Süßwasserfauna von Mitteleuropa

Reinhard Gerecke *Editor*
Ilse Bartsch · Kees Davids · Ralf Deichsel
Antonio Di Sabatino · Grzegorz Gabryś · Reinhard Gerecke
Terence Gledhill · Peter Jäger · Joanna Makol · Harry Smit
Henk van der Hammen · Gerd Weigmann
Andreas Wohltmann · Eberhard Wurst

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Ilse Bartsch Kees Davids Ralf Deichsel Antonio Di Sabatino Grzegorz Gabryś
Reinhard Gerecke Terence Gledhill Peter Jäger Joanna Mąkol Harry Smit
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Ilse Bartsch
Frankfurt am Main, Deutschland

Kees Davids
Amsterdam, Niederlande

Ralf Deichsel
Berlin, Deutschland

Antonio Di Sabatino
Coppito L'Aquila, Italien

Grzegorz Gabryś
Zielona Góra, Polen

Reinhard Gerecke
Tübingen, Deutschland

Terence Gledhill
Kendal, Großbritannien

Peter Jäger
Frankfurt, Deutschland

Joanna Makol
Wroclaw, Polen

Harry Smit
Amsterdam, Niederlande

Henk van der Hammen
Amsterdam, Niederlande

Gerd Weigmann
Berlin, Deutschland

Andreas Wohltmann
Bremen, Deutschland

Eberhard Wurst
Stuttgart, Deutschland

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Verzeichnis der Autoren

Dr. Ilse Bartsch
Forschungsinstitut Senckenberg, c/o DESY
Notkestraße 85
D- 22607 Hamburg, Germany
email: bartsch@meeresforschung.de

Dr. Kees Davids (†)
Vakgroep Aquatische Oecologie
Universiteit van Amsterdam
Kruislaan 320
NL- 1098 SM Amsterdam, The Netherlands

Ralf Deichsel
Laboratory for Soil Zoology & Ecology
Grunewaldstraße 34
D- 12165 Berlin, Germany
email: flar@zedat.fu-berlin.de

Dr. Antonio Di Sabatino
Dipartimento di Scienze Ambientali
Università dell'Aquila
Via Vetoio 20,
I- 67100 L'Aquila, Italy
e-mail: adisab@univaq.it

Prof. Dr. Grzegorz Gabryś
Department of Biology
Institute of Biotechnology & Environmental Sciences
University of Zielona Góra
Monte Cassino 21B
PL- 65-561 Zielona Góra, Poland
e-mail: g.gabrys@ibos.uz.zgora.pl

Dr. Reinhard Gerecke
Biesingerstraße 11
D- 72070 Tübingen, Germany
email: reinhard.gerecke@uni-tuebingen.de

CBiol MIBiol FLS Terence Gledhill
Freshwater Biological Association
Windermere Laboratory
The Ferry House, Far Sawrey
GB Ambleside Cumbria, LA 22 OLP,
United Kingdom
email: allgledhills@hotmail.com

Dr. Peter Jäger
Forschungsinstitut Senckenberg
Senckenberganlage 25
D- 60325 Frankfurt am Main, Germany
email: peter.jaeger@senckenberg.de

Dr. Joanna Mąkol
Department of Zoology and Ecology
Agricultural University of Wrocław
Kozuchowska 5b
PL- 51-631 Wrocław, Poland
email: makol@ozi.ar.wroc.pl

Drs Harry Smit
Zoological Museum, University of Amsterdam
Plantage Middenlaan 64
NL- 1018 DH Amsterdam, The Netherlands
email: smit.h@wolmail.nl

Dr. Henk van der Hammen (†)
Amsterdam, The Netherlands

Prof. Dr. Gerd Weigmann
Laboratory for Soil Zoology & Ecology
Grunewaldstraße 34
D- 12165 Berlin, Germany
email: weigmann@zedat.fu-berlin.de

Dr. Andreas Wohltmann
Institut für Ökologie und Evolutionsbiologie
Universität Bremen, Fachbereich 2
Postfach 33 04 40
D- 28334 Bremen, Germany
email: wohltman@uni-bremen.de

Dr. Eberhard Wurst
Fachgebiet Parasitologie (220 B)
(Institut für Zoologie)
Universität Hohenheim
Emil-Wolff-Straße 34
D- 70599 Stuttgart, Germany
email: wurst@uni-hohenheim.de

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7. Acari: Hydrachnidia I

(Kees Davids [†], Antonio Di Sabatino, Reinhard Gerecke, Terence Gledhill, Harry Smit and Henk van der Hammen [†])

1. Order Araneae

Peter Jäger

General part

Diagnosis

Small to large in size (body length 0.4–100 mm); body divided into two parts, these called prosoma and opisthosoma, these connected by a thin petiolus prosoma including segments I–VI with chelicerae, palps, and four pairs of walking legs, with dorsal shield and ventral sternum; chelicerae two-segmented with basal limb large, with hairs and usually teeth, the secondary limb as heavily sclerotised fang with opening of a poison gland on its tip; palps with six, legs with seven segments (additional metatarsus between tarsus and tibia); palpal coxae used as mouthparts together with the unpaired labium; opisthosoma consisting of the fused body segments VII–XVII, only in Mesothelae slightly segmented; ventral opisthosoma with 2–4 openings for book-lungs, a genital opening and a tracheal spiracle; plesiotypically two pair of spinnerets on each of the segments X and XI, these shifted in all groups but Mesothelae to the end of the opisthosoma; number of spinnerets reduced usually to six, in some taxa to four or two.

Sexual reproduction. Sperm transfer indirect by using the modified tarsi of male pedipalps as transfer organ (gonopod); postembryonal development with 5–10 stages, all of which with complete number of appendages and moulting inbetween.

General introduction

True spiders (Arachnida: Araneae) are distributed roughly worldwide and live in almost all kinds of terrestrial habitats from the sea shore to mountain ranges up to altitudes of nearly 7000 metres. Only one of 38000 currently known species – the water spider *Argyroneta aquatica* (Clerck, 1757) – is secondarily adapted to aquatic life in fresh water. Individuals live, hunt, feed, moult and mate under water, by using a web as a diving bell filled with air. All other species are not capable to perform their whole life cycle under water. Inspite, there are several species from various families, which occur on fresh water sites. Among them are forms whose ecological needs do not allow a life in places without a certain humidity or even open water. Some wolf spiders for example (members of the family Lycosidae) hunt on the water surface and survive floodings while hiding in their retreats between or under stones. Others build their catching webs exclusively close to the water surface (e.g. *Theridiosoma gemmosum* L. Koch, 1877). Representatives of one family (Desidae) are hunting in the tidal zones of the sea shore. They are able to rest during the high tide in their retreats under water. Beside these specialised forms there are ubiquists, which may settle in every kind of habitat (e.g. some Linyphiidae). Between these two extremes spiders developed all sorts of partitioning.

Morphological features of the spider body are explained in Figure *1-1 c, e, g–h, j–k*. For the special terminology see in the glossary at the end of this chapter.

I. Bartsch et al., *Süßwasserfauna von Mitteleuropa, Vol. 7/2-1 Chelicerata: Araneae/Acari I*, Süßwasserfauna von Mitteleuropa,
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Special part

Area treated

The following key includes all spider families which are likely to be found in the Palearctic directly on the water surface, in vegetation standing in the water or in the vegetation belt close to the shore line. The present key is not only valid for Central Europe, but may also be of help in most of the eastern parts of the Palearctic region. However, some tropical and subtropical elements remain excluded, especially species occurring in China and Japan. For information on taxonomy and biology of species representing further genera or families which in Central Europe may appear in such habitats by accident, see NENTWIG et al. (2003) and for information on the distribution ranges within Germany see STAUDT (2005). Only short information is given on ten of the eleven included families, including a list of species occuring at fresh water habitats (for compilations see BELLMANN 2001, NENTWIG et al. 2003). Only *Argyroneta aquatica* is treated in a separate paragraph in detail.

Key to spider families occurring on fresh water sites

1 Each tarsus with two distal claws (*1-1 d*), sometimes hidden by claw tufts of adhesive hairs (*1-1 g*). 2

– Each tarsus with three distal claws, median claw in several species tiny and hardly recognizable (*1-1 j, 1-2 c, l, 1-3 m, q, , 1-4 e–f*). 4

2 Anterior median eyes very large (*1-1 a*), eyes in three rows (4 - 2 - 2), posterior eyes forming a rectangle (*1-1 b*). . . . . **Salticidae**
Small to medium-sized spiders with stout legs; hunting in vegetation and on the ground, building retreats between leaves, behind bark and under stones. E.g. *Heliophanus patagiatus* THORELL, 1875, *Marpissa radiata* (GRUBE, 1859), *Mendoza canestrinii* (NINNI, 1868), *Sitticus caricis* (WESTRING, 1861), *S. distinguendus* (SIMON, 1868), *S. floricola* (C.L. KOCH, 1837).

– Eyes subequal and in two rows (4 - 4) (*1-1 c, e–f*). 3

3 Legs laterigrade, i.e. especially legs I + II tilted to their retrolateral side and being longer and in most species distinctly stronger than legs III + IV, tibia and metatarsus I + II with double rows of short and stout spines (*1-1 c*). . . . . **Thomisidae**
Medium-sized spiders with a crab-like habit; hunting in vegetation and on the ground; females building only retreats for their egg-sacs. E.g. *Heriaeus graminicola* (DOLESCHALL, 1852) (*1-1 c*), *Xysticus ulmi* (HAHN, 1831).

– Legs prograde, not tilted to their retrolateral side, tibia and metatarsus I + II only with single spines (*1-1 e*). . . . . **Clubionidae**
Medium-sized spiders with a velvet-like appearance; hunting in vegetation and on the ground; building retreats between leaves and behind bark, some species building a special kind of retreat by folding a lanceolate grass leave twice. E.g. *Clubiona lutescens* WESTRING, 1851; *C. phragmitis* C.L. KOCH, 1843*; C. reclusa* O.P.-CAMBRIDGE, 1863; *C. stagnatilis* KULCZYNSKI, 1897.

4 Lateral eyes separated by more than two diameters of an anterior lateral eye, posterior eye row strongly recurved, forming a trapezoid (*1-1 h–j, k–l*). 5

– Lateral eyes touching each other or separated by about one diameter of the anterior lateral eye, posterior eye row only slightly recurved, straight or procurved (*1-2 a–b, g, n–o, 1-3 d, h–i, p, u–t, 1-3 a–b, h–j, n–p*). 6

5 Posterior median eyes enlarged, clypeus short, i.e. about one diameter of anterior eyes in frontal view (*1-1h*), anterior eyes and in many cases posterior median eyes reaching the frontal margin of the dorsal shield of prosoma in dorsal view (*1-1 i*). . . . . **Lycosidae**
Medium-sized to large spiders; hunting on the ground and on the water surface; females carrying their egg-sac attached to the spinnerets and later, the offspring on their opisthosoma; some species being able to dive (*Pirata* spp.) or to stay in their retreat under water during a period of flooding (e.g. *Arctosa cinerea* (FABRICIUS, 1777) in river gravels, or *Pardosa purbeckensis* F.O.P.-CAMBRIDGE, 1895 in salt water habitats on coast lines). E.g. *Arctosa cinerea* (FABRICIUS,

1777), *A. leopardus* (SUNDEVALL, 1833), *A. maculata* (HAHN, 1822), *A. stigmosa* (THORELL, 1875), *Pardosa agricola* (THORELL, 1856), *P. saturatior* SIMON, 1937, *P. wagleri* (HAHN, 1822), *Pirata hygrophilus* THORELL 1872, *P. insularis* EMERTON, 1885, *P. knorri* (SCOPOLI, 1763), *P. latitans* (BLACKWALL, 1841), *P. piraticus* (CLERCK, 1757), *P. piscatorius* (CLERCK, 1757), *P. tenuitarsis* SIMON, 1876.

– Posterior median eyes not enlarged, clypeus wide, i.e. about three diameters of the anterior eyes in frontal view (*1-1 k*), anterior eyes and posterior eyes never reaching frontal margin of the dorsal shield of prosoma in dorsal view (*1-1 l*). . . . . **Pisauridae**
Large spiders; juveniles of *Dolomedes* spp. hunting in vegetation of swampy areas like meadows around springs; adults of *Dolomedes* sitting at the shore line and holding the fore-legs on the water surface using the latter as a 'fluid spider web' in means of getting information of movements of potential prey; hunting on the water surface or even under water; *Pisaura mirabilis* (CLERCK, 1757) hunting in all stages in vegetation; females of all species carrying their egg-sac in the chelicerae. *Dolomedes fimbriatus* (CLERCK, 1757) , *D. plantarius* (CLERCK, 1757); ubiquist: *Pisaura mirabilis* (CLERCK, 1757).

6 Tarsi with two rows of trichobothria (*1–2 c*), leg III–IV with long and dense hairs (*1–2 d*), spination of legs differing between forelegs and hindlegs, i.e. leg I+II almost without spines, leg III+IV with many spines (*1-2 e–f*). . . . . **Argyronetidae** (*Argyroneta aquatica*), see next paragraph.

– Tarsi without trichobothria (*1-3 m, q, 1-4 e–f*), all legs with similar length of hairs and spination (*1-2 j–k, 1-3 k–l*). 7

7 Gnathocoxae elongated (2–3 times as long as wide), proximal part laterally bent (*1-2 p:* arrow), i.e. lateral outline concave (*1-2 h:* arrow, *1-3 a,c*), male paracymbium elongated, as half as cymbium length (*1-2 m, q*) or complex (*1-3 b, e*). 7

– Gnathocoxae not elongated (1–2 times as long as wide), proximal part directed to median line (*1-3 g, n, 1-4 c:* arrow) or sub-rectangular (*1-4 k*), male paracymbium smaller (*1-3 r, v–w, 1-4 l, q*) or absent (*1-4 k*) 9

8 Chelicerae elongated and diverging (*1-2 g, n)*, basal femora dorsally with one or more rows of trichobothria (*1-2 i*), male paracymbium elongated with one knob-like protrusion (*1-2 m, q:* arrows) and parallel to cymbium length axis, females without sclerotized epigyne, i.e. no folds or copulatory opening visible (*1-2 r*). . . . . **Tetragnathidae**
Medium-sized spiders; orb-weavers (except for hunting adults of *Pachygnatha* spp.); especially *Tetragnatha* spp. abundant in vegetation close to water sites or in reed-belts; sitting in a characteristic posture, stretching the legs forewards and backwards, imitating a stalk of vegetation. E.g. *Pachygnatha clercki* SUNDEVALL, 1823; *Tetragnatha dearmata* THORELL, 1873; *T. extensa* (LINNAEUS, 1758); *T. montana* SIMON, 1874; *T. nigrita* LENDL, 1886; *T. reimoseri* (ROSCA, 1939); *T. striata* L. KOCH, 1862.

– Chelicerae neither elongated nor diverging, femora without trichobothria, male paracymbium complex and transversal to cymbium length axis (*1-3 b, e)*, females with (partly sclerotized) epigyne, i.e. folds and copulatory opening visible (*1-3 f*). . . . . **Metinae** (**Tetragnathidae**)
Medium-sized to large spiders; spinning orb-webs with open hub; living in humid places, sometimes close to streams (*Metellina* spp.), or in caves and similar habitats (*Meta* spp.). E.g. *Meta bourneti* SIMON, 1922; *M. menardi* (LATREILLE, 1804); *Metellina merianae* (SCOPOLI, 1763).

9 Sternum with two pits close to labium (openings of sternal glands) (*1-3 g*), small spiders (1.5–3.0 mm body length) with spheroidal opisthosoma (*1-3 j*), this with silver-shimmery pattern. . . . . **Theridiosomatidae**
Tiny to small spiders; spinning a small 3-dimensional orbweb directly above the water surface of stagnant water sites. *Theridiosoma gemmosum* L. KOCH, 1877 (*1-3 g–m*).

– Sternum without pits (*1-3 n*), small to medium-sized spiders. 10

10 Chelicerae laterally with stridulatory files (in some species weak) (*1-3 o:* arrow), male paracymbium sickle shaped (*1-3 r, v–w)*, paracymbium separated from cymbium by a membraneous part (*1-3 w: arrow*), males of many smaller species with cephalic lobes (*1-3 o*) and tibial apophysis (*1-3 r:* arrow) . . . . . **Linyphiidae**
Tiny to medium-sized spiders; spinning sheet-webs in the vegetation or on the ground; several species of this largest Palearctic spider family are pioneer-settlers (*Erigone* spp.), various stages being able to balloon and thus, to land on or close to open water surfaces. E.g. *Hypomma*

bituberculatum (WIDER, 1834), *Kaestneria dorsalis* (WIDER, 1834), *Microlinyphia impigra* (O.P.-CAMBRIDGE, 1871), *M. pusilla* (SUNDEVALL, 1830), ubiquists: *Erigone atra* BLACKWALL, 1833, *E. dentipalpis* (WIDER, 1834), *Linyphia triangularis* (CLERCK, 1757).

– Chelicerae laterally without stridulatory files, male paracymbium absent (*1-4 g*) or knob-like (*1-4 l, q:* arrows). 11

11 Anterior eyes reaching in most species not the frontal margin of the dorsal shield of prosoma in a dorsal view (*1-4 a*), clypeus mostly wide (*1-4 b*), males without a paracymbium, but with long bristles covering the bulbus (*1-4 g*), females mostly with simple epigynal pit without scapus (exception: few species with craniad scapus), epigynal structures mostly separated from epigastric furrow (exception: *1-4 d*), ventral tarsus IV with serrated bristles, these in a higher density than dorsal hairs (*1-4 e*, exception: males of some species, *1-4 f*). . . . . **Theridiidae**
Small to medium-sized spiders; spinning 3-dimensional webs in the vegetation, some of them with gum-foots; prey being wrapped with sticky silk pulled out of the spinnerets with the serrated bristles of the tarsi of the fourth pair of legs. E.g. *Crustulina sticta* (O.P.-CAMBRIDGE, 1861), *Enoplognatha caricis* (FICKERT, 1876), *Robertus arundineti* (O.P.-CAMBRIDGE, 1871), *Rugathodes instabilis* (O.P.-CAMBRIDGE, 1871), *Theonoe minutissima* (O.P.-CAMBRIDGE, 1879), *Theridion hemerobium* SIMON, 1914.

– Anterior eyes reaching frontal margin of the dorsal shield of prosoma in dorsal view, eyes in most species integrated in a characteristic silhouette (*1-4 h, n*), clypeus mostly short (*1-4 j, o–p*, exception: males of few species, *1-4 i*), male paracymbium knob-like (*1-4 l, q:* arrows), females with caudad scapus (*1-4 r*) or epigyne (here: copulatory openings) connected with epigastric furrow by folds (*1-4 m*), ventral tarsus IV without serrated bristles. . . . . **Araneidae**
Medium-sized to large spiders; spinning orb-webs in vegetation along the shore line or in reedbelts. E.g. *Hypsosinga heri* (HAHN, 1831), *Larinia bonneti* SPASSKY, 1939, *L. elegans* SPASSKY, 1939, *Larinioides cornutus* (CLERCK, 1757), *L. ixobolus* (THORELL, 1873), *L. sclopetarius* (CLERCK, 1757), *Singa nitidula* C.L. KOCH, 1844.

Family Argyronetidae THORELL, 1870

The family contains 12 genera with 149 species (PLATNICK 2004). It was formerly placed as subfamily in the Agelenidae C.L. KOCH, 1837. LEHTINEN (1967) considered it a subfamily of Dictynidae O.P.-CAMBRIDGE 1871, FORSTER (1970) elevated it to family rank. SELDEN (2002) divides Argyronetidae (sub Cybaeidae) into two subgroups, the Argyronetinae THORELL, 1870 and 'other cybaeids' (= Cybaeinae BANKS, 1892). Together with *Argyroneta aquatica*, he placed the extinct *Vectaraneus yulei* SELDEN, 2001 (upper Eocene) and an extinct unnamed *Argyroneta* species (Miocene) in Argyronetinae and considered all three taxa derived members of this family.

N.B.: Argyronetidae and thus Argyronetinae are the valid names for the family and subfamily (see International Code of Zoological Nomenclature [ICZN 1999: Article 23.3], i.e. Argyronetidae is not a *nomen oblitum* as indirectly indicated in PLATNICK 2004).

Genus *Argyroneta* LATREILLE, 1804

1804 *Argyroneta* LATREILLE, Histoire naturelle générale et particulière des Crustacés et des Insectes. Paris. 7: 134.

Four species were originally described in this genus: *A. antiqua* von HEYDEN, 1859, *A. aquatica*, *A. longipes* HEER, 1865 and *Argyroneta palustris* RISSO, 1826. The extinct *A. antiqua* and *A. longipes* were regarded by SELDEN (2002) as species *incertae sedis* within araneomorph spiders. The status of *Argyroneta palustris* RISSO, 1826, described from France, is not yet clear. In the subsequent paragraph only the extant water-dwelling species *Argyroneta aquatica* is treated.

Argyroneta aquatica (CLERCK, 1757) (*1-2 a–f, 1-5 a–l*)

1757 *Araneus aquaticus* CLERCK, Svenska spindlar, uti sina hufvud-slågter indelte samt under några och sextio särskildte arter beskrefne och med illuminerade figurer uplyste. Stockholm: 143, pl. 6, fig. 8.

1758 *Aranea aquatica* LINNAEUS, Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus differentiis, synonymis, locis. Editio decima, reformata. Stockholm: 623.

1761 *Aranea urinatoria* PODA, Insecta Musei Graecensis, quae in ordines, genera et species juxta systema naturae Caroli Linnaei. Graz: 123.

1775 *Aranea aquatica* FABRICIUS, Systema entomologiae, sistens insectorum classes, ordines, genera, species, adiectis, synonymis, locis descriptionibus observationibus. Flensburg and Leipzig: 436.

1776 *Aranea amphibia* MÜLLER, Zoologicae danicae prodromus, seu animalium daniae et norvegiae indigenarum, characteres, nomina et synonyma imprimis popularium. Copenhagen: 194.

1804 *Argyroneta aquatica* LATREILLE, Histoire naturelle générale et particulière des Crustacés et des Insectes. Paris. 7: 134.

1837 *Clubiona fallax* WALCKENAER, Histoire naturelle des insectes. Aptères. Paris. 1: 603.

2002 *Argyroneta aquatica japonica* ONO, Bulletin of the National Science Museum, Series A (Zoology), 28 (1): 53.

2002 *Argyroneta aquatica aquatica* ONO, Bulletin of the National Science Museum, Series A (Zoology), 28 (1): 53.

For further citations see PLATNICK (2004).

This unique species is known to science since CAROLUS CLERCK (1757: pl 6, fig. 8) illustrated a male in his book on Swedish spiders. Even tiny details such as genitalia or the eye arrangements were included in the excellent colour illustrations. Since the original description only few (three) synonyms were described despite the wide geographical range (PLATNICK 2004, see below).

ONO (2002) described a subspecies from Japan: *Argyroneta aquatica japonica* ONO, 2002. Both subspecies are treated here as one ecological unit, as no differentiating data are present for *A. a. japonica*. Examination of European material in comparison with original drawings of both subspecies revealed difficulties to distinguish both forms. Therefore it is referred in the taxonomic part only to the nominal form.

Information of the following paragraphs was compiled from BELLMANN (2001), CROME (1951), GROTHENDIECK & KRAUS (1994), ONO (2002), ROBERTS (1995) and own observations.

Description: Medium-sized spider, males being larger than females both in body size and leg span; body length (male): 10–20 mm, (female): 8–12 mm; chelicerae with 2 promarginal and 3 retromarginal teeth, in males 2 distal teeth more separated from the 3 basal teeth (*1-5 e–f*); spinnerets slightly conical; tracheal spiracle close to epigastric furrow (*1-5 l*); opisthosoma and sternum in living specimens with a quicksilver-like appearance when submerged due to adherent aircover; prosoma and legs brown to dark-brown, opisthosoma grey to greyish-black; body and legs densely covered by specialised hairs, these longer on leg III and IV.

Male copulatory organ (*1-5 a–d*): Distal cymbium elongated (cymbium length / width distal retrolateral tibial apophysis = 4.75–6.25) and with several spines, some of which variable in position; subtegulum clearly visible in ventral view; embolus arising from tegulum in 10-o'clock-position, running a semi-circle, its distal part covered by functional conductor (retrolateral part of tegulum), embolus occupying two thirds of the functional conductor,

this latter with curved tip, which is resting close to soft membrane of tarsus-tibia-joint; palpal tibia with broad and blunt retrolateral tibial apophysis.

Female genitalia (*1-5 g–k*): Epigyne simple, consisting of two short sclerotised rims at the copulatory openings, the former variable in shape; slit sense organs may be present in an anterio-lateral position to the copulatory openings; internal duct system with short intromittent ducts and spherical spermathecae; fertilisation ducts arising from ventral position, running in a semi-circle to the dorsally situated uterus externus.

Habitat: Fresh water with only little current and rich underwater vegetation.

Biology: *Argyroneta aquatica* is the only spider which is able to live almost its whole lifetime under water. Spiders construct a silken diving bell, which is filled with air. For this purpose the spider comes to the water surface, stick the opisthosoma out and take some air hold by the hindlegs and carry it to the retreat, where it is released. In different kinds of diving bells the spiders moult, filling the palps with sperms, mate, lay eggs or hibernate. Prey is caught in the water usually outside the retreat, when a prey animal touches a thread of the capturing web. In rare cases *A. aquatica* was observed taking prey above the water surface. Consumption takes place in the air bubble, as the extraoral digestion does not work in the water. Adults are found all-the-year round. In some cases snail-shells were documented as hibernation sites. *Argyroneta aquatica* swims upside down using the legs as paddles (elongated hairs of legs II and IV).

The poison of *A. aquatica* is not harmless to humans: a bite causes pain and numbness in the bitten parts. However, symptoms will disappear at the latest after 14 days without leaving any damage.

Distribution: Palearctic; country records according to YAGINUMA (1986) and BONNET (1955): Austria, Belarussia, Belgium, Bulgaria, Czech Republic, China, Denmark, Finland, France, Germany, Great Britain, Greece, Japan, Korea, Ireland, The Netherlands, Norway, Poland, Romania, Russia, Serbia, Slowakia, Sweden, Switzerland.

In Germany – and probably also in other countries – the water spider is endangered mostly by eutrophication. For this reason, several former records (some about 100 years ago) had to be cancelled from recent distribution maps.

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Glossary

bristle	derivate of cuticle, stiff (→) „hair“, thinner than a (→) „spine“
bulb	ventral part of palpal (→) „tarsus“ of adult male spiders, hairless
chelicera	appendage of the first prosomal segment of Chelicerata, in spiders two-segmented, with the distal segment acting as fang against the toothed basal segment.
claw tufts	dense brush of fine hairs at the tip of (→) „tarsus“, enabling the spider to walk on smooth surfaces
claw	sclerotised structure at the tip of (→) „tarsus“
conductor	part of male (→) „bulb“, which guides the (→) „embolus“ during copulation and insertion, may consist of analogous structures
cymbium	dorsal part of palpal (→) „tarsus“ of adult male spiders, bearing hairs (versus ventral hairless part = bulb)
dorsal shield of prosoma	sclerotised usually domed plate on the dorsal side of (→) „prosoma“ (= [err.] „carapace“)
embolus	part of male (→) „bulb“, which is inserted during copulation for transferring sperm
epigastric furrow	posterior margin of the body segment VIII
epigyne	sclerotised structure in front of genital opening of adult females, for anchoring the male genital organ via apopyhses
fertilisation duct	inner parts of (→) „epigyne“, where male sperm is transferred from (→) „spermathecae“ to the (→) „ uterus externus“
gnathocoxa	coxa of (→) „palps“, usually with serrated anterior margin (serrula), used during chewing prey and cutting threads (= [err.] „maxilla“)
hair	derivate of the cuticle, in most cases innervated and working as sensillum, e.g. (→) „trichobothrium“
leg	appendage of segments III–VI, consisting of seven segments (coxa, trochanter, femur, patella, tibia, metatarsus, tarsus).
metatarsus	see „leg“, is lacking in palp
opisthosoma	hind part of the body, consists of fused segments VII–XVII (= [err.] „abdomen“)
palp	second pair of appendage, consisting of six segments (metatarsus missing), see „leg“
paracymbium	basal, retrolateral apophysis of the male (→) „cymbium“, having a characteristic shape in different families
pedipalp	see „palp“

prosoma	front part of the body, consists of fused segments I–VI (= [err.] „cephalothorax“)
scapus	nail-like structure of the (→) „epigyne“, male apophysis may be fixed with scapus during copulation
spermatheca	inner parts of (→) „epigyne“, where male sperm is deposited
spine	derivate of cuticle, stiff and thickened (→) „hair“, with well developed base, thicker than a (→) „bristle“
spinneret	reduced paired appendages of (→) „opisthosoma“ segments X and XI, situated at the posterior end of (→) „opisthosoma“, one- to three-jointed, bearing spigots, which are connected by fine tubes with the silk glands
sternum	sclerotised ventral shield of (→) „prosoma“
stridulatory files	fine ridges, which are used in combination with peg teeth or spines to produce sounds either in defensive or mating behaviour
subtegulum	basal sclerotised part of the (→) „bulb“
tarsus	see „leg“
tegulum	second basal sclerotised part of the (→) „bulb“
tibia	see „leg“
tracheal spiracle	opening of the tracheal system, situated on ventral (→) „opisthosoma“
trichobothrium	fine (→) „hair“ on appendages with special base, arising at a right angle, for receiving air vibrations, arranged in characteristic patterns in different families
uterus externus	duct connecting the ovar and the uterus internus with the genital opening, eggs are fertilised most likely in this part, while being laid

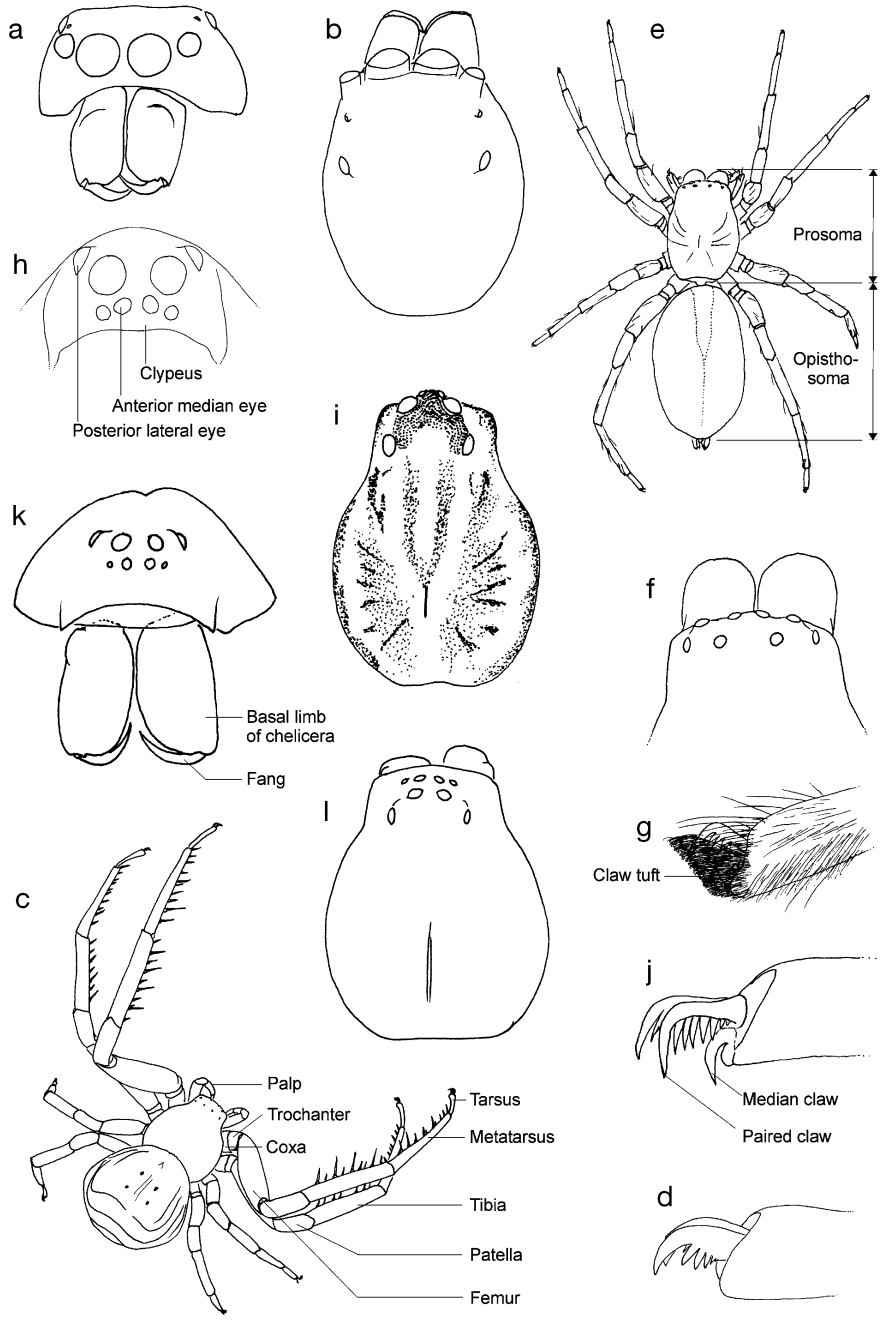

Fig. 1-1: a–b, Salticidae: *Marpissa radiata*, eye arrangement of female (a, frontal; b, dorsal), **c–d, Thomisidae**: *Heriaeus graminicola*, female (c, habitus, dorsal; d, leg claws, prolateral), **e–g, Clubionidae**: *Clubiona stagnatilis*, female (e, habitus, dorsal; f, eye arrangement, dorsal; g, leg claws and claw tuft, prolateral), **h–j, Lycosidae**: *Pirata hygrophilus* (h–i, eye arrangement of male, h, frontal, i, dorsal; j, leg claws, prolateral), **k–l, Pisauridae**: *Dolomedes fimbriatus*, eye arrangement of female (k, frontal; l, dorsal).

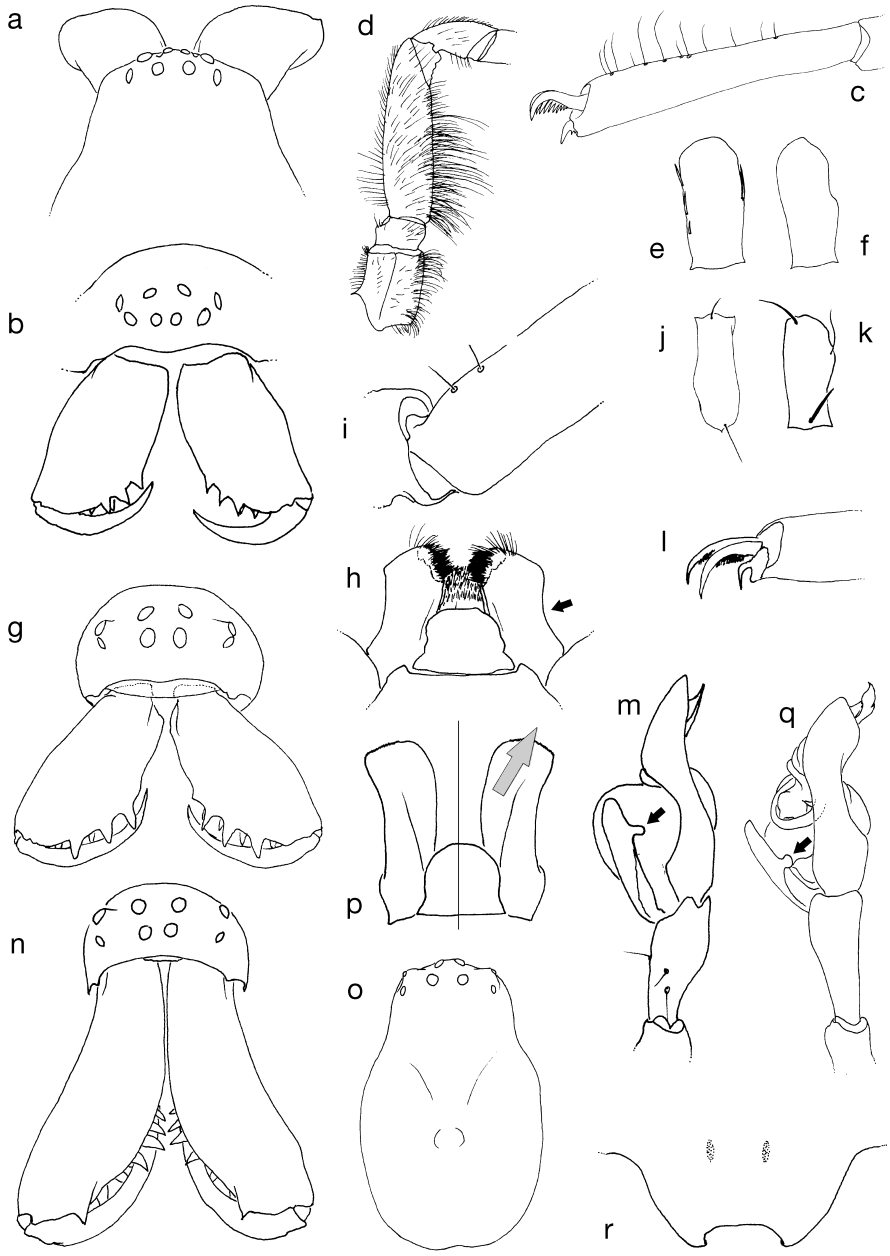

Fig. 1-2: a–f, Argyronetidae: *Argyroneta aquatica*, female (a–b, eye arrangement, a, dorsal, b, frontal; c, tarsus of leg I with claws and trichobothria, retrolateral; d, coxa to patella of leg IV showing dense and long hairs, prolateral; e–f, patella, dorsal, e, leg IV, f, leg I), **g–r, Tetragnathidae**: g–i, l–m, *Pachygnatha clercki*, g–i, l female, m, male (g, eye arrangement and chelicerae, frontal; h, gnathocoxae and labium, ventral; i, basal part of femur IV showing dorsal trichobothria, prolateral; l, leg claws, prolateral; m, male palpus, retrolateral); j–k, n–r, *Tetragnatha extensa*, j–k, n–p, r, female, q, male (e–f, patella, dorsal, j, leg I, k, leg IV; n, eye arrangement and chelicerae, frontal; o, prosoma, dorsal; p, gnathocoxae and labium, ventral; q, male palpus, retrolateral; r, epigyne, ventral).

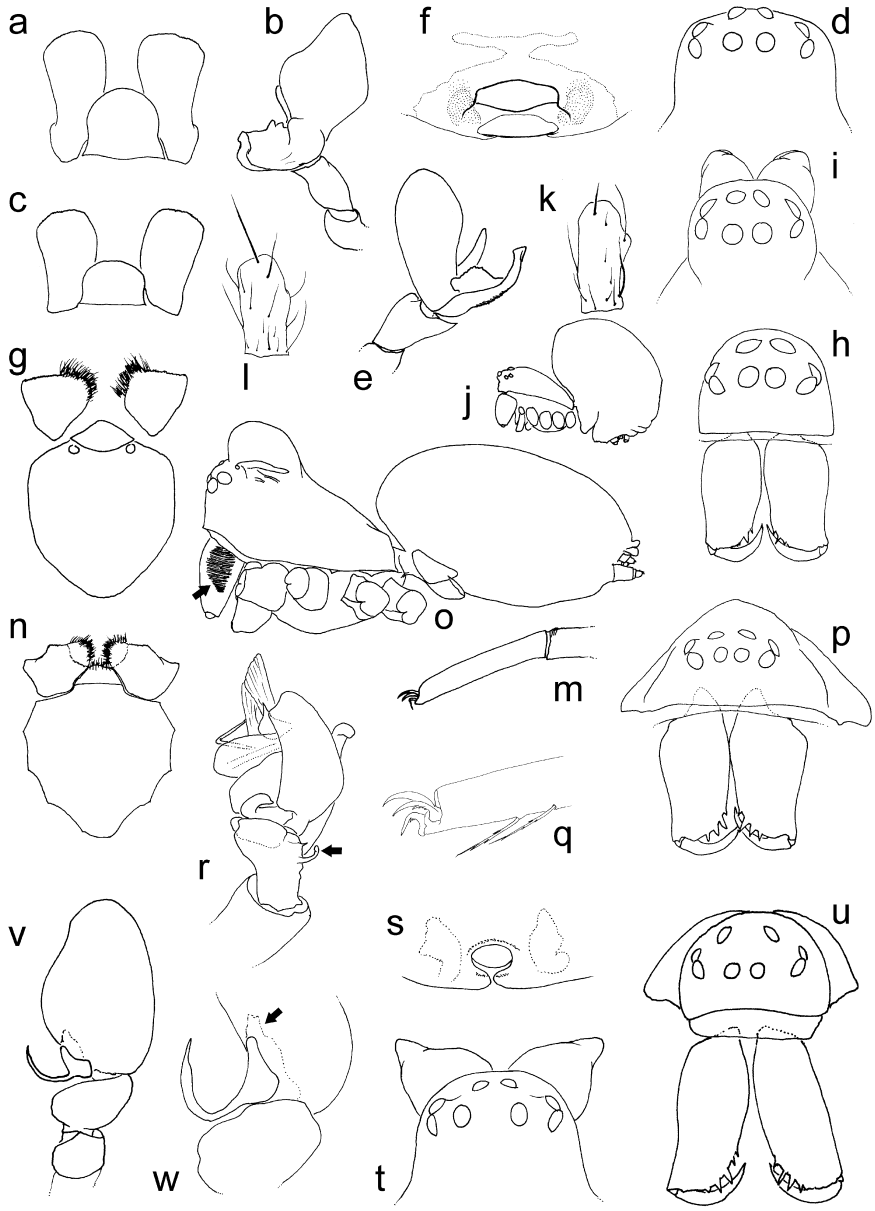

Fig. 1-3: a–f, Metinae: a–b, *Meta menardi*, male (a, gnathocoxae and labium, ventral; b, male palpus, dorsal); c–f *Metellina merianae*, c–d, f, female, e male (c, gnathocoxae and labium, ventral; d, eye arrangement, dorsal; e, male palpus, dorsal; f, epigyne, ventral), **g–m, Theridiosomatidae**: *Theridiosoma gemmosum*, female (g, gnathocoxae, labium and sternum, ventral; h–i, eye arrangement, h, frontal, i, dorsal; j, habitus, lateral; k–l, patella, dorsal, k, leg IV, l, leg I; m, tarsus of leg I with leg claws, prolateral), **n–w, Linyphiidae**: n–s, *Hypomma cornutum* (BLACKWALL 1833), n, p–q, s, female, o, r, male (n, gnathocoxae, labium and sternum, ventral; o, habitus, lateral; p, eye arrangement and chelicerae, frontal; q, distal tip of tarsus IV with leg claws, prolateral; r, male palpus, retrolateral; s, epigyne, ventral), t–u, *Microlinyphia impigra*, eye arrangement of female (t, dorsal; u, frontal), v–w, *Neriene clathrata* (SUNDEVALL 1830), male palpus (v, dorsal, w, retrolateral, enlarged).

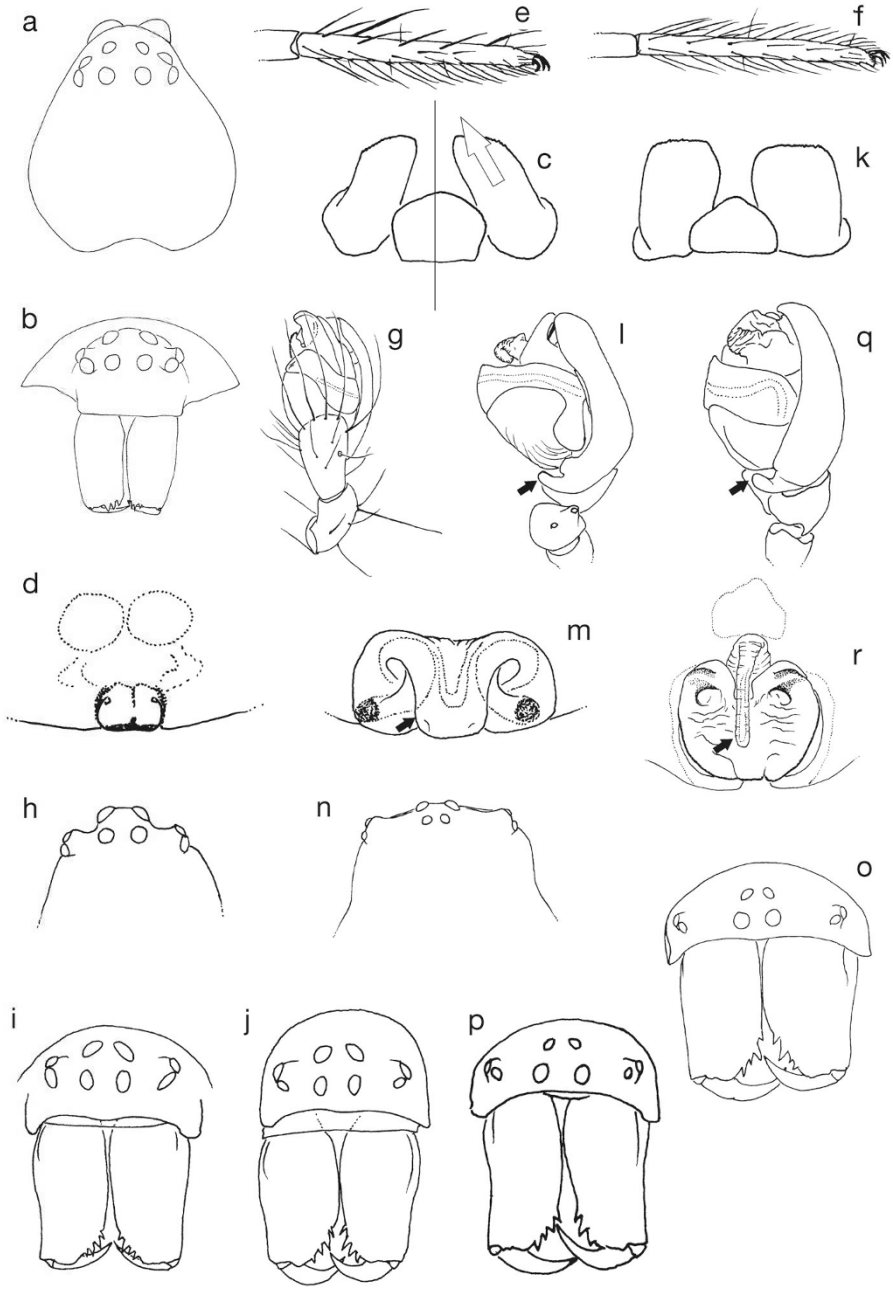

Fig. 1-4: a–g, Theridiidae: a–e, *Rugathodes bellicosus* (SIMON, 1873), female (a–b, eye arrangement, a, dorsal, b, frontal; c, gnathocoxae and labium; d, epigyne, ventral; e, tarsus of leg IV, prolateral), f–g, *Rugathodes instabilis*, male (f, tarsus of leg IV, prolateral; g, male palpus, retrolateral), **h–r, Araneidae**: h–m, *Hypsosinga heri*, h–i, k–l, male, j, m, female (h–j, eye arrangement, h, dorsal, i–j, frontal; k, gnathocoxae and labium; l, male palpus, retrolateral; m, epigyne, ventral), n–o, r, *Larinioides ixobolus*, female (n–o, eye arrangement, n, dorsal, o, frontal; r, epigyne, ventral), p–q, *Larinioides sclopetarius*, male (p, eye arrangement, frontal; q, male palpus, retrolateral).

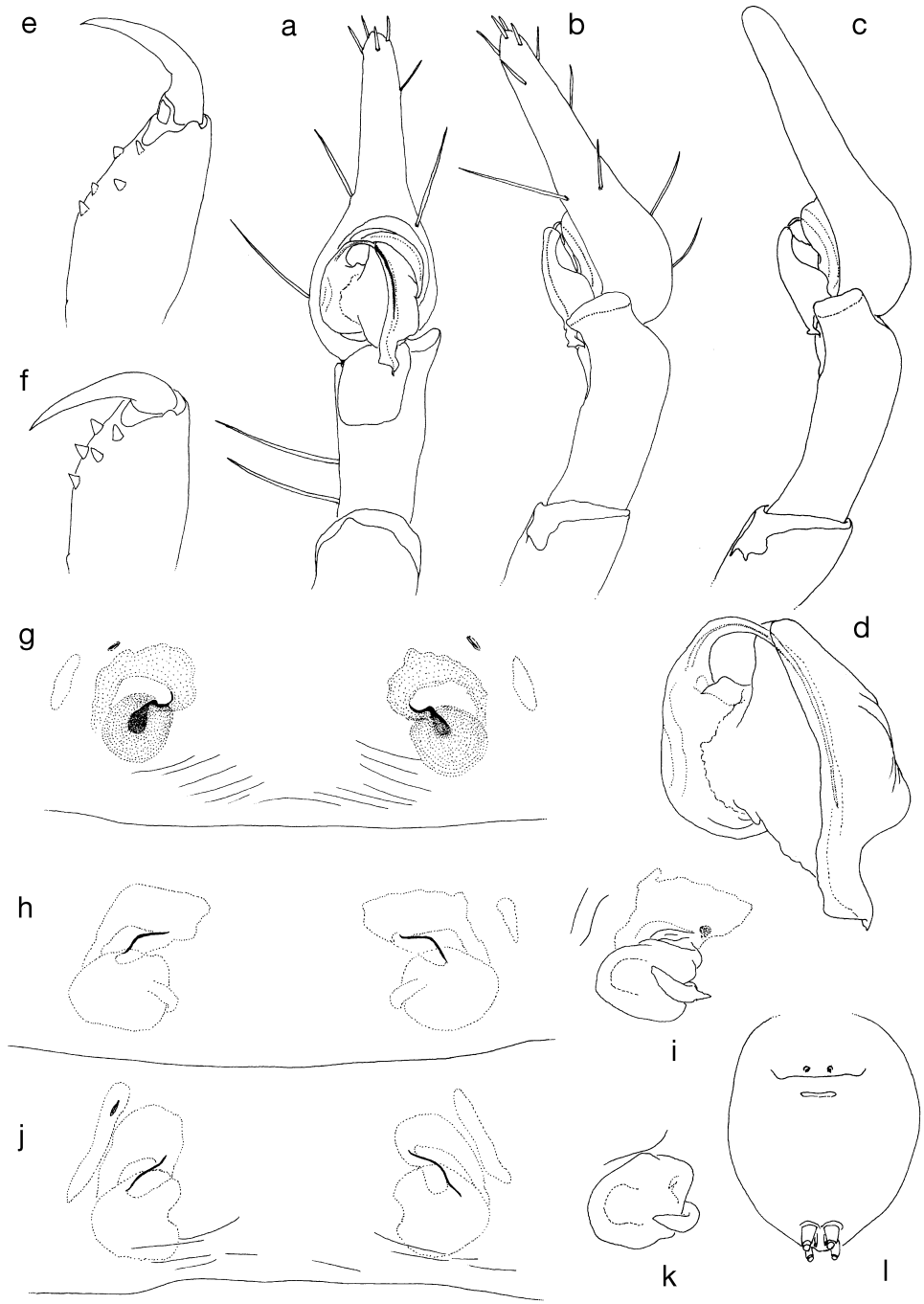

Fig. 1-5: Argyronetidae: *Argyroneta aquatica*, a–e, male, f–k, female (a–d, male palp, a, ventral, b–c, retrolateral, c, spines omitted; d, tegulum, ventral; e–f, chelicera, ventral; g–l, female genitalia, g–h, j epigyne, ventral; i, k, left half of internal duct system, dorsal; l, opisthosoma showing tracheal spiracle close to epigastric furrow, ventral).

2. Order Acari - General introduction and key to the major groups

Reinhard Gerecke, Gerd Weigmann, Andreas Wohltmann & Eberhard Wurst

Diagnosis

Small to minute in size (body length in general 0.2-2.0 mm, in extreme cases 0.1-30 mm). The ancestral arachnid tagmata, the prosoma and the opisthosoma, not apparent as main body divisions (*2-1*). Opisthosoma completely fused to prosoma; body secondarily divided into: (1) the gnathosoma bearing as appendages the chelicerae and palps, formed in different kinds by the palp coxae and further sclerotized elements of the palp segment; (2) the idiosoma formed by fusion of the leg-bearing region (called podosoma) and the opisthosoma. Often, leg-bearing segments grouped in two parts, with a large area (transversal furrow) separating the segments of legs I and II (propodosoma) from those of legs III and IV (metapodosoma). If metapodosoma and opisthosoma form a functional unit, then the proterosoma (gnathosoma + propodosoma) separated from the hysterosoma (metapodosoma + opisthosoma), thus forming a third level of body subdivision. Genital opening in anterior part of opisthosoma, anal opening in posterior part, both ventrally. Respiratory system evolved in different ways within the main taxa. Postembryonal development plesiotypically including five free-living stages (plus the non-hatching prelarva): larva with three pairs of legs only (*2-3*), three nymphal stages (*2-2, 2-4 g-h*) and the adult (*2-4 a-f*) with the typical arachnid pattern of four pairs of walking legs. Developmental stages relinquished or realized under particular conditions; e.g. in Parasitengona two of the nymphal stages transformed into pupa-like resting stages without appendages (*2-2*).

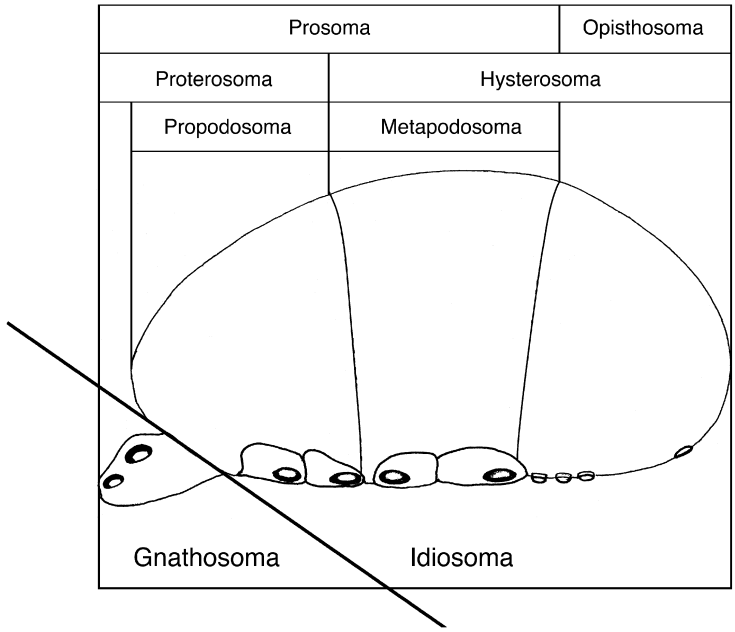

Fig. 2-1: Mite ground plan and basic terminology - for details see chapters „Diagnosis“ and „General introduction“.

I. Bartsch et al., *Süßwasserfauna von Mitteleuropa, Vol. 7/2-1 Chelicerata: Araneae/Acari I*, Süßwasserfauna von Mitteleuropa,
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Introduction

Like other Arachnida, mites are primarily terrestrial, and therefore aquatic mite taxa are derivatives from terrestrial ancestors. The small body size, name-giving for this group of animals (Greek: το ακαρὶ = the mite, from ακαριαῖος = tiny), developed in several groups to an extreme extent. Species so small may appear „terrestrial" only at a first glance: often they are bound to elevated moisture and important steps in mite phylogeny may have taken place in hygric microhabitats. Mites demonstrate a range of morphological and physiological adaptations not found in other orders of Chelicerata. They can be herbivores, carnivores or parasites; they disperse by active migration, passive transport or phoresy, in or without combination with parasitism; they reproduce bisexually or parthenogenetically, and they have radiated successfully in both terrestrial and aquatic habitats.

The suborder Anactinotrichida, with the Opilioacarida, Holothyrida, Gamasida (*2-4 a*) and Ixodida (ticks, *2-3 a*), only includes a few hygrophilic species, mainly in the Gamasida, but not one aquatic taxon. In contrast, in the other suborder, the Actinotrichida, many different clades include hygrophilous species regularly found in aquatic fauna samples, and adaptations to submerged life evolved several times independently. An exploitation of freshwater and marine biotopes, with subsequent adaptive radiation, took place only in two clades: the Halacaroidea, a morphologically homogenous monotypical superfamily with ecological gravitation in marine habitats, and the Hydrachnidia, a subtaxon of the phalanx Parasitengona including about 50 families whose representatives are restricted mostly to freshwater habitats. Both, halacarid mites and hydrachnid mites developed similar morphological and physiological adaptations to a submerged life (e.g. closed spiracles) but display different strategies in their life cycles: halacarid mites are quite homogeneous in morphology and particularly minute in size, and their eggs and early stages can be distributed passively both by water currents and attached to larger animals. Some, or all stages in the life cycle of their freshwater representatives are capable of colonizing extreme aquatic habitats such as high mountain pools with extreme changes in water level. Here they coexist with microcrustaceans, nematodes, oligochaetes, flight active insects, and hygrophilous representatives of „terrestrial" mite groups, „true freshwater mites" (Hydrachnidia) being absent. A prerequisite for the evolutionary success of the Hydrachnidia was probably the presence of a parasitic-phoretic stage in the life cycle of their stem group, the Parasitengona. Parasitism on flying insects enable the Hydrachnidia to migrate horizontally and thus to compensate for the disappearance of habitats due to summer drought or due to changes over a longer time scale. This is obviously necessary for long-term colonization success of inland waters.

Due to the particular radiation of these two mite groups (resulting in about 1000 known species of Halacaroidea and 5000 of Hydrachnidia), the presence of representatives of other mite taxa in aquatic habitats has often been neglected. However, in many habitats such as mountain springs, temporary lowland pools or the hyporheic interstitial, species of Trombidiidae, Oribatida or Acaridida may be found to be dominant in terms of population density. Many of them display well developed adaptations to a submerged life, sometimes during all life stages.

Morphology and terminology

The basic morphological ground plan of the mite body is explained in Fig. *2-1*. Several systems of morphological terminology have developed in terrestrial and aquatic acarological research, particularly in North American, West European and East European scientific traditions. Therefore, a detailed explanation of the morphological terminology and a

specific glossary for each of the mite groups treated in this work are provided in the appropriate chapters.

Sampling and sample processing

Collecting

Due to the minute size of mites, they require a special treatment both during field work and in the laboratory (e.g., BARR 1973, SMITH & COOK 1991, for methodological discussion with particular regard to spring habitats, see GERECKE & DI SABATINO in press). If standard techniques such as Surber sampling, dredging, hand netting or drift sampling are applied (for details see SCHWOERBEL 1994), adult Hydrachnidia can be collected adequately only if the mesh size does not exceed 250 µm. For collecting their larval stages as well as the smaller representatives of mite groups such as halacarids, a mesh size of 100 µm is necessary. Many limnological sampling methods have, however, two major disadvantages: first, they do not adequately represent species with a patchy distribution - species adapted to particular life conditions, accumulating in particular microhabitats at the edge of water bodies, may be easily overlooked or underestimated. Second, especially many species of Hydrachnidia as specialized predators and/or parasites, may be present in population densities which are lower by an order of magnitude compared with other elements of the meiofauna or macrofauna (GERECKE et al. 2005). Consequently, such species, often characteristic elements of the studied habitat, are hardly represented in collections applying area- or time-limited standard methods. For a representative investigation of the acarological diversity, intensive hand-netting is obligatory in all microhabitats. The sediment should be dispersed locally, tufts of plant material vigorously shaken and the material washed and filtered through a net. This method does not allow for quantification, but differences in the relative abundance between the species can be studied.

Since most Hydrachnidia (like many limnic insects) are aerial during particular phases, the use of Malaise traps and sweep nets helps to estimate population densities and both instruments are indispensable tools to investigate population development and phenology. Moreover, soil probing and hand collecting during the dry phases of temporary waters allows the detection of resistant stages and the estimation of survival strategies in such habitats. In the following, we give a more detailed survey on sampling techniques and their application in various habitat types:

Lentic habitats:

1. Dip-nets are often used by hand for sampling in the littoral vegetation, but this technique is also useful in scubadiving in vegetation deeper than 1-2 m.

2. Frame-nets operate like a dip-net but have a square, round or triangular opening. Collecting is accomplished by pulling a frame-net for a certain distance through the sediment to a depth of 2.0-2.5 cm. Each sample taken represents a certain area. Samples are passed through a sieve and are further sorted by eye (TEN WINKEL 1987). Vertical haul: nets are lowered to the bottom and hauled vertically (BAGGE et al. 1996).

3. Grabs are suitable for estimating the density of the organisms living on the bottom. Organisms swimming close to the bottom will also be collected (K. VIETS 1930).

4. Underwater traps can attract mites to a light source or to some kind of bait. Light traps may work on the base of electric (PIECZYNSKI 1962, 1969; BAGGE et al. 1996) or chemoluminescent light sources (BARR 1979a, see there for more practical details) placed in the centre of a polyethylene container with a wire-basket like entrance. Many Hydrachnidia are attracted in particular to yellow-orange light. However, the technique works selectively: a few species, *e.g. Hygrobates nigromaculatus* and *H. trigonicus*, show no positive

phototaxis (DAVIDS et al. 1994). CONROY (1973) proposed an underwater trap working with bait instead of a light source.

Lotic habitats:

1. Extracting and washing of submerged substrata (plants, detritus, stones). The material is at best transferred under water into a net and then put into a white tray filled up to a few cm of clear water. Regular collection of a constant amount of determinate material (e.g. a certain volume of mosses) may provide quantitative indications (BADER 1977). Larger, immovable structures such as trunks of trees and large rocks are brushed *in situ* and the material collected in a hand net.

2. Kick sampling: In a gravelly stream habitat a net is held vertically in the stream, with the mouth opening upstream. The collector stands upstream from the net and vigorously disturbs the substratum to a depth of 15-20 cm, so that detritus and animals are washed into the net. The net is then withdrawn from the water and the sediment collected distributed over the bottom of a white tray (BARR 1973).

4. Additional species with a patchy distribution may be detected by drift netting. In contrast to other stream invertebrates, Hydrachnidia drift with maximum abundance in daylight (SCHMIDT 1969).

5. DEWEZ & WAUTHY (1984) worked with an artificial substratum kept submerged for at least eight weeks. At the end of the experiment, mites were extracted and counted.

Interstitial habitats:

1. The „Karaman-Chappuis" digging is in most cases the technique best suitable for collecting the biocoenosis in the hyporheic interstitial (CHAPPUIS 1942). A hole is dug in the exposed gravels of a stream, deep enough to penetrate the water table. The interstitial water percolating into the hole is removed using a small bucket or bowl and washed through a net or sieves to eliminate turbidity.

2. The use of a so called „Bou Rouch" pump is an often applied alternative (VIGNA TAGLIANTI et al. 1969; BOULTON et al. 1992). This technique has the advantage of being applicable in the absence of gravel banks, pumping the sample directly from the interstitial below the bed of the stream. However, in general, in small streams without sand or gravel banks, the sediments below the running water do not provide habitats suitable for colonization by hyporheobiont specialists. In general, as compared with digging, pumping produces lower numbers of specimens and species and a lower amount of hygrophilous ripicoles, but a higher percentage of species confined to hyporheic habitats (GERECKE et al. 2005).

Semiterrestrial habitats:

For quantitative collecting hygric populations of Acaridida, Oribatida and terrestrial Parasitengona, it is recommended that substrate (algae, moss cushions, detritus) be brought into the laboratory. Mites can be easily extracted from the substrate using a heat-driven dynamic extraction method such as a Berlese- or MacFadyen-apparatus, or the mites can be sorted from the samples directly. However, these methods work selectively and are not suitable for extracting halacarids.

Treatment of samples

Due to their bright colours and/or active behaviour, most deutonymphs and adults of the Parasitengona may be sorted on the spot from the collected material if light is favourable and a flat white pan or tray is used. Mites become active a short time after the sample is poured into the pan and can easily be sorted by eye and picked up with a pipette. Samples with much detritus and silt should be washed carefully through a set of two sieves. By stir-

ring clean water through the upper sieve (mesh size about 1.5 mm.), the mites will accumulate in the lower sieve (mesh size 100 µm). Typical lotic species do not move actively when the sample is removed from the habitat. However, under the influence of rising temperature and decreasing oxygen availability, Hydrachnidia leave the collected substrata to swim or crawl in the open water. Mites living in moss growing at the air-water interface or in cascades often cling tightly. To extract them, a clump of moss is picked apart in a tray of water, strand by strand, with a pair of forceps, carefully searching for mites, or the sample is stirred vigorously until the mites become detached. Sorting in the field is of particular importance if the remaining sample is to be preserved in a fixative such as formalin or alcohol (see below). However, not only representatives of the Halacaridae, Acaridida and many groups of Oribatida which are small in size and less agile, but also larvae and small nymphs of Parasitengona can be sorted only in the laboratory under a stereo microscope, preferably from the living material. Living samples are best transported at a low and stable temperature, bathed by, but not submerged in water (in order to avoid mechanical damage), and in contact with a large volume of air for oxygenation. Most mites are rather resistant against many kinds of stress during sampling and transport and are found still alive in the sample when many of the other invertebrates have died. Also in the laboratory, sorting should be processed through stacked sieves, the top one with a mesh size of 1000 µm, and the bottom one with 60–100 µm, being rinsed with a strong water jet.

In the laboratory, mites can be extracted from bottom mud by placing the sample for 10 minutes in a concentrated magnesium sulphate solution. The sample is stirred occasionally to allow animals to float to the top and the floating mites are subsequently decanted (EFFORD 1965). Further flotation methods, which make use of the specific weight of the animals work with solutions of sodium chloride, sugar or silicate. PROCTOR (2001) got good results with a kerosene-flotation technique. FAIRCHILD et al. (1987) were successful in extracting Hydrachnidia from moss samples by inducing them to respond to a temperature gradient. Preserved samples with little detritus can be stained with Bengal red.

Classification of undissected material

The mastery of dissection and slide mounting techniques (see below) is an important prerequisite not only for the inexperienced student. Confronted with material from little known habitat types or unstudied geographical areas, even a specialist who is an old hand at classifying mites is obliged to produce series of preparations in order to investigate diagnostic characters and their variability range. However, once a certain experience and familiarity with a local fauna is built up, most of the recorded mites may be recognized without preparative work. For instance, large parts of collections from habitats regularly investigated in the course of long term monitoring projects may be sorted under the stereomicroscope to species level. For the solution of problems requiring stronger magnifications (recognition of sexes, separation of similar sister species) it is in general sufficient to examine selected character states under the light microscope, temporarily placing the undissected mites on a concavity slide or, in order to bring the specimen into a particular position, on a slide prepared by the application of a viscous medium such as HOYER'S fluid (see below). In this manner classifying mites from aquatic habitats may become as routine as the study of other groups of benthic invertebrates.

However, specimens which are conspicuous e.g. due to particular dimensions, coloration patterns or aberrant characters merit special attention and should be dissected and slide mounted. Water mites tend to form monstrosities, often probably due to developmental disturbance at the proto- and tritonymphal resting stages, but there are also very rare, often enigmatic species of particular faunistic interest which appear only on rare occasions. Furthermore, selected specimens of the more problematic species should be regularly slide

mounted at regular intervals in order to control the correct taxonomic attribution. In any case, slides as well as material classified without slide mounting should be carefully labelled and conserved for later reinvestigations. For long term preservation in vials, both KOENIKE'S fluid (see below) or 96 % glycerine are suitable media (BARR 1973).

Rearing

The most satisfactory method of obtaining larval material for study is from eggs laid by identified females in the laboratory. Depending on the scope of the study, mites are isolated in couples or as single females in small vials or petri dishes together with substrata suitable for spermatophore and/or egg deposition (e.g. plant stems or pieces of filter paper). Temperature is best at a stable level similar to that of the species' natural habitat. As most species are adapted to starvation, in most cases feeding is not necessary for successful reproduction, at least if females are ovigerous at the start of the experiment. However, eggs should be kept separate from parents in order to avoid feeding by parents on their progeny. If the whole life cycle of a parasitengone species is to be studied, potential hosts are exposed to the freshly hatched mite larvae in small aquaterraria. Completing a parasitic phase demands much ingenuity and effort, no general rules can be given. For the resolution of questions concerning the host range of a selected species, it is recommended to interrupt the experiment when larvae have attached to their hosts and prepare them on microscopical slides (MARTIN 2000, 2003). A rather simple method for investigating parasite-host relations under natural conditions is the exposure of sediments which include both a mite population and their presumptive hosts in plastic bags in the field (GERECKE & MARTIN 2006). However a good knowledge of the fauna of the site is necessary because attribution of larvae and adults cannot be made with 100 % certainty. Bibliography concerning the wide field of specific requirements for successful reproduction is cited in the special part.

Preservation

Mites of the „terrestrial" groups (acaridids, oribatids, terrestrial Parasitengona), also halacarids can be preserved in ethanol (75 %). Some drops of glycerine may be added to prevent the sample from drying out if the ethanol accidently evaporates (see KRANTZ 1978). Formalin should be avoided, at least the animals should be transferred to ethanol as quickly as possible. For histological studies animals should be preserved with glutar aldehyde or Bouin's solution and subsequently be transferred to ethanol. If a sample dries up completely, water with a drop of washing-up liquid or some vinegar should be added. After soaking, the mites are transferred to ethanol. For Hydrachnidia required for dissection and light microscope studies, preservatives containing formalin or alcohol, are particularly disadvantageous. These substances fix the tissues in such a way that they cannot be properly cleared in either basic or acid corrosives. In general, clearing with lactic acid leads to acceptable results in all mite groups.

In the case of strongly sclerotized species like many oribatids, a preceding exposure to hot (90 °C) 10 % KOH is advantageous; combination of KOH followed by lactic acid may also allow clearing of mites preserved in formalin or alcohol. Water mite workers traditionally use as a preservative a glycerine - acetic acid - water mixture commonly referred to as „Koenike's fluid". In the first days following fixation, this liquid may cause a shrinking of the animal and gas bubbles may fill parts of its body. A few days later, the animal extends again, the gas disappears and it becomes clear due to tissue breakdown. At the end of this process, all important characters of the skin as well as the sclerotized parts are clearly visible.

Molecular aspects which have gained increasing importance during the past years can be studied best on specimens preserved in special buffer solutions. Indications that molecular