

## A new host association for the Bombyliidae (Diptera): an *Exhyalanthrax* sp. reared from cockroach oothecae, *Heterogamisca chopardi* (Dictyoptera: Polyphagidae) in Saudi Arabia

D.J. GREATHEAD<sup>1</sup> & P. GRANDCOLAS<sup>2</sup>

<sup>1</sup>Centre for Population Biology, Imperial College, Silwood Park, Ascot, SL5 7PY, UK.

<sup>2</sup>URA 373 CNRS, Laboratoire de Primatologie – Biologie évolutive, Station Biologique de Paimpont, F-35380 Paimpont, France.

**Key words:** Parasitism, cockroach, *Exhyalanthrax*, *E. blattae* sp.nov.

### Introduction

Hitherto, *Exhyalanthrax* spp. have been known exclusively as pupal parasitoids. For example, there are records of the common Palaearctic species, *E. afer* (Fabricius), reared from pupae of tachinid and ichneumonid parasitoids of the pine processionary caterpillar, *Thaumetopoea pityocampa* (Denis & Schiffermüller), and from the pupae of this and other Lepidoptera and also from cocoons of the pine sawfly, *Neodiprion sertifer* (Geoffroy), (references in Du Merle, 1975). Several African species have been reared on numerous occasions from the puparia of tsetse flies (*Glossina* spp.) and also, less frequently, from puparia of other Diptera (Du Merle, 1975; Greathead, 1980b). Thus, the discovery of an *Exhyalanthrax* sp. preying on the oothecae of a cockroach, *Heterogamisca chopardi* Uvarov in Saudi Arabia (by PG) is both interesting and unexpected.

In this paper the *Exhyalanthrax* sp. is described (by DJG), details of the ecology of the *Exhyalanthrax*-cockroach relationship are provided (by PG) and the host relations of *Exhyalanthrax* spp. are discussed.

### Abbreviations

Natural History Museum (British Museum (Natural History)), London, BMNH; D.J. Greathead collection, DJG; Musée National d'Histoire Naturelle, Paris, MNHN; Zoologisches Museum, Berlin, ZMB.

### The *Exhyalanthrax unicolor* Becker group

The specimens reared from *H. chopardi* lack the antennal flagellum but show the other characters of *Exhyalanthrax*, most notably the characteristic male genitalia

(Greathead, 1981) so that there can be no doubt as to their generic placement. It is not among the species previously known from Arabia (Greathead, 1980a, 1988) and differs from these in having no trace of dark black or brown scales on the thorax and abdomen. Such unusually pale coloration is frequently encountered in species of Bombyliidae from desert areas and is common among other genera of Villini from Arabia.

Similar species have been described with hyaline wings and predominantly pale vestiture; viz., *E. unicolor* (Becker) from Egypt, *E. innocens* (Austen) from Cyprus, *E. amoenus* (Austen) from Palestine and *E. luteolus* (Bezzi) from eastern Africa. Therefore, these species were examined to clarify the status of the new species from Saudi Arabia.

***Exhyalanthrax unicolor* (Becker) comb. nov.**

*Anthrax unicolor* Becker (1902: 24) Egypt [examined].

*Thyridanthrax unicolor* (Becker) Bezzi (1925: 232).

*Pachyanthrax unicolor* (Becker) Greathead (1981: 320).

The unique holotype specimen had not been examined when it was allocated to the genus *Pachyanthrax* by Greathead (1981). However, examination of the genitalia of the holotype makes it clear that it is a species of *Exhyalanthrax* since it has the flat blade-like epiphallus with dorsal thorn-like processes characteristic of *Exhyalanthrax* (Fig. 7, 8). It also differs from the new species in having entirely pale thoracic macrochetæ, face conically prominent, cell cua<sub>1</sub> long, as well as in having uniformly ochreous scales on the abdominal tergites and in the shape of the eighth tergite and genitalia.

Material examined. Holotype M. [Egypt]: Alexandria (45049.v.) in ZMB.

***Exhyalanthrax innocens* (Austen)**

*Thyridanthrax innocens* Austen (1936: 195) Cyprus [examined]

*Thyridanthrax amoenus* Austen (1939: 155) Palestine [examined] **syn. nov.**

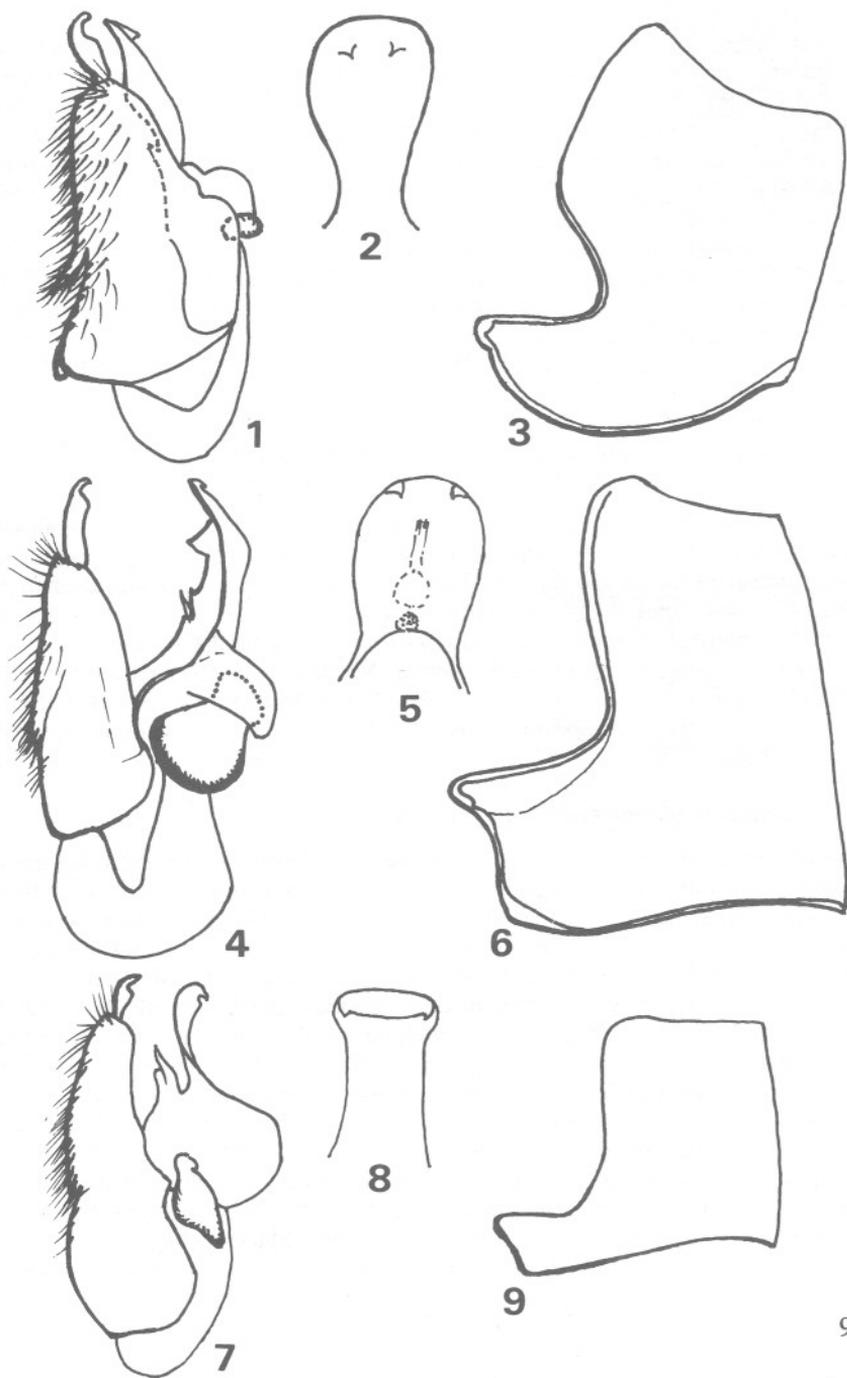
*Exhyalanthrax amoenus* (Austen) Greathead (1981: 318)

*Exhyalanthrax innocens* (Austen) Greathead (1981: 318)

The two syntypes of *E. innocens* and the syntype series of *E. amoenus* have been examined and no significant differences were found so that *E. amoenus* is designated a junior synonym of *E. innocens*. Unlike the new species, *E. innocens* has some black hair among the pale ones on the pleura and prosternum, although this is variable in extent and less conspicuous in female specimens. It also has: darker brown-buff

**Legends to Figures**

Figs 1-9. Male genitalia of *Exhyalanthrax unicolor* (Becker) group. 1-3, *E. blattæ*; 1, hypopygium, lateral view; 2, epiphallus, dorsal view; 3, ninth tergite, lateral view: 4-6 *E. innocens*; 4, hypopygium, lateral view; 5, epiphallus, dorsal view; 6, ninth tergite, lateral view: 7-9, *E. unicolor*; 7, hypopygium, lateral view; 8, epiphallus, dorsal view; 9, ninth tergite, lateral view.



rather than pale ochreous scaling on the frons and dorsal surface of the thorax and abdomen; glistening whitish scales on the lower part of the frons above the antennae and not uniformly dull ochreous scales; all thoracic macrochetæ black rather than those on the mesothorax being pale yellowish; legs almost black not brown; abdominal sternites with black not pale hair; and wing veins a paler brown not blackish-brown; as well as a more angular ninth tergite (Fig. 6) and a differently shaped epiphallus (Fig. 5) in males.

Material examined. Syntypes of *E. innocens*. Cyprus: Limassol, 1F, 7.v.1923 (G.A. Mavromoustakis); 1F (labelled as a male), 9.v.1923, both in BMNH. Syntypes of *E. amoenus*. Palestine: near Jerisheh, 4-7 miles NE Jaffa, 1M, 1-8.v.1918 (E.E. Austen); El-Belah, 8 miles SW Gaza, 1M2F, 21.iv.1917 (E.E. Austen); Alaka, coastal zone, 1F, 28.vi.1921 (P.A. Buxton) all in BMNH.

### *Exhyalanthrax luteolus* (Bezzi)

*Thyridanthrax luteolus* Bezzi (1924: 200) Kenya [examined]

*Exhyalanthrax luteolus* (Bezzi) Greathead (1981: 318)

This African species is rather variable in the presence of a band of black scales on the second abdominal tergite and the degree of whiteness of the notopleural stripes on the mesonotum (Greathead, 1970). It is a darker, more robust species than the others in the *E. unicolor* group and so cannot be confused with the new species although the phallosome (Greathead, 1970: Fig. 7) is similar in shape.

Material examined. Holotype F. Kenya: Moyale, 10.x.1911 (R.J. Stordy) in BMNH. Kenya: Voi, 29.xii.1972, 2M3F; Tsavo, Keneni, 30.i.83, 2F (all D.J. Greathead) in DJG. Also specimens listed for Kenya, Sudan, Tanzania and Uganda in Greathead (1970).

### *Exhyalanthrax blattae* Greathead sp. nov.

The new species differs from all described species of *Exhyalanthrax* in having almost completely white to pale ochreous vestiture; black hair is present only on the frons margin of the scutellum and margins of the fifth and sixth abdominal tergites. The male genitalia are typical of the genus, having crested gonocoxae and a broad flat epiphallus bearing a pair of small thorn-like spines on the dorsal surface.

Holotype M. Head. Black. Frons at vertex as wide as ocellar triangle. Face bluntly prominent. Hair on frons black with pale ochreous scales beneath; hair on face white, scales pale ochreous, scales on occiput white. Antennae blackish-brown with long black hairs on scape and pedicel (flagellum missing). Proboscis dark brown, as long as buccal cavity. Thorax. Black. Macrochaetae pale whitish, except for weak black ones at the margin of the scutellum. Hair white but tinged ochreous on anterior margin of mesonotum and tuft of long hair on anepisternum; scales on mesonotum and scutellum pale ochreous, notopleural stripes and scales on pleura white. Legs. Brown with bases of femora and tarsomeres darkened. Macrochetæ black and scales whitish. Claws black. Wing. Base and costal cell tinged yellowish, otherwise

hyaline. Veins dark brown. Vein r-m at basal  $\frac{1}{4}$  of discal cell, discal cell truncate and vein  $m_1$ - $m_2$  long, contact of discal cell and cell  $cua_1$  twice length of basal vein of  $cua_1$ .

Squama with a fringe of white scales. Haltere pale yellow. Abdomen. Black. Hair white, except for a few black ones on posterior margins of tergites five and six scales white except for third tergite with ochreous ones on dorsal surface. Sternites with white hair and scales. Hypopygium, Figs. 1-3. Eighth tergite emarginate. Gonocoxae large with an elongate ventral crest; gonostyli narrow, hooked; epiphallus broad, flattened and with a pair of dorsal thorn-like spines. Length: 5 mm; wing, 6 mm.

Paratype F. As holotype but frons  $1\frac{1}{2}x$  width of ocellar triangle at vertex.

Material examined. Holotype M. Saudi Arabia: 30 km E Taif, route Al Suddayrah, réserve NWRC enclose 3 ans,  $21^{\circ}14'46N$   $40^{\circ}42'05E$ , 1400 m, vi. 1992 (P. Grandcolas) in MNHN. Paratype F. As holotype in MNHN.

The type specimens were reared from oothecae of *Heterogamisca chopardi* and are accompanied by pupal exuviae. There are also two unemerged pupae projecting from oothecae (in MNHN), one from the same protected site as the type series and one from the grazed site (zone surpurée) at the same map reference, see below.

### Key to species of the *Exhyalanthrax unicolor* (Becker group)

1. Scales predominantly or entirely pale ochreous to white; black scales, if present, inconspicuous and only rarely forming distinct bands on abdominal tergites (sometimes there is a distinct black band on the second tergite in *E. luteolus*); wing at most with only the costal cell infuscated yellowish . . . . . *E. unicolor* group

- Scales black, brown and white; abdomen with distinct bands of black scales on the dorsal surface not predominantly or entirely pale ochreous to white; wing often with a dark basicostal infuscation or dark spots ... other species of *Exhyalanthrax*, 2

2. Postalar macrochetae pale; all hair on prosternum and pleura pale; femora brown . . . . . 3

- Postalar macrochetae black; some black or dark brown hair on prosternum and sometimes also on pleura; femora black . . . . . 4

3. Prealar macrochetae black; body cuticle black; face bluntly prominent; claws black; abdominal scales not uniformly ochreous; veins blackish; cell  $cua_1$  short; male genitalia Figs 1-3; Saudi Arabia . . . . . *blattae* sp. nov.

- All macrochetae except those on margin of scutellum pale; cuticle brown; face conically prominent; claws pale at bases; abdominal scales uniformly ochreous; veins brown; cell  $cua_1$  long; male genitalia Figs 7-9; Egypt. *unicolor* (Becker)

4. Scales on frons above antennae dull ochreous; tibiae brown; hair on abdominal sternites pale; no notopleural stripes at sides of mesonotum; male genitalia (Greathead, 1970: Fig. 7); eastern Africa . . . . . *luteolus* Bezzi

- Scales on frons above antennae large, glistening; legs black; hair on abdominal sternites black; notopleural stripes at sides of mesonotum white; male genitalia Figs 4-6; Cyprus, Palestine..... *innocens* (Austen)

### Ecology of the *Exhyalanthrax*-cockroach relationship

The cockroach host, *Heterogamisca chopardi*, belongs to the subfamily Polyphaginae, which comprises only oviparous taxa (Roth, 1970) and is often found in deserts (Chopard, 1938; Bey-Bienko, 1950; Grandcolas, 1994b). The genus is found in North Africa and the Middle East from Algeria to Iran (Chopard, 1929; Bey-Bienko, 1950; Princis, 1962). Three species are present in Saudi Arabia (Grandcolas, 1994a).

*H. chopardi* was found in the Asir at middle elevation (above 1200 m) in desertic locations (Grandcolas & Donskoff, 1992) burrowing in the sand under cushion shrubs. In June 1992, when the collections were made, the females were not seen moving on the sand surface. Oothecae appeared to be carried by the females for a few days before being shed in the sand at a depth of between 5 cm and 30 cm, without any particular treatment (coating or concealment). This corresponds with the oviposition behaviour observed by McKittrick (1964) for two American polyphagids, *Arenivaga bolliana* (Saussure) and *A. apache* (Saussure). Adult females of *H. chopardi* are not present throughout the year and so oothecae are only present seasonally. They are relatively small, 5 mm long, and containing a mean of six eggs.

Oothecae were collected during a thorough sampling of two areas, located respectively in a grazed area and in a protected area in the vicinity of Taif, at the border of the Asir Mountains (1400 m) – see locality data. A total of 129 oothecae were found in the two areas, of which 20 still contained developing eggs, four of these (20%) were parasitized. Each contained one fly; two emerged as adults and two died as pharate adults inside the pupal exuvia after the anterior part of the pupa had emerged from the ootheca. The parasitized oothecae were found under shrubs; *Lycium* sp. in the grazed area and *Cornulaca* sp. in the protected area.

### Discussion

To the best of our knowledge (Roth & Willis, 1960; pers. obs.) the only other record of parasitism/predation of cockroach oothecae by Diptera is that of Edmunds (1952). He reared a single specimen of *Coenosia basalis* Stein (Muscidae) and four of *Megascelia* sp. (Phoridae) all from a single ootheca from a total of 447 oothecae of *Parcoblatta* sp. in North American woodlands. *Coenosia* spp. females deposit their larvae as third instars which feed as generalist predators and *Megascelia* spp. are well known as saprophages (Ferrari, 1987); thus, neither is likely to be more than an incidental cause of mortality. However, the study of the natural enemies of cockroaches has been neglected, except for domestic species.

On the other hand, there are a large number of observations on parasitism of

cockroach eggs by Hymenoptera, especially by Evaniidae and Chalcidoidea (Roth & Willis, 1960; Lebeck, 1991). Evaniidae have been shown to cause mortality in field populations ranging from 6.9% to 13.1% (Edmunds, 1952; Deleporte, 1976). Thus, the present record, although based on a small sample, indicates that the impact of *E. blattae* on *H. chopardi* may be substantial.

This discovery further blurs the distinction between parasitoids and predators in the family Bombyliidae. Most of the genera, of which species have been reared, are predators or ectoparasitoids on larvae and pupae of Hymenoptera Apocrita within their nests (e.g., *Toxophora*, *Bombylius*, *Anthrax*) or predators on the eggs of Acrididae remaining within a single egg-pod to feed (e.g., *Systoechus*, *Anastoechus*, *Cytherea*). True internal parasitoids are found in the genera *Systropus* and *Geron* (Systropodinae) and some genera of Villini (*Villa*, *Poecilanthrax*, *Hemipenthes*, *Exhyalanthrax*) feeding as internal parasitoids within the pupae of Lepidoptera and Tabanidae or on the pupae of their parasitoids — Tachinidae and Ichneumonidae (see Du Merle, 1975). Now we have an example of an *Exhyalanthrax* sp. feeding on an egg mass within a chitinous capsule, comparable to a dipterous puparium or the pupal cuticle of a moth in providing protection for bombyliid larvae feeding inside.

### Acknowledgements

PG is grateful to Abdulrahman Khoja, Sylvain Biquand and George Schwede for their invitation to work as a guest researcher at the National Wildlife Research Center (NWRC) in Saudi Arabia. He also wishes to thank the staff of NWRC for their kind assistance, L. Tsacas and P Du Merle for their advice and J. Marshall for the loan of the holotype of *H. chopardi* deposited in the Natural History Museum, London.

DJG is grateful to Dr H. Schumann, Museum für Naturkunde der Humboldt-Universität zu Berlin, for the loan of the holotype of *E. unicolor* and to Mr J. Chainey for arranging the loan of a syntype male of *E. amoenus* and permission to dissect the genitalia.

### Summary

*Exhyalanthrax blattae* sp. nov. is described from specimens reared from the oothecae of a cockroach, *Heterogamisca chopardi* Uvarov, collected in Saudi Arabia. This new species is compared with related species of *Exhyalanthrax* allied to *E. unicolor* (Becker) stat. nov. One of them, *E. amoenus* (Austen) is shown to be a synonym of *E. innocens* (Austen). A key to species in the *E. unicolor* group is provided. The ecology of the *Exhyalanthrax*-cockroach relationship is described and discussed in relation to the host relations of the Bombyliidae.

### References

- Austen, E.E. 1936 New Palaearctic Bombyliidae (Diptera). *Annals and Magazine of Natural History*, Series 10, **18**: 181-204.

- Austen, E.E. 1939 *Bombyliidae of Palestine*. London, British Museum (Natural History).
- Becker, T. (1902) Aegyptische Dipteren. *Mitteilungen aus dem Zoologische Museum in Berlin*, **2(1)**: 1-66.
- Bey-Bienko, G.I. (1950) *Blattodea*. Moscow, Fauna of the USSR.
- Bezzi, M. (1924) *Bombyliidae of the Ethiopian Region*. London, British Museum (Natural History).
- Bezzi, M. (1925) Quelques notes sur les Bombyliides (Dipt.) d'Égypte, avec description d'espèces nouvelles. *Bulletin de la Société Royale Entomologique d'Égypte*, **1924**: 159-242.
- Chopard, L. (1929) Orthoptera palaeartica critica. VII. Les polyphagiens de la faune paléarctique. *Eos, Madrid*, **5**: 223-358.
- Chopard, L. (1938) *La biologie des Orthoptères. XX*. Encyclopédie entomologique. Paris, Lechevalier.
- Deleporte, P. (1976) L'organisation sociale chez *Periplaneta americana* (Dictyoptères): aspects éco-éthologiques, ontogénèse des relations interindividuelles. Université Rennes, *Thèse Doctorat 3ème cycle*.
- Du Merle, P. (1975) Les hôtes et les stades pré-imaginaux des Diptères Bombyliidae: revue bibliographique annotée. *Bulletin SROP*, **1975/4**: 289 pp.
- Edmunds, L.R. (1952) Some notes on the habits and parasites of native wood-roaches in Ohio (Orthoptera: Blattellidae). *Entomological News*, **63**: 141-145.
- Ferrar, P. (1987) *A guide to the breeding habits and immature stages of Diptera Cyclorrhapha*. Entomograph No. 8: Leiden, E.J. Brill. 2 vols.
- Grandcolas, P. (1994a) *Blattaris* (Insecta: Dictyoptera) of Saudi Arabia: a preliminary report. *Fauna of Saudi Arabia*, **14**: 40-58.
- Grandcolas, P. (1994b) Phylogenetic systematics of the subfamily Polyphaginae, with the assignment of *Cryptocercus* Scuder, 1862 to this taxon (Blattaria, Blaberoidea, Polyphagidae). *Systematic Entomology*, **19**: 145-158.
- Grandcolas, P. & Donskoff, M. (1992) *Ecology of cockroaches, grasshoppers and crickets in undisturbed and overgrazed areas: a preliminary report*. Taif, National Wildlife Research Center.
- Greathead, D.J. (1970) Notes on Bombyliidae (Diptera) from the southern borderlands of the Sahara with descriptions of new species. *Journal of Natural History*, **4**: 89-118.
- Greathead, D.J. (1980a) *Insects of Saudi Arabia. Diptera: Fam. Bombyliidae*. Fauna of Saudi Arabia, **2**: 291-337.
- Greathead, D.J. (1980b) Biological control of tsetse flies: an assessment of insect parasitoids as control agents. *Biocontrol News and Information*, **1**: 111-123.
- Greathead, D.J. (1981) The *Villa* group of genera in Africa and Eurasia with a review of the genera comprising *Thyridanthrax sensu Bezzi* 1924 (Diptera: Bombyliidae). *Journal of Natural History*, **15**: 309-326.
- Greathead, D.J. (1988) *Diptera Fam. Bombyliidae of Saudi Arabia (part 2)*. Fauna of Saudi Arabia, **9**: 90-113.
- Lebeck, L.M. (1991) A review of the hymenopterous natural enemies of cockroaches with emphasis on biological control. *Entomophaga*, **36**: 335-352.
- McKittrick, F.A. (1964) Evolutionary studies of cockroaches. *Memoir of the Cornell University Agricultural Experiment Station*, **389**: 1-197.
- Princis, K. (1962) Pars 3: Blattariae: Subordo Polyphagoidea: Fam. Polyphagidae. In M. Beier (Ed.), pp. 1-74. *Orthopterorum Catalogus. 's-Gravenhage, Junk*.
- Roth, L.M. (1970) Evolution and taxonomic significance of reproduction in Blattaria. *Annual Review of Entomology*, **15**: 75-96.
- Roth, L.M. & Willis, E.R. (1960) The biotic associations of cockroaches. *Smithsonian Miscellaneous Collections*, **141**: 1-470.