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

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In 1995, *Chymomyza* flies were reared from larvae collected underneath bark, mostly of beech, in a Midland forest at low altitude, and of spruce logs in an alpine lumberyard at higher altitude. In total 540 flies emerged. As in the year before, *C. caudatula* was first to emerge after larvae were collected from beech, while *C. fuscimana* began to emerge 4 or 5 days later, suggesting association as well as temporal resource partitioning. In both areas, spruce yielded *C. fuscimana* and *C. costata*. The spruce logs in the alpine lumberyard also yielded *C. distincta,* whereas no *C. caudatula* emerged from any log. In *C. fuscimana* the period of emergence, in days, was longer than in the other species, suggesting prolonged oviposition. The yield by piece of bark varied between 1 and 3 *Chymomyza* species.

Keywords: *Chymomyza*, association, coexistence, Lonchaeidae.

INTRODUCTION

Of the four native species of the drosophilid genus *Chymomyza*, namely *C. caudatula, C. costata, C. distincta*, and *C. fuscimana*, BURLA (1995b) found larvae of *C. caudatula, C. distincta*, and *C. fuscimana* underneath bark of trees. In a temporal sequence, *C. caudatula* and *C. fuscimana* jointly utilized the same breeding site, which was freshly damaged bark of beech. Larvae of both *C. distincta* and *C. fuscimana* were collected from bark of spruce. The present effort was made to obtain more *C. distincta* larvae of which only two specimens were recorded the year before, and to find *C. costata* which was not reared at all from a place at low altitude, although among adult *C. costata* flies may coexist with the other three species (BURLA, 1995a). At the Midland place, collecting of larvae was again restricted to spruce and beech, and at the Alpine place on spruce. Both tree species are abundant in forests at low altitude while beech is lacking at the Alpine place. In both areas, spruce is the preferred object for wood cutting. According to MORGE (1963), *C. costata* and *C. distincta* also develop under bark of European Larch (*Larix decidua*) and Arolla Pine (*Pinus cembra*).

The underside of damaged bark of trees seems to be the regular breeding site of various species of *Chymomyza*, and thus is an important characteristic of the genus. SPIETH (1957) found preimaginal stages of the Nearctic *C. aldrichii* in Minnesota under the exposed bark of damaged aspen. TESKEY (1976) reported that *C. aldrichii* had emerged from under bark of spruce, trembling aspen and birch logs in Canada. BAND (1996a) found preimaginal stages of *Chymomyza* under loose bark of damaged oaks (*Quercus alba*), and reared a male of *C. procnemoides* from one of the collected pupae. ENOMOTO (1981) mentioned that in Hokkaido, "*C. costata* passed the winter by the final (3rd) larval instar under bark of trees and stumps."

Possible breeding sites are indicated by adult *Chymomyza* flies when they come to, and display on, damaged bark of forest trees. There the flies become enga-

ged in courtship and copulation. BAND (1996a) observed *C. procnemoides* as it moved along the rim of broken bark and eventually disappeared under it. A similar observation had stimulated the earlier report of the present author (BURLA, 1995b). BAND (1996a) listed damaged trees and cut wood of ten tree species in Virginia, U.S.A., which had attracted *Chymomyza* flies. If all these trees, and many more at other places and in other countries, belong to the breeding niche of *Chymomyza* species, the resource is large enough to allow for ecological diversification among the members of the genus.

As an exception, the semidomestic species *C. amoena* which was recently introduced into Europe (MACA & BÄCHLI, 1994; BAND, 1995) apparently does not breed under bark, but was reared from acorns, chestnuts and a variety of fruits such as domestic apples (BAND, 1996b). This species encounters acorns and chestnuts in the forests, and domestic apples in open cultivated land.

MATERIAL AND METHODS

Sampled trees and logs

Larvae of *Chymomyza* were collected underneath bark of trees in a forest at Gockhausen (altitude 550 m) and underneath bark of spruce logs in an alpine lumberyard at Tinizong (1230 m). The method of collecting as well as the location of both places are described in the first report (BURLA, 1995b).

At Gockhausen, the following trees were sampled:

- "barn beech" A beech inside a deciduous forest, 10 m behind a barn of the forestry service. There another tree which was cut by end of August hit the beech, removing a narrow band of bark from the ground about 3 m upward.
- "broken beech" During a storm on July 13, 1995, a beech was broken about 8 m above the ground. This was inside the forest at the same altitude as Gockhausen, about 2 km from it and 30 meters from a meadow (the following trees were about 1 km deeper in the same forest). In the upper part of the trunk which was lying on the floor all dipteran larvae under bark were Lonchaeidae. The still standing lower trunk had small parts of the bark removed. *Chymomyza* larvae were found underneath the rim of the damages.
- "bent Beech" When a big spruce was cut a thin beech was hit and remained in a bent position. A narrow band of bark was removed by the impact of the falling tree, from the ground about 5 m upwards. The rim of the bark yielded *Chymomyza* larvae.
- "thin beech" at the same place on the opposite side of a forest road.
- "spruce stump" 20 m from the former tree. A few larvae were found at the edge of the cut where the bark was detached and small pieces could be broken off.

The three first mentioned beeches were sampled on six days between September 5 and 22, 1995. On October 10 the same trees were sampled again, together with the thin beech and the spruce stump.

In the lumberyard at Tinizong a large number of spruce logs was piled up. Some of the trees had been cut a few weeks earlier at about 1600 m in the alpine forest which covers the west slope of the valley. Most *Chymomyza* larvae were found underneath the bark at the cut ends, fewer were seen underneath spots of damaged bark along the logs. The bark of many old logs was heavily infested with bark beetles, and dipteran larvae were Lonchaeidae. Collecting lasted from October 2 to 5, 1995.

Handling the larvae

After collecting, the larvae were put in cups of polyethylene, base 22 by 22 mm, height 9 mm, filled to the rim with culture medium which was roughed at the

surface and partly covered by a small piece of filter paper. Larvae placed in the cup dug into the culture medium or hid underneath the paper; therefore, none of them escaped. Each cup was later transferred to an empty vial with diameter 26 mm, height 76 mm, closed with a polyethylene foam stopper. When many larvae grew in a cup a part of them was transferred to a vial with fresh food. Most cups contained enough food and space to accomodate up to 30 larvae through pupation. All cups were daily checked for larvae, pupae and emerged flies, and the food was wetted if dry. On such occasions granules of yeast were added in crowded cups. The vials were kept in a room with temperature 18 to 20 °C, relative humidity 60 % or above and 18 hours of light per day.

After collecting at Gockhausen, larvae from each tree were kept in separate cups. Consequently, all flies which later emerged from a cup were from the same tree, and often from the same piece of damaged bark. The same precaution was intended at Tinizong but not carried through consistently. Therefore, in part of the cups the larvae were from different logs.

RESULTS

General

At each locality, Gockhausen and Tinizong, 21 cups had been used to accomodate the collected larvae. *Chymomyza* flies emerged from every cup from Gockhausen. Of the cups from Tinizong, 14 yielded *Chymomyza* exclusively, 5 yielded *Chymomyza* but also contained Lonchaeidae, and 2 cups yielded Lonchaeidae only. The presence of lonchaeids in cups was not intended. At collecting the larvae had been mistaken for *Chymomyza*.

The total number of hatched flies was 540 (Tab. 1). Presence and proportion of species are in line with findings in the year before (BURLA, 1995b). Particularly in Gockhausen the proportion of *C. caudatula* and *C. fuscimana* was roughly the same. In both years *C. caudatula* was numerous at Gockhausen but lacking at Tinizong. This year *C. distincta* was lacking at Gockhausen but again present at Tinizong. There, *C. costata* was more frequent than *C. distincta*. At Gockhausen just one *C. costata* emerged from a larva collected on a spruce stump. The single fly represents a much lower proportion than was observed among adults collected earlier in the same forest (BURLA, 1995a).

Tab. 1. Total numbers of *Chymomyza* flies reared from larvae and pupae which were collected underneath bark in fall of 1995. F, female; M, male.

Chymomyza		*caudatula*		*costata*		*distincta*		*fuscimana*		total
		F	M	F	M	F	M	F	M	
Gockhausen	by sex	98	123	0	1	0	0	104	107	
	sum		221		1		0		211	433
Tinizong	by sex	0	0	10	13	9	3	36	36	
	sum		0		23		12		72	107
total			221		24		12		283	540

Sequence of hatching

As in the year before, from each of three beeches at Gockhausen *C. caudatula* emerged first (Tab. 2). *C. fuscimana* began to emerge 4 or 5 days later and kept emerging over a few more days. Of the flies from Tinizong, *C. costata* and *C. distincta* emerged first, followed a few days later by *C. fuscimana* which kept emerging over a longer period of time. Thus, there is a succession with overlap between *C. caudatula* and *C. fuscimana*, involving a temporal niche separation. It suggests that the former species is the first to exploit freshly damaged bark. As a conjecture, the females of *C. caudatula* inoculate the bast with yeasts and bacteria while laying eggs. Only then odors of fermentation and/or decomposition are formed and attract *C. fuscimana*. Its prolonged emergence suggests that oviposition was continued over days and perhaps weeks.

Tab. 2. Numbers of emerged flies, arranged by the number of days (dt) which elapsed after the respective larvae were collected. Separate by sampled trees. cau, *C. caudatula*; cos, *C. costata*; dis, *C. distincta*; fus, *C. fuscimana*.

	Gockhausen									Tinizong		
tree	barn beech		broken beech		bent beech		thin beech	spruce stump		spruce logs on lumberyard		
	cau	fus	cau	fus	cau	fus	fus	cos	fus	cos	dis	fus
dt												
10	1											
11	16											
12	14				5							
13	26		1		23						1	
14	9				21					1	1	
15	4	1	1		8				1	3	3	
16	4	2	24		5				2	6	3	1
17	1	6	32	3		15			1	3	2	3
18		31	22	5		14	2		2	1	1	8
19		24	4	7		8			2	5	1	3
20		11		6		13			1	1		6
21		2		4		6				1		7
22		1		3		4	1					8
23		1		1		1			3			2
24				1						1		7
25		1		1		1			1	1		3
26						1						8
27								1				2
28						4						
29				1		1						5
30												2
31												3
32												1
33				1		2						
34						1						1
35												
36				1		2						
37						2						
38				2		2						2
39				1								
40				1								
SUM	75	80	84	38	62	77	3	1	13	23	12	72
total												540

Preadult viability

At Gockhausen 522 larvae and 3 pupae were counted at collecting. From them 433 *Chymomyza* flies emerged, representing 82% of the collected larvae and pupae. At Tinizong 107 *Chymomyza* flies emerged from 130 collected larvae, again 82%. The difference between counts of larvae and emerged flies may have several causes. One may be preadult mortality, another, diapause. Six permament pupae from Gockhausen were dissected and turned out to be viable *C. caudatula*, three of each sex.

Equality of the sexes

In *C. caudatula* and *C. fuscimana*, the sex ratio did not consistently differ from 50% (Tab. 3). In every species males and females had about the same frequency distribution of dt, resulting in about the same average dt (as in Tab. 2, dt means number of days elapsed after having collected the respective larvae).

Coexistence of species

In all 21 cups from Gockhausen *C. fuscimana* was present, suggesting that in the Gockhausen forests this species is ubiquitous. While in two cups only *C. fuscimana* emerged, in 18 cups *C. caudatula* emerged as well. In one cup *C. costata* emerged along with the other two species. Not only do *Chymomyza* species coexist as adults on leks, but also as larvae at their breeding site.

It means that larvae of two or three species feed side by side on the same resource. It remains to find out whether under such conditions the species randomly intermingle, or keep separate from each other by at least a short distance.

Time span between damage of bark and oviposition by Chymomyza

In Gockhausen the windfall of a beech occurred on July 13. On September 5 *Chymomyza* larvae were collected from it for the first time. This was 44 days after

Tab. 3. Comparing sexes with respect to number of emerged flies (N), sex ratio (% males), and average dt, dt meaning number of days elapsed between collecting a larva and emergence of the fly. Abbreviations of sex as in Tab. 1.

		Gockhausen						Tinizong	
		barn beech		broken beech		bent beech			
Chymomyza		F	M	F	M	F	M	F	M
caudatula	N	30	45	35	49	33	29		
	% M		60		58		47		
	average dt	12.5	13.0	17.1	17.0	13.5	14.0		
costata	N							10	13
	% M								57
	average dt							18.1	17.7
distincta	N							10	2
	% M								17
	average dt							16.0	15.5
fuscimana	N	38	42	23	15	36	41	36	36
	% M		53		39		53		50
	average dt	19.0	18.4	23.2	22.4	22.6	20.9	24.0	23.3

the tree was broken. The first fly, a *C. caudatula*, emerged on September 22 which was 17 days after collecting larvae and 51 days after the windfall. In stocks it takes the species about 30 days to develop from the egg to the emergence of a fly. Subtracting 30 days from 51, it may be conjectured that the respective egg was layed about 3 weeks after the tree was injured. Data from the previous year, however, showed that eggs were layed almost immediately after two beeches were damaged.

Influence of the tree species

All *C. caudatula* flies were obtained from beech. In 1994 there were 195 specimens from two beeches (BURLA, 1995b) and now 221 specimens from three beeches. No *C. caudatula* fly was reared from spruce. Why did the species not show up in Tinizong? Beech is the dominant deciduous tree in most forests of the northern Swiss lowland. In Switzerland beech ranges north of the Alps from low altitude (in the Midland) to about 800 m (on the northern slope of the Alps). There are no beeches in Tinizong because the place is above their altitudinal limit. This may explain why *C. caudatula* was not recorded from Savognin (BURLA, 1995a) and Tinizong.

While in Gockhausen *C. costata* was absent from all three beeches, a single specimen showed up among 13 *Chymomyza* flies which were reared from 14 larvae collected from a spruce stump. It suggests that *C. costata* avoids beech but is linked to spruce. It shows that two or more tree species should be sampled with equal effort in order to obtain reliable evidence for niche separation between species.

The question remains in which trees of Midland forests *C. distincta* develops. More intensive collection of larvae on spruce may give an answer. The species was reared the year before from spruce (BURLA, 1995b). Adult *C. distincta* were seen to be the only *Chymomyza* species on stumps of freshly cut spruce (BURLA, 1995a).

Lonchaeidae

If trees had been cut months ago and damage to the bark was old, such trees, logs and stumps usually were infested with bark beetles while the bast had turned into frass. Under this condition no *Chymomyza* larvae could be found. Instead, larvae of the dipteran family Lonchaeidae were present. Other than in *Chymomyza* these larvae are sluggish, rounded, white to yellowish, the skin less transparent, the posterior end blunt and the posterior stigmata blackish, and the larvae may grow to a larger size. Hence, lonchaeid larvae of a later stage can be easily told apart from *Chymomyza*. The same applies for pupae which differ considerably between the two families. While underneath bark some of the *Chymomyza* larvae may occur in groups, lonchaeid larvae appear to be spaced more widely. Yet in the Tinizong lumberyard two groups of first instar lonchaeid larvae were seen under bark of spruce logs. The clumps suggested social oviposition of several females, or oviposition in batches by a single female. Lonchaeid larvae kept in food cups tended to cluster at the bottom. At an older stage they crawled into the filter paper and thouroughly tunneled it, making it possible to recognize their presence at a glance. Some lonchaeids took much longer to develop than *Chymomyza*. It seems that *Chymomyza* larvae are the first to explore the decaying bast of the bark of a tree after it is damaged. Lonchaeid larvae join in weeks or months later, and eventually replace *Chymomyza*. It is doubtful whether larvae of both families simultaneously coexist on the same spot of damaged bark. Emergence of flies of both families in cups from Tinizong was probably the effect of accumulating larvae from more than one log in a cup.

Informations on Lonchaeidae are provided by MORGE (1963). Some of the many species may attack pupae of bark beetles. During the present study, in two cups lonchaeid larvae had opened lonchaeid pupae and eaten their content. In no cup containing larvae of both families was it observed beyond doubt that lonchaeid larvae predated on larvae or pupae of *Chymomyza*.

It may be asked whether the presence of lonchaeid larvae in some cups from Tinizong reduced the viability of coexisting *Chymomyza* larvae. In such cups the mean number of emerged *Chymomyza* flies was 5.2 while in cups yielding only *Chymomyza* it was 7.4. However, the difference between the two means is statistically not significant (t=0.845, p=0.412). This may be due to both small sample size and large variation of fly number in each class.

ZUSAMMENFASSUNG

In Fortsetzung einer früheren Studie ergab das erneute Sammeln von Dipterenlarven unter verletzter Rinde von Waldbäumen und die Aufzucht der Larven bis zur Imago wiederum *Chymomyza*. Handelte es sich um alte Rindenverletzungen oder war die Rinde von Borkenkäfern befallen, entwickelten sich Lonchaeidae. Larven, die in einem Laubmischwald bei Zürich in grösserer Zahl unter der Rinde von drei Buchen gesammelt wurden, ergaben zuerst nur *C. caudatula*, vier bis fünf Tage später auch *C. fuscimana*. Anscheinend sind die beiden Arten assoziiert und offenbar erschliesst *C. caudatula* die Ressource mit zeitlichem Vorsprung. Eine einzige *C. costata* entwickelte sich aus einer von 14 Larven, die unter der Rinde eines Fichtenstrunks gefunden wurden. Aus Larven, die in einem alpinen Holzlager unter der Rinde von Fichtenstämmen gesammelt wurden, entwickelten sich *C. costata, C. distincta* und *C. fuscimana*. In diesem Fall fehlte *C. caudatula*. Anscheinend ist das Vorkommen dieser Art auf tiefere Lagen oder das Vorkommen von Buchen beschränkt.

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