Early Cretaceous Spider Web with Its Prey

Enrique Peñalver,[1] David. A. Grimaldi,[1]* Xavier Delclòs[2]

Spider silk is uncommonly fossilized, primarily in amber and usually as isolated strands. The oldest record is from the Early Cretaceous, which is a single silk strand with droplets in Lebanese amber (*1*). Here we describe an association of insects trapped within a spider web made by Araneoidea preserved in an aerial, cylindrical stalactitic mass of amber from the San Just site in Spain, which is Early Cretaceous in age (~110 million years ago).

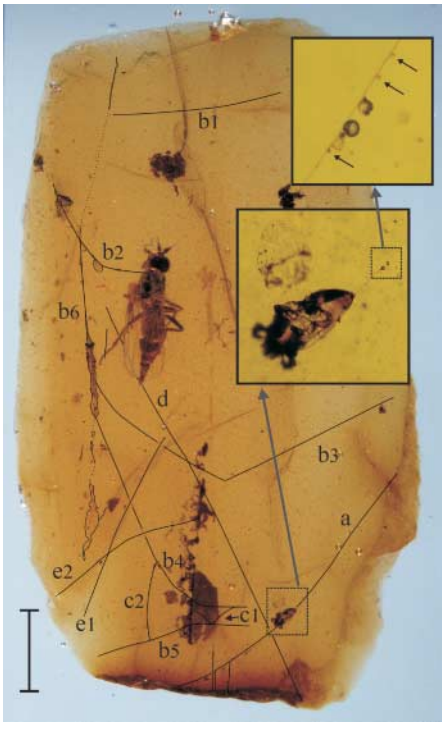

Fig. 1. Spider web with adhered arthropods from the Early Cretaceous of Spain (strands are not visible in the photomicrograph, so they have been drawn in here). A map of silk strands in the amber portion, with a *Microphorites* fly and a mite (CPT-963 and CPT-964), also shows details of the rectilinear strand with droplets to which a mite adheres (upper box shows the measured droplets, two big and three small, arrows). Five strands are in the same plane and have a similar orientation and thickness (b1 to b5), and three of them are connected perpendicularly to an incomplete strand (b6), but the other two strands are possibly also connected. Two consecutive main strands are connected by two very thin strands (c1 and c2); one of them was broken inside the resin and appears bent (c1). Another long strand is crossed by a longer rectilinear strand with the same thickness (d). These two strands cross at an acute angle, like the intersection of two silks in this amber portion but which lie in a different plane and are unconnected to the main group (e1 and e2). Other views of the amber piece reveal a more extensive web. Scale bar, 1 mm.

The amber stalactite, originally 18 mm × 7.5 mm, was prepared in three small sections of amber embedded in epoxy resin to stabilize it. There are at least 26 silk strands in the three amber sections that are rectilinear or slightly curved, but two strands have the shape of hanks (fig. S1). Glue droplets are visible on two strands (diameter 3.4 μm; two droplets have a large diameter, 11.3 to 13.0 μm, surely a result of water absorption); the droplets are unusually small compared with the size range of other fossil droplets, but they are within the range of extant species, as in the case of Linyphiidae with 2 to 10 μm (*2*). The two viscid strands are one rectilinear, long strand with an adhering mite (Fig. 1) and another with an adhering beetle (Cucujidae). The longest strand is 5.7 mm in length. The thickness of the silk strands ranges from 0.6 to 1.9 μm.

The most interesting web fragment is in the amber section with a *Microphorites* fly and a mite trapped by the strands. This section contains 16 silk strands, 5 of which are in the same plane and have a similar orientation and thickness. Three of these five strands are connected perpendicularly to an incomplete strand, but the other two strands are possibly also connected. Two consecutive main strands are connected by two thin strands that can be interpreted as two contiguous strands of a sticky spiral between two consecutive radii (Fig. 1). The above-described web portion suggests an orb web, but the overall geometry preserved indicates that other kind of webs are possible, e.g., a comb-footed spider cobweb. In another amber section (fig. S1), there is a thicker bifurcate thread, which is made up of numerous thinner strands without droplets and which snagged one leg of a *Cretevania* wasp.

Two strands in the amber pieces without droplets but forming hanks indicate that the silk had great elasticity. The web apparently made partial contact with the resin and then some of the strands contracted violently because of the release of tension from breaking. Elasticity allows the web to absorb the kinetic energy of flying prey. The web had a vertical orientation, because the longest main strands of the three amber portions were originally oriented in a similar direction as the longitudinal axis of the runnel. The high diversity of Araneoidea compared with Deinopoidea is associated with the replacement of primitive cribellar capture thread by viscous adhesive thread and with a change from a horizontal to a vertical orb-web orientation. As a consequence, the changes increased the orb web's capacity to intercept and retain winged insects (*3*).

The diversification of spiders is thought to be related to the radiation of insects (*4*), and this is likely the case for aerial webs and winged (pterygote) insects. Many paraneopterans are of appropriate size for capture in webs, but the most diverse flying insects are the four large orders in the Holometabola: Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Major radiations within each of these and several other orders occurred with the angiosperm radiations in the Cretaceous (*5*). Small (1- to 2-mm-long) Diptera, then Hymenoptera, then Coleoptera are the most abundant prey of modern araneid spiders (*6*), and these are represented as the prey items in the fossil web. Spider webs may have imposed substantial selection pressures for Cretaceous insects, and this amber record confirms that araneoid web capture is indeed old enough to have affected the early evolution of diverse groups of flying insects.

References and Notes

1. S. Zschokke, *Nature* **424**, 636 (2003).
2. S. Zschokke, *European Arachnology* **2003**, 367 (2004).
3. J. E. Bond, B. D. Opell, *Evolution* **52**, 403 (1998).
4. D. Penney, *Trans. R. Soc. Edinb. Earth Sci.* **94**, 275 (2004).
5. D. A. Grimaldi, M. S. Engel, *Evolution of the Insects* (Cambridge Univ. Press, New York, 2005).
6. W. Nentwig, *Oecologia* **66**, 580 (1985).
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Supporting Online Material

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Figs. S1 and S2

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[1]Department of Entomology, American Museum of Natural History, New York, NY 10024, USA. [2]Departament d'Estratigrafia, Paleontologia i Geociències Marines, Facultat de Geologia, Universitat de Barcelona, 08028 Barcelona, Spain.

*To whom correspondence should be addressed. E-mail: grimaldi@amnh.org

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*To whom correspondence should be addressed. E-mail: grimaldi@amnh.org

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This PDF file includes:

Figs. S1 and S2

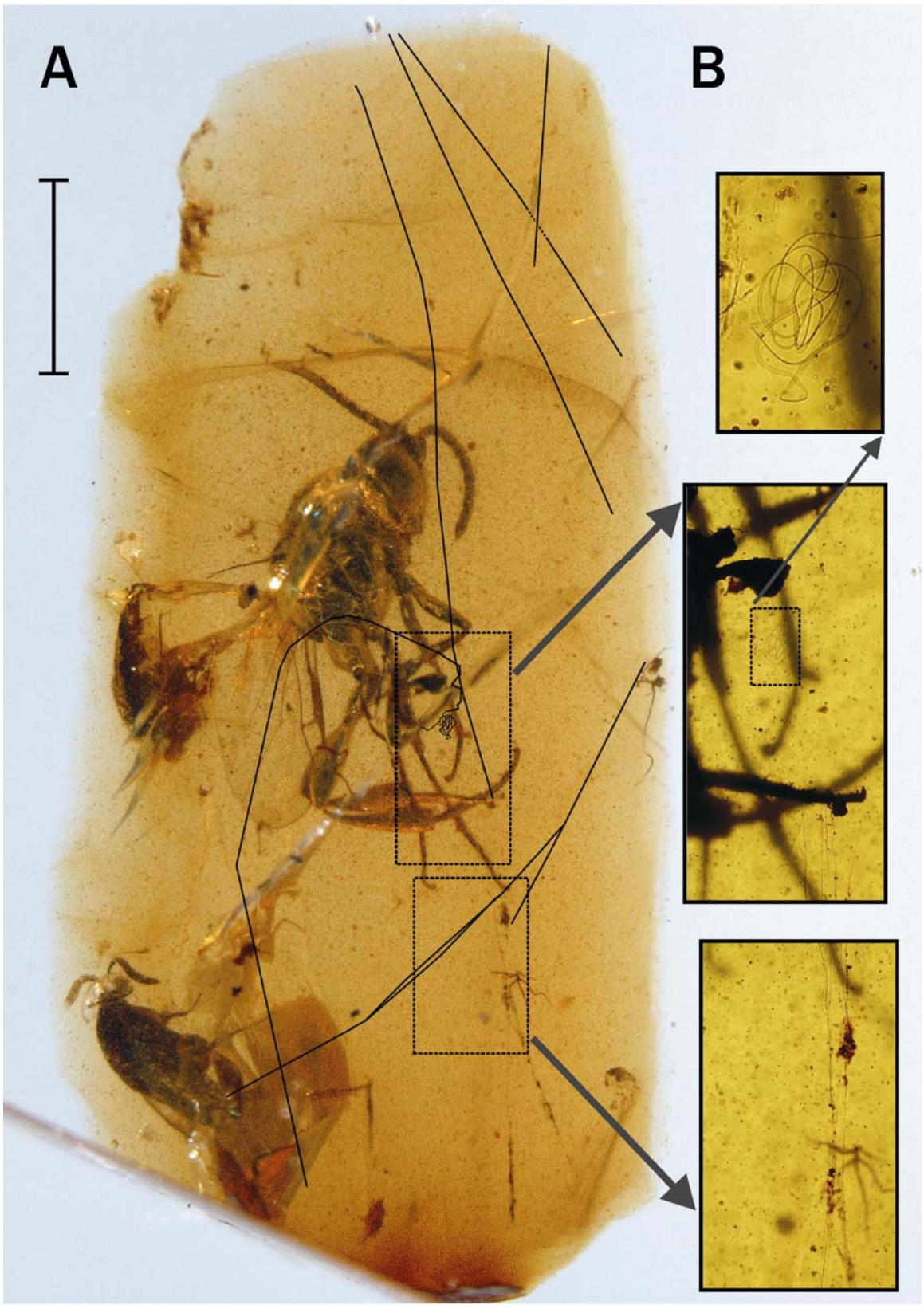
A
B

Fig. S1. c.110-million years old piece of amber from San Just, Spain, preserving a spider web with captured prey. Only some strands are visible in the photograph and so most are traced here as black lines. (**A**) map of silk strands in the amber portion with a *Cretevania* and stigmaphronid wasp (CPT-960 and CPT-961; collection of the "Fundación Conjunto Paleontológico de Teruel", Spain). (**B**) Details of the thicker bifurcate thread that snagged the leg of the *Cretevania*, comprised of numerous thin strands without droplets, and one hank-shaped strand. In this portion also there are 7 silk strands in the same plane, with a geometry and thickness like that in the *Microphorites* portion, some of them in contact with the *Cretevania* wasp and the thicker bifurcate thread. The wasp has the metasoma partially damaged and impregnated with resin, like the *Microphorites* and the beetle, indicating they were dead before immersion in the resin, much the way insect prey remains on a web after the spider siphons the liquified internal organs. The longest axis of the piece corresponds to the original longitudinal axis of the runnel. Scale bar 1 mm.

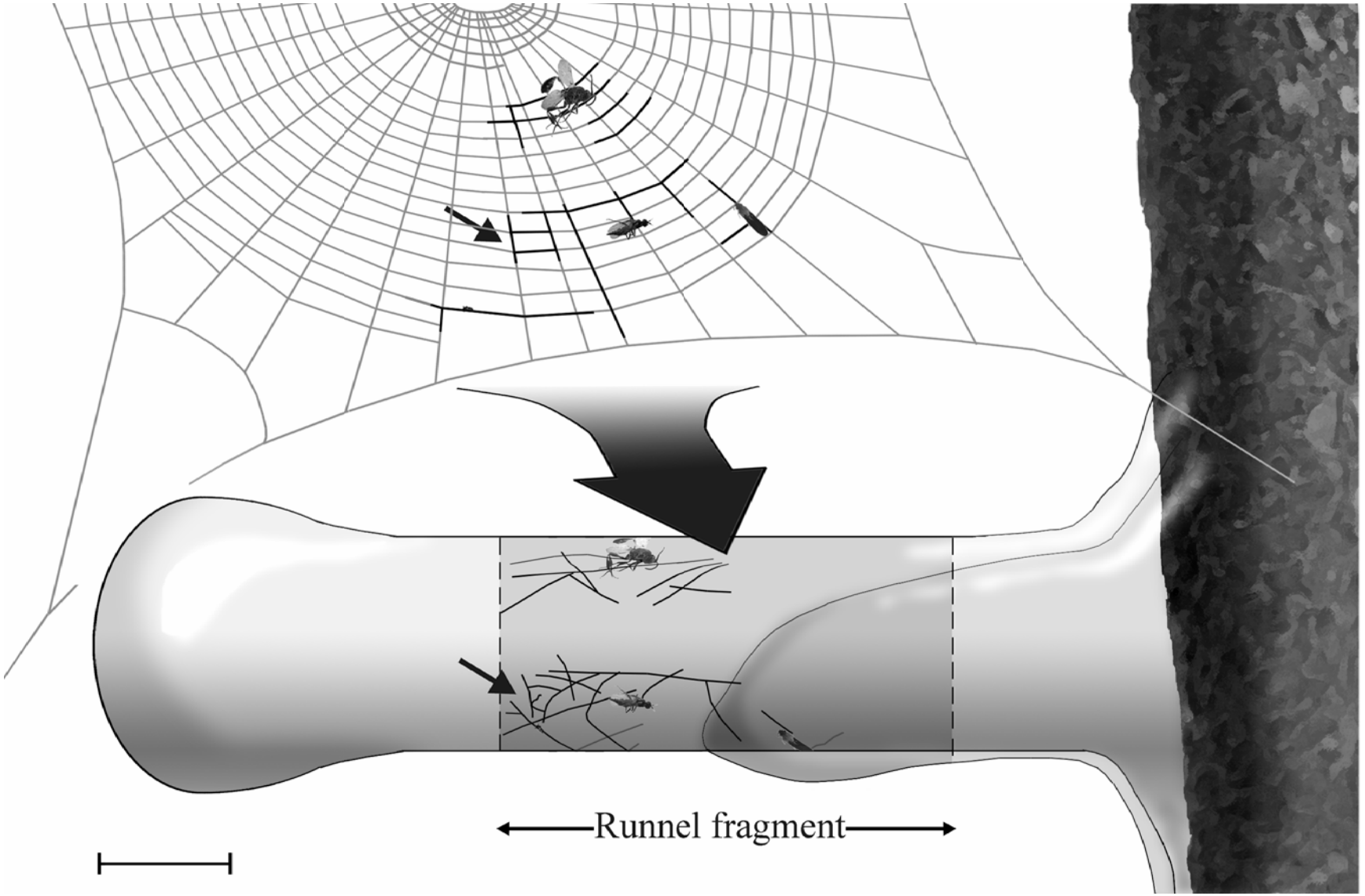
Runnel fragment

Fig. S2. A possible reconstruction of the fossil web, based on fragments with arthropods in the amber runnel. A small, idealized orb web was constructed on or near an araucarian branch, showing only those arthropods with direct contact with the silks. The arrows indicate the portion that can be interpreted as two contiguous strands of the sticky spiral between two consecutive radii. Scale bar 0.5 cm.