

Observations on the biology of *Baryscapus* (Hymenoptera: Eulophidae: Tetrastichinae) with description of a new koinobiont hyperparasitoid with delayed development

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Abstract. What is known of the developmental biology of the tetrastichine eulophid genus *Baryscapus* Förster, 1856 is reviewed. *Baryscapus bouceki* sp. nov. is described from Tunisia, and its biology as a true koinobiont hyperparasitoid of the pierid butterfly *Euchloe belemia* (Esper, 1800) via the braconid wasp *Microplitis* sp. is discussed. The type series of four females was reared from a *Microplitis* Förster, 1862 cocoon 35 months after its formation. As the *Microplitis* was seen to be still alive 21 months after it had formed its cocoon, with the *Baryscapus.bouceki* sp. nov. still invisibly inside it, the period of koinobiosis practised by this brood of *B. bouceki* sp. nov. was at least 21 and probably closer to 35 months. It is suggested that development of the endoparasitic *B. bouceki* sp. nov. is probably delayed while the *Microplitis* remains in diapause, and that the capacity for prolonged diapause by this desert-inhabiting *Microplitis* species is an adaptation to survive failure of winter rains.

Taxonomy, new species, Hymenoptera, Eulophidae, *Baryscapus*, prolonged koinobiosis, Braconidae, *Microplitis*, drought adaptation, Lepidoptera, *Euchloe belemia*, hyperparasitism

INTRODUCTION

Baryscapus Förster, 1856, as recognized by Graham (1991), is a large genus of Tetrastichinae with about 60 species in Europe and North Africa. Although the biology of only very few of these species is known in any detail, hosts (primary or secondary) are recorded for about three-quarters. These hosts are drawn from Hemiptera, Neuroptera, Coleoptera, Hymenoptera, Lepidoptera and Diptera, and there is much variety in the ways in which they are exploited. Nonetheless, certain generalizations about host relations are possible.

All species develop endophagously and, in larger hosts, gregariously (the erroneous statement that *B. aenescens* Askew, 1997 is an ectoparasitoid (Askew & Blasco-Zumeta 1997) was corrected by Askew & Blasco-Zumeta (2000)). Available information indicates that each species of *Baryscapus* tends to utilize hosts in a more or less specific and restricted situation, but monophagy is rare. Secondary parasitism, sometimes facultative but for some species either obligatory or the preferred mode of development, is common.

Among species for which at least some biological details are recorded, *B. दौरا* (Walker, 1839) is one of a group attacking Tephritidae (Diptera) living in seed heads of Asteraceae. Here it develops as a gregarious endoparasitoid in larvae of both gall forming *Urophora stylata* (Fabricius, 1775) and non-gall forming *Terellia serratulae* (Linné, 1758) in capitula of *Cirsium vulgare* (Redfern 1983: partly as *Tetrastichus cirsii* (Kurdjumov, 1913)) and of gall forming *Urophora jaceana* (Hering, 1935) and non-gall forming *Chaetoriella jaceae* (Robineau-Desvoidy, 1830) in

Centaurea heads (Varley 1947). Considerable diversity in host selection is displayed by *Baryscapus gradwelli* Graham, 1991, another gregarious parasitoid in larvae of *Urophora jaceana*, which is known sometimes to behave as a secondary parasitoid through the chalcidoids *Eurytoma tibialis* Boheman, 1836 (= *E. curta* Walker, 1832, misidentified), *E. robusta* Mayr, 1878, *Pteromalus elevatus* (Walker, 1834) (= *P. trypetae* Thomson, 1878, misidentified) and the ichneumonid *Scambus buolianae* (Hartig, 1838) (Varley 1947: as *Tetra-stichus* sp. B).

Although such broad ranges of hosts as exhibited by *Baryscapus gradwelli* are unusual for endoparasitoids unless they are idiobionts (i.e. parasitoids that prevent the hosts' further development at the time of attack), there appears to be more scope for this among koinobiont endoparasitoids when they are behaving as hyperparasitoids through Hymenoptera. Askew & Shaw (1986) noted the relatively broad host ranges of species of *Mesochorus* Gravenhorst, 1829 (Ichneumonidae: Mesochorinae), which are koinobionts and obligatory hyperparasitoids, and raised the still unanswered question whether it indicated that there had been less selection pressure on primary parasitic Hymenoptera than on their host groups to evolve a potent physiological defence system, or whether it suggested some peculiarity of *Mesochorus* that enabled them broadly to overcome such defensive systems. Therefore the wide host range of *B. gradwelli* does not necessarily suggest that it is an idiobiont. In any case, koinobiosis, albeit of perhaps rather short duration, is known in *B. galactopus* (Ratzeburg, 1844) (= *Tetrastichus rapo* auctorum non Walker, 1839). This is an apparently obligatory hyperparasitoid, predominantly of *Cotesia* Cameron, 1891 species (Braconidae) developing in caterpillars of *Artogeia* Verity, 1947, *Pieris* Schrank, 1801, *Pontia* Fabricius, 1807 and *Colias* Fabricius, 1807 (Lepidoptera: Pieridae) but other hosts, primary (*Hyposoter* Förster, 1868 – Hymenoptera: Ichneumonidae) and secondary (*Cerura* Schrank, 1802 – Lepidoptera: Notodontidae), are also recorded. Sometimes the *Cotesia* are attacked after they have left the body of their caterpillar host (pseudohyperparasitism), but more often oviposition is into the braconid larva inside a partly or fully grown caterpillar. Female *Baryscapus galactopus* may discriminate between parasitized and unparasitized caterpillars before insertion of the ovipositor (Martelli 1907, but not Picard 1921). Usually, parasitized braconid larvae soon emerge from their primary host, and are killed only after they have spun cocoons from which adult *B. galactopus* eventually emerge (Martelli 1907, Gautier & Bonnamour 1924, Ferrière & Faure 1925, Clausen 1940).

In summary, *Baryscapus* species are endoparasitoids but often relatively polyphagous. The extent to which the primary host continues to live and develop after parasitization is uncertain in some species whose host associations are otherwise well documented, and some might be either idiobionts or only briefly koinobiotic. However, prolonged koinobiotic development certainly occurs in the new species of *Baryscapus* described below.

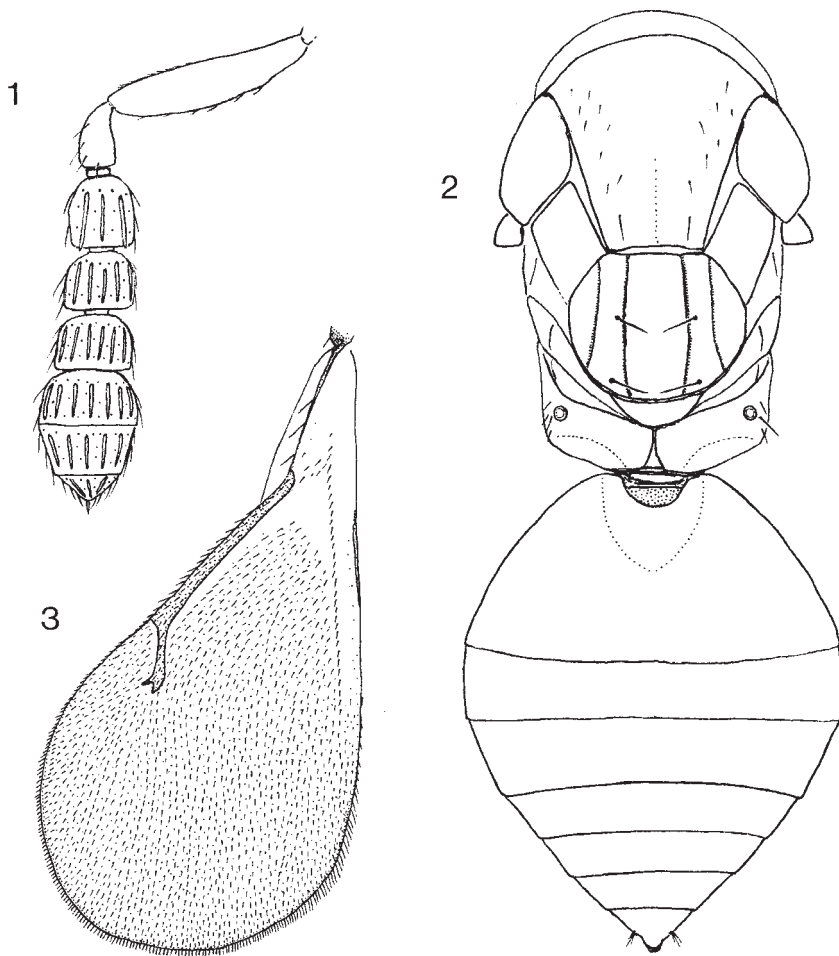
TAXONOMY

Baryscapus bouceki sp. nov.

(Figs 1–3)

DESCRIPTION. Female. Body dark green, slightly bluish, sutures of thoracic dorsum and longitudinal lines of scutellum coppery. Scape dark green, rest of antenna black. Coxae and most of femora concolorous with thorax, apical one-fifth of all femora pale yellow; tibiae brown with tips somewhat paler; tarsi brown, the two basal segments of meso- and metatarsi paler. Tegulae black. Wings clear, venation brownish, an indistinct pale spot between marginal vein and parastigma. Length 1.6–1.7 mm.

Head (collapsed in all available specimens) apparently not quite as broad as mesoscutum; POL 2.7 OOL, OOL almost twice ocellar diameter; malar space 0.6 times height of eye, suture strongly



Figs 1–3. *Baryscapus bouceki* sp. nov., holotype female, 1) antenna, 2) meso- and metasoma in dorsal view, 3) left forewing.

curved. Antenna with scape 0.77 times height of eye; pedicel plus flagellum (Fig. 1) 0.77 times breadth of mesoscutum; pedicel much longer than F1, about twice as long as broad; funicle with F1 much stouter than pedicel and subquadrate, F2 and F3 very slightly transverse, all funicle segments subequal in length; clava distinctly broader than funicle, 1.3–1.4 times as long as broad, longer than F2 plus F3, all segments transverse, apical spine about 0.4 times length of C3; sensillae numerous, in a single transverse row on each segment; pilosity relatively long.

Mesosoma (Fig. 2) 1.45 times as long as broad, 1.15 times as broad as deep. Mesoscutum with mid-lobe about as broad as long; moderately shiny with very fine, engraved reticulation and

median line subobsolete, visible only posteriorly in oblique view; 8–12 adnotaular setae on each side with a broad, bare strip in the middle. Scutellum 1.2 times as broad as long, convex; submedian lines distinctly closer to sublateral lines than to each other, enclosing a space 2.3–2.4 times as long as broad; setae about 0.85 times as long as distance between submedian lines, the anterior pair in front of the middle. Dorsellum about 2.4 times as broad as long. Propodeum medially about 1.3 times as long as dorsellum; shiny with weak, superficial reticulation, the median carina broadening in posterior half so that at posterior margin of propodeum it is rather more than twice as long as broad; spiracle shortly oval, separated from metanotum by about 0.75 times its length; callus with 3–6 setae.

Forewing (Fig. 3) 2.05 times as long as broad; ratio lengths costal cell: marginal vein plus parastigma: stigmal vein as 86:106:35; postmarginal vein rudimentary; submarginal vein with 3–4 dorsal setae and 6–7 ventral setae in basal half, the row of ventral setae continuing on undersurface of membrane in apical half of costal cell; basal vein pilose with a few additional hairs in apical half of basal cell; speculum moderately large, closed below; wing pilosity moderately dense, short, the apical cilia hardly longer than narrowest breadth of stigmal vein. Hindwing rounded at apex.

Gaster (Fig. 2) roundish, 1.1–1.3 times as long as broad, broader than and about as long as mesosoma; ovipositor sheath hardly projecting; hypopygium tip at about 0.3 gaster length.

Male. Unknown.

TYPE MATERIAL. Holotype, ♀: Tunisia, Tataouine near Krachaoua, 240m, one of brood of four ex cocoon of *Microplitis* (Hym., Braconidae) reared from larva of *Euchloe belemia* (Esper) (Lep., Pieridae) collected 11.iv.2000, P. J. C. Russell leg. Deposited in National Museums of Scotland, Edinburgh; Paratypes, 3♀♀, from same brood as holotype. Deposited in the Natural History Museum, London and in Askew's collection.

NAME DERIVATION. Named after Zdeněk Bouček, in recognition of his immense contribution to our knowledge and understanding of Chalcidoidea.

COMMENTS. Assignment of *Baryscapus bouceki* sp. nov. to one of the two species-groups recognized by Graham (1991: 76) is uncertain because the submedian lines of the scutellum are closer to the sublateral lines than to each other (character of *B. दौरa*-group) but enclose a space clearly more than twice as long as broad (*B. evonymellae*-group). The propodeum is medially longer than the dorsellum (*B. दौरa*-group), but the spiracles are separated from the metanotum by about three-quarters of their diameter (*B. evonymellae*-group). Absence of a clearly-defined hyaline spot between marginal vein and parastigma, and the host relations, are indicative of the *B. evonymellae*-group in which *B. bouceki* sp. nov. may be distinguished in Graham's (1991: 77) key by its combination of short gaster, short antennal segments and dark scape and tegula. *B. bouceki* sp. nov. differs from all species included in Graham's (1991: 142) key to the *B. दौरa*-group by the relatively elongated space between the submedian scutellar lines together with its short gaster and three or more dorsal setae on the submarginal vein.

BIOLOGY. A larva of *Euchloe belemia* (Esper, 1800), the secondary host of *Baryscapus bouceki* sp. nov., was collected in April 2000 and eight days later produced a larva of *Microplitis* sp., the primary host, which immediately spun an extremely tough cocoon. This was sent to MRS soon after and stored in a corked tube in an outdoor shed. Nothing having emerged 21 months later, the cocoon was opened on 10.i.2002 and found to contain a living *Microplitis* Förster, 1862 pupa which was not coloured-up. This, still in its partly opened cocoon, was placed in a small gelatine capsule and returned to the shed. When next examined, on 2.iii.2003, four active chalcidoid larvae were seen. These were then kept indoors and each produced an adult *B. bouceki* sp. nov. on 24.iii.2003, 35 months after the secondary host had been collected.

The *Microplitis* assumed to have been parasitized by *B. bouceki* sp. nov. in the field, when itself developing in the *Euchloe belemia* caterpillar. It is highly improbable that *B. bouceki* sp. nov.

attacked the captive *Microplitis* cocoon. Thus, *B. bouceki* sp. nov. is a true hyperparasitoid and koinobiont, presumably ovipositing in the larva of its braconid primary host but not killing the latter until after it had pupated. Koinobiosis lasted at least 21 and probably nearer 35 months. It is seems probable that *B. bouceki* sp. nov. remains as a first instar larva inside the *Microplitis* larva until its further development is triggered by hormonal events when the *Microplitis* pupates.

The *Microplitis* primary parasitoid of *Euchloe belemia* is apparently adapted to a desert environment, overwintering in a tough, drought-resistant cocoon. There is evidence that development of overwintered *Microplitis* cocoons is triggered by dampness, and delayed development would be of survival value to a desert-adapted species when winter rains fail. It would be similarly advantageous for *B. bouceki* sp. nov. to be developmentally synchronized with the *Microplitis* population.

Baryscapus aenescens Askew, 1997, a gregarious endoparasitoid of the phytophagous *Blascoa ephedrae* Askew, 1997 (Hymenoptera: Pteromalidae) in seeds of *Ephedra* (Askew & Blasco-Zumeta 1997, 2000), is a primary parasitoid but, like *B. bouceki* sp. nov., it inhabits a very dry environment (the steppe-like Monegros of eastern Spain) and adult emergence may be delayed. Up to eight winters can be passed in an immature state, although emergence of adults is staggered and some appear after just one winter. The host, *Blascoa ephedrae*, also has a staggered emergence, interpreted as a means of enabling the species to survive years in which *Ephedra* seed-production fails because of drought.

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