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Araneus legonensis n.sp. (Araneidae: Araneae) from Ghana, West Africa, and its free sector web

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Summary

A new species of *Araneus* sensu lato, *Araneus legonensis*, is described from Ghana. The pedipalp bulb of the male is remarkable, for it has none of the apophyses that are common in the terminal region of other species of *Araneus*; and because the stipes and embolus are fused to form one sclerite. Some aspects of the spider's ecology are described, especially the web. This has a free sector like the web of *Zygiella* spp. However *A. legonensis* is morphologically quite distinct from *Zygiella*. The adaptive significance and possible evolution of the free sector are discussed. It is thought to be an adaptation to catching prey during the daytime, even though the spider waits for the prey in the retreat.

Introduction

During 1971-1973 the ecology of several species of araneid spiders was studied at Legon, Ghana, when a species of *Araneus* which is evidently new, was found. It occurred at the University of Ghana, Legon (*ca* 16 km north of Accra; 5° 40′ N, 0° 10′ W; altitude *ca* 100-140 m). The surrounding area is coastal savanna (Lawson, 1966), but this species was found on the campus of the university, where the vegetation is park-like, with cut grass and pruned shrubs. However a small part was allowed to grow unattended for two years, during which time a high population of *Araneus legonensis* built up, especially on one *Bougainvillea* bush. Elsewhere on the campus the spider was rare. Unfortunately only one male and one female were preserved before the bush was cut without the author's prior knowledge. From then no mature specimens were seen (there was a drastic reduction in the whole araneid population at that time, probably due to severe drought). The spider was not found elsewhere in Ghana, though as it is small it is probably easily overlooked.

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Family **Araneidae**, Subfamily **Araneinae**, Tribus **Araneini**, Genus *Araneus* sensu lato.

Araneus legonensis n.sp.

Total length: ♀ 5.2 mm, ♂ 4.4 mm. *Cephalothorax:* length ♀ 2.6 mm, ♂ 2.3 mm; width ♀♂ 1.8 mm. *Abdomen:* length ♀ 4.0 mm, ♂ 2.3 mm; width ♀ 3.4 mm, ♂ 2.0 mm. *Fresh weight:* ♀ 39 mg, ♂ 12 mg.

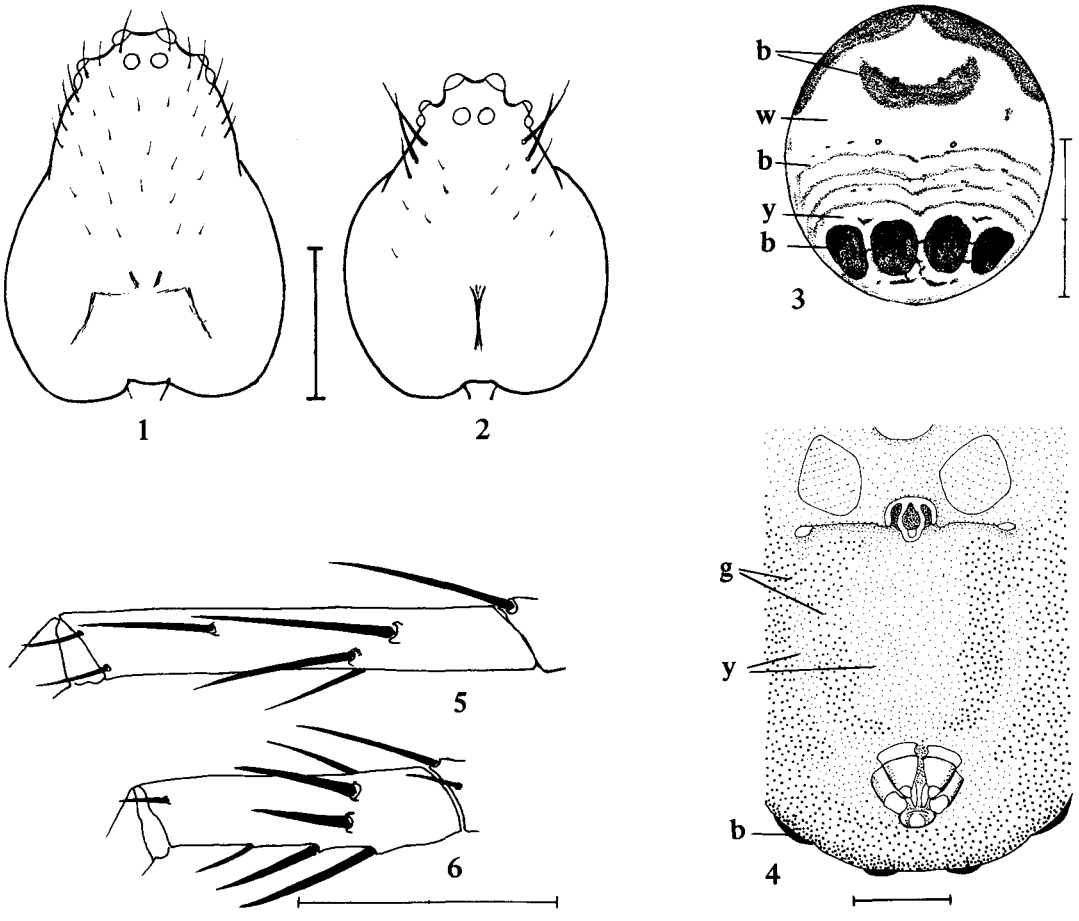
Cephalothorax: form typical for the Araneini (Figs. 1, 2). *Colouration:* both sexes and subadults are similar. Carapace and sternum: chestnut brown; eyes surrounded by black rings. Abdomen: dorsal surface (Fig. 3) white, with black anterior crescent and black on anterior edge, sometimes the two black areas fusing (amount of fusion varying between specimens), and black and yellow markings posteriorly; ventral surface (Fig. 4) bright green and yellow in females, green in males; in alcohol green and yellow fade and white discolours, so white and green appear as dirty white guanophores in fawn matrix, and ventral yellow area as fawn without guanophores. *Legs:* chestnut and olive brown with a black annulation on the end of each tibia and metatarsus; tibiae I-II of male (Figs. 5, 6) with prolateral spines which are slightly thicker than normal spines; coxa II without boss; coxa I with ventro-retrolateral hook and femur II with corresponding baso-dorsal groove.

Length (mm):

	I	II	III	IV
Male	8.0	7.0	4.0	6.0
Female	8.5	7.5	4.5	7.0

Male palp: coxa with pointed lateral boss, patella with two dorsal apical spines, tibia broader than long (as in *Araneus* sensu stricto), paracymbium a slender plug as in most other Araneinae. *Palpal bulb* (Figs. 7, 8): the male bulb is remarkable, because all

apophyses which are common in the terminal region in other Araneinae are lacking; the stipes (Figs. 7, 8, s) and the short pointed embolus (e) form one fused sclerite; the radix (r) is large. The basal and median part of the bulb are formed as in other Araneinae: the tegulum (t), with a boss (b), bears the median apophysis (m) and the conductor (c), on which the tip of the embolus is pressed and thus protected. The median apophysis forms a strong hook, which doubtless clings to the spoon-like apical furrow of the epigyne during copulation. *Epigyne* (Figs. 9-11): short and compact, the scapus is short and immovable, it arises from the antero-ventral surface of the epigyne as a wide plate with a deep median furrow that forms a pocket-like cavity at its posterior end (Fig. 10). The openings are lateral (Fig. 9), and the short vulvae run to large receptacula (Fig. 11, dotted line).



Figs. 1-6: *Araneus legonensis* n.sp. **1** Female cephalothorax; **2** Male cephalothorax; **3** Female abdomen, dorsal view; **4** Ditto, ventral view (colouration in live specimens: b = black, g = green, w = white, y = yellow: green and yellow appear fawn in preserved specimens); **5** Prolateral view of male tibia I; **6** Ditto, tibia II.
Scale lines: 1-3, 5, 6 = 2.0 mm; 4 = 0.5 mm.

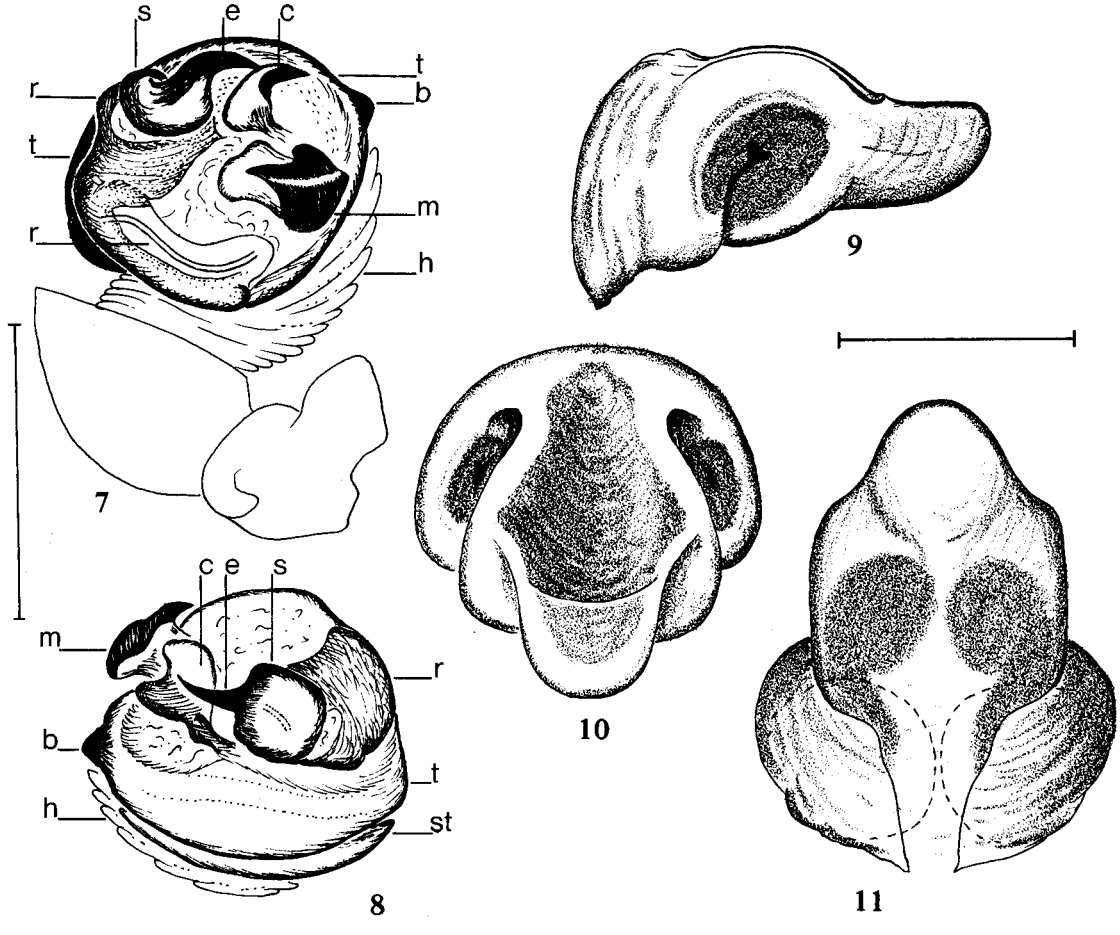
Material

The material has been deposited in the collection of the Senckenberg Museum: 1♂ holotype (SMF 29966), 1♀, 1 juv. paratypes (SMF 29967).

Affinities

The new species has to be placed into the genus *Araneus* sensu lato. It does not belong to the genus *Araneus* sensu stricto (Grasshoff, 1976), which includes many palaearctic and nearctic species, e.g. *Araneus diadematus* Clerck, *A. angulatus* Clerck and other familiar orb-weavers. On the other hand, the species will not fit into any other genus, but a description of a new genus seems to be inappropriate without a wider revision of the Tribe Araneini. The position of *A. legonensis* in *Araneus* sensu lato will undoubtedly by corrected with such a revision.

Although the orb-web of *A. legonensis* has a missing segment, which is a typical feature of the web



Figs. 7-11: *Araneus legonensis* n.sp. **7** Male palpal bulb, view of the median apophysis; **8** Ditto, view of the stipes-embolus region (c = conductor, b = boss of tegulum, e = embolus, h = basal haematodocha, m = median apophysis, r = radix, s = stipes, t = tegulum); **9** Female epigyne, lateral view (black = epigyne opening); **10** Ditto, anterior ventral view, with deep furrow and posterior scape pocket; **11** Ditto, posterior view (dotted line = receptacula).
Scale lines: 7, 8 = 0.5 mm; 9-11 = 0.25 mm.

of *Zygiella*, they are morphologically dissimilar, especially in the copulatory organs.

The structure of the male palpal bulb is remarkable, as it has no terminal or subterminal apophyses, which commonly occur in other species of Araneinae.

The web of *Araneus legonensis*

Structure of web

The web of *Araneus legonensis* has a free sector like that of *Zygiella* spp. (Fig. 12). There is a retreat at one corner to which runs a guide line from the hub, and to which are attached the top and side frame threads. The commonest shape of the frame is triangular, though webs with more than three attachment points occur occasionally. However, except for the corner by the retreat, there are secondary frame threads that restrict the catching area. The catching area is oval along the axis of the guide line, but the quarter away from the retreat is the largest. The hub is pulled towards the retreat by the guide line. The radii on either side of the free sector are bowed away from it by the tension of the spirals. These are probably laid along the radii by the spider turning back at the free sector, as alternating thick and thin sections can be seen along these radii. This indicates that these spirals are not bitten out. No webs were seen without a free sector, though very small spiders were not found. The angle between the radii bordering the free sector and the angle the guide line makes with the vertical in the webs of six spiders are given in Table 1.

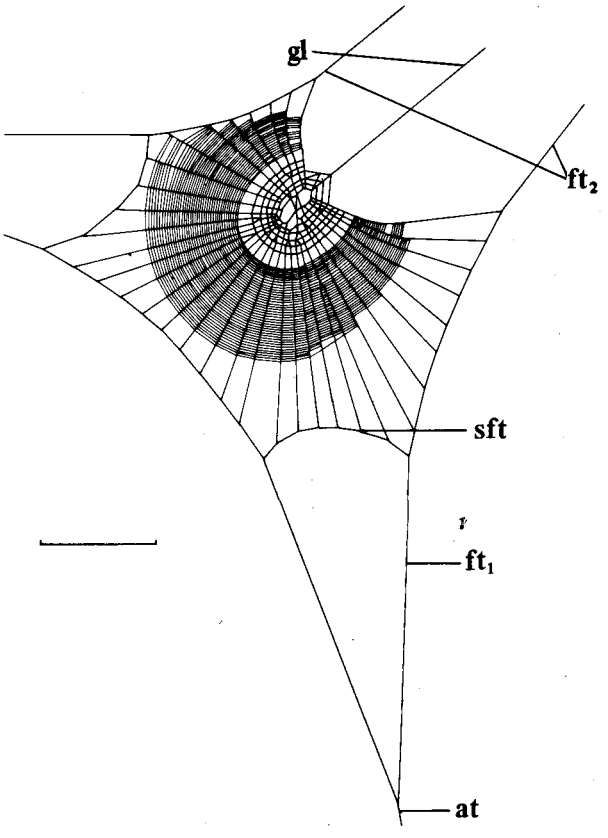


Fig. 12: Web of *Araneus legonensis*. This web spanned a wide space, and so had long anchor and frame threads, of which only parts are shown (gl = guide line to retreat; ft_1 = frame threads; ft_2 = frame threads going to retreat; sft = secondary frame threads; at = anchor threads).
Scale line = 50 mm.

Retreat

In all webs seen, the retreat was in the same plane as the web. The retreat consists of a silk sheet, about 15 mm long, on the upper surface of a leaf. It causes the edge of the leaf to curl up slightly, and only leaves of approximately 30 x 15 mm are used. The spider builds a retreat by spinning threads in different directions from one side of the leaf to the other (Fig. 13). Then the spider, with its spinnerets spread, covers first the outer then the inner surface with opaque white silk laid down in a series of circles and irregular zig-zags. The spider rests on the under surface of the silk sheet, usually with the tips of its first pair of legs just visible on the guide line. The retreat is undoubtedly defensive, hiding the spider from visually orientated predators. The commonest of these in the area are probably the sphecid wasps, *Sceliphron spirifex* L. and *Chalybion fuscipenne* Smith. *A. legonensis* was never found in their nests, though the other *Araneus* found in the area, *A. rufi-*

Angle of guide line from vertical	70°	30°	50°	50°	50°	80°	**mean** 55°
Angle of free sector	75°	70°	50°	100°	90°	50°	72.5°

Table 1: Angle of guide line from vertical, and angle between radii bordering free sector in six webs of *Araneus legonensis*.

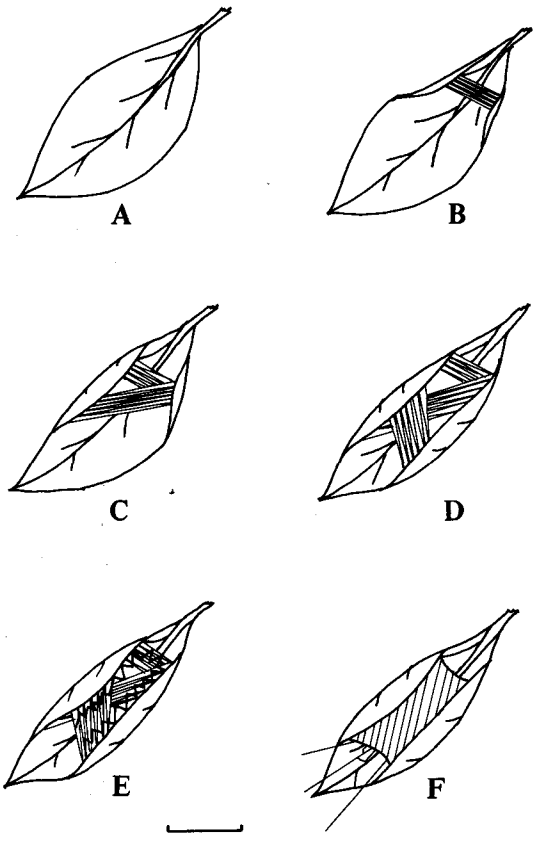


Fig. 13: The building of a retreat by *Araneus legonensis*. **A** Upper surface of leaf before retreat is built; **B-D** Fine silk threads laid (diagram shows direction of threads, but not exact number); **E** Thick, opaque silk laid in irregular zig-zags on fine silk; **F** Completed retreat with two threads from frame of web, and in the centre, the guide line on which the spider's first legs are resting.
Scale line = 10 mm.

palpis (Lucas) and *A. cereolus* (Simon), were both taken by the wasps. The spider's colouration is probably protective: the dorsal surface of the abdomen is white and is probably cryptic against the silk sheet if seen from an opening of the retreat; the ventral surface is green and is cryptic against a leaf. The retreat is also a protection against predation by the olfactorily orientated red weaver ant, *Oecophylla longinoda* (Latreille), a voracious carnivore which frequently occurred in the vegetation, where webs of *A. legonensis* were found. Ants forced to run over leaves with retreats of *A. legonensis* did not attempt to enter the retreat, and when the spider was present avoided the silk sheet, though they occasionally crossed the silk of empty retreats. However, on one occasion a spider was seen at the web hub, while three ants investigated the retreat, although they did not attempt to enter it. The retreats that were examined had fine threads across both ends. Spiders usually dropped from the retreat when disturbed, though they occasionally ran onto the web. In one instance a male and female were taken from what appeared to be a single retreat.

Position of web and prey capture

The web is completely or partially attached to the same bush as the retreat. It may either be built close to the surface of the vegetation, sometimes penetrating into it, or else spanning a space between widely separated branches, sometimes on different bushes. Because of this variability in position, the length of the frame, and especially the anchor threads, varies considerably, and anchor threads of more than one metre are fairly common. Threads are seldom attached to the ground. The webs are usually about two metres from the ground (Table 2). A third of the webs (n = 30) were found in full sunlight at midday, though none were in sunlight for all the day, but they were seldom found in deep shade. The web is relatively small and fine meshed, usually at a slight angle to the vertical (Table 2). As is to be expected the prey caught are small: of 30 prey items, 86.7%

Measurement	Mean	Standard error	Range
Height of web hub from ground (m)	1.81	0.085	0.8 – 2.8
Diameter of web (mm)	120	4.4	50 – 200
No. spirals crossing 50 mm of radial	28.5	–	36 – 21
Angle from vertical (°)	9.5	–	0 – 40

Table 2: Height of web hub from ground, diameter of web (mean of vertical and horizontal diameters), mesh size and angle of web from vertical in *Araneus legonensis* (n = 30).

were < 5 mm and the rest were 5-9 mm. *A. legonensis* readily responds to prey during the day. Nevertheless, the number of prey captures in eight hours (from *ca* 08.00 – 16.00) was on average only 0.39, and spiders were observed eating on only 6.3% of 382 observations. The web of *A. legonensis* was smaller and finer than that of *A. rufipalpis* and *A. cereolus* living in the same biotope (Edmunds, in prep.); from casual observation on the latter two species they catch larger prey, especially Lepidoptera. *A. legonensis* caught fewer prey items than any other species of araneid in the area for which there are detailed data (Edmunds, in prep.).

Web building

The webs of *A. legonensis* nearly always appeared newly built in the early morning about 07.30 (sunrise is at 06.00 ± *ca* 15 mins.). Heavy rain at about dawn usually results in the spiders not building that day, though sometimes webs are built late. Badly damaged webs are usually taken down by the spider during the day. Three webs that had been badly damaged by prey were seen between three-quarters of an hour and one and three-quarters of an hour later to be completely destroyed, and a web that was damaged by the observer was later replaced by the spider with a single thread. After a heavy rainstorm several spiders had one or a few new threads, and none had damaged webs. Two of these spiders started to rebuild; for one a complete web was seen, the other was caught by a salticid after it had laid a few radials. Although spiders rebuilt on most mornings, in 21.0% of the observations (n = 795) they did not do so. In such cases they remained in the retreat, and webs were never left up from the previous day, unlike the web of *A. rufipalpis* with thicker threads, which was sometimes left for more than one day.

The evolution of webs with free sectors

Although the web of *A. legonensis* appears similar to that of *Zygiella* spp. there are some differences. The web of *A. legonensis* seems to be less variable than does that of *Zygiella*, though further observations are required to confirm this. The retreat in *A. legonensis* is always in the same plane as the web, above the hub, and there is always a free sector. In *Zygiella* the retreat may be in a different plane from the web, it may very occasionally be below the hub, and the web may be entire (Marples & Marples, 1971; pers. obs.). Wiehle (1927) observed that *Z. x-notata* (Clerck) always builds an entire web if the retreat is at an angle of 40° or more to the plane of the web; the web form is determined as the frame is laid down; entire webs have complete frames, whereas in those with a free sector a gap is left in the frame with threads going to the retreat. Since there are considerable morphological differences between *Zygiella* and *A. legonensis* there seems to be no doubt that the free sector evolved independently in the two. A free sector has also evolved in the webs of some smaller species of *Metazygia* (H. W. Levi, pers. comm.).

A. legonensis catches prey readily during the day. In this it contrasts with the two other species of *Araneus* in the same biotope. *A. rufipalpis*, which has an entire web with a guide line to the hub, remains deep in its long retreat of leaves during the day, and seldom responds to prey, or responds slowly. However at dusk it either sits at the hub, or else at the edge of the web, or beside its retreat; such behaviour is seen in several species of *Araneus*. *A. cereolus* has a web that is only present during the hours of darkness. During the day and at dusk, *A. legonensis* always remains in its retreat with its front legs on the guide line, ready to respond to prey. *Zygiella* also remains in its retreat during the day, but comes out onto the web when prey is struggling in it. However, at night, *Z. x-notata* and *Z. atrica* (C. L. Koch) sit at the web hub (Marples & Marples, 1971), which will allow even quicker access to all parts of the web. During the day, *Z. x-notata* reaches the hub rapidly; Tilquin (1942) observed that it can reach the hub faster than *Araneus redii* (Scopoli), but doubted if this was an advantage, and considered the free sector to be 'neutral' and of no function.

However, evolution is brought about by transformations that increase the efficiency of the system. Therefore, we have to explain the development of all structures as adaptations (Peters & Gutmann, 1971). The observations on the behaviour of *A. legonensis* and *Zygiella* given above, support the theory that the free sector is an adaptation to increasing the efficiency of prey capture during the daytime. If the mechanical characteristics of the web are considered, the evolution of the free sector can be outlined.

The best position for a spider when it is catching

prey is at the centre of the web, the hub, from where it can climb along the radial threads to reach every part of the web. However, in this position, the spider is exposed to visually orientated flying predators, which explains why many orb-weavers, especially Araneinae, spend the daytime in a retreat, and only sit at the hub during darkness or at dusk and dawn. Under these circumstances, it is an advantage for the spider that catches prey during the daytime to move rapidly from its retreat to the hub only when prey is actually struggling in the web. This behaviour may be observed in *A. diadematus* and *A. marmoreus* Clerck when they begin to catch prey during a bright afternoon, and always occurs in *A. legonensis*. Since the spider always uses the same thread to reach the hub from its retreat, the spiral threads attached to this radius will tend to become damaged and to impede the spider's movement. There are two ways in which the disadvantage of these sticky threads can be overcome. Firstly they can be removed either by biting them out, or by omitting them altogether when the web is built. The thread so produced is a guide line which allows the spider to reach the hub quickly from the retreat. Alternatively the retreat and guide line from it to the hub may be displaced from the plane of the web.

In a web with a free sector there is a reduction in catching area, but this disadvantage is evidently outweighed by the advantage of being hidden in a retreat and yet being able to reach the hub quickly. There is no such reduction in catching area if the retreat and guide line are behind an entire web. Both possibilities occur in *Zygiella*, but in other species one method can evolve without the other, and the two are not necessarily steps in one evolutionary sequence. A free sector is apparently always present in *A. legonensis*. Thus it appears that a free sector can only evolve when the retreat is in approximately the same plane as the web. It is an adaptation giving increased efficiency in prey capture when the spider remains in the retreat during the day, as it has rapid access to the web.

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