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A new species of *Amphorophora* (Homoptera: Aphididae) on *Geranium macrorrhizum* in Britain

P. A. BROWN and R. L. BLACKMAN

Department of Entomology, British Museum (Natural History), London

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Amphorophora tuberculata sp. nov. is described from *Geranium macrorrhizum* L. in Britain. It is specific to this host plant which is native to montane regions of central and southern Europe. All morphs are described. This species has the lowest possible chromosome number, $2n(♀)=4$.

Introduction

The genus *Amphorophora* is mainly associated with *Rubus*, but some species occur on other Rosaceae and a few have become specialized feeders on certain other plants, notably ferns. The only geranium-feeding species of *Amphorophora* known hitherto have been nearctic; *A. geranii* Gillette and Palmer occurs on wild geraniums (*G. richardsonii*) in mid-western U.S.A., and *A. coloutensis* Smith and Knowlton has recently been described from *G. richardsonii* and *G. fremontii* in the same area.

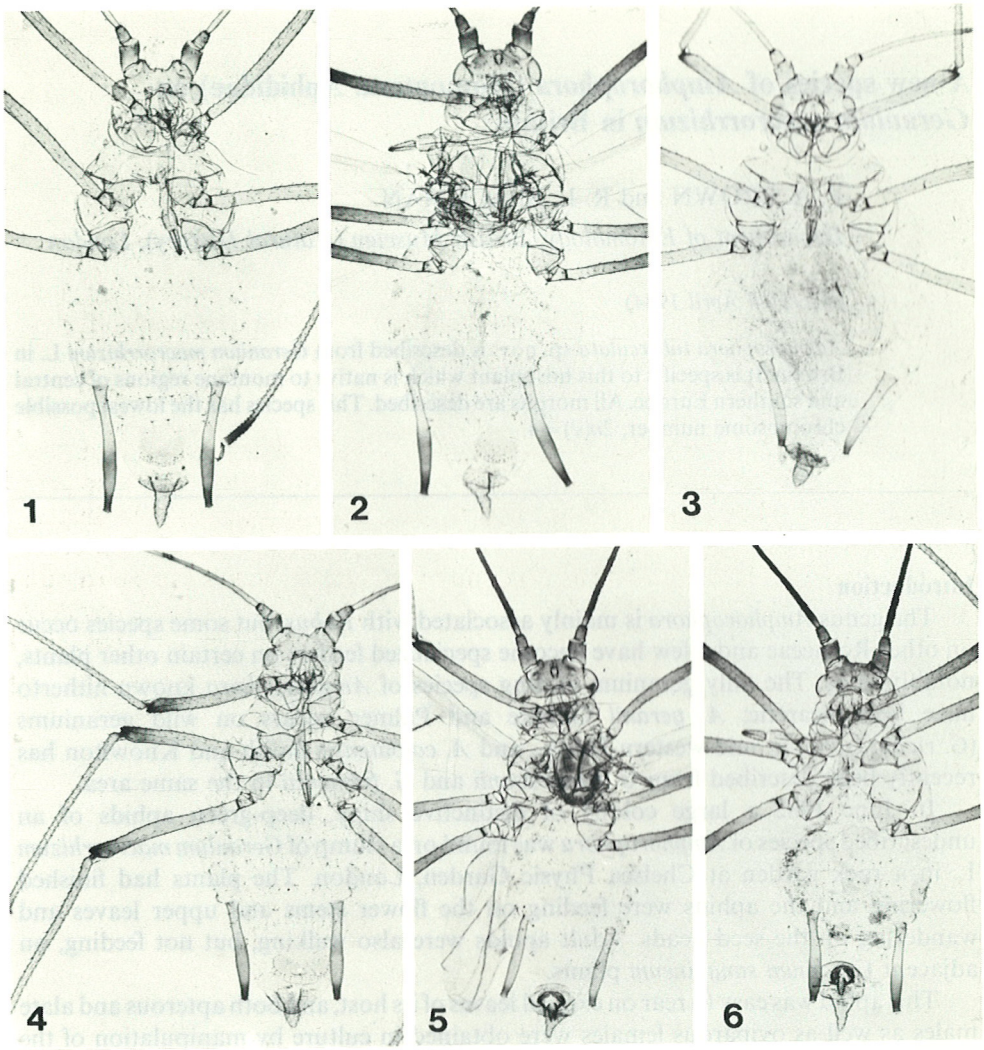
In June 1982 a large colony of distinctive shiny, deep-green aphids of an undescribed species of *Amphorophora* was found on a clump of *Geranium macrorrhizum* L. in a rock garden at Chelsea Physic Garden, London. The plants had finished flowering and the aphids were feeding on the flower stems and upper leaves and wandering on the seed heads. Adult aphids were also walking, but not feeding, on adjacent *Geranium sanguineum* plants.

This aphid was easy to rear on excised leaves of its host, and both apterous and alate males as well as oviparous females were obtained in culture by manipulation of the photoperiod. In spring 1983 some fundatrices were collected from *G. macrorrhizum* in a garden in Chiswick, West London, so that description of all morphs of the new species can now be given, together with information about the karyotype, host plant relations and biology.

Amphorophora tuberculata sp. nov.

(Figs. 1–9)

Apterous viviparous female (fig. 1) (based on 42 specimens). Pigmentation in life: head yellow-green with eyes dark red; antennal segments I and II yellow-green, segments III, IV and V yellow-green each shading to black distally, segment VI mainly black; rostrum yellow-green with dark apex to last segment. Thorax dark shiny green; coxae pale, femora yellow-green becoming yellow fuscous distally and black apically, tibiae yellow with black apices, tarsi black. Abdomen uniformly green, shiny, slightly lighter than thorax; siphunculi pale green on basal half, shading distally through fuscous to black at apices; cauda very pale green. Immature stages pale grey-green in early instars, becoming deeper green in later instars.



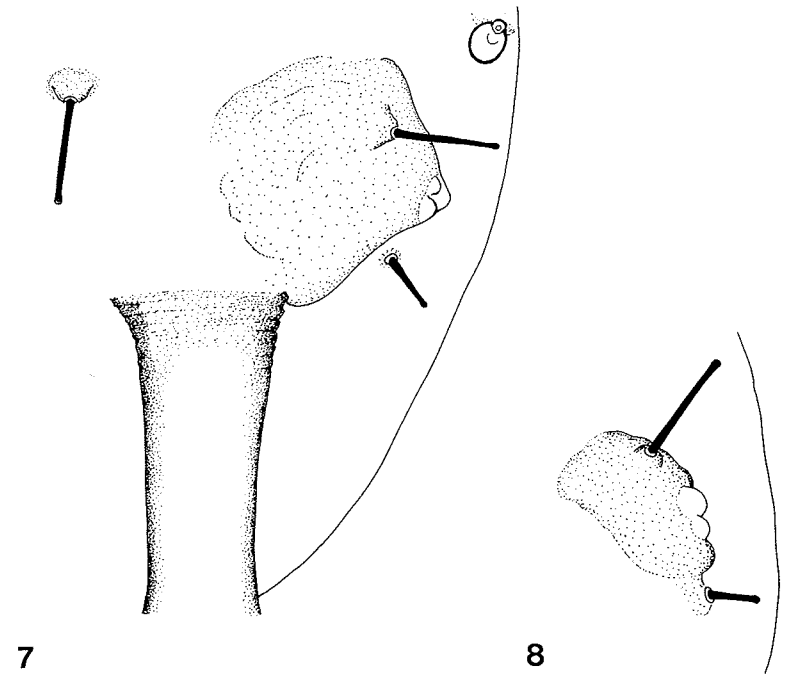
FIGS. 1–6. *Amphorophora tuberculata* sp. nov. 1, apterous viviparous female (HOLOTYPE); 2, alate viviparous female; 3, fundatrix; 4, oviparous female; 5, alate male; 6, apterous male.

Body 2·18–3·42 mm. long, broadly spindle-shaped with maximum width at abdominal segment III. Head smooth with well-developed, smooth, divergent tubercles. Dorsal cephalic hairs long, more than 1·5 times longer than basal diameter of antennal segment III, with thickened apices. Antennae 1·2–1·5 times longer than body; processus terminalis 4·7–7·3 times longer than base of antennal segment VI and 1·1–1·6 times longer than segment III. Ratios of lengths of antennal segments III and VI are 100 : 95 : 75 : 22 + 138. Some individuals (seven out of 42) have one or two secondary rhinaria on basal third of antennal segment III. Antennal hairs rather long with thickened apices; longest hairs on III 30–40μ, 0·7–1·2 times longer than basal diameter of segment. Rostrum extending to third coxae, with apical segment 0·17–0·20 mm. long 1·9–2·6 times as long as the short second segment of the hind tarsus, and bearing 21–28

accessory hairs. First tarsal chaetotaxy 3,3,3; second segment of hind tarsus with 8–14 hairs.

Abdominal tergum pale, mainly membranous, rather smooth. Siphunculi rather large and clavate to a varying degree, the maximum width of the swollen part 1·2–1·9 times greater than the minimum width basal to the swelling; siphunculi 2·1–2·6 times longer than cauda, 0·9–1·2 times as long as antennal segment III and 0·26–0·34 times as long as the body, mainly smooth with a few transverse striae just below the well-developed flange. Cauda long, rather pointed, tapering but with a slight constriction just basal to the mid-point of its length; 0·10–0·14 of body length and bearing 10–19 long, curved hairs with pointed apices. Dorsal abdominal hairs 30–70 μ long with thickened apices, numbering six to ten on tergite III and five to eight on tergite VIII; the bases of the dorsal hairs are often slightly tuberculate and placed on small pale sclerites. Sub-genital plate pale, with two to eight anterior hairs and 9–16 hairs on the posterior margin.

Lateral tubercles are generally present and usually well-developed on the prothorax and abdominal segments II to V. Usually one or more large transparent tubercles are placed on a raised and lightly sclerotized area of cuticle, most prominent on abdominal segment V where it forms a rounded or conical process at the base of the siphunculus (figs. 7–8). Two lateral hairs of unequal length are usually associated with each tubercle; one anterio-dorsal to the tubercle and similar in length to or longer than the nearest pleural hair, about 1·5–2·0 times longer than the other, which is posterio-ventral to the tubercle. The shorter, more ventral hair is sometimes duplicated.



FIGS. 7, 8 Lateral tubercles of *A. tuberculata*. 7, on abdominal segment V; 8, on abdominal segment IV.

Alate viviparous female (fig. 2) (based on 26 specimens). Pigmentation in life: head yellow-green shading to fuscous on frons with ocelli conspicuously ringed with black. Antennae black except for base of segment I and extreme base of segment III. Thoracic lobes pale yellow-brown. Legs darker than in aptera. Wing veins dark brown, not bordered. Abdomen uniformly pale green, shining dorsally.

Body length 2·64–3·10 mm. Antennae 1·3–1·5 times longer than body; processus terminalis 5·7–7·3 times longer than base of antennal segment VI and 1·3–1·6 times longer than segment III. Ratios of lengths of antennal segments III to VI are 100:95:77:23 + 147. Antennal segment III with a row of 11–19 secondary rhinaria extending over most of its length; segment IV with zero to three rhinaria (one to three present in 8% of individuals examined). Wing venation normal, media twice-branched.

Abdomen usually with small, lightly pigmented intersegmental pleural sclerites, and with very pale and ill-defined raised lateral sclerites on abdominal segments II to V which, as in the aptera, usually bear large tubercles and two hairs of unequal length. In the alata the area of lateral sclerite between the lateral tubercle and the spiracle on each of abdominal segments II to IV bears rows of minute spinules. Siphunculi are rather more clavate than in the aptera; maximum width of swollen part 1·5–2·3 times the minimum width basal to the swelling, Siphunculi 2·5–3·4 times longer than cauda, 0·8–1·1 times as long as antennal segment III and 0·26–0·32 of body length. Cauda about 0·10 of body length and bearing 10–15 hairs.

Fundatrix (fig. 3) (based on five specimens). Pigmentation in life is similar to apterous vivipara. Body oval, broader than that of apterous vivipara, 2·66–3·00 mm. long. Antennae 1·1–1·3 times longer than body; processus terminalis 5·5–6·1 times longer than base of antennal segment VI and 1·0–1·2 times longer than segment III. Ratios of segments III to VI are 100:66:55:19 + 112. Siphunculi only slightly swollen, width 1·1–1·3 times minimum width basal to swelling; 2·4–2·9 times longer than cauda which is about 0·09 of body length. Lateral abdominal tubercles evident but less well developed than in apterous vivipara. Other characters as in apterous vivipara.

Oviparous female (fig. 4) (based on 25 specimens). Pigmentation in life very similar to apterous vivipara. Body length 2·17–2·82 mm. Antennae 1·2–1·6 times longer than body; processus terminalis 5·8–7·0 times longer than base of antennal segment VI and 1·2–1·6 times longer than segment III. Antennal ratios 100:90:70:22 + 139. Antennal segment III without secondary rhinaria in all specimens examined. Hind tibia slightly swollen on proximal half with 13–65 scent glands. Cauda 0·09–0·12 of body length, with 12–24 hairs. Sub-genital plate with 9–15 hairs on the anterior part and 15–24 hairs on the posterior margin. Other characters like those of apterous vivipara.

Alate male (fig. 5) (based on 21 specimens). Pigmentation in life: like alate viviparous female except that predominant colour of unsclerotized parts is pale yellow, rather than yellow-green or green. Antennal segment I dark green at base shading to black at apex, rest of antenna black. Genitalia with black claspers. Thoracic lobes pale yellow-brown. Immature stages very pale yellow.

Body 1·97–2·64 mm. long, more slender than alate viviparous female. Antennae 1·2–1·7 times longer than body; processus terminalis 4·4–6·5 times longer than base of antennal segment VI and 1·1–1·5 times longer than segment III. Antennal ratios 100:92:71:23 + 137. Secondary rhinaria distributed 21–32 on segment III, 15–30 on IV, 6–16 on V. Pattern and extent of abdominal sclerotization variable; paired, lightly pigmented intersegmental pleural sclerites usually present and often rather more extensive than in alate female, and lateral sclerites tend to be more clearly defined than in alate female, but still only lightly pigmented. Cauda and siphunculi shorter than in

apterous or alate female; siphunculi 2·2–3·6 times longer than cauda, 0·72–0·85 times as long as antennal segment III and 0·21–0·27 times body length. Cauda 0·07–0·12 of body length.

Alatiform males have yellow-brown thoracic lobes but with wings either greatly reduced or absent.

Apterous male (fig. 6) (based on 25 specimens). Pigmentation in life like that of alate male but with pale yellow thorax. Immature stages very pale yellow. Body 1·73–2·55 mm. long, rather slender. Antennae 1·4–2·0 times longer than body, processus terminalis 5·4–7·0 times longer than base of segment VI, and 1·3–1·7 times longer than segment III. Segment III often shorter than IV; antennal ratios 100:102:73:23 + 148. Secondary rhinaria distributed 19–27 on III, 16–30 on IV, 8–18 on V. Pattern of dorsal abdominal sclerotization very weakly developed, as in alate viviparous female. Siphunculi 2·3–3·2 times longer than cauda, 0·67–0·88 of length of antennal segment III and 0·24–0·31 of length of body. Cauda 0·09–0·13 of body length.

Representative biometric data for all morphs are given in the table.

Karyotype. The female diploid number observed in somatic cells from embryos is $2n = 4$, the single autosome pair being about twice the length of the X-chromosome pair (fig. 9). This is the lowest chromosome number possible in a holocyclic aphid, and has only been found in two other, unrelated species; *Myzaphis rosarum* (Kalt.) and *Gypsoaphis oestlundi* Hottes. Male embryos have $2n = 3$ in somatic cells, and primary and secondary spermatocytes with $n = 2$ were observed in testis tissue from first and second instar males.

Type material. HOLOTYPE: apterous viviparous female ex culture at 16 hours photoperiod and 16°C, originating from Chelsea Physic Garden, London, 2.vi.82 (clone No. 2798). PARATYPES: apterous viviparous females, oviparous females, alate males and apterous males of clone 2798; fundatrices and apterous viviparous females from Chiswick, London, 14.iv.83 and 21.iv.83; apterous and alate females ex culture originating from Chiswick (clone No. 2857). Paratype apterae and alatae have been sent to: Smithsonian Institute, Washington D.C.; Zoological Institute, Academy of Sciences, Leningrad; Academy of Sciences, Prague; Abteilung Taxonomie der Insekten, Akademie der Landwirtschaftswissenschaften der DDR, Eberswalde; Institut Pasteur, Paris; Zoological Institute, Lund, Sweden. Holotype and remaining paratypes in BM(NH) collection. + Dr O.E. Heie, Institute of Biology, Laerarhojskola, Copenhagen, Museum of Natural History, Nagai Higashi-sumiyoshi-ku, Osaka JAPAN; Dr David Voegtlin Illinois State Natural History Survey, URBANA ILLINOIS, N.C. University, RALEIGH, North Carolina

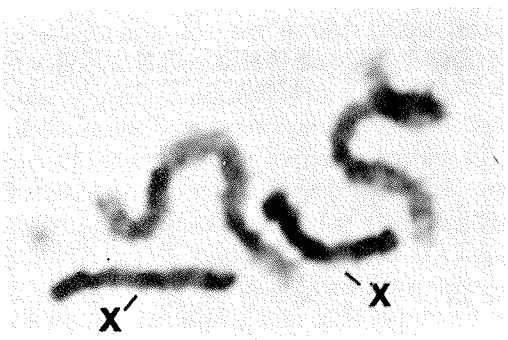


FIG. 9. Somatic prometaphase cell from female embryo of *A. tuberculata*, $2n = 4$. Sex chromosomes labelled 'X'.

Measurements of representative specimens of *Amphorophora tuberculata*. Lengths measured in millimetres.

Morph	Body length	Antennal segments III	IV	V	VI	p.t.	Ultimate rostral segment	Hind femur	Hind tibia	Hind tarsus II	Siphunculi	Cauda
Apterous vivipara HOLOTYPE	3.09	0·88	0·87	0·64	0·18	1·14	0·19	1·43	2·73	0·08	0·89	0·35
	2·18	0·74	0·68	0·56	0·18	0·98	0·19	1·09	2·12	0·08	0·71	0·33
	2·79	0·65	0·79	0·60	0·18	1·05	0·19	1·20	2·18	0·08	0·78	0·33
	3·14	0·84	0·81	0·62	0·19	1·14	0·19	1·39	2·66	0·09	0·90	0·37
	3·42	0·91	0·91	0·68	0·16	1·25	0·20	1·42	2·71	0·09	0·89	0·38
Alate vivipara	2·68	0·71	0·74	0·57	0·18	1·09	0·19	1·13	2·35	0·08	0·73	0·28
	2·70	0·79	0·77	0·62	0·20	1·31	0·18	1·23	2·36	0·09	0·74	0·25
	2·78	0·77	0·72	0·57	0·20	1·12	0·19	1·20	2·29	0·08	0·77	0·28
	3·10	0·90	0·93	0·70	0·19	1·36	0·20	1·43	2·82	0·10	0·90	0·29
Fundatrix	2·66	0·78	0·51	0·44	0·15	0·91	0·18	1·12	1·84	0·10	0·62	0·24
	2·99	0·96	0·58	0·49	0·17	1·01	0·16	1·26	2·22	0·10	0·71	0·26
Ovipara	2·39	0·71	0·73	0·56	0·19	1·14	0·18	1·13	2·12	0·08	0·69	0·26
	2·65	0·78	0·70	0·54	0·18	1·05	0·18	1·10	2·08	0·08	0·69	0·26
Apterous male	2·30	0·73	0·81	0·58	0·21	1·12	0·18	1·13	2·16	0·09	0·59	0·22
	2·52	0·81	0·83	0·62	0·19	1·20	0·18	1·25	2·36	0·10	0·64	0·26
Alate male	1·97	0·60	0·52	0·44	0·15	0·89	0·16	0·91	1·87	0·08	0·49	0·17
	2·61	0·79	0·73	0·57	0·17	1·10	0·17	1·18	2·46	0·09	0·61	0·20

Comments. This is a distinctive species, and it is remarkable that it has previously been overlooked. The aphid, like its host plant, is presumably native to central or southern European mountain regions; but *Geranium macrorrhizum* is a good ground-cover plant with a strong, characteristic aroma which has been established in gardens in western Europe for many years. The circumstances are very similar to those of another recently described species, *Acyrthosiphon auriculae*, found in Britain on cultivated *Primula* (garden auricula) which is also originally native to alpine Europe (Martin 1981).

A. tuberculata resembles the North American *Geranium*-feeding *Amphorophora* in having apterae with a low number of rhinaria on antennal segment III. Compared with paratypes of *A. geranii* in the BM(NH) collection, *A. tuberculata* has a shorter last rostral segment with fewer accessory hairs, fewer hairs on hind tarsus II, fewer secondary rhinaria on antennal segment III in the aptera, smoother siphunculi and different lateral abdominal chaetotaxy (see below). Compared with the published description of *A. coloutensis* (Smith and Knowlton 1983), *A. tuberculata* differs in colour in life, and has more accessory hairs on the last rostral segment and smoother siphunculi.

The well-developed lateral tubercles, placed between hairs of clearly unequal length, are a characteristic feature of all morphs of *A. tuberculata* and should enable this species to be easily recognized, although populations may occur in which the tubercles are developed to a lesser extent. The North American species *A. rubitoxica* and *A. stachyophila* have similar lateral abdominal chaetotaxy but lateral tubercles are weakly developed in these species. In other *Amphorophora* lateral tubercles are variably present and in some species, including *A. geranii*, they are often well-developed, but the pleural and lateral hairs around the tubercles are greater in number and all of similar length.

Chromosome numbers in the genus *Amphorophora* now encompass the complete range known in aphids, from $2n = 4$ to 72. It is now clear that variation in chromosome number is not confined to *Rubus*-feeding *Amphorophora* (Blackman 1980), but is found in the genus as a whole. Other additional chromosome numbers recorded for this genus since Blackman (1980) are: *A. rossi* Hottes and Frison, from *Geum* in North America, $2n = 46$; *A. tigwatensa* Hottes, from *Rubus strigosus* in North America, $2n = 40$; and *A. amurensis* (Mordvilko) from *R. idaeus* in Japan, $2n = 14$.

Biology. In south-east England *A. tuberculata* is holocyclic on *Geranium macrorrhizum*, feeding on the undersides of the leaves, with a tendency to concentrate on the mid-rib near the base of the leaf, and on the flower stems. It is apparently specific to this host plant, as attempts to rear it on excised leaves of other *Geranium* (*robertianum*, *sanguineum*) and *Pelargonium* (*inodorum*, *zonale*) species were unsuccessful, except that it could survive temporarily with a considerable reduced reproductive rate on leaves of *G. dalmaticum*, the species considered to be most closely related to *G. macrorrhizum*. Neither of these species is native to Britain or western Europe.

Two clones were started on excised leaves of *G. macrorrhizum* in the laboratory; one (No. 2798) from an apterous vivipara collected at Chelsea Physic Garden on 2.vi.82, and the second (No. 2857) from a fundatrix collected at Chiswick on 21.iv.83. First-born progeny of each generation were separated from their mothers at birth. Both clones showed certain notable features. Clone 2798 produced only apterous viviparae during eight generations of rearing at 16 hours photoperiod and 16°C, but in the ninth generation two alate males appeared despite the long day conditions, in the 18th generation of rearing 20% of individuals were alate males, and the 20th generation

comprised 80% alate and alatiform males. In ten subsequent generations alate or alatiform males occurred only sporadically in small numbers, and a few alate viviparous females were also produced.

The progeny of the fundatrix used to start clone 2857 were all alate viviparous females, as were the pooled progeny of the other field-collected fundatrices, but in subsequent generations of this clone alate females occurred rarely, as in clone 2798. Production of large numbers of alate fundatrigeniae is a common feature of host-alternating Aphidinae, but not of monoecious species.

Response to a short photoperiod was tested by transferring fourth instar larvae of clone 2798 to a 12 hour day at 16°C. Aphids of the next generation were all apterous viviparae; these gave birth initially to oviparae, and thereafter to a mixture of oviparae and males. However, all except one of the males obtained in short photoperiod conditions were apterous, in contrast to the predominantly alate males produced contemporaneously in the long photoperiod culture of the same clone.

Acknowledgments

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