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NOVEL BIOLOGY FOR *TEPHROCHLAMYS RUFIVENTRIS* (MEIGEN, 1830) (DIPTERA: HELEOMYZIDAE)

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Abstract.—A heleomyzid fly *Tephrochlamys rufiventris* (Meigen, 1830), was reared from a form of blue cheese aging in a refrigerated, dark, aging room of a small northern California creamery. The third-instar larva is redescribed and the puparium is described for the first time.

Key Words: fungi, carrion, feces, creamery, blue cheese

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In January 2014 the staff at a small creamery in northern California contacted us about a fly problem in some of their cheeses. The creamery was located in the vicinity of northern Marin County and southern Sonoma County, less than 20 miles east of the Pacific Coast. They persistently had flies breeding on cheese in one of their refrigerated aging rooms. There were two unusual aspects of this infestation. First, the infestation occurred in a continuously cold, dark room. Second, the fly causing the infestation did not belong to any of the taxa commonly known to infest cheeses, such as species of *Piophila* Fallén (Piophilidae) but turned out to be the heleomyzid, *Tephrochlamys rufiventris* (Meigen, 1830).

The general biology and life histories of heleomyzid flies remain poorly characterized, and outside of a few observations where flies emerged from various substrates, the biology of the genus *Tephrochlamys* Loew, 1862 seems particularly obscure. These flies largely appear to be scavengers and coprophages as larvae, having been recorded breeding in a diversity of decomposing organic materials, largely consisting of mammal, bird or even insect droppings, carrion and fungi (summarized by Ferrar 1987). *Tephrochlamys rufiventris* has been reared from birds' nests, carrion, human excrement, mammal burrows, rotting potato and *Spirea* (Rosaceae) an ornamental shrub (Howard 1900, Saunt 1934, Gill 1962, Skidmore 1962, Hackman 1963, Okadome 1991). Soszyńska-Maj and Moźnica (2016) collected *T. rufiventris* on snow in temperatures between -3° and 5°C; although unusual, other species in this family can withstand considerably colder temperatures (Worland et al. 2000). This species has also been reared from fungi (Buxton 1960, Chandler 1978, Hackman & Meinander 1979). Cheese is never mentioned with this species, and the only mention of cheese associated with the

family is a reference by Hackman (1963) to two specimens of *Tephrochlamys flavipes* (Zetterstedt) captured from a cheese bait.

The immature stages of only a few species of *Tephrochlamys* have been described. Okadome (1990) described third-instar larvae of *T. japonica* Okadome. Hennig 1952 and Lovanov 1970 gave an incomplete description of *T. rufiventris* larvae.

Materials

The creamery aging room was small, 11x7ft. (3.35x2.13m), without windows, and with a single door. Although the room was kept dark, it was occasionally illuminated by a single 48in. (1.22m) double bulb fluorescent fixture. The room environment was maintained at 10-13°C and 95% relative humidity. The cheese wheels were arranged on wood aging boards on open metal shelving (Fig. 1A). The room was kept dark, except when someone entered the room to turn the cheese. This never involved more than two hours every other day, and the door was kept closed during the activity. Aside from the door there was an 18x24in. ceiling vent that opened directly into the attic. Directly above this opening was a turbine-type vent, which was the most likely route of entry for the flies. Additionally, the creamery housing the aging room was located adjacent to a large pasture containing sheep and horses, with nearby cattle and woodland.

All of the cheese wheels involved were of a variety of blue cheese, which has an irregular surface, with numerous cracks and fissures. This type of cheese undergoes considerable proteolysis and lipolysis due to the molds involved. As a result of these processes the cheese gives off ammonia as well as various aldehydes, methyl ketones and even skatol (Auerbach et al. 2008, Dartey and Kinsella 1971, McSweeney 2004, Nielsen et al. 2006). This particular cheese had been treated with more salt than usual and had developed a very strong ammonia+skatol odor, which could be detected outside the building.

Results

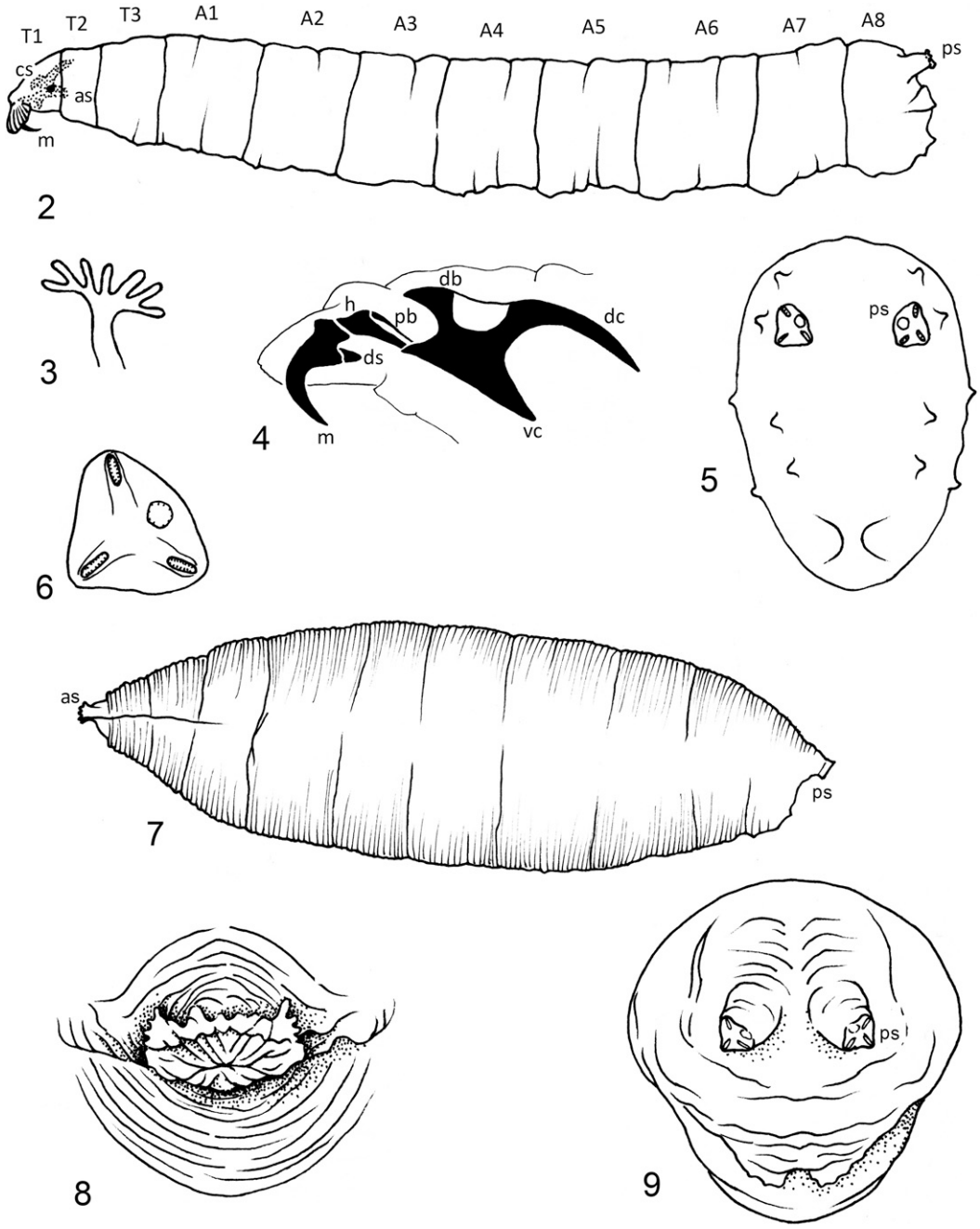
Two wheels of cheese out of 100 were found to be infested, with maggots and pupae on the underside of the cheese and in tunnels in the cheese (similar to Fig. 1B). More than a dozen larvae were observed retreating into tunnels in the cheese wheels, others were found beneath the wheels. Adults were found alive on the walls of the aging room and an equal number were found dead on the floor beneath the rack holding the cheese. All life stages of the fly were found beneath, in the cheese, and in the vicinity of the cheeses in this room.

Description of Immature Stages

Third-instar larva (terminology following Teskey 1981) (Figs. 2-6). Body length 6.3-6.8 mm, breadth 0.8-0.9 mm, subcylindrical, tapered anteriorly, truncate posteriorly (Fig. 2); off-white coloration. Body segmentation indicated by cuticular folds; abdominal segments without spinules, except caudal segment with several pairs of distinct spine-like tubercles. Anterior spiracle T-shaped, with a long stalk and seven antler-like papillae along outer margin (Fig. 3), located laterally along first thoracic segment. Maxillary and antennal papillae short, inconspicuous. Oral ridges numerous, up to 20 or more laying alongside cephalopharyngeal skeleton. Cephalopharyngeal skeleton (Fig. 4), with mandible simple without accessory teeth, dental sclerite acutely triangular, hypopharynx elongate, tapering posteriorly, parastomal bar slender, slightly swelling

Fig. 1. Cheese wheels infested by *Tephrochlamys rufiventris*. A, Wheels on curing rack. B, Close-up of larval tunnel (no larvae in evidence).

anteriorly, ventral cornu acutely triangular in lateral view, dorsal cornu apically elongate, slender and tapering to point, medially less sclerotized between dorsal cornu and dorsal bridge than other parts of skeleton. Posterior caudal end with 8 pairs of spine-like tubercles, 2 dorsal, 2 submedial, 2 posteromedial,



Figs. 2–9. *Tephrochlamys rufiventris*. Details of immature stages. 2-6. Third-instar larva. 2, Habitus, left lateral view. 3, Anterior spiracle. 4, Cephalopharyngeal skeleton, left lateral view. 5, Posterior view, showing posterior spiracles and tubercles. 6, Detail of posterior spiracle. 7-9. Puparium. 7, Habitus, left lateral view. 8, Anterior view, showing annuli. 9, Posterior view, showing posterior spiracles. Abbreviations: A1-8 = abdominal segments, as = anterior spiracle, cs = cephalopharyngeal skeleton, db = dorsal bridge, dc = dorsal cornu, ds = dental sclerite, h = hypopharynx, m = mandible, pb = parastomal bar, ps = posterior spiracle, T1-3 = thoracic segments; vc = ventral cornu.

2 posteroventromedial (Fig. 5); posterior spiracle located at apex of cylindrical stalk (Fig. 2), consisting of 3 short spiracular slits at slightly obtuse angles, and a complete peritreme and ecdysial scar (Figs. 6).

Puparium (Figs. 7-9). 5.9-6.3 mm long, 1.8-2.0 mm broad, tapering anteriorly and posteriorly, segments covered with fine, dense annuli; spiracular characteristics as in third instar (Fig. 7); anterior end showing dense annuli (Fig. 8); in posterior view, caudal spine-like tubercles inconspicuous (Fig. 9).

Discussion

The mostly likely entry point for the flies into the curing room was through the ceiling vent. Screening the vent between the room and the vent turbine might prevent a future infestation. The flies may have originated in manure and/or decaying materials in the adjacent pasture.

The larva and puparium described here are similar to the descriptions of this species and others of this genus, e.g., Hennig (1952) and Okadome (1990). The exception is that Lobanov (1970) illustrated the anterior spiracle in *Tephrochlamys rufiventris* as being short-stalked and rather evenly roseate-shaped in his key to species, while our specimens were more typical of the long-stalked and antler-like shapes characterizing other *Tephrochlamys* (Papp 1998) including *T. tarsalis* (Zetterstedt) and *T. japonica* Okadome, as illustrated in Hennig (1952) and Okadome (1990) respectively. Despite the condition described by Lobanov (1970), this form of the anterior spiracle may be typical for this genus.

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