On the identity of Bhatia and Keilin's (1937) malacophagous dipterous larvae parasitizing *Vertigo* sp.

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Since the seminal discovery of obligate malacophagy (Mollusc-feeding) in the dipteran family Sciomyzidae by BERG (1953), there has been a steady increase in our knowledge of the family (BERG & KNUTSON 1978; MURPHY et al. 2012) so that today, lifecycles are known in 203 species out of a total described number of species of 539 (38% of the family) making Sciomyzidae among the most biologically well-known dipterous families in the world (KNUTSON & VALA 2011). The family was originally valued as biological control agents of intermediate hosts of snail-borne trematode diseases of man and livestock e.g. schistosomiasis and fascioliasis (BERG 1964). More recently, they are valued as biological controls of slug pests in glasshouses (HYNES et al. 2014; BISTLINE-EAST et al. 2020; AHMED et al 2019), as a paradigm for the evolution of predatory-parasitoid transition (KNUTSON & VALA 2002), the evolution of aquatic-terrestrial transitions (CHAPMAN et al. 2016; 2012) and as biological indicators of dipteran diversity in general (RYDER et al. 2005; CAREY et al. 2017a; 2017b).

Approximately sixteen years prior to BERG'S discovery, David KEILIN, who is rightly remembered in history for his discovery of cytochromes, but who kept up his interest in entomology throughout his life (MANN 1964), and his then-student M. L. BHATIA, who was himself to go on to a distinguished academic career in India, published a paper in "Parasitology", on unknown dipterous larvae that were attacking snails identified as *Vertigo genesii* (GREDLER 1856). Following the publication of WALDÉN (1966) it was clear that all Irish records of *V. genesii* were actually *Vertigo geyeri* LINDHOLM 1925, now a Habitat's Directive Annex II protected species. Photographs of modern *V. genesii* and *V. geyeri* are shown below in Fig. 1 and Fig. 2, respectively. It will be noted that Fig. 2 agrees well with BHATIA & KEILIN'S (1937) Fig. 1, especially with respect to the teeth. The snails were collected by Mr R. A. PHILLIPS from a bog in Tuam, Co. Galway[1] and then apparently sent to BOYCOTT, who forwarded them to BHATIA and KEILIN. Unfortunately, that bog is now drained, and we can only suppose that the snails were inhabiting the minerotrophic so-called "lag" of the bog, the location of which was obvious in a 1998 survey, but the habitat was too dry to support *Vertigo geyeri*.

BHATIA and KEILIN provide excellent drawings of the as-then unknown dipterous larvae. These drawings, together with other facts, allow us to make the following conclusions:

1) The current extant Sciomyzidae fauna of Ireland is only 60 species (SPEIGHT & KNUTSON 2011)[2]. We can be confident that BHATIA and KEILIN'S larvae are among

[1] note: BHATIA and KEILIN mis-name this location as Taum in their paper

[2] Note: SPEIGHT & KNUTSON (2011) incorrectly sum the total number of Sciomyzidae species in Ireland to 59. Counting up their species mentioned in their text, however, results in the true number of 60.

these species it being very unlikely that the species has since become locally extinct in Ireland.

2) *Vertigo geyeri* is a terrestrial species from saturated spring seepage habitats. This together with the fact that BHATIA and KEILIN describe a rather intimate association, which is probably parasitoidal (*sensu* KNUTSON & VALA 2011) in nature. This narrows our search down to those species occupying KNUTSON & VALA'S (2011) behavioural groups 6 and 7.
3) Working through the key to Palearctic larvae presented in KNUTSON & VALA (2011) – see pages 306 – 308, together with the excellent drawings of BHATIA & KEILIN (1937), which are reproduced in this note – see below. The key brings you to the genus *Trypetoptera* HENDEL.
4) There are only two extant species of *Trypetoptera* in the world. The Nearctic *Trypetoptera canadensis* (MACQUART), which does not occur in Ireland, and *Trypetoptera punctulata* (SCOPOLI), which does. We, therefore, suggest that the identity of BHATIA & KEILIN'S (1937) malacophagous dipterous larvae are this species.
5) BHATIA & KEILIN'S (1937) figures compare very well with the figures of second-instar (but not third-instar) larvae of *T. punctulata* in VALA (1986) but not other terrestrial Sciomyzidae known from Ireland. It should be noted that VALA (1986) did not rear *T. punctulata* from *Vertigo* spp., but did so from many other snails. Professor VALA has communicated to us that he neither attempted to rear *T. punctulata* from *Vertigo* spp. Nor, however, did he ever collect *Vertigo* spp. from nature that were infested with this species of Sciomyzidae (VALA pers comm).

Vertigo geyeri is a species of conservation interest (BYRNE et al. 2009) and the depredations of *Trypetoptera punctulata* may be a cause for concern. This is not the first time that a sciomyzid poses a threat to a Gastropod of conservation concern cf. Kerry slug (*Geomalacus maculosus* ALLMAN) predation by *Tetanocera elata* (FABRICIUS) (GIORDANI et al. 2014). Had PHILLIPS, BOYCOTT, BHATIA or KEILIN been able to rear out the various larvae they collected to adult flies, the malacophagous nature of the family Sciomyzidae may have been elucidated some sixteen years earlier than it was.

Acknowledgements

This short note is dedicated to the memory of Dr Lloyd KNUTSON, doyen of Sciomyzidae research, and the person who first suggested this communication.

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FIGURES

Fig. 1: *Vertigo genesii* (GREDLER 1856). Note the absence of teeth.

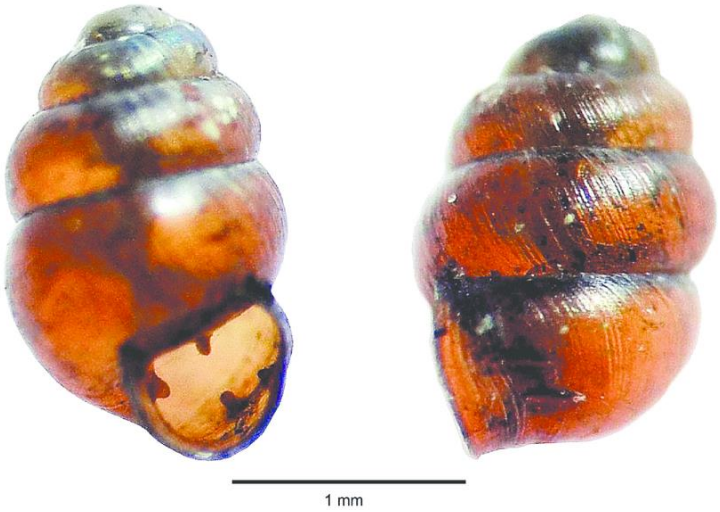

Fig. 2: *Vertigo geyeri* Lindholm 1925. Note the presence of teeth as in BHATIA & KEILIN'S (1937) Figure 1.