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RESEARCH LETTER

Chymomyza procnemoides Wheeler (Diptera: Drosophilidae): will it succeed as a biological invader?

HENRETTA TRENT BAND* *The University of Virginia's Mt. Lake Biological Station, Pembroke, VA 24136, U.S.A.*

Abstract. A single male *Chymomyza procnemoides*, Wheeler, a drosophilid fly native to North America was captured in a forest near Budapest, Hungary in 1990 (Papp, 1992). It was among a group of four other *Chymomyza* Czerny species, including a second Nearctic *Chymomyza* species, *C. amoena* (Loew). *Chymomyza amoena* was first reported in Europe in 1975 and has spread rapidly. The ecology and behaviour of these two Nearctic species are compared to assess the probability that *C. procnemoides* will become established and expand its range in the Old World.

Key words. *Chymomyza procnemoides*, biological invasion, forest *Chymomyza*, mating behaviour, oviposition, Drosophilidae.

It is difficult to predict in advance whether an alien species will be successful in colonizing another region. Parsons (1981, 1983) has stated that a successful colonizing *Drosophila* needs to be able to cope with physical climatic stresses and generally capable of exploiting ethanol as a resource. This favours adaptation to the fermented fruit breeding niche and characterizes endemic West Coast *Drosophila pseudoobscura* Frolova (Coyne, Boussy, & Bryant, 1984) which is a recent immigrant to New Zealand (Parsons, 1983; Millar & Lambert, 1985), and widespread European *D. subobscura* Collin, now a successful spreading invader in Chile and the west coast of North America (Parsons, 1983; Ayala, Serra & Prevosti, 1989; Beckenbach & Prevosti, 1986; Prevosti *et al.*, 1990; Burla & Bächli, 1991).

The genus *Chymomyza* Czerny, now known to be older than the genus *Drosophila* Fallén (Beverley & Wilson, 1984; Band, 1988a; Kwiatowski *et al.*, 1992), has long been associated with cut/damaged wood (Sturtevant, 1916; Wheeler, 1952; Bächli & Burla 1985; Watabe, 1985; Watabe & Liang, 1990; Band, 1988a; Grimaldi & Fenster, 1989; Papp, 1992). Neither Throckmorton (1975) nor Ferrar (1987) listed *Chymomyza* as fruit breeders. Nevertheless, Okada (1976) reported Nearctic *C. procnemis* Williston invaded Japan on melons and has spread; Band (1988a,b,c,d, 1989a, 1991) found *C. amoena* (Loew) to be breeding in parasitized fruits and nuts over a wide area, and Burla & Bächli (1991, 1992) bred *C. amoena* from fruits (apples, wild cherries) and nuts (chestnuts, acorns) in Switzerland. Nearctic *Chymomyza amoena* was first reported in Eastern Europe in 1975 and has been spreading rapidly (Bächli & Rocha Pité, 1981, 1982; Burla & Bächli, 1992). Its coldhardiness preadapts it to the European climate (Schumann, 1987). Burla & Bächli (1992) noted *C. amoena* was already a forest/garden inhabitant before it invaded Europe.

However, Nearctic *C. procnemoides* has also been captured in Europe on poplar logs, near Budapest, Hungary in May, 1990. Also captured were: *C. amoena*, Holarctic *C. caudatula* Oldenberg and two Palearctic species, *C. distincta* (Egger) and *C. fuscimana* (Zetterstadt) (Papp, 1992). Although only one *C. procnemoides* male was captured, Papp (1992) postulates that it is more widespread in Europe than currently verified. In Hungary, its sympatric occurrence with other *Chymomyza* species duplicates findings in the Mt Lake area, Giles County, Virginia (Band, 1988a, 1989b, 1994a,b).

At 1200 m elevation, *C. procnemoides* has been the predominant *Chymomyza* species captured during July. Sixty-eight males and thirty-nine females have been captured. The second most frequent *Chymomyza* species is *C. aldrichii* Sturtevant (33 males, 11 females). The excess of males to females is typical

*Current address: Department of Zoology, Michigan State University, East Lansing, MI 48824, U.S.A.

(Watabe, 1985; Band, 1989b, 1994a,b; Papp, 1992). Table 1 shows the numbers of *C. procnemoides* males and females, the damaged trees on which they were collected, the dates of collection in the individual summers, and the cause of the tree damage. In 1992 there was a return visit on 1–2 October.

As shown in Table 1, *C. procnemoides* is attracted to a variety of newly damaged trees. Damage occurred from both natural and man-made causes. This also included peeling bark from an American chestnut *Castanea dentata* (Marshall) Borkhausen in 1991 to see if *Chymomyza* would be attracted to this species also. In 1987 collecting continued into August to determine that flies would come to a specific site over an extended time period. Papp (1992) also collected over several weeks. The brief visit in July, 1990 was only to collect acorns to verify that no other species besides *C. amoena* oviposited in them despite the existence of several *Chymomyza* species in the Mt Lake area (Band, 1991).

Flies appear to use the damaged trees as mating sites. In 1986 and 1987 mating pairs could be seen during the day and into the evening at the 1200m elevation (Band, 1988a). Direct sun is avoided. In 1992 most matings were found to occur in the morning (ten matings). Matings continued to be observed in the afternoon (three matings) and evening (one mating). Grimaldi & Fenster (1989) have argued that mating sites are also oviposition sites, but only in 1992 were damaged white oaks found to provide oviposition opportunities for *C. procnemoides* females at MLBS (Band, 1993, 1994a).

Chymomyza species have assault-type mating; flies approach one another frontally, wingwaving and splaying the forelegs. In *C. procnemoides*, foreleg bicolor, ie. jet black foreforemora, tibiae and metatarsi terminating in four pale apicals (Wheeler, 1952) and foreleg movements suggest that flies are visually oriented and females readily able to distinguish conspecific males from other sympatrically occurring males. This is an aggressive species with no courtship, females approaching males tend to be ready to mate. One mating in 1992 continued from 0810 to 0850 or 40 min. This is in agreement with an average mating duration of over a half-hour (Band, 1989b, 1994a: 32.9 ± 3.6 min, $n = 36$).

In contrast with findings for *Drosophila melanogaster* Meigen and *D. pseudoobscura* where large males have the greater reproductive success (Partridge, Hoffman & Jones, 1987; Pitnick, 1991; see also Watson & Thornhill, 1994), *C. procnemoides* females mate almost as many times with small as with large males. A single female paired with two unequal sized males in 1988 and in 1992 mated with the small male almost as many times as with the large male over a 2–3 day period. In a total of eighteen matings, the females mated with a small male 40% of the time, the large male 60% of the time. In the laboratory repeat matings by females is characteristic (Band, 1989b, 1994a). The repeat mating phenomenon is presumed to be characteristic of females in nature and not an artifact of culture confinement. However few matings have resulted in progeny production (Band, 1989b, 1994a). By contrast, a small population of newly captured *C. amoena* in 1989 produced fertile eggs though no

Table 1. Number of *Chymomyza procnemoides* Wheeler captured during July collection periods, 1986–92.

Year	Date	Trees	Cause of damage	*C. procnemoides* ♂♂	*C. procnemoides* ♀♀
1986	VII 15–25	*Prunus* L. sp.	Natural wound	12	7
1987	VII 18–VIII 5	*Acer pensylvanicum* L.	Construction	7	2
1987	VII 14–19	*Quercus* L. logs	Lot clearing	4	1
1988	VII 1–13	*Acer pensylvanicum* L.	Roadside clearing	7	3
1989	VII 17–25	*Quercus rubra* L.	Storm causing tree fall	8	7
1991	VII 17–19	*Quercus alba* L.	Storm causing tree fall	9	2
1991	VII 17–19	*Castanea dentata* (Marshall) Borkhausen	Peeled bark (man-made)	1	0
1992	VII 8–24	*Quercus alba* L.	Construction	19	15
1992	VII 8–24	*Acer rubrum* L.	Construction	1	1
1992	VII 21–24	*Robinia pseudoacacia* L.	Construction	0	1
Totals				68	39

matings were observed, and it continues to be the only *Chymomyza* in the MLBS area breeding in both nuts and fruits (Band, 1988a,b,d, 1989a, 1991).

Oviposition near sap flow under bark of white oaks *Quercus alba* also in association with frass and other insect larvae is the only breeding site located for *C. procnemoides* to date in the Mt Lake area in Virginia's Allegheny Mountains (Band, 1993, 1994a). Low numbers of *Chymomyza* larvae counted are in agreement with the one example of successful reproduction by a captured and mated *C. procnemoides* female in 1991. Only nine F_1 adults emerged although thirty-two 3rd instar larvae and five pupae were transferred to fresh, non-mouldy medium (Band, 1994a). Other forest *Chymomyza* species have also been found to breed only in association with wood, tree wounds, bark (Spieth, 1957; Hackman *et al.*, 1970; Teskey, 1976; Enomoto, 1981). A *C. procnemoides* male emerging from a pupa under oak bark collected in October 1992 verified that this species was breeding there; it had not been possible to successfully rear the larvae found in summer to the imago stage. It also verifies from the one example of successful reproduction in the laboratory that this species has more than one generation a year.

Little is known about the forest *Chymomyza*. *Chymomyza caudatula* was recorded in Michigan in the 1950s (Wheeler, 1952) but not reported to be captured in Virginia's Allegheny Mountains until the 1980s (Band, 1988a). By contrast, the species was described from the southern Carpathian Mountains in 1914 (Sturtevant, 1916) and not collected in the eastern Carpathian Mountains until 1985 (Ceianu, 1989). However, it had invaded Finland by 1968 (Hackman *et al.*, 1970). It may be slowly spreading on both Continents. Among the *Chymomyza* new to Budapest, Hungary, it was the most numerous (Papp, 1992), though is rarely captured at Mt Lake, Virginia (Band, 1988a).

On the other hand, an initial capture does not herald a successful invasion for forest *Drosophila*. *Drosophila lummei* Hackman was transported on logs from the Eurasian continent to Japan. Since Watabe's (1985) initial report of three individuals among other drosophilids captured at timberyards, there seems to be no other. Toda's (1987, 1992) extensive forest collections have yielded no further specimens. Therefore, whether *C. procnemoides* will be a slow successful spreader as *C. caudatula* or an apparently unsuccessful invader as *D. lummei* cannot at this time be predicted. However, it seems unlikely to repeat the rapid spread of *C. amoena* in Europe (Burla & Bächli, 1992).

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