margin of epigyne (CM) in lateral view (Figs 101, 104, 107).

**Note.** One male was found at the same locality with a female (Ko Chang). Additional evidence for conspecificity was given by the congruence of the embolus sticking in the female epigyne.

**Redescription.** Male (Koh Chang). PL 2.0, PW 1.8, AW 0.7, [opisthosoma absent]. Eye diametres: AME 0.16, ALE 0.08, PME 0.19, PLE 0.15. Eye interdistances: AME–AME 0.08, AME–ALE 0.07, PME–PME 0.18, PME–PLE 0.15, AME–PME 0.19, ALE–PLE 0.05, clypeus AME 0.07, clypeus ALE 0.09. Leg and pedipalpus measurements: pedipalpus 1.47 (0.40, 0.16, 0.21, -, 0.70); leg I–II [missing]; leg III 4.72 (1.48, 0.52, 0.93,
1.11, 0.68); leg IV 7.01 (2.13, 0.70, 1.46, 1.87, 0.75). Leg formula. 43. Cheliceral furrow with 15–20 tiny denticles and 4 anterior and 3 posterior teeth. Chelicerae length 0.61. Palp as in diagnosis. Broken embolus tip as wide as long, with two triangular processes (one of which containing sperm duct) and semicircular sperm duct attached (Fig. 98). Embolus in situ with membranous part between the two triangular processes, thus one process hidden (Fig. 93). Embolus without distinct kink. Distal conductor with strong ridges distally (Fig. 94). Median apophysis with two equal branches (Fig. 97).


**Description.** Female (Ko Chang). PL 5.2, PW 4.5, AW 2.3, OL 8.3, OW 7.6. Eye diameters: AME 0.31, ALE 0.19, PME 0.35, PLE 0.31. Eye interdistances: AME–AME 0.26, AME–ALE 0.42, PME–PME 0.41, PME–PLE 0.74, AME–PME 0.55, ALE–PLE 0.02, clypeus AME 0.18, clypeus ALE 0.24. Leg and pedipalpus measurements: pedipalpus 5.9 (1.9, 0.7, 1.4, -, 1.9); leg I 27.9 (8.3, 2.3, 6.7, 8.5, 2.1), leg II 29.9 (8.9, 2.5, 7.3, 9.1, 2.1); leg III 14.2 (5.6, 1.8, 3.0, 2.7, 1.1); leg IV 27.3 (9.3, 2.5, 5.8, 8.0, 1.7). Leg formula. 2143. Chelicerae length 1.8, with c. 27 denticles in field along entire furrow, and 4 strong anterior and 3 posterior teeth. Palpal claw with 10 teeth.

Copulatory organ as in diagnosis. Epigyne with rectangular patch anteriorly and one to three slit sense organs anterolaterally on each side (Figs 99, 102, 105). Spermathecae elongate oval, anteriorly concave (Figs 101, 107). Lateral margins straight to concave (Figs 100, 103, 106). Rim with white lip. Median septum and posterior plate bright with darker (redbrown) transversal band in between (SMF 61733, www).

Colour in ethanol (SMF 61733, www). Yellowish to reddish brown. Dorsal prosoma with mainly radial and irregular pattern of dark patches and white hairs. Sternum with median white band and 2 pairs of white patches in dark lateral bands. Ventral Coxae with black and white pattern, coxa IV wit distinctly more white parts. Chelicerae with bright frontal oval patch and brighter inner sides. Palps almost entirely yellowish pale. Legs (especially femora, but also patellae and tibiae) with dark patches, femora between patches spotted, metatarsi and tarsi reddish brown. Dorsal opisthosoma with three thin transversal lines in front of broad transversal band consisting of black anterior and orange posterior part, anterior band with 5 larger and several smaller white patches. Posterior third behind white transverse band alternating black and orange with transverse rows of white patches. Lateral opisthosoma with irregular pattern. Ventral opisthosoma with two white parallel stripes and three pairs of white median patches with posterior pair largest and fused with lateral stripes. Spinnerets orange.

**Variation.** PL 3.9–5.3, PW 3.6–4.5, AW 1.7–2.1; OL 6.5–6.8, OW 6.2–7.1. Palpal claw with 10–12 teeth.

**Distribution.** Known from China (Yunnan Province; type locality), Laos (Champasak Province: Muang Bachieng; Khammouan Province: Thakek; Bolikhamsay Province: Lak Sao) and Thailand (Trat Province: Ko Chang; Songkhla Province: Hat Yai) (Fig. 1674, 7–9, 12–13). First records for Laos and Thailand.
**Argiope aetheroides** Yin, Wang, Zhang & Peng 1989 (Figs 108–110, 167: 3)

**Material examined** (1 male). CHINA. **1 male, 1 subadult female** (HNU), Hunan Province, Shimen County, Huping Mountain, X.J. Peng & L.P. Xie leg. 25.VI.-5.VII.1992.

A broken embolus was illustrated by Yin et al. (1989: fig. 1E). It resembles that of *A. jinghongensis* (Fig. 98). When the embolus tip in situ of the present material is viewed from behind (Fig. 109) it is similar to *A. luzona* (cf. Fig. 113) with its two pointed structures. Males show a distinct pattern of fine transversal lines on their dorsal opisthosoma, which is absent in males of other species of this group.

**Argiope luzona** (Walckenaer 1841) (Figs 111–114)

**Material examined** (1 male, 7 females, 8 emboli). PHILIPPINES. **7 females [3 females: without embolus, 4 females: 2 emboli, 1 on each side], 6 juvenile females** (SMF 31444, www), Luzon, Mt. Makiling, Baker leg., Levi det. 1981. **1 male** (SMF 61140, RII 4431, www), Laguna, Luzon Island, Mt. Maquiling.

A multiple plugging as in *A. argentata* does not seem to be possible in this species, due to the lack of space in the depression when plugged with one embolus. Beside the shape of the distal part also the acute tip at the breaking zone is characteristic (Figs 111–112).

The following species (*A. pulchella*, *A. pulchelloides*, *A. dang*) and *A. versicolor* (Dolenschall 1859) exhibit an embolus distally split or furcate. *A. dang* may represent a transition to the following group of species (*A. aetherea* and others), i.e. the inner branch of the bifurcate embolus tip would be homologous to the embolic pendant.

**Argiope pulchella** Thorell 1881 (Figs 115–118)

Broken emboli as well as variation of epigynes were illustrated by Jäger & Praxaysombath (2009). Emboli can break in this species exceptionally at three different points (Levi 1983, present study): 1. rarely at the point where also the sperm duct breaks, 2. sometimes at the distal hook, 3. mostly between these positions. When it breaks in the latter position, the sperm duct extending beyond the broken embolus (see 3. above; Figs 116–117) is characteristic beside the shape of the embolus: it describes an extended semicircle, in some cases with straight parts included. The new findings match these descriptions. In all cases broken emboli were easy to remove from epigynes. The characteristic cross-shaped web decorations were observed in female webs in Laos. These might be indistinct to absent (SMF 58681, www). In juveniles and subadult males a circular web decoration as described for A. chloreis was found.

Argiope pulchelloides Yin, Wang, Zhang & Peng 1989 (Figs 119–120, 167: 1–2)

Material examined (1 male, 1 female). CHINA. 1 male paratype (HNU), Sichuan Province, Miyi County, X. E. Chen leg. 1 female paratype (HNU), Sichuan Province, X.E. Chen leg. VII. 1988 [year probably mistaken, Peng personal communication].

The male palp was not fully sclerotised, part of the median apophysis was destroyed (Fig. 120: right end). Distinguished from A. pulchella by the shorter embolus and its less strongly split tip (Fig. 119). The spur of the median apophysis arises medially on the particular branch (Fig. 120; distally in A. pulchella: Fig. 118). Broken emboli are illustrated by Yin et al. (1989: fig. 4E, 1997: fig. 18g). These as well as epigynes are similar to those of A. pulchella.

Argiope dang Jäger & Praxaysombath 2009 (Figs 121–122, 167: 6, 10)

Material examined (2 males, 6 females, 1 embolus). LAOS: VIENTIANE. Holotype male (SMF 58757, www), Vang Vieng, Nam Song, L22, riverbanks, vegetation, at night, by hand, P. Jäger & F. Steinmetz leg. 12–13.III.2007. 1 male, 2 female paratypes
(SMF 58758), with same data as for holotype. 2 females [with 1 left embolus], 1 juvenile female (SMF 56382), with same data as for holotype, vegetation close to river, by hand, by night, P. Jäger & S. Bayer leg. 16.XI.2009. 1 female, 1 immature female (SMF 60916, www), with same data as for preceding specimens, 12.XI.2009. CHAMPASAK. 1 female (SMF 60915), SE slopes of Phou Kao, Ban Nongsao, Wat Phou, 11 air km SW of Champasak, N 14°50'53.64", E 105°48'51.92", 110–200 m altitude, rocks, vegetation, by hand, by day, P. Jäger & S. Bayer leg. 28.XI.2009.

From the rounded embolus, the kink and pendant (Fig. 120–121) it is similar and probably close to *A. pulchella* and *A. pulchelloides*.

**Argiope mangal** Koh 1991 (Fig. 167: 14)

No material examined. From illustrations of Koh (1991) the species may key out close to *A. pulchella* or the *aetherea* group sensu Levi (1983) due to its embolus with a kink and rounded bent embolus tip and the rounded V-shaped epigynal roof in ventral view. The projection of the rim in lateral view is unique within this species-group but similar to *A. macrochoera*. Koh (1991) compares this species with *A. ocula* and *A. macrochoera*. A closer relationship with the first can be excluded by the distinctly different male palpal conformation. Males are distinguished also by the large basal outgrowth of the conductor.

The following species (*A. cameloides*, *A. modesta*, *A. pictula*, *A. appensa*, *A. brunescentia*, *A. squallica*, *A. bougainvila*, *A. aetherea*, *A. picta*) possess an embolus with a subdistal membranous pendant. Shape, size and position of this pendant vary between species, but are invariable within species. It might be a good character for further revision of this group.

**Argiope cameloides** Zhu & Song 1994 (Figs 123–125, 167: 5)

**Material examined** (1 male). CHINA: HAINAN. **Holotype male** (MHBU), Ledong County, Jianfengling Mountains, N 18°42', E 108°48', Mao-Bin Gu leg. 15.VIII.1989. Description: See Zhu & Song (1994). Measurements [with data from original description if different]: PL 2.1, PW 1.7 [2.0], AW 0.7, OL 2.3 [2.2], OW 1.6 [1.2]. Chelicerae length 0.67, with 4 anterior, 3 [1] tiny posterior teeth and ca. 10 [not mentioned] denticles. The original illustrations showed no embolic pendant (Zhu *et al.* 1994: fig. 8B). In the holotype such an appendage was present in both palps (Figs 123–125), in the left
palp the tip of the pendant was bent (Figs 123–124). The latter condition and the thin membranous structure make it difficult to recognise this outgrowth. However, for future revisions material of this species group should be carefully examined in this respect. According to this feature the species appears related to those species of the aetherea group sensu Levi (1983) with an embolic pendant. It can be distinguished from A. pulchella and A. dang by the embolic pendant arising from the embolus distal portion of the embolus at a right angle (Fig. 125; more or less parallel to embolus tip in A. dang and A. pulchella), and from A. modesta (Figs 126–127), A. pictula (Figs, 131–133), A. sqallica (Fig. 153), A. appensa (Fig. 147), A. aetherea (Fig. 155) and A. brunnescentia (Fig. 152) by its distinctly shorter pendant, and from A. picta (Figs 159, 161, 163, 165) by its pendant pointing in a right angle (pointing to embolus tip in A. picta). However, with the presence of an embolic pendant and considering the diversity within this species group the status of the species should certainly approved by a female considering similar emboli in the aetherea-group.

**Argiope modesta** Thorell 1881 (Figs 126–130)


**Argiope aetherea keyensis** Strand 1911 is removed from the synonymy of A. aetherea and placed in synonymy of A. modesta. The present females have the typical banded pattern of the aetherea-group (SMF 3461, www) like in A. pulchella or A. jinghongensis. They can probably be distinguished by a bright median longitudinal band in the posterior half on the ventral opisthosoma. The male is unknown, but the emboli sticking in epigynes (Figs 126–127) suggest a close relationship with A. appensa and A. aetherea. Epigyne with converging lateral margins of septum in posterior view (Fig. 129).

**Argiope pictula** Strand 1911 (Figs 131–146)

**Material examined** (1 male, 11 females, 2 emboli). INDONESIA: SULAWESI. 2 female syntypes of A. crenulata pictula Strand 1911 (SMF 3532, www), SE Sulawesi,

Argiope boetonica Strand 1915 is removed from the synonymy of A. appensa and recognised as junior synonym of A. pictula, since the embolus of the holotype of A. boetonica and especially its pendant was congruent with broken emboli in females from the type locality (Boeton = Buton) of A. crenulata pictula. Although females show variation in the opisthosomal colour pattern, the shape of opisthosomal margins (lobed or not) and in shape of the epigyne, both names are considered synonyms due to the striking similarity of epigynal lips in ventral and lateral view. There are transitions (SMF 3529, www) between the clear colour pattern of the syntypes of A. pictula (SMF 3532, www) and other material from the type locality.

The embols shows distinct differences to all other known males of the aetherea-group: the embolic pendant shows a toothed to serrated distal margin (Figs 131–133) and is intermediate in its strength between the slender shape of the majority of aetherea-group males and the broad pendant of A. brunnescentia. Moreover, the median apophysis exhibits a different shape. It is therefore removed from the synonymy of A. modesta. Broken emboli (Figs 132–133) were found in females identified as A. crenulata. Shape and strength of the embolic pendant point to conspecificity with A. pictula. However, female copulatory organs (Figs 135–146) and colour pattern show an intermediate position between A. modesta and A. appensa.

Argiope appensa (Walckenaer 1841) (Figs 147–151)

Material examined (1 male, 11 females, 1 embolus). PHILIPPINES. 1 female (SMF, RII 4407), Sulu-Islands, Chrysanthus det. 1959. INDONESIA: SULAWESI. 1 male, 1 female (SMF, RII 824, www), Roewer det. 1931. PALAU. 2 females (SMF, RII 4391), Palau Islands, Roewer det. 1934. 1 female (SMF 3584), Palau, Angaur, E. Wolf leg. 1909, Strand det. sub A. picta. MICRONESIA. 2 females (SMF 3531), W-Caroline Islands, Yap, E. Wolf, leg. 20.IX.1909, Strand det. 1910 sub A. crenulata. 1 female (SMF 3530), W-Caroline Islands, Feis, E. Wolf, leg. 3.X.1909, Strand det. 1910 sub A. crenulata. 1 female (SMF 31424, www), Caroline Islands, Tobi, Levi det. 1981. PAPUA NEW GUINEA. 2 females [1 embolus] (SMF 61157), Sandaun, Eitape (Aitape), leg. 1912.

Epigynes of some females (SMF 3530, 3531) are similar to those illustrated sub A. modesta by Levi (1983), especially in lateral view. However, dorsal and ventral opisthosomal pattern as well as the known distribution range let suggest that they belong to A. appensa. Embolus exhibits a long pendant with a blunt tip (Fig. 147).
Argiope brunnescentia Strand 1911 (Figs 152)

Material examined (37 females, 1 embryo). PAPUA NEW GUINEA. 2 female syntypes (SMF 3482, www), Squally Island (Emirau Island), E. Wolf leg. 30.IV.1909, Strand det. 1910 sub A. a. brunnescentia. 1 female (SMF 3488), Squally Island (Emirau Island), E. Wolf leg. 1909, Strand det. 1910 sub A. avara. 1 female syntype of Argiope avara tristipes Strand 1911 (SMF 3500, www), Squally Island, E. Wolf leg. 1909, Strand det. 1910. 5 female, 3 subadult female syntypes of Argiope avara tristipes Strand 1911 (SMF 3501), Squally Island, E. Wolf leg. 30.IV.1909, Strand det. 1910. 1 female syntype of A. aetherea angulicosta Strand 1911 (SMF 3491), Keule Island [= Koil Island], E. Wolf leg. 17.IV.1909, Strand det. 1910 sub A. avara. 8 female syntypes of A. aetherea angulicosta Strand 1911 (SMF 3492), Keule Island [= Koil Island], E. Wolf leg. 17.IV.1909, Levi rev. 1981 sub A. aetherea. 6 female syntypes of A. aetherea angulicosta [1 embolus] (SMF 3494), Keule Island, E. Wolf leg. 17.IV.1909, Levi rev. 1981, sub A. aetherea. 1 female (SMF 3495, www), Keule Island [= Koil Island], E. Wolf leg. 17.IV.1909, Strand det. 1910 sub A. avara. 1 female (SMF 3496, www), Keule Island [= Koil Island], E. Wolf leg. 17.IV.1909, Strand det. 1910 sub A. avara. 2 female syntypes of A. aetherea ocelligera Strand 1911 (SMF 3497), Keule Island [= Koil Island], E. Wolf leg. 17.IV.1909, Levi rev. 1981 sub A. aetherea. 1 female (SMF 3498), Archipel, E. Wolf leg. IV.–V.1909, Strand det. 1910 sub A. avara. 1 female (SMF 3499), Wogo (=Vokeo, neighbour to Koil Island), Schouten Islands [most likely a mistake], E. Wolf leg. 12.IX.1909, Strand det. 1910 sub A. avara ocelligera. 1 female (SMF 3487), Wogo (=Vokeo, neighbour to Koil Island), Schouten Islands [most likely a mistake], E. Wolf leg. 1909, Strand det. 1910 sub A. avara. 1 female syntype of Argiope avara tristipes Strand 1911 (SMF 3503), Admiralty Islands, Lo Island, E. Wolf leg. 10.IX.1909, Strand det. 1910. 2 female syntypes of Argiope avara tristipes Strand 1911 (SMF 3502), small island close to St. Matthias, E. Wolf leg. 29.IV.1909, Strand det. 1910. Holotype female of Argiope lihirica Strand 1913 (SMF 3546), New Ireland, E. Wolf leg. 3.V.1909, Strand det., Levi rev. sub A. aetherea. 1 immature female syntype of A. aetherea tangana Strand 1911 (SMF 3470), N of New Ireland, Tanga Islands, E. Wolf leg. 4.V.1909, Strand det.

Argiope avara angulicosta Strand 1911, A. a. ocelligera Strand 1911, A. a. tristipes Strand 1911, A. aetherea tangana Strand 1911 and A. lihirica Strand 1913 are removed from the synonymy of A. aetherea (sensu Levi 1983: 313) and placed in the synonymy of A. brunnescentia, as all specimens show clearly opisthosomal shape and coloration characteristic for the latter species. As Levi (1983) assumed the male he illustrated as belonging to A. brunnescentia is most likely not conspecific. New evidence for this hypothesis is given by one broken embolus from an A. brunnescentia epigyne (SMF 3494) which exhibits a broad and toothed embolic pendant (Fig. 152), distinctly different from all others in the aetherea-group. It cannot be determined to which species Levi’s male belongs. Females can be recognised by the shape of their epigyne (see Levi 1983: figs 279–281), the shape of the opisthosoma (combination of a rounded pentagonal shape and a pointed posterior tip), colouration of the sternum (black with one central and 5 peripheral orange to pale yellow patches; this pattern may be indistinct in brighter specimens), dorsal opisthosoma with transversal rows of muscle sigilla reaching from...
lateral in a marginal zone (these rows may be darkly coloured; sigilla in females after egg laying often indistinct), prosoma dark reddish brown, flat. Opisthosoma may be black (greyish in ethanol) with or without white patches (melanistic forms mentioned by Levi 1983: 314 had been affiliated to *A. aetherea*). Size varies strongly: body length 15.5–28.0 mm. Only one out of 37 females had a broken embolus.

**Argiope squalllica** Strand 1915 (Figs 153–154)

Material examined (1 male). PAPUA NEW GUINEA. **Holotype male** (SMF 3588, www), Squally Island (Emirau Island), E. Wolf leg. 30.IV.1909, Strand det., Levi rev. sub *A. brunnescentia*.

The embolus (in situ) showed a large gap between the embolus tip and the pendant. Within this gap a small tooth-like appendage was present (Fig. 153). According to a comparison with a broken embolus in an *A. brunnescentia* epigyne (SMF 3494, see above; Fig. 152), it is definitely not a synonym of this species. It is removed from the synonymy here and placed as valid species, although it is possible that it belongs to one of the described species from the *aetherea*-group (*A. aetherea, A. modesta*). For shape of the median apophysis see Fig. 154.

**Argiope bougainvilla** (Walckenaer 1847)

Material examined (25 females). PAPUA NEW GUINEA. **3 female, 3 juvenile female syntypes of Argiope leopardina clavifemur** Strand 1911 (SMF 3503), Admirality Islands, Lo Island, E. Wolf leg. 10.IX.1909, Strand det. 1910. **13 females, 1 subadult female, 2 juvenile females** (SMF 3544), Solomon Islands, Duka, E. Wolf leg. 29.VIII.–2. IX.1909, Strand det. sub *A. leopardina*. **8 females, 1 juvenile female** (SMF 31421, www), Madang Province, Madang, Finel Sier, Schauinsland leg. 1906, Levi det. 1981. **1 female** (SMF 61158), Bougainville, W-coast, Toboroi leg. 1908.

Some of the specimens examined have a brighter and more reticulate pattern (SMF 31421, www) in comparison to that shown by Levi (1983: 289). Few specimens exhibited a bright transversal patch on the dorsal opisthosoma anteriorly. In others the bright paraxial bands on the ventral opisthosoma are extended as a bright broad ring around the spinnerets (SMF 31421, www).
**Argiope aetherea (Walckenaer 1841)** (Figs 155–156)

*Argiope aetherea annulipes* Thorell 1881: 68 (description of female; female holotype from Yule Islands, New Guinea, MCSN, not examined).

**Note.** Levi (1983: 313) examined the holotype and included this subspecies in the synonymy of *A. aetherea* (as proposed by Bonnet 1955: 668), but it was not followed by Platnick (2011).


Levi (1983) lumped many species and subspecies (23 in total) within this widely spread species. Some of these synonymies were contradicted by results of the present study (see also notes in *A. modesta* and *A. brunnescentia*). I doubt that *A. aetherea* is in fact that variable in respect to its opisthosomal shape for instance as proposed by Levi. The specimen illustrated by him (Levi 1983: figs 306–307) from the Solomon Islands (New Georgia) appears from the shape of the opisthosoma and the sternal pattern more close to *A. brunnescentia* than to *A. aetherea*. Syntypes of *A. friedericii* Strand 1911 exhibit a far longer epigyne in lateral view as shown for *A. aetherea*. The holotype female of *A. wogeonicola* shows also considerable differences to the *aetherea* epigyne illustrated by Levi (1983). The dorsal opisthosomal colour pattern of the syntypes of
A. udjirica and A. wolfi varies distinctly from what Levi (1983) illustrated as aetherea, sternal pattern of the latter species resembles more A. brunnescenstia. As the species status cannot be solved here, all species mentioned above are kept in the synonymy as proposed by Levi (1983).

**Argiope picta** L. Koch 1871 (Figs 157–166)


**Note.** The subadult female holotype showed clearly the characteristic colour pattern (dorsal and ventral opisthosoma and sternum) of *A. picta* as shown in Levi (1983: figs 313–314) and in this paper (SMF 31423, www).


One male was found with one left embolus broken off. However, in only one of the females examined (n=85) a left broken embolus could be observed. The pendant of this embolus had two tiny apices (Figs 157–158) in contrast to that illustrated by Levi in situ (1983: fig. 315). Another male (SMF 3586) from Aru Islands, showed differences in the pendant as well as in the shape of the median apophysis (Figs 159–160). One feature shared by males examined was the broad and proximally extending base of the stout pendant (Figs 157, 159, 161, 63, 165) in contrast to other species of the *aetherea*-group.

**Argiope comorica** Bjørn 1997 (Figs 490–494)

**Material examined (1 female).** COMORES. **1 female** (RMCA 208.322), Mayotte, Coconi [12°50’2.49”S, 45° 8’11.72”E], campus de la DAF, by hand, R. Jocqué leg. 18.VII.1998, M. Grasshoff det.

The female represents the second record in general and the first record from Mayotte Island (type locality is Grande Comore [=Ngazidja] c. 230 air km apart from the new locality). The present female is slightly larger than the holotype (Bjørn 1997: 229, total length 4.6): PL 2.65, PW 2.5, AW 1.3, OL 4.5, OW 3.6. Chelicerae have 4 anterior and 3 left and 4 right posterior teeth with ca. 20 denticles in the cheliceral furrow.
Misplaced species

*Nephila clavata* L. Koch 1878

*Argiope maja* Bösenberg & Strand 1906: 201, text-fig. 1 (description of female; female holotype from Yokohama; according to the editorial by Strand material should be deposited in the Senckenberg collection, but the type could not be found, most likely lost). **Syn. nov.**

**Note.** Levi (1983: 262) suspected that this species indeed represents a female of *N. clavata*. A careful comparison of the original text description (in German) and material from the SMF collection showed several characters, which point definitely to a synonymy of both species names: 1. Triangular labium with median longitudinal yellow-orange band, the same band at sternum interrupted in the centre of the sternum. 2. The colour pattern described especially of the legs fits exactly the specimens examined; opisthosomal pattern and colouration is variable and sometimes faded, therefore not good in this respect. 3. Size of 20 mm body length: there are only few species with this size and similar colouration in Japan: *Argiope amoena*, *A. bruennichi*, *A. boesenbergi* and *A. aemula*, all of which lacking diagnostic characters mentioned. *Nephila pilipes*, another large species, has a different colour pattern. One confusing issue is the epigyne illustrated together with the text description: a median cleft should be surrounded by one dark crescent bulge on each side. One explanation for this discrepancy may be the bad optics at the time of the description. Indeed, there are two dark lateral areas in the epigyne of *N. clavata*, which might be interpreted as bulges. Another explanation could be a confusion of original drawings by Bösenberg, which were compiled together by Strand after Bösenberg died (Bösenberg & Strand 1906: foreword).

*Cyrtophora moluccensis* (Doleschall 1857)

*Epeira moluccensis* Doleschall 1857: 418 (description of female; type[s] from Amboina, not found according to Tanikawa *et al.* 2010)

*Argiope thai* Levi 1983: 292, figs 152–156, map 4 (description of female; holotype female from Thailand, Chantaburi, Preuw, MCZ, not examined). **Syn. nov.**

**Note.** Levi (1983) described this species from one female in poor condition. From his illustrations of opisthosomal colouration and female copulatory organ it is clearly a synonym of *C. moluccensis*, as analysed and illustrated by Tanikawa *et al.* (2010). Especially ventral and lateral view of the epigyne differentiates *C. moluccensis* from *C. ikomosanensis* (Bösenberg & Strand 1906) (Tanikawa *et al.* 2010: figs 8–17).
DISCUSSION

It could be confirmed that males of *Argiope* spp. break regularly their emboli during the copulation. Although in some species no broken emboli could be found it is not clear whether this is an artefact due to preservation in ethanol, or whether only the short tip is broken, which is hardly recognisable without a maceration (cf. Uhl et al. 2007). Another explanation could be that the embolus usually breaks during copulation and the shape of the epigyne (widely open depression without distinct rims) impedes retaining of larger parts of emboli (e.g., in *A. picta*). From the results it is not clear whether in all species with broken emboli these structures are good for an effective plugging in respect of sexual competition between males (‘first come, first serve’). In species with multiple plugging, e.g. *A. argentata*, with up to 5 emboli sticking in one side of the epigyne, it seemed as if one embolus was really sticking in and plugging the copulatory duct, and additional emboli were more or less loosely attached, although properly fixed in the epigynal depression. This provides evidence that only the hook may represent the efficient plug of the narrow copulatory duct (cf. Uhl et al. 2007). Evidences of broken hook parts are seen in various species. However, only paternity experiments can give a clue about functional aspects (cf. Nessler et al. 2006, 2007).

In some species no emboli were recorded in epigynes, e.g., *Argiope picta* L. Koch 1871 (with 35 females examined). It cannot be excluded that only the distal tip breaks off in this species as shown for *A. bruennichi* by Nessler et al. (2006: figs C–D) with macerated female copulatory organs. Apparently, the construction of epigynes with wide atria or the functional interaction between an epigyne with a wide atrial opening and an embolus does not allow a retaining of a larger embolus tip. In contrast, in some species a rim was found within the epigynal atrium, where the hook of the embolic breaking point (H in Figs 77, 81) was fixed in that way that a removal of a broken tip with micro-pins or forceps was difficult (e.g., *A. bivittigera*). Levi (1983) mentioned that emboli usually are ‘wedged into the opening’. An ‘exudate’ (secretion) mentioned by Levi (1983: 250) could not be observed in any of the species treated (exception: Fig. 43: *A. aurantia*). Some emboli are hidden as for instance in *A. aurantia* or *A. bruennichi*. In *Argiope* species there are usually two breaking zones in male emboli and usage of breaking points differs between populations of the same species (Uhl et al. 2007: *A. bruennichi*, Jäger & Praxaysombath 2009: *A. pulchella*, present study). In some species numerous emboli have been found in epigynes, e.g. *A. argentata* with five emboli stuck in the right half of the epigyne (SMF 31446). Another female of the same species had 4 emboli on each side. One *Argiope sector* female from Tunisia (SMF 37082) had 4 right and 3 left emboli. In all cases encountered left emboli were found in the left half of the epigyne and right palps accordingly.

When using emboli as identification aid it became clear that certain restrictions have to be considered. While comparing broken emboli with emboli in situ on an intact palp it was apparent that they change their shape when they were fixed in an epigyne. This is true for specimens freshly collected as well as for material preserved 100 years ago. Emboli coil or bend mostly in direction of their membranous flange at the concave side (F in Figs 34, 44, 59, 68, 127, 157), the degree of coiling or bending varies. It may be that this membranous flange in combination with the rigid antagonistic convex part is
essential for bending and fixing the embolus or its tip in the copulatory opening, thus being a possible morphological precondition for using emboli as plugs. In contrast, emboli without such flanges are known to retain their original shape within seconds after removal from the copulatory ducts due to the elastic properties of the exocuticle (e.g., Holconia sp., Sparassidae, with more than 7 distal embolus coils, Jäger unpublished). The present paper cannot trace this question in depth, as a broad comparison between embolus and palp morphology in groups of plugging and non-plugging Araneidae and probably other families would be necessary. Functional aspects would have to be investigated experimentally. However, Grasshoff (1984: figs 11–13) showed such flanges for broken embolis of Caerostris species.

Finally, few ambiguous cases of African species occurred in the present study, where broken emboli and epigynes did not match at least when using diagnostic characters listed in the key of Bjørn (1997) (see illustrations of A. lobata and A. australis in the present paper). Four options are possible: 1. Males mate with females of other species, 2. Females have a much higher variability than shown in Bjørn (1997), 3. Males have a higher variability, 4. Both forms belong to one species with a high degree of variability. It may occur that among these four possibilities the last one is true, i.e. that both forms represent in fact one species with a wide distribution and a strong variability (Bjørn, in litt., present study). Larger sample sizes may be help in finding answers.

In general, not all species could be distinguished by emboli, especially in cases of simple emboli without any special outgrowths. In these cases a thorough analysis of the base of the broken embolus may help to find diagnostic characters.

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FIGURES 29–43. Argiope spp., copulatory organs (29, 32–38, 42–43 Broken embolus [35 same embolus as in Fig. 34, but in different view]; 30, 40 Epigyne ventral view; 31 Epigyne posterior view; 39 Tip of embolus in situ; 41 Epigyne lateral view). 29–31 Argiope doleschalli Thorell 1873, female holotype from Indonesia, Maluku Islands, Ambon (NMNH). 32 Argiope sp., female from Indonesia, Maluku Islands, Aru Islands (SMF 3520). 33 Argiope boesenbergi Levi 1983 from Japan (SMF 3464). 34–35 Argiope amoena L. Koch 1878 from Japan (34 SMF 3481; 35 SMF 31417). 36 Argiope magnifica L. Koch 1871 from Papua New Guinea (SMF 3460). 37–41 Argiope bruennichi Scopoli 1772 (37 from Greece, Crete, RII 815; 38 from female holotype of Argiope bruennichi orientalis Strand 1907 from W-Europe [see remark in text], SMF 31604; 39–41 from Japan, SMF 3509). 42–43 Argiope aurantia Lucas 1833 from USA, Texas (SMF 61099). F — Membranous flange at concave side of embolus.


FIGURES 59–92. Argiope spp., copulatory organs (62, 65, 68, 84, 88 Embolus in situ; 59, 63–64, 66–67, 74–83, Broken embolus; 60, 72 Epigyne, posterior view; 69 Epigyne, ventral posterior view; 70–71 Epigyne, between ventral and posterior view; 72 Epigyne, lateral view; 85 Median apophysis; 86 Internal duct system, lateral view; 87 Internal duct system, dorsal view). 59–60 Argiope sp. cf. tapinolobata Bjørn 1997 from Namibia (SMF 61122). 61 Argiope coquereli (Vinson 1863) from Madagascar (SMF 3526). 62–64 Argiope flavipalpis (Lucas 1858) (62 from Congo, SMF 61133; 63 from Ivory


FIGURE 167 Records of Asian Argiope spp. in China (1–5), Laos (6–10), Vietnam (11), Thailand (12–13), and Singapore (14) with new species, new country records and species previously not mapped in revisions. Asterisks mark type localities. 1–2 Argiope pulchelloides, China, Sichuan Province (1 Miyi County; 2 Emei Shan). 3 Argiope aetheroides, China, Hunan Province, Shimen County. 4, 7–9, 12–13 Argiope jin-ghongensis (4 China, Yunnan Province, Jinghong County, type locality; 7 Laos, Bolikhamsay Province, Ban Na Deua; 8 Laos, Khammouan Province, c. 9 km NE Thakek; 9 Laos, Champasak Province, Tad Paxuam; 12 Thailand, Trat Province, Koh Chang; 13 Thailand, Song Khla Province). 5 Argiope cameloides, China, Hainan Province, Mt. Jianfengling. 6, 10 Argiope dang, Laos (1 Champasak Province, Wat Phou; 13 Champasak Province, Wat Phou). 7 Argiope hinderlichi spec. nov., Laos, Bolikhamsay Province, Lak Sao, type locality. 10 Argiope chloreis, Laos, Champasak Province, Tha Hou, first country record, most northern record. 11 Argiope vietnamensis, Vietnam, Thua Hien-Hue Province, close to Bach Ma National Park, type locality. 14 Argiope mangal, Singapore.
Argiope spp.

Photo Legends

Photos 1–11. Argiope spp., habitus (1, 3, 6, 9 dorsal; 2, 4, 7, 10 ventral; 5, 8, 11 lateral). 1–5 Argiope bivittigera Strand 1911, females from Indonesia, Maluku Islands, Kai Islands (1–2 SMF 3535; 3–4 Syntype, SMF 3538; 5 Syntype SMF 3539). 6–11 Argiope reinwardti (Doleschall 1859), females from Indonesia, Java (6–8 SMF 61732, 9–11 Syntype, NMNH).


Argiope spp.
Argiope spp. (cont.)
Argiope spp. (cont.)
Argiope spp. (cont.)

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