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Autor: Band, Henretta T. / Band, R. Neal / Bächli, Gerhard

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Nearctic *Chymomyza amoena* (LOEW) is breeding in parasitized chestnuts and domestic apples in Northern Italy and is widespread in Austria

HENRETTA T. BAND[1], R. NEAL BAND[1], & GERHARD BÄCHLI[2]

[1]Department of Zoology, Michigan State University, East Lansing, MI 48823, U.S.A.; band@pilot.msu.edu
[2]Zoological Museum, Winterthurerstrasse 190, University of Zürich-Irchel, CH-8057 Zürich, Switzerland; baechli@zoolmus.unizh.ch

Nearctic *Chymomyza amoen*a has entered the chestnut (*Castanea sativa*) forests in Northern Italy. It is breeding in fallen parasitized chestnuts in the Orobie Alps in the Valtellina region and in the Cozie Alps in the Piedmont region. It is the only drosophilid in chestnuts among the array of drosophilids netted in the chestnut forests in both regions. It can also be found in fallen parasitized domestic apples (*Malus domesticus*) in mid-summer in each area. The Valtellina region is a fruit-growing region while chestnuts are harvested commercially in the Piedmont region. It is among the drosophilids netted in chestnut forests in Austria in July but is primarily breeding in fallen parasitized domestic apples and some English walnuts (*Juglans regia*) at this time of year. It is now widespread in Austria.

Keywords: *Chymomyza amoena*, European chestnuts *Castanea sativa*, domestic apples *Malus domesticus*, English walnuts *Juglans regia*, Italy, Austria

INTRODUCTION

Chymomyza amoena (LOEW, 1862), a North American drosophilid, has spread widely in Eastern and Central Europe since it was first discovered in the former Czechoslovakia in the 1970s. It entered Switzerland's Canton Ticino in 1988 and has become well established there (BURLA & BÄCHLI 1991, 1992; BAND *et al.* 1998, 1999). Its presence in the forest drosophilid community has been well documented in the Maggia Valley (BURLA & BÄCHLI 1992), in the mountains above Cevio and in the Bolle di Magadino (BAND *et al.* 1998). In the Val Blenio it was also present among nondomestic drosophilids netted in the mixed chestnut forest below Corzonesco and in the wooded area below Acquarossa (BAND *et al.* 1999). Many European forest *Drosophila* breed in mushrooms or wild fruits (SHORROCKS 1982; BURLA *et. al.* 1990; BURLA & BÄCHLI 1991). In the United States *Chymomyza amoena* breeds primarily in parasitized nuts (acorns *Quercus* spp, black walnut husks *Juglans nigra*) and fruits (native: endemic crabapple *Malus coronaria*; imported: domestic apple *Malus domesticus*, plums *Prunus domestica*, pears *Pyrus communis*) (BAND 1988a, 1988b, 1989, 1991, 1996). In Canton Ticino it has been reared from parasitized European chestnuts *Castanea sativa* and acorns *Quercus robur*, damaged hazelnuts *Corylus avellana*, domestic apples *Malus domesticus*, wild apples *Malus sylvestris* and wild sweet cherries *Prunus avium* in the Maggia Valley (BURLA & BÄCHLI 1991, 1992; BAND *et al.* 1998) and from acorns in the Bolle di Magadino, a protected forest preserve close to Gordola on Lake Maggiore (BAND *et al.* 1998, 1999). In Southern Ticino in the Malcantone region it was found in both chestnuts and domestic apples and in the Valle di Muggio also in domestic apples (BAND *et al.* 1999).

In Italy one C. *amoena* was netted among drosophilids in the Veneto region in 1998 (BÄCHLI *et al.* 1999) and it was also captured among drosophilids in a forest near Padua (BÄCHLI 2002). In July/August 2000 we investigated the Valtellina region and in July 2002 the Torre Pellice area in the Piedmont region to determine if *C. amoena* was in the chestnut forests of Northern Italy. In the Valtellina region the Rhaelian Alps are shared between Switzerland and Italy while the Orobie Alps lie completely within Italy. Chestnut forests cover the north facing slopes of the Orobie Alps, apple orchards line the valley between Sondrio and Tirano; vineyards cover the south facing slopes of the Rhaelian Alps. Chestnuts are harvested commercially in the Piedmont region.

MACA & BÄCHLI (1994) reported that *C. amoena* had been found only in Vienna in Austria despite numerous captures in the Czech Republic, Slovakia, Hungary and Germany. In July 2001 we investigated the chestnut forests of southern Austria. In both Italy and Austria we determined if *C. amoena* was also breeding in domestic apples in both countries.

As expected, *C. amoena* is among the drosophilids netted in the chestnut forests of Italy but is the only drosophilid breeding in parasitized chestnuts. In both the Piedmont and Valtellina regions females also switch to available fallen parasitized apples in mid/late July. In Austria it is among the drosophilids netted in the chestnut forests in July; however nuts were dry. The species was widespread in fallen frassy apples and could also be found in damaged English walnuts *Juglans regia*. *Chymomyza amoena* has become Europe's only nut-breeding drosophilid while also retaining an affinity for breeding in fallen parasitized (frassy) apples.

MATERIALS AND METHODS

Chymomyza amoena is distinctive among drosophilids with its black banded wings and wing waving habit. Eggs, larvae and pupae are also distinctively different from *Drosophila* (PATTERSON 1943; THROCKMORTON 1975; SCHUMANN 1987) with which it may potentially share fallen fruits. Eggs can also be distinguished from those of the lesser apple worm, *Grapholita prunivora* (WALSH, 1868) which also occurs in Europe (BAND 1989).

In general collections were handled as in 1998 (BAND *et al.* 1999). Parasitized or damaged domestic apples under trees in yards, roadside, or unsprayed orchards were gathered and inspected for the presence of *C. amoena* eggs and larvae with the aid of a dissecting microscope. The number, distribution of eggs (stem, calyx, hole) and presence of frass (insect excreta) were noted. Parasitized apples were also cut open to determine if *C. amoena* eggs had been deposited in a tunnel made by a pest larva and number of eggs inside were counted. *C. amoena* eggs and larvae were transferred to vials containing modified LAKOVAARA's malt medium. The presence of *Drosophila* eggs, if any, was also noted and these were also transferred to the prepared vials. If a weevil *Rhychitis* sp. or codling moth larva, *Cydia pomonella* (LINNAEUS, 1758), was present, this too was noted.

For chestnuts, efforts were made to collect only parasitized chestnuts. These were then dissected under a dissecting microscope, presence of any pest larvae noted (BOVEY *et al.* 1975; ARZONE *et al.* 1993; ALMA 2002) and presence of *C. amoena* larvae and pupae. There were few *C. amoena* eggs in chestnuts. In Austria fallen English walnuts were soft at the stem end; nuts were frequently damaged. *C. amoena* preadult stages were transferred to prepared vials.

Vials containing modified LAKOVAARA's malt medium were prepared at Michigan State University, airmailed to the University of Zürich-Irchel, refrigerated until

departure, then packed in styrofoam coolers for transportation to the collecting sites. At the end of each collecting period vials were airmailed back to Michigan State University to record emergence.

In both Italian regions and in Austria, drosophilids were netted over bait in the chestnut forests. Global positioning was used to record altitude, latitude and longitude of sites where substrates (apples, chestnuts, walnuts) were collected and where baits were set for netting drosophilids. Sites were numbered but named after the nearest places on regional maps.

Valtellina region, Italy

Parasitized apples were collected under trees at Calcarola, a small village slightly west of Tirano, on 28 and 30 July 2000. Parasitized chestnuts (with holes) were gathered at three forest locations: an area just above San Sebastiano at 500 m, designated A, and in the forest at San Sebastiano (B) on 30 July; west of San Sebastiano near Castel dell'Acqua at 554 m on 31 July and east of Tirano near #417 trail marker at 509 m on 2 August 2000.

Flies were netted over bait evening and morning at a site between the Swiss/Italian border and Tirano from 29 July to 3 August, at San Sebastiano B site from 31 July to 2 August. Flies were also netted over bait at Bormio, elevation 1193 m, evenings only, but no chestnut forest is in this area, so results will not be included here.

Torre Pellice area, Italy

Parasitized chestnuts were collected at Villar Pellice, 729 m, on 9 and 10 July 2002; at Cognetti also on 9 and 10 July. None of the 89 chestnuts with holes collected at Cognetti on 10 July had *C. amoena* preadults although 17 had arrested *C. splendana* larvae. Chestnuts collected on 12 July at the Communità Montana property at 759 m, opposite Torre Pellice, were too dry. Nevertheless, of the 134 with holes but without *C. amoena* preadults, 10 still contained arrested *Cydia splendana* (HÜBNER, 1799) larvae, 73 were shells and 21 contained ants. 30 chestnuts with holes collected at Bobbio Pellice also lacked *C. amoena* preadults and only 1 had arrested *C. splendana* larvae.

Apples were collected at Podio, 890 m, on 11 July as were walnuts; at Bobbio Pellice, 758 m, and Podio again on 13 July and at Inverso Fienminuto, 700 m, near Cognetti also on 13 July.

Flies were netted over bait at Villar Pellice evening and morning 9 July through 13 July.

Southern Austria, July 2001

Apples were collected at Leutschach, 370 m, on 13 July; at an organic farm at Salzerkogel, 500 m, also on 13 July as were chestnuts with holes and English walnuts. Chestnuts were dry and contained neither arrested pest larvae nor *C. amoena* larvae. Of the 87 chestnuts with holes, 14 were shells and 2 had ants.

Chestnuts were collected in the woods at Spitzmühle, 417 m, on 14 July, as were plums at a nearby winery, and apples at a mill also in the area. None contained *C. amoena* preadults. Chestnuts were dry; of the 71 with holes and 22 that were shells, 18 had ants.

Chestnuts (dry) and English walnuts were collected at Heckerl, 500 m, on 15 July. Of the 21 chestnuts with holes and 8 shells, 6 had ants. Chestnuts were also dry near Moserhof, 760 m. Of 8 with holes and 9 shells, 4 had ants.

Also on 15 July fallen parasitized apples were collected at Jäggeritsch, 692 m. On 16 July walnuts were again collected at Moserhof and parasitized apples at 3 locations along the Weinbergstrasse, 552 m, 463 m and 427 m. On 17 July parasitized apples were gathered at Gaisfeld, 386 m, and in the old orchard at Schloss Seggau, 367 m. English walnuts were also gathered at Schloss Seggau.

Flies were netted over bait in chestnut forests at Spitzmühle, Heckerl and Moserhof evening and morning from 13 July to 17 July.

A small collection of parasitized apples and walnuts was obtained at Vienna on 21 July but there were no *C. amoena* stages in any of the 7 walnut hulls. A walnut collection was made at Epinassey/Saint-Maurice in Canton Wallis in Switzerland on 23 July. Tab. 1 gives the place, altitude, latitude and longitude of all sites where *C. amoena* was found in substrates collected.

Tab. 1. GPS coordinates giving altitude (m), latitude (N) and longitude (E) for places sampled for substrates containing *C. amoena* preadults and/or drosophilids netted over bait in Northern Italy in July 2000 and 2002 and Southern Austria in 2001.

Country	Region	Site	Altitude	Latitude (N)	Longitude (E)
Italy	Valtellina	border/Tirano	405 m	46°13.58'	10°08.81'
		Calcarola		46°09.96'	10°06.48'
		San Sebastiano (A)	500 m	46°08.84'	10°02.45'
		San Sebastiano (B)	496 m	46°08.87'	10°02.37'
		Castel dell'Acqua	554 m	46°08.99'	10°00.54'
		#417 trail marker	509 m	46°12.31'	10°09.90'
Italy	Piedmont	Villar Pellice	729 m	44°47.92'	7°08.99'
		Cognetti	720 m	44°47.98'	7°08.70'
		Podio	888 m	44°48.57'	7°06.48'
		Agricult. Res. Area	759 m	44°48.49'	7°12.27'
		Bobbio Pellice	758 m	44°48.47'	7°06.86'
		Inverso Fienminuto	700 m	44°47.09'	7°08.92'
Austria	Steiermark	Spitzmühle	417 m	46°38.27'	15°28.18'
		Heckerl	500 m	46°38.05'	15°28.65'
		Moserhof	760 m	46°37.48'	15°28.84'
		Leutschach	370 m	46°40.60'	15°28.12'
		Salzerkogel	500 m	46°39.60'	15°24.80'
		Jäggeritsch	692 m	46°37.56'	15°30.33'
		Weinbergstrasse-a	552 m	46°38.21'	15°29.52'
		Weinbergstrasse-b	463 m	46°38.94'	15°28.91'
		Weinbergstrasse-c	427 m	46°39.17'	15°28.60'
		Gaisfeld	386 m	47°01.28'	15°12.04'
		Schloss Seggau	367 m	46°46.98'	15°31.45'
Switzerland	Wallis	Epinassey	466 m	46°11.79'	7°00.36'

RESULTS

Valtellina region, Italy: Despite the extensive presence of commercial dwarf columnar apple orchards, old untended apple trees still existed. At Calcarola, collections were made under two trees, one producing red apples, one producing green apples. Tab. 2 shows the percentage of parasitized apples found to contain *C. amoena* eggs, 18.1 %. This agrees with the percentage infected apples found in Switzerland in 1998

(BAND *et al.* 1999). Tab. 3 shows the number of parasitized chestnuts found to have *C. amoena* preadult stages in the 4 places in the Orobie Alps. Whereas eggs predominated in apples, 3rd instar larvae were present in infected chestnuts ($\chi^2 = 91.275$; d.f. = 2; $P < 0.00001$).

Tab. 2. Fallen domestic apples *Malus domesticus* containing *C. amoena* eggs (e) and larvae (l) collected under trees at Calcarola in the Valtellina region of Italy, July 2000. The % apples with *C. amoena* preadults is calculated by dividing the number of apples with C. *amoena* preadults in the sample by the total number of apples collected.

Collection	Total No. Apples	Parasitized Apples No *C. amoena*	With *C. amoena*	*C. amoena* No. (e,l)	%	Emerged
green	31	11	3	6 (6,0)	9.7	1
red	63	43	14	40 (38,2)	22.2	5
Total	94	54	17	46 (44,2)	18.1	6

Tab. 3. Parasitized chestnuts *Castanea sativa* with *C. amoena* eggs (e), larvae (l) and pupae (p) collected at 4 places in the Orobie Alps, Valtellina region, Northern Italy, in July/August 2000. The % chestnuts with *C. amoena* preadults is calculated by dividing the number of nuts with *C. amoena* in the sample by the total number of parasitized chestnuts collected.

Place	Shells	No Hole	Parasitized Nuts No *C. amoena*	With *C. amoena*	%	*C. amoena* No. (e, l, p)	Emerged
San Sebastiano (A)	26	19	47	2	4.1	3 (0, 3,0)	
San Sebastiano (B)	37	9	40	5	11.1	22 (1,17,4)	1
Castel dell'Acqua	71	a 18	48	5	9.6	12 (0,11,1)	1
#417 trail marker	166	19	55	8	12.7	20 (0,17,3)	
Total	300	65	190	20	9.5	57 (1,48,8)	2

Three apples also contained a total of 7 *Drosophila* eggs and 1 *Drosophila* larva (*D. subobscura* COLLIN, 1936, on emergence). Codling moth larvae were still present in some collected apples. No other *Drosophila* was found in the parasitized chestnuts. Arrested pest larvae, typically *Cydia splendana,* continued to be present in some collected chestnuts (BOVEY *et al.* 1975). Twenty-five *C. amoena* preadults shared chestnuts with them; 32 preadult *C. amoena* were in parasitized nuts in which pest larvae had exited.

Flies collected over bait will be summarized later.

Piedmont region, Italy: Despite the fact that chestnuts are harvested commercially in the Piedmont region, nuts, mostly with evidence of parasitism, still remained on the ground. As shown in Tab. 4, parasitized chestnuts collected at two localities had *C. amoena* preadults (28 larvae, 1 pupa). Apples were forming on the trees and had begun to fall. Weevil larvae were found in some fallen apples at Podio. Codling moth larvae were also present in apples in Inverso. One apple at each place was found to have a *C. amoena* egg, as shown in Tab. 5. As in the Valtellina region, larvae predominated in chestnuts. However, in early/mid July females had just begun to oviposit in parasitized apples. The contrast in preadult stages present in the two substrates is significant ($\chi^2 = 31$; d.f.= 2; $P < 0.0001$).

Tab. 4. Parasitized chestnuts with *C. amoena* larvae (l) and pupae (p) collected at two places in the Val Pellice, Piedmont region, Northern Italy, July 2002. The % nuts with *C. amoena* is calculated as in Tab.3.

Place	Shells	No hole	Parasitized Chestnuts		*C. amoena*	%
			No *C. amoena*	With *C. amoena*	No. (l,p)	
Villar Pellice	2	36	106	2*	4 (4,0)	1.8
Cognetti	5	15	62	2	25 (24,1)	3.1
Total	7	51	168	4	29 (28,1)	2.3

* 1 *Cydia splendana* larva also in the nut

Tab. 5. Fallen domestic apples with *C. amoena* eggs (e) and larvae (l) at two places in the Val Pellice, Piedmont region, Northern Italy, July 2002. The % apples with *C. amoena* is calculated as in Tab. 2.

Place	Total	Parasitized Apples		*C. amoena*	%
	No. Apples	No *C. amoena*	With *C. amoena*	No. (e,l)	
Podio	2	0	1	1 (1,0)	50.0
Inverso	24	18	1	1 (1,0)	4.1
Total	26	18	2	2 (2,0)	7.7

Although some parasitized chestnuts contained arrested *C. splendana* larvae, 28 of the 29 *C. amoena* preadults were in nuts from which pest larvae had exited. Pest larvae had also exited the apples in which *C. amoena* eggs were found. No *Drosophila* eggs were present in apples.

Drosophilids netted over bait near/in chestnut forests in Italy

Tab. 6 shows the numbers of drosophilids netted over bait in late July/early August at two sites in the Valtellina region and in early/mid-July at three adjacent sites in Villar Pellice in the Piedmont region. The two sites in the Valtellina region were some 200 m lower in elevation than the location in the Piedmont region. Chestnut trees were across the road from the site at Tirano. Chestnuts containing *C. amoena* larvae were also gathered at the San Sebastiano site, as indicated in Tab. 3. Despite the occurrence of 11 other drosophilid species in that area and 18 overall at that elevation, only *C. amoena* preadults were found in the chestnuts. *D. subobscura* was the only other drosophilid in parasitized apples.

Numbers of drosophilids netted at Villar Pellice in early/mid-July in 2002 were 5 times the number captured in late July/early August 2000 at Tirano and San Sebastiano. Again, *C. amoena* was the only drosophilid recovered from the parasitized chestnuts. No other *Drosophila* was found in apples at that time despite the presence of at least 5 fruit breeding *Drosophila* species at Villar Pellice: *D. melanogaster* MEIGEN, 1830, *D. simulans* STURTEVANT, 1919, *D. immigrans* STURTEVANT, 1921, *D. subobscura*, *D. obscura* FALLÉN 1823. All prefer damaged apples in a ripe to fermenting state (BURLA & BÄCHLI 1991; BAND *et al.* 1998).

Southern Austria: Tab. 7 shows the number of parasitized apples containing *C. amoena* eggs and a few larvae. The overall percentage of the collected apples which were infected with *C. amoena* was 13.3 %, lower than levels found in Switzerland and the Valtellina region of Italy but still within percentages sometimes found

Tab. 6. Drosophilids netted over bait near/in chestnut forests at two places in the Valtellina region in July/August 2000 and at 3 adjacent sites at one place in the Val Pellice, Piedmont region, Northern Italy in July 2002.

Region	Valtellina		Piedmont	Total
Place altitude dates	Tirano 495 m 29/7-3/8	San Sebastiano 496 m 31/7-3/8	Villar Pellice 729 m 9/7-13/7	
Drosophila				
D. andalusiaca	1			1
D. bifasciata	1		1	2
D. deflexa	1			1
D. fenestrarum	17			17
D. funebris	1	2	102	105
D. helvetica	4	5	1649	1658
D. histrio	342	52		394
D. hydei			6	6
D. immigrans	56	14	467	537
D. kuntzei	501	325	138	964
D. limbata	4	1		5
D. littoralis	1			1
D. melanogaster			20	20
D. obscura	18	8	232	258
D. phalerata	421	58	575	1054
D. repleta		3	16	19
D. simulans	1		10	11
D. subobscura	87	42	5954	6083
D. testacea	428	70	574	1072
D. transversa	4		9	13
D. tristis			333	333
Amiota				
A. semivirgo			11	11
Chymomyza				
C. amoena	1	18	35	54
C. caudatula			4	4
Leucophenga				
L. maculata			2	2
Scaptomyza				
S. pallida	5		1	6
Totals	1894	598	10139	12631
No. species	19	12	20	26

at U. S. sites (BAND 1988a). A codling moth larva was still in an apple with *C. amoena* eggs at Salzerkogel and at Jäggeritsch. At Schloss Seggau one apple had only *Drosophila* and no *C. amoena* eggs (*D. melanogaster* emerged); one apple with 8 *C. amoena* eggs also had 1 *Drosophila* egg. At Spitzmühle, no collected plums had *C. amoena* eggs, but one had 2 *Drosophila* eggs; *D. subobscura* emerged. This species breeds in domestic plums in Switzerland (BURLA & BÄCHLI 1993). Apples collected throughout Austria were especially frassy (deposits of insect excreta). A total of 162 *C. amoena* eggs and larvae were associated with frass, 9 were not. This agrees with findings in the U. S. that *C. amoena* females exploit frassy substrates (apples, pears, nuts) for oviposition (BAND 1988a, 1995a).

Although the collected chestnuts were dry, *C. amoena* females were also found to oviposit in fallen English walnuts at 4 sites in Austria as shown in Tab. 8. Where apples

were also available, at Salzerkogel and at Schloss Seggau, more oviposition occured in apples than in walnuts as is evident from the comparison of Tabs 7 and 8. Heckerl and Moserhof were both wooded sites where nondomestic drosophilids were collected over a 5-day period. Overall, the rate of *C. amoena* oviposition in walnuts in Austria, 12.2%, is in agreement with that in apples, 13.3%. The fact that *C. amoena* oviposition in walnuts was also found at Epinassey in Switzerland confirms that this substrate can be widely used as a breeding site by *C. amoena*. Three *Drosophila* eggs were also found in a walnut hull at Moserhof. SCHATZMANN (1977) reared over a thousand *D. busckii* Coquillett, 1903 and several *D. subobscura* from walnut hulls in Switzerland collected in October at a compost heap. However, *D. busckii* was not among the drosophilids netted in the chestnut forests adjacent to the walnut stands in Austria.

Tab. 9 shows the total numbers of drosophilids netted over bait at 3 sites in chestnuts woods in Austria on 13-17 July 2001. A total of 26 species was found in Austria compared to 20 or 12 at the various Italian sites. However, the total numbers of drosophilids netted compare favorably with numbers netted over bait at Villar Pellice although in Austria *D. obscura* outnumbered *D. subobscura*. Numbers of *C. amoena* captured in the chestnut forests at Villar Pellice (35) and in southern Aus-

Tab. 7. Fallen domestic apples with *C. amoena* eggs (e) and larvae (l) throughout Southern Austria in July 2001. One apple collection from Vienna is also included.

Place	Total Apples	Parasitized Apples		*C. amoena*	%	Emerged
		No *C. amoena*	With *C. amoena*	No. (e, l)		
Leutschach	38	10	5	33 (32, l)	13.2	
Salzerkogel	33	15	6*	18 (18, 0)	18.2	
Jäggeritsch	28	21	6**	17 (16, 1)	21.4	1 male
WS-463 m	18	16	2	3 (3, 0)	11.1	
WS-427 m	33	30	1	3 (3, 0)	3.0	
Gaisfeld	14	12	1	9 (9, 0)	7.1	
Schloss Seggau	96	62	15	87 (84, 3)	15.6	
Vienna	18	11	1	1 (1, 0)	5.6	
Total	278	177	37	171 (166, 5)	13.3	

*Codling moth larva in 1 apple with 3 *C. amoena* eggs in frass on side
**Codling moth larva in 1 apple with 2 *C. amoena* eggs in frass outside on side
Vienna: 2 rotting apples, 3 *Drosophila*, no *C. amoena* in them
Schloss Seggau: 1 apple with *Drosophila* and no *C. amoena*; 1 apple with 8 *C. amoena* and 1 *Drosophila melanogaster*
Spitzmühle: 9 plums, *no C. amoena*, 1 with *Drosophila subobscura*

Tab. 8. Fallen English walnuts *Juglans regia* containing *C. amoena* eggs (e) in Southern Austria and at one place in Switzerland in July 2001.

Place	No *C. amoena*	With *C. amoena*	%	No. eggs	Emerged
Salzerkogel	23	2	8.0	4	
Heckerl	13	4	23.5	10	1 female
Moserhof	10	2	16.7	3*	
Schloss Seggau	16	4	20.0	10	
Epinassey	13	1	7.1	2	
Total	75	13	14.8	29	1

*also 4 *Drosophila*

Tab. 9. Drosophilids netted over bait in chestnut forests in Austria, 13–17 July 2001.

	Spitzmühle 471 m Site 1	Heckerl 500m Site 2	Moserhof 760 m Site 3	Total
Drosophila				
ambigua	1	6	3	10
bifasciata	11	0	0	11
deflexa	2	2	1	5
fenestrarum	6	0	0	6
funebris	3	1	2	6
helvetica	34	93	27	154
histrio	17	0	0	17
hydei	24	147	18	189
immigrans	135	59	18	212
kuntzei	219	31	12	262
limbata	5	0	0	5
littoralis	5	0	0	5
melanogaster	14	30	7	51
nigricolor	29	0	0	29
obscura	971	1423	1895	4289
phalerata	517	86	27	630
subobscura	586	1269	1538	3393
subsilvestris	1	0	0	1
testacea	630	197	39	866
transversa	8	0	2	10
tristis	44	52	21	117
Amiota				
rufenscens	1	0	0	1
variegata	1	3	0	4
Chymomyza				
amoena	18	1	9	28
Scaptomyza				
graminum	2	0	0	2
pallida	15	0	0	15
Totals	3299	3400	3619	10318
no. species	26	15	15	26

tria (28) were also comparable. The fact that chestnuts at that time of year were dry verifies the need for other breeding substrates for this species in summer and early fall.

DISCUSSION

Nearctic *C. amoena*, an introduced drosophilid, is now widespread in southern Austria and northern Italy. In Austria, it was first captured in Vienna in 1990 (MACA & BÄCHLI 1994) but it is not known when it entered Italy. Two years after one male was captured in the Veneto region in 1998 (BÄCHLI *et al.* 1999), our collecting results show that it was already well established in the chestnut forests around Tirano.

The American chestnut, *Castanea dentata*, was decimated by chestnut blight *Cryphonectria* (*Endothia*) *parasitica* in the early decades of the 20th century. Blight was also observed in European chestnuts around Genoa in 1938 and spread, much

as it had in the U. S. However, beginning in the late 1950s, chestnut trees began to recover from the blight and by the late 1970s the process of recovery had largely been completed in Italy (NUSS 1992). The chestnut remains an important commercial and forest species in Europe (BOUNOUS 2002).

In 1990, two years after *C. amoena* had been captured in Canton Ticino in three places, it was reared from parasitized chestnuts collected in the Maggia Valley as well as domestic apples (BURLA & BÄCHLI 1991). A more detailed study in 1991 confirmed that *C. amoena* had indeed invaded parasitized chestnuts as well as parasitized acorns in the Maggia Valley (BURLA & BÄCHLI 1992) and in 1998 it was found in chestnut forests in the Val Blenio and in chestnuts and apples in the Malcantone region near the Italian border (BAND *et al.* 1999). Results now confirm that it has entered the chestnut forests over a wide area of Southern Europe: Northern Italy and Southern Austria. However, the fact that fallen nuts may become dry during the summer also confirms the need for alternate breeding substrates for ovipositing females.

Chestnuts develop in burrs on the trees in summer; burrs split in autumn after the first frost, exposing the nuts. When they fall to the ground, it stimulates pest larvae, if present, to leave the nuts. Chestnuts in Canton Ticino and Northern Italy share the same two major pests, the weevil *Curculio elephas* (GYLLENHAL, 1836) and the moth *Cydia splendana* (BOVEY *et al.* 1975; ARZONE *et al.* 1993). *C. splendana* may lay more than one egg in a nut; however, only one caterpillar emerges to spin a cocoon; the remainder go into arrested development (BOVEY *et al.* 1975). Two other pest species, *Pammene fasciana* (LINNAEUS, 1761) and *Cydia fagiglandana* (ZELLER, 1841) (ALMA 2002) may be present in chestnuts elsewhere.

C. amoena is cold hardy, overwintering in the 3rd instar larval stage (BAND & BAND 1980, 1984, 1987). Females ovipositing in parasitized nuts in late autumn are actually producing the first generation to emerge in spring/early summer, typically early May in Michigan. Minimum generation time during the breeding season is 30 days; additional oviposition/larval feeding substrates are necessary for C. *amoena* to become an established biological invader. In Northern Italy, it would appear that fallen parasitized chestnuts are available as breeding substrates for this species well into mid-summer after which fallen parasitized domestic apples begin to become available. This would account for why 3rd instar larvae are present in parasitized chestnuts while eggs occur in parasitized apples in mid/late July. BAND *et al.* (1998) hypothesized that chestnuts might provide an overwintering/early summer breeding niche for this species from studies conducted in the Maggia Valley in 1990/91 (BURLA & BÄCHLI 1992) and July, 1997. Studies in Northern Italy support this hypothesis.

When chestnuts become dry, as in Austria in July 2001, females must either seek apples or other substrates. The fact that *C. amoena* can also utilize damaged walnuts is consistent with its capacity to act as a "versatile, colonizing species" (BAND 1995b). It was found in hazelnuts as well as domestic and wild apples in the Maggia Valley in Switzerland in July, 1997 when both chestnuts and acorns there were dry (BAND *et al.* 1998).

Oviposition in frass is consistent with its behavior in the United States where *C. amoena*'s breeding in parasitized substrates is probably of prehistoric vintage, and it only needed pests to attack domestic (imported) apples to utilize this substrate also (BAND 1994, 1995a). However, whereas other drosophilids can now be found to be sharing frassy apples by late summer in both Michigan and the Mid-South (BAND 1995a), there is little evidence yet that *Drosophila* in Europe are also uti-

lizing frassy apples. *D. subobscura* tends not to share breeding sites (BURLA *et al.* 1987), so the finding of both *D. subobscura* and *C. amoena* in frassy apples may be atypical or the latter could have oviposited later.

MACA & BÄCHLI (1994) postulated that *C. amoena*'s success as a biological invader was due to the fact that it entered open niches. BAND *et al.* (1998) agreed; no European drosophilids have been consistently characterized as "nut breeders." Results in Italy support this view.

"Open niche" is synonymous with "vacant niche", a controversial topic in ecology since Hutchinson in 1957 redefined niche in terms of properties of the occupying species (GRIESEMER 1992; COLWELL 1992). MACK *et al.* (2002) sought to circumvent the problem of vacant niches by suggesting alternatively that a biological invader may make use of "unused" or "underused" resources. Since *C. amoena* depends upon primary pest insects to attack substrates first, substrates are not "unused." On the other hand, resources utilized might be termed "underused." WINSTON's (1956) analysis of acorn decay illustrates that fallen nuts may harbor a variety of stage specific insects or other organisms prior to finally reaching a "shell" stage that may be used by ants, the most frequent forest floor insect species observed in the empty shells. Regarding fruit usage, when fallen fruits are ripe or fermenting enough to attract *D. melanogaster*, displaying *C. amoena* typically have already moved to less ripe fruits.

However, the behavioral properties of *C. amoena* as a biological invader in Europe seem unchanged from properties demonstrated in the United States; it remains a parasitized fruit and nut-breeder and a versatile opportunist. Its expansion into the chestnut forests of northern Italy and southern Austria has enabled it to utilize fallen parasitized chestnuts for breeding, to exploit domestic apples in mid/late summer and also damaged walnuts. Species cohesion maintained by similarities in female oviposition behavior over wide distances in the United States (BAND 1996) has promoted behavioral stability as *C. amoena* has become an established, widely distributed invader in Europe.

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REFERENCES

ALMA, A. 2002. Insetti e acari. *In*: BOUNOUS, G. (ed.), Il Castagno, coltura, ambiente ed utilizzazioni in Italia e nel mondo, pp. 115–123. Edagricole, Bologna, Italy.

ARZONE, A., ALMA, A., TAVELLA, L, BONELLI, S., GALLIANO, A. & ASCHERI, B. 1993. Researches on the main insects of chestnut in Piedmontese plantations. Proceedings of the International Congress on Chestnut. Spoleto, October 20–23, 1993, pp. 617–620.

BÄCHLI, G. 2002. Drosophilidae. *In*: MASON, F., CERRETTI, P., TAGLIAPIETRA, A., SPEIGHT, M.C.D., & ZAPPAROLI, M. (eds), Invertebrati di una foresta della Pianura Padana Bosco della Fontana. p. 128. Mantova, Gianluigi Arcari Editore

BÄCHLI, G., PAPP, L., & VANIN, S. 1999. New records of Aulacigastridae and Drosophilidae (Diptera) from Switzerland, Italy and Greece. Mitt. Schweiz. Ent. Ges. 72: 119–122.

BAND, H.T. 1988a. Host shifts of *Chymomyza amoena* (Diptera: Drosophilidae). Am. Midl. Nat. 120: 163–182.

BAND, H.T. 1988b. *Chymomyza amoena* (Diptera: Drosophilidae): an unusual urban drosophilid. Va. J. Sci. 39: 242–249.
BAND, H.T. 1989. Aggregated oviposition by *Chymomyza amoena* (Diptera: Drosophilidae). Experientia 45: 893–895.
BAND, H.T. 1991. Acorns as breeding sites for *Chymomyza amoena* (Loew) (Diptera: Drosophilidae) in Virginia and Michigan. Great Lakes Entomol. 24: 45–50.
BAND, H.T. 1994. The vine loving pomace fly and the pretty pomace fly. Michigan Academician 27: 95–109.
BAND, H.T. 1995a. Frassy substrates as oviposition/breeding sites for *Drosophila*. Va. J. Sci. 46: 11–23.
BAND, H.T. 1995b. Is *Chymomyza amoena* a versatile colonizing species? Mitt. Schweiz. Ent. Ges. 68: 23–33.
BAND, H.T. 1996. Sympatry and niche shift among temperate zone *Chymomyza* (Diptera: Drosophilidae) and the mate recognition controversy. Evol. Biol. 29: 151–214.
BAND, H.T., BÄCHLI, G., & BAND, R.N. 1999. Nearctic *Chymomyza amoena* (LOEW) (Diptera: Drosophilidae) remains a domestic species in Switzerland. Mitt. Schweiz. Ent. Ges 72: 75–82.
BAND, H.T. & BAND, R.N. 1980. Overwintering of *Chymomyza amoena* larvae in apples in Michigan and preliminary studies on the mechanism of cold hardiness. Experientia 36: 1182–1183.
BAND, H.T. & BAND, R.N. 1984. A mild winter delays supercooling point elevation in freeze tolerant *Chymomyza amoena* larvae (Diptera: Drosophilidae). Experientia 40: 889–891
BAND, H.T. & BAND, R.N. 1987. Amino acid and allozyme frequency changes in overwintering *Chymomyza amoena* (Diptera: Drosophilidae) larvae. Experientia 43: 1027–1029.
BAND, H.T., BAND, R.N. & BÄCHLI, G. 1998. Further studies on Nearctic *Chymomyza amoena* (LOEW) (Diptera: Drosophilidae) in Switzerland. Mitt. Schweiz. Ent. Ges. 71: 395–405.
BOUNOUS, G. (ed.) 2002. Il Castagno, coltura, ambiente ed utilizzazioni in Italia e nel mondo. Edagricole, Bologna, Italy.
BOVEY, P., LINDER, A. & MÜLLER, O. 1975. Recherches sur les insectes des châtaignes au Tessin (Suisse). Schweiz. Z. Forstwesen 126: 781–820.
BURLA, H. & BÄCHLI, G. 1991. Beitrag zur Kenntnis von Substraten, in denen sich Drosophiliden-Arten entwickeln. Mitt. Schweiz. Ent. Ges. 64: 45–53.
BURLA, H. & BÄCHLI, G. 1992. *Chymomyza amoena* (Diptera: Drosophilidae) reared from chestnuts, acorns and fruits collected in Canton Ticino, Switzerland. Mitt. Schweiz. Ent. Ges. 65: 25–32.
BURLA, H. & BÄCHLI, G. 1993. Aggregated breeding dispersion of *Drosophila* species reared from Cornelian cherries (*Cornus mas*) and plums (*Prunus domesticus*). Mitt. Schweiz. Ent. Ges. 66: 183–196.
BURLA, H., BÄCHLI, G. & HUBER, H. 1990. *Drosophila* reared from the stinkhorn, *Phallus impudicus*, near Zurich, Switzerland. Z. zool. Syst. Evolut.-forsch. 29: 97–107.
BURLA, H., KÜNZLI, H. & PFAENDLER, U. 1987. Laboratory experiments on natural breeding substrates in *Drosophila subobscura*. Genét. Ibér. 39: 269–285.
COLWELL, R.K. 1992. Niche: a bifurcation in the conceptual lineage of the term. *In*: KELLER, E.F. & LLOYD, E.A. (eds), Keywords in Evolutionary Biology, pp. 241–248.
GRIESEMER, J.R. 1992. Niche: historical perspectives. *In*: KELLER, E.F. & LLOYD, E.A. (eds), Keywords in Evolutionary Biology, pp. 232–240. Harvard Univ. Press, Cambridge, MA. Harvard Univ. Press, Cambridge, MA.
MACA, J. & BÄCHLI, G. 1994. On the distribution of *Chymomyza amoena* (LOEW), a species recently introduced into Europe. Mitt. Schweiz. Ent. Ges. 67: 183–188.
MACK, R.N., BARRETT, S.C.H., DEFUR, P.L., MACDONALD, W.L., MADDEN, L.V., MARSHALL, D.S., MCCULLOUGH, D.G., MCEVOY, P.B., NYROP, J.P., REICHARD, S.E.H., RICE, K.J. & TOLIN, S.A. 2002. Predicting Invasions of Nonindigenous Plants and Plant Pests. National Academy Press, Washington, DC.
NUSS, D.L. 1992. Biological control of chestnut blight: an example of virus-mediated attenuation of fungal pathogenesis. Microbiological Reviews 56: 561–576.
PATTERSON, J.T. (ed.). 1943. Studies in the genetics of Drosophila. III. The Drosophilidae of the Southwest. Univ. Texas Publ. 4313 : 1–216.
SCHATZMANN, E. 1977. Früchte als natürliche Entwicklungssubstrate von Drosophiliden. Mitt. schweiz. ent. Ges. 50: 135–148.
SCHUMANN, H. 1987. *Chymomyza amoena* (LOEW, 1862) – eine für die Fauna DDR neue amerikanische Drosophilidenart (Diptera). Ent. Nachr. Berlin 31: 125–127.
SHORROCKS, B. 1982. The breeding sites of temperate woodland Drosophila. *In*: ASHBURNER, M., CARSON, H.L., & THOMPSON, J.N., jr. (eds.), The Genetics and Biology of Drosophila. Vol. 3b, pp. 385–428. Academic Press, London.
THROCKMORTON, L.H. 1975. The phylogeny, ecology, and geography of Drosophila. *In*: KING, R.C., (ed.), Handbook of Genetics. Vol. 3, pp. 421–469. Plenum Press, New York.
WINSTON, P.W. 1956. The acorn microsere, with special reference to arthropods. Ecology 37: 120–132.