was no effect against larvae added 4 wk after treatment. These larvae did not pick up a lethal dose of fungus even though it was present at the bottom of the sites. Laboratory bioassays of water samples from top and bottom of test sites in previous trials indicated that the conidia sink to the bottom within 48 hr after treatment (Sweeney et al. 1983) which suggests that rapid sinking of spores may be a serious impediment to effective recycling. More consistent results may be obtained if formulations could be developed which are stable on prolonged storage and which permit the conidia to remain for a longer time within the feeding zone of mosquito larvae.

This paper is published with the approval of the Director General of Army Health Services and was supported by grants from the UNDP/World Bank/World Health Organization Special Programme for Research and Training in Tropical Diseases and by the Australian National Health and Medical Research Council.

References Cited

Cooper, R. and A. W. Sweeney. 1982. The comparative activity of the Australian and United States strains of *Culicinomyces clavisporus* bioassayed in mosquito larvae of three different genera. J. Invertebr. Pathol. 40:383–387.

Cooper, R. D. and A. W. Sweeney. 1986. Laboratory studies on the recycling potential of the mosquito fungus *Culicinomyces clavisporus*. J. Invertebr. Pathol. 48.

Frances, S. P., R. C. Russell and C. Panter. 1984. Persistence of the mosquito pathogenic fungus *Culicinomyces* in artificial aquatic environments. Mosq. News 44:321–324.

Frances, S. P., D. J. Lee, R. C. Russell and C. Panter. 1985a. Seasonal occurrence of the mosquito pathogenic fungus *Culicinomyces clavisporus* in a natural habitat. J. Aust. Entomol. Soc. 24:241–246.

Frances, S. P., R. C. Russell and C. Panter. 1985b. Persistence of the mosquito pathogenic fungus *Culicinomyces clavisporus* in a natural environment. Gen. Appl. Entomol. (N.S.W.). 17:47–52.

Schaefer, C. H., T. Miura, F. S. Mulligan and E. Durpas, Jr. 1974. Insect development inhibitors: Formulation research on Altosid. Proc. Annu. Conf. Calif. Mosq. Assoc. 42:140–145.

Sweeney, A. W. 1978. The effects of temperature on the mosquito pathogenic fungus *Culicinomyces*. Aust. J. Zool. 26:47–53.

Sweeney, A. W. 1981. Preliminary field tests of the fungus *Culicinomyces* against mosquito larvae in Australia. Mosq. News 41:470–476.

Sweeney, A. W., R. Cooper, B. E. Medcraft, R. C. Russell, M. O'Donnell and C. Panter. 1983. Field tests of the mosquito fungus *Culicinomyces clavisporus* against the Australian encephalitis vector *Culex annulirostris*. Mosq. News 43:290–297.

FAILURE OF MOSQUITOES TO COLONIZE TEASEL AXILS IN ILLINOIS

DONALD L. BAUMGARTNER

Northwest Mosquito Abatement District,
147 W. Hintz Road, Wheeling, IL 60090

Small volumes of water in natural and artificial receptacles are occasional oviposition sites for many mosquito species and frequent larval sites for a few species (Horsfall 1955). Worldwide, at least 400 mosquito species from 15 genera develop in 1,500 plant species which impound water (Fish 1983).

The cut-leaved teasel plant, *Dipsacus laciniatus* Linn., (Dipsacaceae) has received little attention in regard to mosquito production. Its pinnately lobed leaves are fused at their bases, forming a prominent cup at each node in which rain water and organic debris accumulate. An introduction from Europe and escapee from flower gardens and florists, it ranges from Massachusetts to Michigan (Fernald 1950) and is known from at least 25 counties in Illinois (Mohlenbrock and Ladd 1978), where it is apparently spreading. In Russia, larvae of the malarial mosquito, *Anopheles maculipennis* Meigen, are common in the axil water of these plants, found near human habitations (Borob'ev 1960). In New York, *Aedes triseriatus* (Say) and *Anopheles punctipennis* (Say) have also been infrequently recovered from teasels (Means 1973). This study was undertaken: (1) to assess the distribution, stand size and density, and water retention of these plants in northwestern Cook County, Illinois and; (2) to determine the incidence of mosquito breeding in the axils and species involved.

During the summer of 1985, 33 teasel stands were mapped within a 116 sq mile suburban area (pop. 404,800, 1980 census) in northwestern Cook County; the majority (72%) of stands located in southern Elk Grove and Maine townships. The size and density of these stands varied from 14 to 1500 m^2 ($\bar{x}=251$ m^2) and from 0.5 to 13.1 ($\bar{x}=5.4$) mature plants per m^2. Stands were found along roadsides, railroad tracks, in cemeteries (waste ground), behind buildings, and in other disturbed areas, proliferating in open, sunny fields. Leaves browned and withered towards the end of August with about 90% wilted by early September.

The number of microreservoirs per plant varied from 4 to 8, a few branching teasels possessing up to 10, on a plant 1.5–2.1 m high. The coneshaped cups at the leaf axils were largest at the bottom of each plant and decreased in size apically. Lowermost axils were on the average 10–14 cm diam and 8 cm deep, containing 150–350 ml of water, while uppermost axils were 1–2.5 cm diam and 2.5 cm deep, containing 5–25 ml of water. Thus, the total volume of water in a single teasel plant ranged from 200 to 750 ml, depending on size, with as much as 1,000 ml supported by very large, branched plants. Mid-height axils appeared to be the most suitable for mosquito colonization and development. Lowermost leaves did not retain water long because they usually browned and dried up, and uppermost leaves were too small.

Throughout August, 14 teasel stands containing 20,000 plants were surveyed 3 or more days after rain. At least one water-containing axil of each plant was inspected for the presence of eggs or larvae. The contents of each axil were removed with a modified meat baster and placed into a conventional dipper for inspection.

No eggs or mosquito larvae were found in 1,063 plants surveyed. Over the last 10 years, larvae had not been found in teasels within the District (D. Oemick, personal communication), even though container-breeding mosquitoes such as *Ae. triseriatus, Culex restuans* Theobald, and *Culex pipiens* Linn. were frequently in nearby catch basins, tree holes, and tires. Possible reasons for the absence of mosquitoes in teasel axils include: (1) lack of, or negative, ovipositional cues for adult females; (2) transitory nature of axil water; (3) lack of microorganisms and organic matter (larval food) in axil water; (4) elevated water temperatures in sun-exposed microreservoirs; (5) hindrance of oviposition or larval development by other environmental factors, e.g., wind, evaporation or rainfall; (6) plant toxins in water, and; (7) coexistence of other invertebrates which compete with, or prey on, immature mosquitoes.

An experiment was therefore carried out, commencing on August 7, 1985 to determine if *Culex* larvae can survive in teasel habitats. Thirty-three randomly selected teasel axils of various heights and sizes at 4 widely separated stands were inoculated with *Cx. pipiens* and *Cx. restuans* egg rafts (1 or 2 per axil) or 10–20 larvae (assorted instars). Six control glass jars containing marsh water (200 ml) placed in the sun at the base of some test plants were simultaneously inoculated with 2 rafts each. Tests and controls were monitored every 3 days (between 1200 and 1500 hr) and spot water temperatures recorded at that time.

Teasel water (pH 7, wide range test paper) appeared to contain enough detritus (dropped flower petals, dead insects) and algae to support some mosquito development. Rotifers and protozoa are also common in teasel water (Masters 1967). The artificially introduced eggs hatched and a small proportion of the total larvae developed into normal adults in controls and tests. In each jar about 30 larvae of 200–500 that hatched survived to maturity whereas in axils between 21 larvae (150 ml axil) and 50 larvae (300 ml axil) matured. Eleven adults were observed to eclose from 6 axils. No natural oviposition was detected during the experiment. In jars the development of egg to adult of *Cx. pipiens* averaged 19 ± 2.2 days (n = 4) at a mean monthly ambient temperature of 20.5°C (Chicago O'Hare Airport data, National Oceanic Atmos. Admin., NOAA), while development was prolonged in axils, requiring 25 ± 2 days (n = 2) for *Cx. restuans* and 34 ± 3.4 days (n = 6) for *Cx. pipiens.* Higher larval density (food limitation) (Barbosa et al. 1972) and a different diet (Horsfall 1955) may explain why these times are longer than the 14 days reported by Madder et al. (1983) for laboratory reared *Cx. pipiens* and *Cx. restuans* (20°C, on powdered liver, 50 larvae/700 ml). The difference of up to 15 days between test and control *Cx. pipiens* may be attributed, in part, to elevated temperatures of axils (frequently 1–2°C above controls at 28–31°C), perhaps approaching its lethal limits. Additionally, differences in the water origin of tests and controls could have affected larval diet and development. Larval mortality was high among 2nd and 3rd instars in both tests and controls, probably the result of overcrowding and competition for limited food reserves (Barbosa et al. 1972). Maximum axil water temperatures were 30–34°C (1–3°C below ambient); the smaller axils heating up more rapidly than larger, lower axils.

Desiccation appeared to be the limiting factor in natural larval survival, although total precipitation for the month was 154 mm, 15 mm above normal (NOAA). Water also drained from the axils through small holes created by herbivorous insects [*Systena frontalis* (Fab.), Chrysomelidae], especially in late summer. At one stand water was present in the axils of 95% of plants 2 days after rain, in 50% after 4 days, and in 10% after 6 days. At a daily mean temperature of 23°C, medium-sized axils retained water 5 to 8 days. In 5 experimental trials the axils dried up, resulting in larval death. Therefore, it was necessary to add water (50–100 ml) weekly to all test axils from nearby axils to prevent larval death due to desiccation. This interference with the larval habitat provided additional food, otherwise unavailable to developing larvae in the closed receptacle system. Water was not added to jars, although volumes declined from 200 to 50 ml in 2–3 wk.

Rainfall also contributed to larval mortality, depending on the severity of the storm, axil height and size, and plant location. On 13 occasions, inoculated teasels had fewer larvae (29–96%) when visited within 12 hr after a heavy rain than before. In 5 axils, larvae were "washed out" completely by rainfall and in others the washed out larvae were found in axils below the test. Little rainwater accumulated in jars because of their ground placement beneath plants.

Adults of *Dasyhelea grisea* (Coq.) (Ceratopogonidae) and *Metriocnemus* sp. near *knabi* Coq. (Chironomidae) were reared from larvae found in axils, with the latter more abundant. Although immatures of both families are known from many different aquatic habitats, including pitcher plants (*knabi*) and Palearctic teasel axils (Borob'ev 1960), in which they feed on algae and detritus, this is apparently the first report of *Metriocnemus* (D. R. Oliver, personal communication) and *Dasyhelea* from Nearctic teasel axils. *Metriocnemus* larvae were detected in axil water ($\bar{x} = 13$/axil) at 6 of 14 stands surveyed. At 2 locations they were abundant, infesting 75% (n = 74) to 78% (n = 65) of those axils inspected, while at other sites they were less common (9%, n = 114; 19%, n = 80). Introduced mosquito larvae, chironomids, and ceratopogonids appeared to coexist with no apparent harm. Mosquito larvae remained mainly at the surface of the water while midge larvae inhabited the bottom detritus. Voucher specimens have been deposited at the Biosystematics Research Institute, Ottawa, Canada.

In summary, mosquito breeding was not observed in the water of teasel plants in northeastern Illinois. However, the midges *Dasyhelea grisea* and *Metriocnemus* sp. near *knabi* are reported for the first time from teasel axils. Experiments demonstrate that *Culex* spp. are able to develop from eggs to adults in teasel axils only if precipitation is well above average, otherwise the majority of reservoirs will desiccate within a week. Single egg ovipositions, often resulting in low larval densities and more rapid development, may explain why only *Aedes* and *Anopheles* spp. have been reported in teasels. My experiments indicate that raft-laying mosquitoes do not colonize teasels because adults do not find the environment attractive for oviposition, not because the environment is lethal to the larvae. Perhaps, other factors such as container size, wind and wave action, absence of shade, water chemistry and water color (reflectance) are important ovipositional deterrents in the teasel system. Means (1973) reported larvae only from cool, shaded plants while all stands in this study were sun-exposed. Additionally, female *Cx. restuans* and *Cx. quinquefasciatus* Say prefer black and dark colored sites over light for oviposition (Belton 1967, Frank 1985). It is possible that green reflecting teasel leaves are similarly not preferred. Alternatively, since teasels are recent introductions, mosquitoes in Illinois may not have had enough time to exploit this new niche. Further investigations may yield more light on the factors responsible which inhibit *Culex* oviposition in teasel axils.

I gratefully acknowledge Don Oemick of the Northwest Mosquito Abatement District for bringing the teasels to my attention, aid in locating some plant stands, and providing experimental egg rafts. I thank Drs. R. E. White (Systematic Entomology Laboratory, IIBIII, ARS, USDA), W. L. Grogan (Salisbury State College, MD), and D. R. Oliver (Biosystematics Research Institute, Agriculture Canada, Ottawa) for their identifications of chrysomelids, ceratopogonids, and chironomids, respectively.

References Cited

Barbosa, P., T. M. Peters, and N. C. Greenough. 1972. Overcrowding of mosquito populations: responses of larval *Aedes aegypti* to stress. Environ. Entomol. 1:89–93.

Belton, P. 1967. The effect of illumination and pool brightness on oviposition by *Culex restuans* (Theo.) in the field. Mosq. News 27:66–68.

Borob'ev, B. A. 1960. Dipterous larvae inhabiting water lying in the leaf axils of the teasel. Entomol. Rev. 39:579–580.

Fernald, M. L. 1950. Gray's manual of botany, 8th ed. Am. Book Co. 1632 pp.

Fish, D. 1983. Phytotelmata: Flora and fauna p. 1–28. *In:* J. H. Frank and L. P. Lounibos (Eds.), Phytotelmata: Terrestrial plants as hosts for aquatic insect communities. Plexus Publ., Marlton, NJ.

Frank, J. H. 1985. Use of an artificial bromeliad to show the importance of color value in restricting colonization of bromeliads by *Aedes aegypti* and *Culex quinquefasciatus*. J. Am. Mosq. Control Assoc. 1:28–32.

Horsfall, W. R. 1955. Mosquitoes—Their bionomics and relation to disease. Hafner Publ., New York, 723 pp.

Madder, D. J., G. A. Surgeoner, and B. V. Helson. 1983. Number of generations, egg production, and developmental time of *Culex pipiens* and *Culex restuans* (Diptera: Culicidae) in southern Ontario. J. Med. Entomol. 20:275–287.

Masters, C. O. 1967. The biota of teasel waters as a science fair project. Carolina Tips 30:21–22.

Means, R. 1973. Mosquito breeding in leaf axils of the teasel (*Dipsacus laciniatus* Linn.,) in New York. Mosq. News 33:107–108.

Mohlenbrock, R. H. and D. M. Ladd. 1978. Distribution of Illinois vascular plants. Southern Illinois Univ. Press. 282 pp.