ANNUAL AND DIURNAL RHYTHMS OF *ERISTALIS* SPECIES (DIPTERA: SYRPHIDAE)

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Summary

Annual activity patterns of the seven most abundant *Eristalis* hoverflies in The Netherlands were studied by collecting every two weeks for two years from April to October. Two distinctly different localities were sampled, a grassland habitat and a dune habitat. Annual variation in abundance varied strongly between years but was also very site-specific. Diurnal rhythms of three *Eristalis* species were studied by handnetting every two hours for ten sunny days. Most flies were active between 10:00 and 16:00 and no drop in activity could be observed around the hottest period of the day. The sex ratio did show a pattern with relatively more females being active around the hottest part of the day.

INTRODUCTION

In The Netherlands the community of *Eristalis* hoverflies consists mainly of seven species. These species are closely related and can be seen foraging on the same flowers. Although all species can be found throughout spring and summer, variation in abundance has been reported (Holloway, 1993; NJN, 1998). The interaction among those species as adults might be an important factor influencing ecology and life history.

Much is known about *Eristalis* hoverflies but relatively little is known about general ecology. Much attention has gone to mimicry (eg. Evans & Waldbauer, 1980), colour pattern variation (Heal, 1983; Ottenheim, 1997) and handbooks (Gilbert, 1986; van der Goot, 1981). For example, NJN (1998) shows many figures with abundance lumped over many years. Although interesting in relation to the overall picture more detailed information about annual rhythms of these insects is of importance to ecological studies.

Eristalis species vary considerably in size, which may influence their activity at daytime. Several climatic factors vary like temperature, humidity and light intensity. In the morning it is normally colder, more humid and the light intensity is lower than at noon. These conditions may influence the flies directly for example causing overheating, but can also influence ecological factors like nectar availability (Wilmer, 1983).

The aim of this paper is to report on observed variation in species abundance over different years and localities and furthermore report on diurnal rhythms in three species of *Eristalis* hoverflies.

MATERIAL AND METHODS

Annual rhythms

Throughout 1993 and 1994 collections of seven *Eristalis* species were made in 'de Horsten', a grassland habitat with small forest patches; and in 'Meijendel' a dune habitat with open patches and shrubs. Both localities are in the neighbourhood of Leiden (The Netherlands) and are only four kilometres apart.

From April to October about every two weeks when the weather was sunny, both areas where sampled in random order for about one hour. This was done to be able to compare the abundance of species over the collection localities and years. The species collected were *E. abustorum, E. abusivus, E. nemorum, E. horticola, E. pertinax, E. tenax* and, *E. intricarius*. Other *Eristalis* species have been found but are extremely rare.

Diurnal rhythms

The experiment was performed on two separate locations around Leiden (The Netherlands) on nine days between the 12th of July and the 29th of July 1994. During this period the weather was hot and sunny. The first site was adjacent to a grassland with many ditches. The second site was situated in a more urban area along a waterway.

On an experimental day every two hours active flies were handnetted for half an hour. The first session was at 8.00 hours and the last at 18.00 hours. Before and after these sessions too few flies could be netted. Only active flies were netted because the aim of this study was to study active flies. An active fly was either foraging or flying. At the end of each session the flies were sexed and the species was determined after which the flies were released. I collected a maximum of around 75 flies within half an hour. Therefore, the number of flies caught at 12.00 and 14.00 is an underestimate of the total population of a species that is active. On all other sessions fly number was limiting instead of capture rate.

Sex ratio was calculated by dividing the number of collected males by the number of collected females. A high sex ratio means relatively more males being active.

RESULTS AND DISCUSSION

Annual rhythms

In total 701 flies were caught in 1993 and 469 in 1994. In appendix I the number of flies caught of both sexes are summarized for the different years and the two collection sites. Distinct differences in abundance can be observed between the species, years and collection sites (figure 1). *E. tenax* is most commonly found at the end of the summer and in autumn in the two study areas. *E. pertinax* shows two peaks in early spring and early summer. *E. horticola* is present from April to July. The most abundant species was *E. nemorum*, which peaked in mid summer. *E. arbustorum* shows no specific activity pattern in the two sample years but is known to have two generations in spring and summer (Holloway, 1993). In this study *E. abusivus* only shows one peak in early summer. The results of *E. intricarius* are not shown in figure 1 because to few flies were collected (appendix I).

From this study it is clear that the annual rhythms of the seven *Eristalis* hoverflies are very different and depend on the collection site. The two larger species *E. tenax* and *E. pertinax* (and to some extent also *E. intricarius*) occur just as much in the dunes as in the 'polder' environment. The smaller species always have a smaller presence in Meijendel than in de Horsten accept *E. horticola*, which has a similar abundance in both localities at the end of the summer. The smaller species do not occur in the dunes in great numbers. Possibly these species are not able to maintain a permanent population in the dunes and this area is re-colonised every year. The larger species may indeed be able to sustain a population or perhaps these are good flyers and are able to forage in the dunes while they reproduce somewhere else.

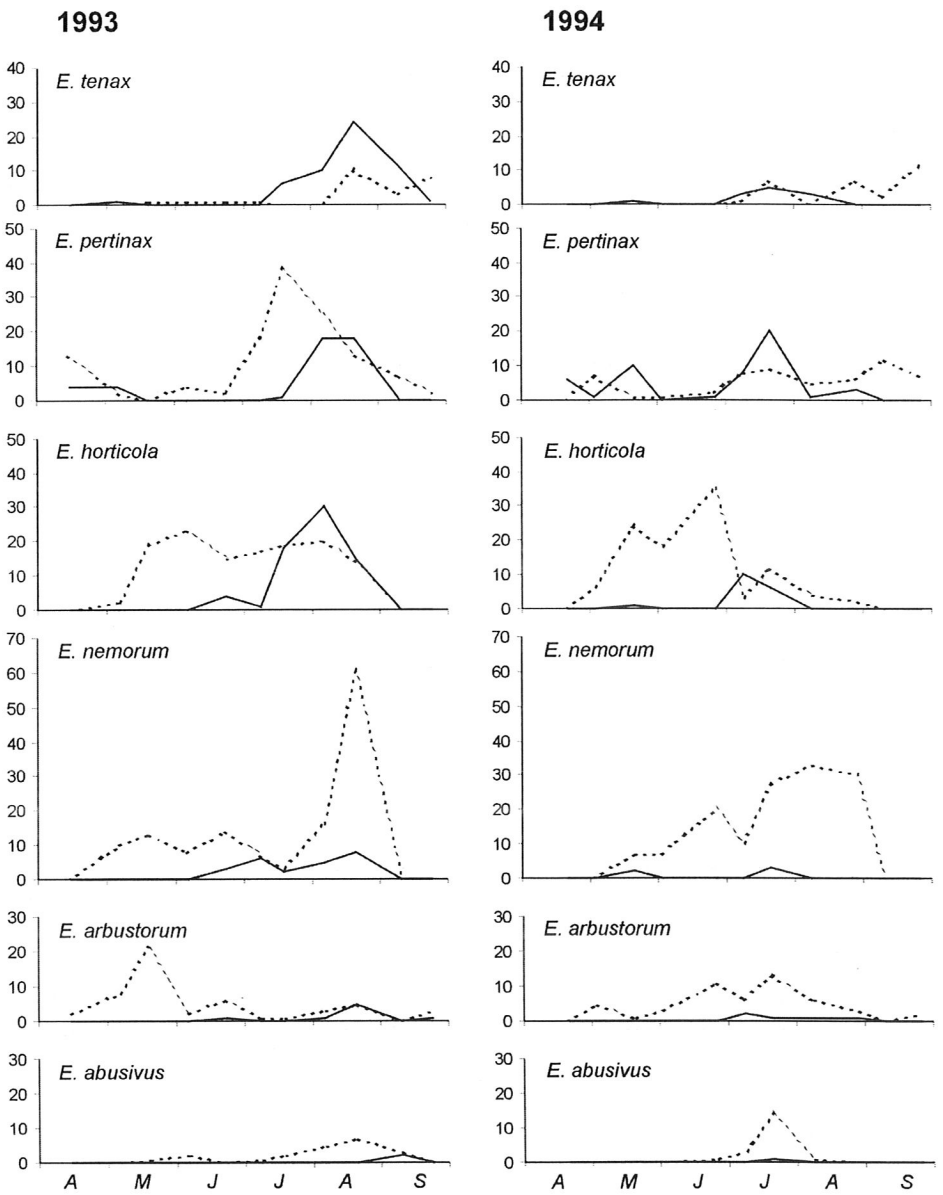

Figure 1. *The number of flies collected in 1993 and 1994. Solid lines represent 'Meijendel', dotted lines represent 'de Horsten'.*

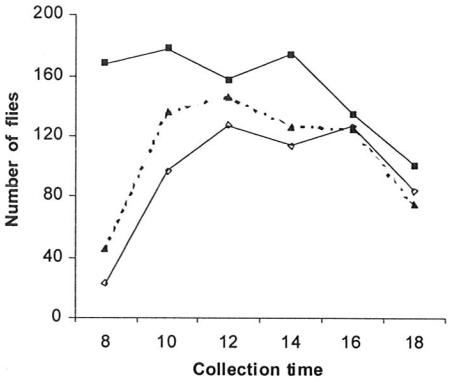

Figure 2. *The number of flies collected at 2-hour intervals. Square = E. abusivus, triangle = E. arbustorum, diamond = E. nemorum.*

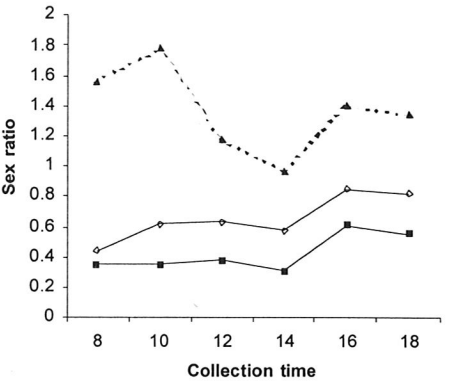

Figure 3. The change in sex ratio during the day. Square = E. abusivus, triangle = E. arbustorum, diamond = E. nemorum.

Diurnal rythms

On the first site, mainly *E. abusivus* and *E. arbustorum* were caught. Other *Eristalis* species only composed a tiny fraction of the hoverfly community. On the second site, around the same number of *E. arbustorum* was caught as on the first site, but *E. abusivus* was caught in very small numbers. Most abundant was *E. horticola* (which was not included in this experiment) followed by *E. nemorum* and *E. tenax* (which was also not included).

Table 1 shows the number of flies caught at a time of day for both sexes. The total number of individuals collected over the day is shown in figure 2. Most flies are active between 10:00 and 16:00 hours accept for *E. abusivus*. Extremely high numbers of active *E. abusivus* are collected at 8:00 hours.

The sex ratio of the active flies also varied over de day (figure 3). More males tended to be active in the afternoon except in *E. arbustorum*. The sex ratio in this species was more male biased than in the other species but shows a clear drop in sex ratio around noon, with relatively more females being active. Males are more active than males, patrolling the flowers in search of mates and overheating might account for this phenomenon.

Wilmer (1983) reported that nectar availability varies strongly over a day. Most nectar is present in the morning and decreases over the day. To optimise foraging the hoverflies should follow this pattern. Interesting this seems not to be the case. Activity of flies was high in the afternoon when nectar availability should be low. The flies could however be foraging on pollen. More detailed study on the ecology of *Eristalis* hoverflies should be done to make more explicit conclusions.

Table 1. *Number of active Eristalis hoverflies netted at different times of the day. m=males, f=females, E. arb.=Eristalis arbustorum, E. abu.=E. abusivus, E. nem.=E. nemorum. Sex ratio is calculated by dividing the number of males by the number of females. A high sex ratio means more males.*

Hour	Sex	Collected flies			Sex ratio		
		E. arb.	*E. abu.*	*E. nem.*	*E. arb.*	*E. abu.*	*E. nem.*
8:00	*m*	28	43	7	1.56	0.34	0.44
	f	18	125	16			
10:00	*m*	87	46	37	1.78	0.35	0.62
	f	49	132	60			
12:00	*m*	79	43	49	1.18	0.37	0.63
	f	67	115	78			
14:00	*m*	62	41	42	0.97	0.31	0.58
	f	64	134	72			
16:00	*m*	73	51	58	1.40	0.61	0.85
	f	52	84	68			
18:00	*m*	43	36	38	1.34	0.55	0.83
	f	32	65	46			

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Appendix I. *Summary of flies caught in 1993 and 1994. H = 'de Horsten', M ='Meijendel'.*

1993	*E. tenax*		*E. pertinax*		*E. horticola*		*E. nemorum*		*E.arbustorum*		*E. abusivus*		*E.intricarius*	
Date	H	M	H	M	H	M	H	M	H	M	H	M	H	M
104	0	0	13	4	0	0	0	0	2	0	0	0	0	0
125	0	1	2	4	2	0	10	0	8	0	0	0	2	0
138	1	0	0	0	19	0	13	0	21	0	1	0	3	0
155	1	0	4	0	23	0	8	0	2	0	2	0	1	0
172	1	0	2	0	15	4	14	3	6	1	0	0	2	3
187	1	0	18	0	17	1	7	6	1	0	1	0	0	0
197	0	6	38	1	19	18	3	2	1	0	2	0	0	1
215	0	10	25	18	20	30	16	5	3	1	5	0	0	3
229	10	24	13	18	14	15	61	8	5	5	7	0	0	2
249	3	11	7	0	0	0	0	0	0	0	3	2	0	1
263	8	1	2	0	0	0	0	0	3	1	0	0	0	0
1994														
110	0	0	0	6	0	0	0	0	0	0	0	0	0	1
122	0	0	7	1	6	0	0	0	5	0	0	0	0	0
139	0	1	1	10	24	1	7	2	1	0	0	0	0	0
152	0	0	1	0	18	0	7	0	3	0	0	0	0	1
175	0	0	2	1	35	0	20	0	11	0	1	0	3	1
187	1	3	8	8	3	10	10	0	6	2	3	0	1	1
199	7	5	9	20	12	6	27	3	13	1	14	1	2	2
217	0	3	5	1	4	0	33	0	6	1	1	0	1	0
237	7	0	6	3	2	0	30	0	3	1	0	0	0	1
249	2	0	12	0	0	0	0	0	0	0	0	0	0	0
265	12	0	7	0	0	0	0	0	2	0	0	0	0	0