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ACORNS AS BREEDING SITES FOR *CHYMOMYZA AMOENA* (LOEW) (DIPTERA: DROSOPHILIDAE) IN VIRGINIA AND MICHIGAN

Henretta Trent Band[1]

ABSTRACT

Chymomyza amoena is the only chymomyzid fly emerging from white oak acorns in Virginia. An average of 2–3 adult flies emerged from a single acorn in July while emergence declined to 0.4 adults/acorns in September. In fall, *Drosophila melanogaster* was also present. The incidence of drosophilid (*Drosophila, Chymomyza*) larvae in parasitized acorns in Virginia (40%) in autumn was significantly greater than in Michigan (14%). The *Chymomyza* larvae present in the parasitized acorns in Michigan most likely were *C. amoena*, from the known adaptation of this species in Michigan to frass-breeding.

Williams (1989a) has compiled a list of North American nut-infesting insects and their host plants. *Chymomyza amoena* (Loew) was among the insects contributing to northern red oak (*Quercus rubra*) acorn decay in Illinois (Winston 1956) and larvae were found in acorns of mixed oak *Quercus* species in West Virginia (Dorsey et al. 1962). Drosophilids do not everywhere use the same breeding substrates. For instance, *Drosophila pseudoobscura* Frolowa and *D. persimilis* Dobzhansky and Epling breed in slime fluxes at Mather, California (Carson 1951, Carson et al. 1956) but not at Blodgett Forest 127 km distant (Spieth 1987). The rarity of slime fluxes led Spieth (1987) to discover that drosophilids could breed in California black oak *Quercus kelloggii* acorns, if moist. *Drosophila subobscura* Collin in England breeds in rowan berries but not elderberries; the reverse occurs in Switzerland (Burla et al. 1987).

Chymomyza amoena breeds in a variety of fruits in Michigan, including domestic (commercial) apples *Malus pumilla*, in apples in Virginia and in black walnuts *Juglans nigra* in Michigan (Band 1988a,b,c,d, 1989a). Larvae have been found to overwinter in a variety of substrates in Michigan (Band and Band 1984, 1987) and in apples in Virginia (Band 1988a). The question arises; does this species also breed in acorns in the two states? Here I demonstrate *C. amoena* emergence from acorns in Virginia. Larval adaptation to frass breeding arising from female exploitation of parasitized substrates for oviposition (Band 1988a,b,d, 1989a) suggests that *C. amoena* is also the chymomyzid in acorns in Michigan.

MATERIALS AND METHODS

Studies in Virginia were carried out at Mountain Lake Biological Station (MLBS), elev. approx 1200 m, Giles Co. Virginia, during the summer and fall of 1989 and at

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two sites in Michigan in the fall of 1989. The 600 acre MLBS site with mixed deciduous and evergreen forests is adjacent to the 100,000 acre Jefferson National Forest. Other *Chymomyza* and *Drosophila* species occur in Giles Co., Virginia (Band 1988c,d, 1989b). *Chymomyza* eggs characteristically have a crown of short filaments (Sturtevant 1921, Throckmorton 1962, Schumann 1987). Larvae can be distinguished by the posterior spiracular region (Hackman et al. 1970). To date, *C. amoena* is the only chymomyzid consistently recorded in frass or frassy interiors (Dorsey et al. 1962, Band 1988a).

Study sites in Michigan were stands of oaks. In the northern lower peninsula the site was between Gaylord and Grayling adjacent to US Interstate route 75 and in mid-Michigan the site was a stand of oaks near a housing development in Meridian Twp., Ingham Co. off Grand River Ave. *Chymomyza procnemoides* has also been collected in Michigan as well as Virginia (Wheeler 1952) but its breeding sites are unknown.

Virginia. White oak acorns identified as *Quercus alba* were collected at two locations near the Station on 12 July and 25 July 1989. The acorns collected were rejects among piles of consumed acorns abandoned by squirrels or were unpiled acorns lying 1–2 m adjacent to a foot trail through the woods. All acorns were microscopically inspected for the presence of *Chymomyza* larvae and/or eggs and tentatively identified as *C. amoena.* Larvae were reared in a glass population jar over moist paper toweling. Some of the emerging *C. amoena* adults were transferred to apple + frass to determine if these acorn flies were comparable to *C. amoena* emerging from other substrates (Band 1988a,b) and could utilize apples as a food source; the rest were maintianed on high protein laboratory medium (Band 1988a).

On 30 September 1989 acorns were more rigorously collected on the ground in order to assess the frequency of those damaged and those infested by drosophilid larvae. All were transported back to Michigan State University where acorns with holes were separated, dissected and inspected for the presence of drosophilid larvae or eggs.

Michigan. On 16 October 1989 large numbers of red oak acorns were collected at a site in northern lower (NL) Michigan in Crawford Co. and on 20 November in mid-Michigan in Ingham Co. (EL). Both groups were sorted, and examined following the same protocols as those for the Virginia Fall season collection.

Data analysis. G-statistics have been calculated according to Sokal and Rohlf (1969).

RESULTS

Virginia. *Chymomyza amoena* was the only chymomyzid to emerge from the infested acorns. Eleven of 16 acorns collected in mid-July contained 31 *C. amoena* larvae and 16 of 20 acorns collected in late July had 133 eggs and larvae. Eggs were found in the vascular elements at the base of the acorn or inside on frassy pulp, as found by Spieth (1987) for drosophilid oviposition in acorns in California. However, no other drosophilids were detected in summer. Table 1 records the numbers of adults emerging from the July and September MLBS acorn collections. Adults emerging readily oviposited on apples + frass; 76 adults emerged and produced an F2. Ten acorn emergents showed the ability to switch to a fruit substrate and retain fertility, as expected (Band 1988a). As observed for *C. amoena* egg counts in apples (Band, 1988a), egg totals in acorns exceeded the numbers of adults emerging.

Twenty-two percent of the acorns collected in September in Virginia were damaged (n = 216) of which 40% had drosophilid larvae inside. No acorns collected in September contained eggs on the outer surface of damaged or undamaged acorns. Only parasitized acorns were used for drosophilid oviposition in September among the newly fallen acorns but the initial parasite, probably a curculionid larva, had

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Table 1. — *Chymomyza amoena* emergence from damaged white oak acorns in Virginia in July and September 1989.

Month	No. infested acorns	Emerged species	No. adults emerged	Ave. no. adults emerged per acorn
mid-July	11	*C. amoena*	24	2.2
late July	16	*C. amoena*	50	3.1
September	17	*D. melanogaster*	4	0.2
		C. amoena	7	0.4

Table 2. — Comparison of acorns infested with *Chymomyza amoena* and other drosophilid larvae from Mt. Lake Biological Station (MLBS), VA, Northern Lower (NL) Michigan and East Lansing (EL), MI in Fall, 1989.

State	Location	Total	Undamaged (%)		Acorns No. Damaged			
					No larvae	With larvae	(%)	Total
Virginia	MLBS	216	168	(79%)	29	19	(40%)	48
Michigan	NL	210	200	(95%)	7	3	(30%)	10
Michigan	EL	327	303	(92%)	22	2	(8%)	24

Comparison among damaged acorns: d.f. = 2; G = 8.72; P 0.05

exited. Five *Drosophila* larvae and 28 *C. amoena* larvae were counted in the 19 acorns; 4 D. *melanogaster* and 7 *C. amoena* adults emerged.

Michigan. Six percent of the total red oak acorns collected (n = 537) were damaged with 14% of these containing drosophilid larvae (Table 2). These infestation rates are significantly lower than that encountered in Virginia. The intervening month between collecting in northern lower Michigan and in mid-Michigan did not increase the rate of drosophilid acorn infestation in mid-Michigan despite area wide *C. amoena* overwintering/substrate utilization studies in past years which established its presence in the greater Lansing/East Lansing area and adjacent communities (Band and Band 1984).

Michigan *C. amoena* females also oviposited only in parasitized acorns. As in Virginia in September, no eggs or remnants of egg cases were detected in vacular elements at the base of the acorns. There were 1 *Drosophila* and 4 *C. amoena* larvae in the 3 NL acorns, 5 *C. amoena* larvae in the 2 EL acorns.

DISCUSSION

Sturtevant (1921) was the first to report that *C. amoena* bred in a variety of fruits and nuts: Banks bred it from acorns, Shannon from walnut and butternut husks, he and Metz obtained it from apples and bananas (p. 61). Winston (1956) reared all larvae to adulthood, thereby determining that *C. amoena* bred in parasitized and decaying acorns. He labeled them fungal feeders and scavengers. Dorsey et al. (1962) found that curculionid larvae were the primary acorn pests in West Virginia forests and listed *C. amoena* among the secondary invaders. Sampling over a year's time, beginning in September, Winston (1956) found that larval-infested acorns were rejected by squirrels. Weckerly et al (1989) discovered that intact acorns from which curculionid larvae had not emerged were consumed by squirrels. Winston (1956) also found that moisture was important, as Spieth (1987) did later.

Since discovering that *C. amoena* in mid-Michigan was using such substrates as unripe firm apples for larval development in summer (Band 1988a,b) and firm

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native crabapples *Malus coronaria* for overwintering (Band and Band 1984), my interests have included comparative substrate use and how females are able to oviposit in firm substrates. Numbers emerging from acorns versus initial numbers of eggs and larvae show a sharp reduction as in apples (Band 1988a). Exit holes made by initial pest larvae (Moffett 1989, Williams 1989b) provide an entrance way, analogous to pest larvae breaking the surface in a developing apple. For Virginia, these findings indicate that the surrounding forest may be the reservoir from which *C. amoena* can invade fallen and unfallen apples yearly. Two major summer sites which have larval-infested apples lack fallen apples by late Fall (Band 1988c). The ability to invade and breed in acorns damaged by primary insect attackers indicates an inter-species dependency that may contribute to the survival of this species in forested and urban areas. The Virginia (reported here), West Virginia (Dorsey et al. 1962) and Illinois (Winston 1956) studies also indicate *C. amoena* was a forest/woodland species where it evidently was breeding in such native nuts and fruits as acorns, black walnuts, and endemic crabapples before the colonists arrived.

The significantly lower numbers of infested Michigan acorns as compared with Virginia may reflect a lower population density and/or totally migrant female oviposition. Neither site is immediately adjacent to areas in northern lower Michigan or mid-Michigan used in past studies on overwintering/substrate utilization (Band and Band 1982, 1984). Biotic factors as availibility of substrates and abiotic factors as altitude, latitude and past glaciation history influence species composition. Oviposition behavior on fruits in summer has been strikingly similar in Michigan and Virginia (Band 1989a).

The presence of *D. melanogaster* in acorns in Virginia is not unexpected. *Drosophila* species can breed in parasitized acorns in California (Spieth 1987) and have emerged from frass in Hawaii (Heed 1968). Three species have adapted to the nephritic gills of crabs (Carson 1974).

To date however, *C. amoena* has been the only chymomyzid in parasitized acorns, a female oviposition behavior and larval developmental adaptation that may have enabled this species to follow other pests into unripe parasitized domestic fruits. Breeding sites and breeding behavior of this species in Europe (Bächli and Rocha Pité 1982, Schumann 1987) remain unknown. Breeding sites for other forest *Chymomyza* in the East remain unknown.

NOTE ADDED

In a letter dated 16 Oct. 1990, Dr. Hans Burla, Zoological Museum, University of Zurich, reported that he had bred 10 females and 14 males of *C. amoena* from 100 chestnuts, *Casatanea sativa* (= *vulgaris* = *vesica*), collected in a forest in the Ticino Canton of Switzerland. The chestnuts were old, and had been collected in the forest, not far from the edge. The shipment also contained crabapples, apples, pears and plums. Thirteen *C. amoena* adults emerged from the 13 apples.

Dr. Burla verified that this species of *Castanea* is native to Europe. This again revives the comment initially made by Bächli and Rocha Pité (1981) after *C. amoena* was collected in eastern Europe, that this species may be introduced, and capable of spreading under favorable conditions as *C. procnemis* did in Japan (Okada 1976) or may indicate that *C. amoena* has a Holarctic ditribution.

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Quercus rubra acorns. Reviewers' comments have been helpful in revising the manuscript.

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