EMERGENCE BEHAVIOUR OF *PHOBOCAMPE* SP. (HYMENOPTERA:ICHNEUMONIDAE), A LARVAL ENDOPARASITOID OF *OPEROPHTERA* SPP. (LEPIDOPTERA:GEOMETRIDAE)

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Phobocampe sp. was first recorded as a larval parasitoid of *Operophtera* species on southern Vancouver Island by Gillespie and Finlayson (1979). It was found to be the most important parasitoid of *Operophtera* spp. in 1976 and 1977 (Gillespie and Finlayson 1981). The large numbers of *Phobocampe* reared from a mixed collection of winter moth, *O. brumata* (L.), and Bruce spanworm, *O. bruceata* (Hulst), indicated that this internal parasitoid attacked the introduced winter moth as effectively as its native host, the Bruce spanworm. Since final-instar *Phobocampe* larvae emerge from final-instar host larvae, the *Operophtera* species attacked in 1976 and 1977 could not definitely be determined from the mass-reared specimens (Gillespie and Finlayson 1981).

The purpose of this paper is to describe the unique emergence behaviour of the final-instar larva of *Phobocampe* and to provide additional host association data for this parasitoid. Willow branches bearing *Operophtera* larvae parasitized by *Phobocampe* were brought into the laboratory for observation. The emergence and cocoon-spinning behaviour of the final-instar parasitoid larvae were observed and photographed during early June, 1982. Camera lucida drawings were prepared from selected 35 mm colour transparencies to illustrate the emergence sequence of the *Phobocampe* larva.

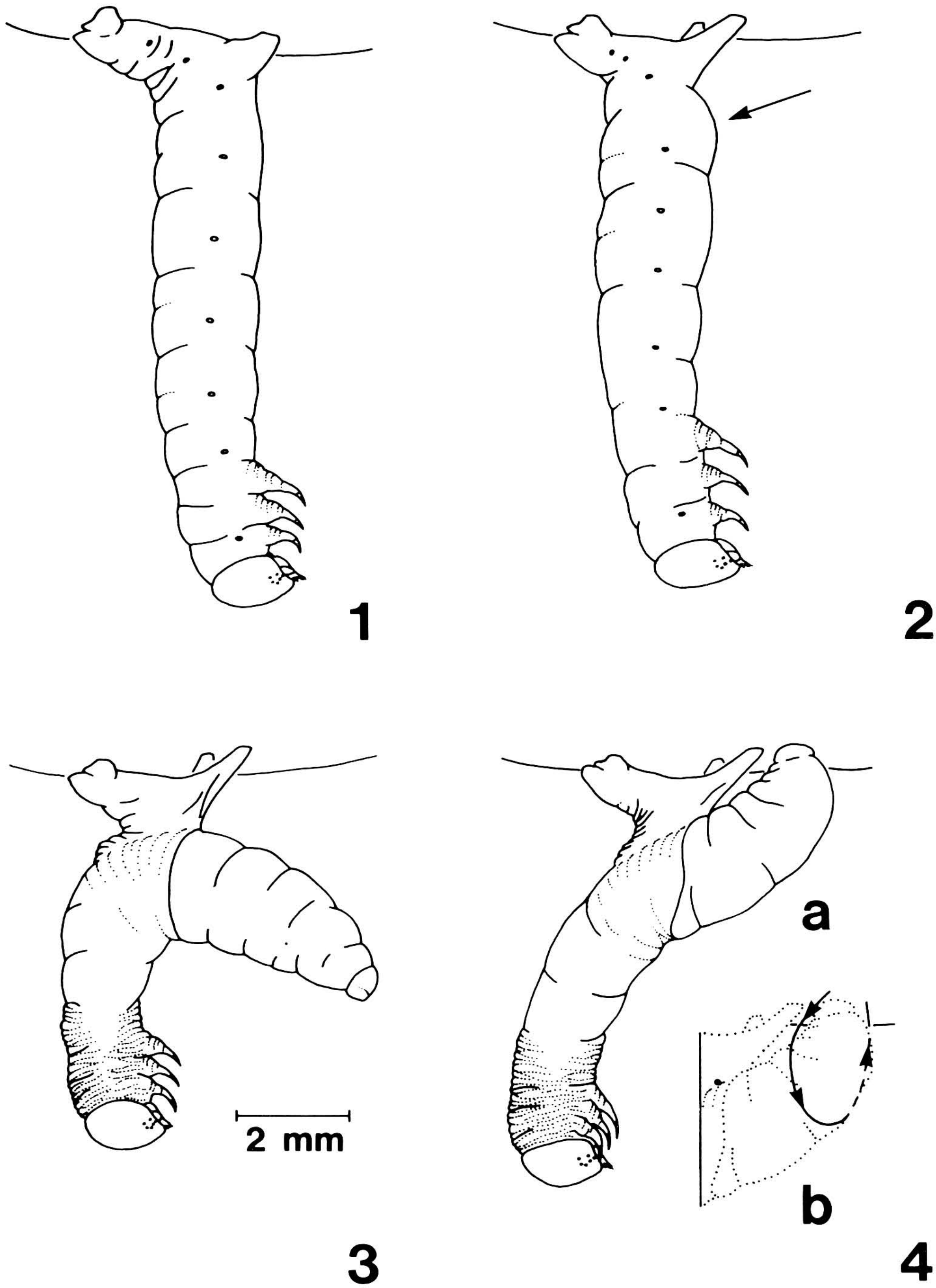
Operophtera larval remains close to *Phobocampe* cocoons were collected by searching foliage and branches of willow. Additional host remains were obtained by individually rearing field collected host larvae parasitized by *Phobocampe*. The *Operophtera* larval remains were mounted on points and the arrangement of larval ocelli examined under a dissecting scope fitted with a filar micrometer at 50X magnification. The larval ocellar characters described by Eidt and Embree (1968) were used to determine the host species.

During the late stages of *Phobocampe* larval development, the parasitized caterpillars exhibit behavioural changes which allow them to be easily identified. Prior to parasitoid emergence, the parasitized host larvae are found hanging head down within the foliage (Fig. 1). The prolegs of the caterpillars are attached to a layer of silk, apparently spun by the larvae themselves, on the underside of a leaf or branch. The *Phobocampe* larva can be seen moving within the host's skin at this time; areas of the host's body occupied by the parasitoid larva appear grayish and the remaining regions pale white. The head of the ichneumonid larva is within the posterior abdominal segments of the host, feeding on the remaining host tissue.

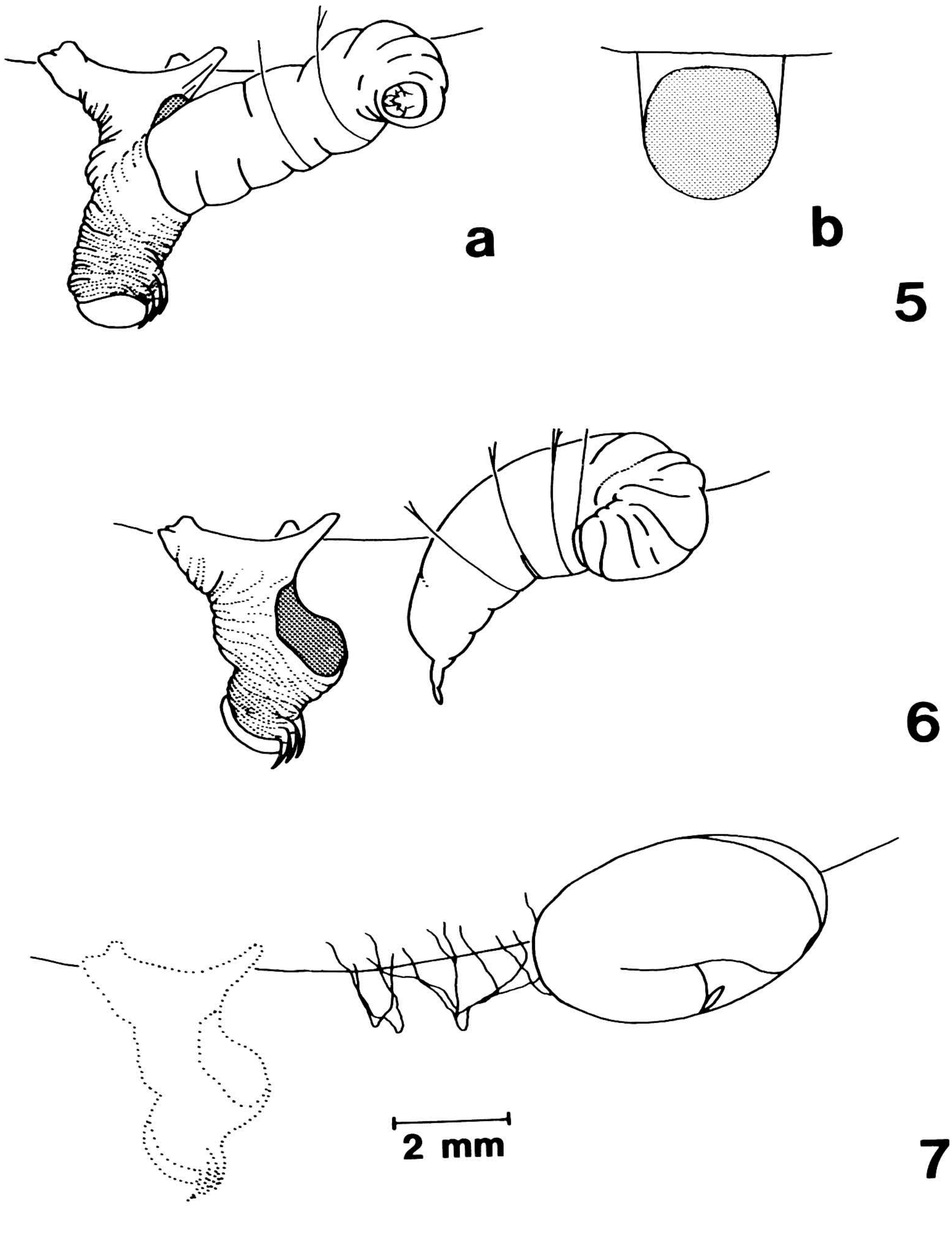
Prior to the emergence of the *Phobocampe* larva, a bulge appears on the ventral surface of the host larva, anterior to the prolegs of the sixth abdominal segment (Fig. 2). The parasitoid larva uses its mandibles to rasp through the host's integument at the site of the bulge, taking 15-30 minutes to break through. Once the initial opening is made, the parasitoid larva forces itself out through the opening, alternately shortening and lengthening its body segments to move them through the opening. These movements continue until the thorax and first 2-3 abdominal segments are free of the host cuticle (Fig. 3). The parasitoid larva then arches its head caudally and downward, looping its head and anterior thoracic segments in a direction along and under one side and then up the other side of its body, spinning a strand of silk around its body (Fig. 4). These spinning movements produce a "sling" of silk (Fig. 5) which suspends the parasitoid larva below the leaf or branch.

Once the *Phobocampe* larva has spun the first loop of the sling, it anchors the anterior part of its body using both the sling and the leaf surface, then pulls more of its abdomen free of the host. Sling spinning continues, as more of the parasitoid larva is freed, until it is completely free of the collapsed host integument (Fig. 6). The *Phobocampe* larva can move up to 2 cm from the host remains, suspended in its silk sling beneath the leaf blade, before spinning its own cocoon (Fig. 7). The elapsed times from the rupture of the *Operophtera* larval integument to the beginning of construction of the parasitoid cocoons, for two emergence sequences timed in the laboratory, were 11 and 25 minutes. The cocoon spinning behaviour of this *Phobocampe* species was described by Gillespie and Finlayson (1979).

Eidt and Embree (1968) showed that the arrangement of ocelli I and II relative to ocelli IV and VI could be used to separate most larvae of the winter moth and Bruce spanworm. Imaginary lines drawn through the two pairs of ocelli were usually parallel in the winter moth (90% of examined larvae) and usually diverged caudad in Bruce spanworm (93% of examined larvae). Some overlap of the ocellar characters was evident, with the lines



Figs. 1-4. Initial stages of emergence sequence of *Phobocampe* sp.: 1, endoparasitized *Operophtera* larva attached to a leaf while *Phobocampe* larva completes feeding; 2, *Operophtera* larva with ventral bulge (arrow); 3, emerging *Phobocampe* larva with thorax and first two abdominal segments free; 4, a, *Phobocampe* larva attaching first silk strand to undersurface of leaf, b, diagrammatic representation of head movements of the *Phobocampe* larva during sling spinning.



Figs. 5-7. Final stages of emergence and site of cocoon construction of *Phobocampe* sp.: 5, a, final-instar larva of *Phobocampe* using sling to free itself from the remains of the host larva, b, diagrammatic cross-section of *Phobocampe* larva suspended in sling; 6, *Phobocampe* larva free of host remains; 7, site of cocoon construction with collapsed sling remnants between *Phobocampe* cocoon and host remains.

diverging caudad in 5% of the winter moth larvae and parallel in 3% of the Bruce spanworm larvae examined. In this study the remains of 44 *Operophtera* larvae associated with *Phobocampe* cocoons were recovered. The arrangement of the ocellar pairs was parallel in 36 of the head capsules, slightly divergent caudad in 7 specimens and was strongly divergent caudad in a single specimen. The proportion of *O. bruceata* represented in the recovered remains cannot be determined exactly because the character overlaps as described between the two *Operophtera* species. However, these data indicate that most of the *Phobocampe* sp. present used *O. brumata* as a host.

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BOOK REVIEW

THE MOSQUITOES OF BRITISH COLUMBIA BY PETER BELTON

Handbook 41, British Columbia Provincial Museum. Victoria, B.C. 1983, p. 189

It is a pleasure to report a second volume on insects in this handbook series — a series which so far has had 18 volumes on plants (including fungi and algae), 15 on vertebrates, five on marine invertebrates and one on marine life. I hope more of the insect fauna will be treated before long.

The work should succeed admirably in its primary aims — to allow identification of mature larvae and females of the species of British Columbia, to outline their distribution within the province, and to provide a brief account of the biology of the group as a whole and of the individual species. The introductory sections are fully adequate; they cover the usual subjects of biology, history of mosquito study in the province, life zones, management (i.e., control), collection and preservation of the various stages, and anatomical terms. An unusual but interesting additon, by E. M. Belton, is "Mosquitoes in the Culture of the Northwest Coast Indians". A useful innovation consists of several blank pages; in this way the larval figures for each species except those of *Anopheles* face the description of the species. The drawings appear to be sufficient in number and detail to allow for ready identification of females and larvae.

Two omissions are unfortunate, One is lack of treatment of the males. The author is correct in saying they are less often encountered than females, but half the specimens reared from larvae or pupae are males, and badly rubbed males can be much more reliably identified than can similar females. The author perhaps felt that the preparation of drawings of male terminalia was not worth the effort, but the drawings in Wood *et al.*, The Mosquitoes of Canada, to which users of this handbook are referred for identification of males, could almost certainly have been used.

The other regrettable omission is of distribution maps. The general distribution within the province is outlined for each species, but maps would have allowed the distributions to be much more quickly perceived, would have indicated which parts of the province are poorly surveyed, and would almost certainly have provided a greater incentive for further collecting. I think four maps to a page would have been possible; with non-overlapping species on one map, 10 pages of maps would probably have been adequate for the 46 species treated.

One surprising statement should not go unremarked: "This order (Diptera) has about 67 families". Williston's Manual of Nearctic Diptera (1908) recognized 60 families, Curran's Manual (1934) 83, the recent Agricultural Canada Manual (1981) 108, and some European authors recognize 120 or more. Not even the most enthusiastic lumper can make a reasonable case for only 67.

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