Zeitschrift: Mitteilungen der Schweizerischen Entomologischen Gesellschaft = Bulletin de la Société Entomologique Suisse = Journal of the Swiss Entomological Society

Herausgeber: Schweizerische Entomologische Gesellschaft

Band: 68 (1995)

Heft: 3-4

Artikel: Natural breeding sites of Chymomyza species (Diptera, Drosophilidae) in Switzerland

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DOI: https://doi.org/10.5169/seals-402595

MITTEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT
BULLETIN DE LA SOCIÉTÉ ENTOMOLOGIQUE SUISSE
68, 251 – 257, 1995

Natural breeding sites of *Chymomyza* species (Diptera, Drosophilidae) in Switzerland

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Chymomyza flies were reared in captivity from larvae and pupae gathered from underneath the bark of cut or fallen spruce and beech trees, at several forest locations. The larvae were seen in, and found to feed on, a brown paste which is a humid stage of bast decomposition. Three out of the four species native to Switzerland were present among the reared flies. They were separated from each other at the preadult stages, whereas all four species are often seen to closely coexist at the adult stage.

Keywords: *Chymomyza,* breeding resource, sex ratio, niche separation.

INTRODUCTION

Of the five *Chymomyza* species which occur in Switzerland (BÄCHLI & BURLA, 1985; BURLA, 1995), one, *C. amoena*, is a fairly recent import from the USA, and is supposed to be particularly adaptable to a variety of environmental habitats including forests and orchards (MACA & BÄCHLI, 1994; BAND, 1995). The other four species *C. caudatula, C. costata, C. distincta,* and *C. fuscimana* are considered to be native to Switzerland. They are almost exclusively found in forests over a wide range in Europe and beyond (WHEELER, 1952; HACKMAN *et al.*, 1970; OKADA, 1976; BÄCHLI & ROCHA PITÉ, 1981; PAPP, 1992). The adult flies may be found on the exposed wood of wounded trees. These species coexist in all sampled forests and seem to aggregate on such sites, displaying lekking behavior (BURLA, 1995).

C. amoena develops in a variety of fruits and nuts (TESKEY, 1976; BURLA & BÄCHLI, 1992; BAND, 1995). What are the breeding resources of the native species? These species were not reported among drosophilids reared from fruits, fungi, rotten leafs or rotten wood (SHORROCKS & CHARLESWORTH, 1980; SHORROCKS, 1982; BURLA & BÄCHLI, 1991; BURLA *et al.*, 1991; OFFENBERGER & KLARENBERG, 1992). Yet, *C. costata* was mentioned "to pass the winter by the final larval instar, in Hokkaido under bark of trees and stumps" (ENOMOTO, 1981). Larvae and pupae of *C. aldrichii*, a nearctic species, were found in the USA underneath the bark of aspen trees (SPIETH, 1957). TESKEY (1976) mentions white spruce, trembling aspen and white birch as breeding sites for *C. aldrichii* in Canada. Another nearctic species, *C. procnemoides*, was cited to develop under oak bark (TESKEY, 1976; BAND, 1993). Larval sites are indicated by *Chymomyza* flies walking along the edge of damaged bark and sometimes disappearing under it. This suggested to systematically inspect the underside of bark of trees in forests for preadult stages of *Chymomyza.*

The present report deals with the species observed as well as the origin of the larvae and pupae from six collecting sites and two tree species.

Collecting larvae and pupae from underneath bark has the practical advantage of obtaining freshly hatched adult flies in considerable numbers almost any time from spring to fall, and thus to be relieved from running stocks if there is no immediate need for these.

MATERIAL AND METHODS

Larvae and pupae of *Chymomyza* species were found underneath the bark of beech (*Fagus sylvatica*) and spruce (*Picea abies*) in forests near two localities, Gockhausen and Tinizong. Gockhausen is a small suburb north of Zurich, in a clearing of the forest which covers the slope of the Adlisberg. Three forest places were sampled: Meisenrain, Langweg, and Buchrain. Tinizong is a small village south of the alpine resort Savognin in the Oberhalbstein valley. At both places, Meisenrain and Langweg, a beech fell in a tempest on August 10, 1994. Their bark was damaged when the trunks hit neighboring trees. At Meisenrain the forestry service cut part of the fallen beech into smaller logs and split them. These as well as the remaining trunk were left on the ground for a month or two. Larvae and pupae were found underneath the bark of the trunk and the scattered logs. At Langweg the fallen beech was cleared of branches and left on the side of a forest road. At Buchrain two spruce trees were cut on September 20. After removing the branches, the logs were left nearby. At Tinizong three places were sampled: a lumberyard on the valley bottom, in a meadow along the bank of the river Julia, as well as two areas in a vast forest which covers the mountain slope west of the valley axis. In one area, mean altitude 1500 m, some 600 spruce trees were cut from July through September 1994. In another area, 1300 m, about 50 such trees had been cut during the previous summer. All useful logs from both areas were later transferred to the lumberyard of Tinizong. In the same valley another lumberyard in a forest was sampled with little success. The largest distance between any two places was about 2 km at Gockhausen and 3 km at Tinizong.

Meisenrain was sampled on 5 days between September 7 and October 2, 1994. Langweg was successfully sampled on September 7 and twice without success two weeks later. Buchrain was sampled on five days between September 15 and October 22. The three Tinizong places were sampled on September 23. The total number of successful visits to all six places was 13. Larvae were found on all 13 successful visits, pupae on 5.

The way to collect *Chymomyza* larvae is to remove pieces of bark from trunks, logs, and stumps of trees, cut or wounded not long ago. Where the bark is a little separated from the xylem along the edge of cuts and cracks, the bast, which is the basal layer of the bark, may decompose and turn into a paste. The paste is humid, slimy or sticky, of brown color. It seems to contain yeasts. The *Chymomyza* larvae were found within the paste. Only a few larvae were found on the xylem where it was wetted by the bark paste. There were larvae of all three instars. If there were pupae underneath the bark, they were found near the paste in dryer parts. Later in the decomposition of the bark, mould develops and the paste dries out, leaving a darkly stained mark. At that stage no more *Chymomyza* larvae can be found whereas pupae still may be present. No *Chymomyza* larvae were found underneath bark which solidly adhered to the xylem, or if detached, was dry underneath. Nor were larvae found underneath bark torn off a tree days or weeks earlier. Apparently, a close contact between bark and xylem is essential for a paste to develop and persist.

The particular niche is explored by a variety of organisms including insects, spiders, worms, snails, and nematodes. The *Chymomyza* larvae are easy to distinguish from other dipteran larvae by size, shape, movement, the slightly protruding posterior spiracles which are of light brown color, and a transparent body which shows the gut full of brown bast paste. This substance proved to be a useful addition to the cooked medium. *Chymomyza* larvae eat it by preference, whether they were gathered underneath bark or transferred from laboratory stocks.

Often a number of *Chymomyza* larvae can be seen closely together under the bark, as if gregarious. Where the bast paste forms a narrow band along the edge of the bark, the larvae are more evenly dispersed along the edge, and then are solitary. At collecting, every aggregation of larvae and pupae was transferred to a separate vial containing a small amount of culture medium (recipe obtained by courtesy of Dr. S. LAKOVAARA, Oulu, Finland). In these vials the larvae and pupae completed development with excellent viability. Emerged flies reached normal size.

RESULTS AND DISCUSSION

General

Three native species emerged. Tab. 1 shows the frequency distribution of time elapsed between the collection of larvae and pupae, and the emergence of adult flies, separately by *Chymomyza* species and the places at which each species was found. The frequency distributions suggest two modes. Evidently, the upper mode corresponds to early emergees derived from collected pupae, the other mode to late emergees derived from collected larvae. The intermode may be arbitrarily set at days 15 and 16. In *C. fuscimana* from Gockhausen, this separation is indistinct. Anyhow, all *C. caudatula* flies from two places, emerged within 15 or 16 days after collection, probably developed from collected pupae. Also, *C. fuscimana* from Meisenrain and Langweg had developed from collected pupae if they hatched within 15 or 16 days, otherwise from collected larvae. All flies from Buchholz and Tinizong were from collected larvae.

Each Gockhausen site yielded two species. Taken together, the three Tinizong sites yielded two species as well. The Gockhausen places yielded the bulk of emergees. The single fallen beech at Meisenrain yielded 260 flies, which is more than half of the total number, 432. The yield from the alpine places is deceptively small in spite of strong collecting effort. In nature, presumably, the dispersion pattern of larvae is strongly aggregated, making it difficult to hit a clump of larvae when sampling a forest area of many cut trees.

As far as the present results go, native *Chymomyza* species breed at the same places where adults are found and may be observed to mate (BURLA, 1995). In conclusion, these species are entirely arboreal.

Discussing species separately

Apparently, of *C. caudatula* only pupae were found, all on beech exclusively. At Langweg this was from a trunk, at Meisenrain also from scattered logs. On the first visit to Meisenrain many pupae were found; they yielded 134 adult *C. caudatula*. On later visits to Meisenrain less pupae were found. The first adults emerged on the second day after the first visit to Meisenrain. Emergence continued daily until the 15th day after the visit, with the exception of the 6th day. Similarly at Langweg:

Tab. 1 – Time elapsed between the collection of larvae and pupae in forests and the emergence of adult flies. Localities: GH, Gockhausen; TZ, Tinizong. Sites: MR, Meisenrain; LW, Langweg; BR, Buchrain. Altitude in meters. Time intervals are two days (leftmost column). Numbers in the other columns indicate counts of the flies which emerged during the respective time interval. For each species, collecting sites are mentioned separately. Sexes are pooled. Information about places and dates of visits in the text.

Chymomyza	*caudatula*		*fuscimana*				*distincta*	
locality	GH	GH	GH	GH	GH	TZ	GH	TZ
site	MR	LW	MR	LW	BR	3 places	BR	lumbery.
altitude	510	620	510	620	600	–	600	1210
tree species	beech	beech	beech	beech spruce	spruce	spruce	spruce	spruce
nr of visits	5	1	5	1	5	3	5	1
days after visit								
1,2	16		1					
3,4	41		3					
5,6	15	6	2					
7,8	36	13	1					
9,10	38	3	2					
11,12	12		1	1				
13,14	11		10					
15,16	4		1					
17,18			2					
19,20			20		2	1	1	
21,22			20	4	6	2		1
23,24			5	9	10	5		
25,26			6	2	36			
27,28			3		37	2		
29,30			1		21	2		
31,32			2	1	3	1		
33,34			7		2	1		
sum by column	173	22	87	17	117	14	1	1
sum by species		195				235		2

a first visit on September 7 yielded pupae from which 22 *C. caudatula* emerged. On two later visits no more larvae or pupae of *C. caudatula* were found. The experience from both places suggests that oviposition was restricted to a few days after the trees fell.

C. fuscimana was found at every place. The yield from spruce at Buchrain was largest while the yield from beech at Meisenrain was not much lower. Fewer flies developed from collected pupae than from larvae.

Only two specimens of *C. distincta* emerged, both females. Two more *C. distincta* females, both dead, were removed from the pupal shells by the end of November.

Species proportions

Among reared flies, the lack of *C. costata* and *C. distincta* is striking in comparison with the numbers of collected flies (Tab. 2). *C. caudatula* reached a higher proportion than it had among the collected flies. However, the records are biased

because the two fallen beech trees were more thoroughly sampled for larvae and pupae than logs were sampled for adults. Another effect, favoring *C. fuscimana*, is due to a difference in behavior (BURLA, 1995): *C. fuscimana* males perform vigorously on leks, and thus are easily seen. Flies of other species seem to be more cautious, or timid, and thus are often not noticed.

Sex ratio

In *C. caudatula* about 55 % of the reared flies were males (Tab. 2), while among collected flies the proportion of males was about 83 %. In *C. fuscimana* more females than males were reared, whereas among collected adults the males outnumbered females by far. Hence, the excess of males as commonly observed among adults on leks is a secondary effect, probably brought about by unequal behavior of the sexes.

Tab. 2 – Numbers of reared flies (top rows) compared to collected adult flies (bottom rows, taken from BURLA, 1995). Comparing the numbers by species, sexes pooled, with the expected numbers as computed from marginal totals, the contingency table chi-square is equal to about 186, d.f. = 3, p = 0.0001.

Chymomyza	*caudatula*		*costata*		*distincta*		*fuscimana*	
collected:	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
larvae and pupae	88	107	0	0	2	0	135	100
sexes pooled		195		0		2		235
expected		*115*		*21*		*32*		*264*
adult flies	14	67	18	33	17	58	91	309
sexes pooled		81		51		75		400
expected		*161*		*30*		*45*		*371*

Niche separation

Of the five *Chymomyza* species which are known to occur in Switzerland, preadult stages of only three are found. This is at variance with the fact that adult flies of four species native to Switzerland may be seen to coexist (BURLA, 1995). The one lacking in the present report is *C. costata*, although adults of it were captured at both places of the Gockhausen forest and at one place above Tinizong. Its absence among gathered larvae suggests an ecological separation from the other species at the preadult stage. Maybe it develops in other parts of the trees, or in trees other than beech and spruce, to which this study was unintentionally confined, or in later stages of bark decomposition. When in a forest place above Tinizong 17 adult *C. costata* including three copulae were collected from a tree stump (BURLA, 1995), it was supposed that its partly loose bark was a breeding site of the species. Because the spruce had been cut a year before, it was, however, feared to be too dry for yielding *Chymomyza* larvae. Yet, ten larvae were found under its bark. They all developed into adult *C. fuscimana*.

C. amoena, a recent import to the country, is also lacking among the reared flies. As with *C. costata*, its adult flies were found in the same forests, however, in lowest numbers (MACA & BÄCHLI, 1994; BURLA, 1995). In the USA this species develops in domestic apples, plums and pears, in crab apples, acorns, and black walnuts (BAND, 1991, 1995). In Switzerland it was reared from chestnuts, acorns, and sweet cherries, and netted over fermenting banana (BURLA & BÄCHLI, 1992). If its breeding niche entirely consist of fruits and nuts, it would not need to compete for larval food with other *Chymomyza* species.

Of the species now recorded, *C.caudatula* was found only under the bark of beech, and *C. fuscimana* under the bark of beech and spruce, suggesting different food niches at the larval stage.

From the larvae gathered on September 7 at Meisenrain, adult *C. fuscimana* flies began hatching on September 17, which is 38 days after the tree fell, and a week later than *C. caudatula* began to emerge. Similarly at Langweg: adult *C. fuscimana* began to emerge when all but one of *C. caudatula* had already hatched. Thus, there is a temporal separation between the two species, suggesting that *C. caudatula* does oviposit on a fallen tree earlier than *C. fuscimana*. Another possible cause could be a difference in development time. However, when species are reared in stocks, *C. fuscimana* takes, on the average, only about one day longer to develop than *C. caudatula*. This difference may be due to the fact that embryonic development seems to be shorter in *C. caudatula*, or to partly take place before the egg is deposited. There is also evidence of a spatial separation. When collecting the subimaginal stages from underneath bark, each batch of larvae was separately transferred into a vial. In no vial did more than one species emerge.

ACKNOWLEDGEMENTS

Drs. H.T. BAND and G. BÄCHLI pointed out pertinent papers and commented on the manuscript. Mrs. Radka DONNELL-VOGT helped with the English.

ZUSAMMENFASSUNG

In Wäldern bei Zürich und Savognin wurden Larven von *Chymomyza* in grösserer Zahl unter der Rinde gefällter oder beschädigter Fichten und Buchen gefunden. Zu den günstigen oder nötigen Voraussetzungen gehört, dass die Beschädigung am Baum nicht lang zurückliegt und sich der Bast (die basale Rindenschicht) bei Feuchtigkeit zu einer dickflüssig pastenartigen Substanz abbaut. Im Labor überlebten fast alle Larven auf einem für *Chymomyza* geeigneten Medium und metamorphosierten. Auch aus den weniger zahlreich gefundenen Puppen schlüpften Fliegen. Das Ergebnis waren 432 Adulte. Sie gehören drei von vier autochthonen Arten an und hatten nach Häufigkeit die gleiche Rangordnung wie bei adulten *Chymomyza*-Fliegen, die im Wald gesammelt wurden. Hingegen war bei den gezüchteten Fliegen das Geschlechtsverhältnis ausgeglichener als bei den gefangenen. Die fehlende Art, *C. costata*, wird im Wald nicht selten gesehen. Im Larvenstadium sind die Arten stärker getrennt als im Adultstadium.

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(erhalten am 28. März 1995; angenommen am 7. April 1995)