NOTES ON THE BIOLOGY OF CERTAIN SNAIL-KILLING FLIES (SCIOMYZIDAE) FROM KHUZESTAN (IRAN)[1]

L. V. Knutson[2]
E. R. Shahgudian[3]
G. H. Sahba[3]

ABSTRACT **The paper contains the first report on the biology of snail-killing flies (Sciomyzidae) in Khuzestan. It is based on field and laboratory studies conducted during November 1971 and April 1973, as well as field observations in May 1972, at the Dezful Medical Research Station. Additional biological information obtained during studies is given for Pherbellia fuscipes (Macquart), P. grisescens (Meigen), Coremacera amoena (Loew). Knutsonia turkestanica (Hendel), Sepedon sphegea (Fabricius), S. s. spinipes (Scopoli) and Colobaea iranica Knutson, together with their habitat distribution.**

INTRODUCTION Schistosomiasis (bilharziasis) is one of the major debilitating diseases of humans in many parts of Africa, northern South America, southeastern Asia, and the Near East. In Iran, the disease is

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2. Systematic Entomology Laboratory, Agricultural Research Service, US Department of Agriculture. Mail address: c/o US National Museum, Washington D.C., 20560, USA.
3. School of Public Health and Institute of Public Health Research, University of Teheran, P.O. Box 1310, Teheran, Iran.

limited to the southwestern part of the country where the flatworm, *Schistosoma haematobium* (Bilharz), is the causative agent of urinary schistosomiasis, and the freshwater snail, Bulinus truncatus (Audouin) is the obligate intermediate host. The control of schistosomiasis in Iran by the staffs of the Institute of Public Health Research and the School of Public Health, University of Tehran, of the Dezful Medical Research Station and the Ministry of Health has been quite successful. By means of snail control with Bayluscide, chemotherapy of infected persons (mainly with Ambilhar), environmental modifications to eliminate snail habitats, and improved sanitation facilities to reduce contamination of frequented waters by eggs of *S. haematobium*, a relatively effective degree of control (but not eradication) of the disease has been achieved. However, extensive irrigation and agricultural development of the Khuzestan plains, made possible by construction of dams on the Dez, Karun, and Karkheh Rivers might result in increase in the prevalence of the disease.

Whether or not the costly control measures used in Iran now can be used to the same degree of effectiveness on a broader scale is unknown. It is likely, however, that the overall costs of control will be considerably higher, and the use of chemical molluscicides, with possibly harmful long-term effects on ecosystems, will increase. Thus it is important to look for supplementary methods of control. Of several alternative or supplementary methods, biological control offers some promising approaches. One of these is control of the intermediate host snails by natural enemies (pathogens, parasites, predators). Of the many known natural enemies of snails, predaceous and parasitoid larvae of sciomyzid flies appear to be likely candidates for use as biological control agents.

This first report on the biology of Sciomyzidae in Khuzestan is based on field and laboratory studies conducted during November 1971 and April 1973, as well as field observations in May 1972 at the Dezful Medical Research Station, Khuzestan. The geographical distribution of Iranian Sciomyzidae, and a key to species occurring and likely to occur in Iran are presented in a separate report (Knutson and Shahgudian, 19).

General Biological Features of Sciomyzidae.

Larvae of the approximately 200 biologically known Sciomyzidae kill and feed, almost without exception, only on pulmonate, freshwater snails, terrestrial snails, eggs of snails, slugs, or fingernail clams. Whereas larvae of most species are free living predators, a few are solitary, internal parasitoids whose host selec-

tion is limited to a single species or genus of molluscs. Most larvae are air-breathers and must keep their posterior spiracles exposed above the surface of the water or above the surface of the snail tissues.

Eggs of the many aquatic and semi-aquatic predators are laid on emergent or shoreline vegetation, whereas those of a few terrestrial parasitoids are placed directly on the shell of the host. After an incubation period of one to several days, the eggs hatch and the first-instar larvae actively search for the prey. The overt predators attack aggressively, rupturing the hemocoel and killing quickly, but the most intimately associated parasitoids may remain buried in the snail up to 10 days before their selective feeding causes its death. Only one snail is killed and eaten during the development of each highly specialized parasitoid, but as many as 30 snails, from newly hatched to mature individuals, are killed and eaten during the several days to weeks required for development of each predaceous larva. Aquatic predators pupate in the water, predators of amphibious or terrestrial snails pupate among shoreline debris or in litter, and a few species, especially parasitoid forms, pupate in the shell of the prey. Most species breed continuously at favourable temperatures. Overwintering may occur in any stage, but it usually takes place in the pupal stage.

Life Cycle Information on Sciomyzidae From Khuzestan

The basic life cycles of 13 of the 18 species of Sciomyzidae occurring in Iran are known from studies conducted elsewhere. Additional biological information obtained during studies in Khuzestan is presented below for *Pherbellia fuscipes* (Macquart), *P. grisescens* (Meigen), *Coremacera amoena* (Loew), *Knutsonia turcestanica* (Hendel), *Sepedon sphegea* (Fabricius), and *S. s. spinipes* (Scopoli). The detailed life cycle of *Colobaea iranica* Knutson is reported separately (Knutson and Bratt, in press).

Considerable work remains to be done on the Iranian Sciomyzidae before their significance in natural or biological control of snails can be established. Especially needed is more information on acceptability of prey or hosts, seasonal activity of all life stages, dynamics of natural populations, and the impact of Sciomyzides on snail populations. Such information would also be critical to determine which, if any, snail-enemy niches are not filled or are weakly exploited and thus what steps could be taken to increase the effectiveness of the endemic natural enemies, as well as being important for selecting exotic natural enemies for introduction.

Colobaea iranica Knutson

The description of *Colobaea iranica* as a new species, a detailed discussion of its life cycle, and descriptions of the immature stages are included with discussions of 4 other species of *Colobaea* in a separate report (Knutson and Bratt, in press). No immature stages of *C. iranica* were collected, but a complete rearing in the laboratory was obtained from adults collected during November 1971 and April 1973 at Shushtar and at 6 localities near Dezful. Adults mated readily and laid many egges on the damp cotton in the breeding jars. Eggs hatched after about 48 hours, and the larvae immediately attacked the small *Gyraulus intermixtus* (Mousson) and *Lymnaea gedrosiana* (Annandale and Prashad) provided for them; the larvae showed a decided preference for *G. intermixtus*. Puparia were formed in the shells of the prey, and a frothy mass of a calcareous material was produced near the aperture of the shell by the pupating larva. The pupal period was about 2 weeks.

Pherbellia fuscipes (Macquart)

The biology of *Pherbellia fuscipes*, based on rearings made in western Europe, was reported by Bratt, et al., 1969. The species is rather common in northern Europe, but rare in southern latitudes. In Khuzestan, it was found at only 6 localities, and only 1 or a few specimens were found at each place.

Adults were swept from herbaceous vegetation, mainly in marshes, but 1 specimen was collected in an orange grove that was only moderately humid (Shah Abad, 10.6 km E Dezful; 29 April).

A pair of adults collected on 16 April at Boneh Sayed Moosa, 16.0 km W Dezful, were not seen to mate in the laboratory, but eggs were first seen on the damp cotton in the breeding jar on 22 April. The eggs hatched within 48 hours, and the larvae attacked living aquatic snails (*Bulinus truncatus*, *Gyraulus intermixtus*, and *Lymnaea gedrosiana*) lying on the damp cotton. Several larvae fed together in each snail, and they continued to eat the decaying tissues for several days after the prey died. The length of larval life was about 6 days. Most larvae pupated in the shells of the food snails, but 1 larva pupated outside. Larvae that pupated in shells produced a thick, well-formed, calcareous plate near the aperture of the shell. Larvae pupated between 29 April and 1 May, and adults merged.

Pherbellia grisescens (Meigen)

The life cycle of *Pherbellia grisescens*, based on rearings from Austria, Spain, and Afghanistan, has been described in detail

by Bratt, et al., 1969. No larvae of *P. grisescens* have been found in snails previously, although larvae and pupae of the related *P. humilis* (Loew) have been found in *Lymnaea* spp. and *Physa* sp. in North America (Bratt, et al., 1969). Several dead *Lymnaea gedrosiana* were collected from the bare, muddy surface of an empty drainage ditch completely shaded by herbaceous vegetation at Baysa, 15 km W Dezful on 13 November. No larvae could be seen in the snails when they were collected; however, from a pupa formed in this rearing container (outside the shell) on 24 November a male P. *grisescens* emerged on 1 December. An undetermined species of Phoridae and several *Allotrichoma* near *laterale* (Loew) (Ephydridae) (det. W. W. Wirth) were also rared from these dead *L. gedrosiana*. A puparium of *P. grisescens* containing an apparently viable pupa was collected at the same locality on 11 November, but it did not produce an adult.

Adults were common in many localities during April 1973. They were frequently swept from low herbaceous vegetation at the muddy margins of marshes. Although some adults collected during April neither mated nor laid eggs, other individuals did mate and laid many eggs. Eggs were characteristically laid on the dry walls of the rearing containers, not on the damp cotton.

Knutsonia turcestanica (Hendel)

The life cycle of *Knutsonia turcestanica* was described by Knutson and Berg (1967) from rearings started with adults collected during March and April in western Crete. On 5 November, we swept a pair of adults from low, marginal vegetation at Boneh Javaz, 41 km SE Dezful. The pair was first seen mating on 7 November; they mated infrequently thereafter and were not seen in copula after 18 December, although the male lived until 2 March, 1972. The female lived until 6 May, 1972, producing a total of 387 eggs between 9 November, 1971 and 8 March, 1972. All eggs hatched within 7 days after being laid. The larvae killed and ate *Bulinus truncatus, Gyraulus intermixtus, Helisoma trivolvis* (Say), *Lymnaea gedrosiana*, and *L. palustris* (Müller), but did not attack small individuals of the operculate snail, *Melanoides tuberculata* (Müller).

A pair of adults collected on 17 April, 1973 in a dry *Juncus-Carex* marsh at Shuhan, 14.0 km SW Dezful, mated between 18 and 28 April, and the female laid 42 eggs between 22 and 28 April. A female collected with this pair was kept without a male in the laboratory and laid 45 eggs. These eggs hatched within 5 days.

Sepedon sphegea (Fabricius)

Biological information on *Sepedon sphegea*, derived mainly from material collected in France and Afghanistan, was presented by Neff and Berg (1966), and Nagatomi and Kushigemachi (1965) discussed the biology of *S. sauteri* Hendel (considered by us as a synonym of *S. sphegea*) from rearings in Japan.

Sepedon sphegea was by far the most common species of Sciomyzidae encountered in Khuzestan, and eggs, larvae, pupae, and adults were collected. The species was taken in all of the major types of aquatic habitats (marshes, ponds, canals, drains, and side-pools), but was most frequently found in exposed, relatively undisturbed marshes. In other parts of Iran, *S. sphegea* has been collected between 13 April and 22 August.

Eggs were collected on 30 April at Bayza by passing a flat, screen mesh snail collector through low *Carex* and grasses emerging through a few inches of water. Five egg masses were found; the masses included 6, 6, 8, 8 and 13 eggs. The eggs were arranged side-by-side and touching one another. First-instar larvae hatched from 2 of the egg masses on April 30. The eggs in the other masses were very dark and swollen, a few had exist holes of parasitic wasps. Ten minute wasps of Chalcididae family emerged from these eggs on 30 April and 1 and 2 May. One or two wasps emerged from each egg.

Many second- and third-instar larvae were collected between 31 October and 5 November, 1971 and between April 16 and 30, 1973. The larvae killed and ate *Bulinus truncatus, Gyraulus intermixtus*, and *Lymnaea gedrosiana* in Iran and *Helisoma trivolvis* and *Physa sp.* during laboratory rearings in Washington. D. C., but they did not attack *Succinea sp.* when these were the only snails offered to them. A third-instar larva was found feeding in a *Lymnaea gedrosiana* collected at Shustar on 24 April.

Third-instar larvae pupated 1-8 November and 25-28 April, 1-4 days after being collected. Puparia formed during laboratory rearings produced adults after pupal periods of 5-8 days. From many pupae found floating amongst emergent vegetation between 31 October and 15 November and between 17 and 30 April adults emerged between 31 October and 22 November and between 24 April and 1 May after observed periods in the puparium of up to 7 days. One adult emerged within 1/2 hour after the puparium was collected on October 31.

A pair of adults that emerged on 3 November were placed together in a breeding jar. They lived 19 days, and first copu-

lated on 6 November. The female first oviposited on 13 November, and laid 68 eggs on the walls of the jar before she died on 22 November. A larva obtained from the breeding jar on 29 November ate only *Helisoma trivolvis* in the laboratory, pupated on 18 December, 1971 and a male emerged on 5 January, 1972.

A male that emerged on 5 November, 1972, and a female that emerged on 3 November were first seen to copulate on 5 November, and they mated frequently until 17 November. The first eggs were laid on 7 November; a total of 160 eggs was laid until the adults died on 23 November. The pre-oviposition periods for the above 2 females that emerged during November were only 4 and 10 days.

Two females collected on 3 November, were placed in 1 breeding jar, and 337 eggs were laid on *Typha* and on the wall of the jar between 5 and 16 November, 1971. One female died on 16 November; the other female lived until 2 March, 1972 and produced 327 more eggs. A male that emerged on 25 November, 1971 was included with the second female on 1 December, and it died on 6 May, 1972. Eggs hatched between 16 November, 1971 and 8 March, 1972.

A pair of adults collected on 24 April at Shushtar laid 36 eggs between 25 and 28 April; 2 females collected with this pair and kept without males also laid viable eggs. A female collected 25 April at Bayza and kept without a male laid viable eggs between 27 and 30 April.

Sepedon spinipes spinipes (Scopoli)

Little seasonal information is available for either the Nearctic or Palearctic subspecies of *Sepedon spinipes*. Neff and Berg (1966) reared *S. s. americana* Steyskal from adults collected in New York and Saskatchewan, and they described the basic life cycle of *S. s. spinipes* from adults collected during July in Belgium and from larvae collected during April in Crete and Corfu, Greece. They noted that female *S. s. spinipes* collected during the spring produced a few eggs; those that emerged in the laboratory lived 160-165 days but did not oviposit; and female *S. s. spinipes* collected during July in Belgium laid eggs in the laboratory.

Adults (3 males, 3 females) were collected in an exposed marsh (Boneh Javaz, 41 km SE Dezful) in the warm plains south of the Zagross Mts. on 5 November, and 3 males and 3 females were collected 7 days later in a cool, dry, shaded, vernal marsh about 200 km north in the Keeyab Valley of the Zagross Mts., near Khoram-Abad. The adults from Boneh Javaz mated on 1 November, and lived from 2 to 250 days in the laboratory. The

females produced 46 eggs between 9 and 15 November, 3 eggs (infertile) on 4 March, 1972, and an additional 359 eggs between 2 April and 3 September, 1972. However, the adults collected near Khoram-Abad on 12 November lived in the laboratory until 16 July, 1972 but neither mated nor laid eggs.

A pair of adults collected on 22 April at Imam Zadeh Jabar (14.0 km SW Dezful) were not seen to mate or oviposit between 22 April and 1 May. However, 2 females collected with this pair were kept isolated from males in the laboratory and both laid fertile eggs (39 and 27) between 24 and 28 April. These eggs hatched within 4 days and the larvae ate the *Gyraulus intermixtus* snails that were provided for them. A larva collected on 22 April at Imam Zadeh Jabar ate *Bulinus truncatus, Gyraulus intermixtus,* and *Lymnaea gedrosiana,* and pupated on 27 April. The puparium was not formed in the water, but was glued to the surface of the rearing container by a transparent, mucilaginous substance. A pupa found floating on 5 November produced a female 1 day later.

Coremacera amoena (Loew)

Coremacera amoena is a rare species, and has not been previously found during the senior author's extensive collecting in the Mediterranean area. Many adults were collected in a large, walled, overground fruit garden at Ghalvand, 18.0 km S Dezful, on 18, 19, and 23 April. The garden is interlaced with many small irrigation ditches, and the humidity is strikingly higher than any other habitats visited. Various densely growing trees and shrubs (orange, apple, mulberry, cherry, quince, apricot, promegranate eucalyptus) cast a more or less continuous shade that is interrupted by paths and occasional small clearings. The adults were swept from grasses and other herbaceous vegetation in the most shaded places in the garden. *Helicella* spp. snails were abundant on low vegetation and in the dense, moist leaf-litter, and *Cionella lubrica* was very common in the leaf-litter. A few *Agriolimax* sp. slugs and 1 *Oxychilus* sp. snail were also found in the litter.

Five pairs of adults and 3 isolated females were kept in small breeding jars (7 cm × 5 cm) in the laboratory from April 18, 1973 until now (June 1973), but none mated or laid eggs. No puparia were found in the leaf-litter or in snail shells collected from the litter, and no larvae were found in many dead or living snails collected where the adults were found.

The absence of immature stages in nature, the presence of many adults, and the lack of reproductive activity may indicate that the adults had emerged recently (perhaps during April).

Breeding and development of the larvae likely occur over a lengthy period, perhaps from May or June through the summer months, as is true of a related species, *Coremacera marginata* (Fabricius) (see Knutson, 1973).

No significant information was obtained on the other 2 species of Sciomyzidae occurring in Khuzestan, *Hydromya dorsalis* (Fabricius) *and Pherbellia cinerella* (Fallén). A few pairs of these species were maintained in the laboratory but the adults neither mated nor oviposited. For information on the life cycle of *H. dorsalis* see Knutson and Berg (1963), and for *P. cinerella* see Bratt, et al. (1969).

Habitat Distribution of Sciomyzidae in Khuzestan

Between 30 October and 16 November, 1971, visits were made to 24 marshes, ponds, streams, and other situations (mainly aquatic) where Sciomyzidae might be expected to occur; 1 to 4 species were found at 13 of the localities. Between 1 and 27 May, 1972, 36 localities with potential as biotopes for Sciomyzidae were visited, 4 species were collected, and 1 or 2 species were found in 22 of the localities. Between 16 April and 1 May, 1973, visits were made to 21 localities, and 1 to 7 species were found at 16 places. *Sepedon sphegea* was by far the most common species, being found at 12 of 13 habitats during 1971, 29 of 36 during 1972, and 9 of 16 during 1973. Other Sciomyzidae collected were, *Colobaea iranica* (10 localities), *Pherbellia cinerella* (10 localities), *P. fuscipes* (10 localities), *P. grisescene* (23 localities), *Hydromya dorsalis* (2 localities), *Knutsonis turcestanica* (6 localities), *Sepedon s. spinipes* (3 localities) and *Coremacera amoena* (2 localities).

The following gastropods were collected in habitats with Sciomyzidae.

Aquatic: *Bulinus truncatus* (Audouin)
Gyraulus intermixtus (Mousson)
Lymnaea gedrosiana (*Annandale* and *Prashad*)
Melanoides tuberculatus (Müller)
Planorbis planorbis (L.)
Viviparus bengalensis (Lamarck)

Terrestrial: *Agriolimax* (= *Deroceras*) sp.
Cionella lubrica
Helicella spp.
Succinea elegans Risso

Few of the localities had ever been treated with molluscicides. Many dead amphibians were found in marshes that had been recently sprayed with a molluscicide (Bayluscide), although the fauna of Sciomyzidae and other aquatic invertebrates (except

snails and nymphs of Odonata) in these habitats did not appear to have been drastically affected.

No Sciomyzidae were found around heavily trampled margins of small strongly disturbed or polluted habits. The greatest variety of species was found in large, relatively undisturbed marshes such as the former marsh near Boneh Sayed Moosa, 16 km west of Dezful, and those at Imam Zadeh Jabar, 14.0 km southwest of Dezful and Boneh Javaz, 41 km southeast of Dezful. These kinds of situations, which are in fact difficult or impossible to treat adequately with molluscicides, appear to be the habitats where attempts at biological control by introduced species of Sciomyzidae would be most likely to succeed. Situations where Bulinus or Lymnaea snails are aestivating around the margins of drying marshes may be particularly suitable for biological control attempts. Snails in these situations are generally not affected by molluscicide treatment (which affects only submerged snails). But these snails are the preferred prey of semi-terrestrial sciomyzidae larvae (such as *Pherbellia grisescens*) that are specially adapted for attacking aquatic snails on wet or drying surfaces. Moderately disturbed, marshy areas used for cattle grazing, such as the habitat at Shush and small, slowly flowing, grass-choked drains, such as the one at Choghasorkh, also may be sites where biological control could be attempted.

The absence of some known Iranian and Mediterranean Sciomyzidae from aquatic situations in Khuzestan that appear to be suitable habitats may be explained by difficulties of dispersal, as well as by the area's biogeographical history, relatively isolated geographical position, and partially surrounding barriers. Most of the habitats where we collected Sciomyzidae were several kilometers from each other. Although practically nothing is known about the dispersal abilities of Sciomyzidae, or their resistance to dry conditions, it is likely that a considerable proportion of emmigrating adults would perish in intervening inimical areas before finding suitbale new habitats. Widespread dispersal of puparia by flood-water is not presently a dispersal mechanism of Sciomyzidae in Khuzestan, although it may well have been previously, when major floods occurred locally. Passive dispersal by other organisms, e.g., by birds, probably is negligible.

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