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ANTHECOLOGICAL RELATIONS BETWEEN REPUTEDLY ANEMOPHILOUS FLOWERS AND SYRPHID FLIES. VI. ASPECTS OF THE ANTHECOLOGY OF CYPERACEAE AND SPARGANIUM ERECTUM L.

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SUMMARY

Cyperaceae and *Sparganium erectum* L. are occasionally visited by representatives of syrphid species of the *Melanostoma-Platycheirus* group. Analyses of the content of crop and gut revealed that some of these flies feed for some time (almost) exclusively on the pollen of Cyperaceae and *S. erectum*, which leads to the conclusion that zoophilous pollination occurs occasionally.

1. INTRODUCTION

Nectar and pollen are the principal sources of food for syrphid flies. By visiting flowers in order to feed, the flies may bring about effective pollination. As shown in previous studies, some hover fly species of the *Melanostoma-Platycheirus* group (M-P group) consume exclusively pollen of anemophilous flowers, such as those of grasses, Cyperaceae and *Plantago lanceolata* L. (VAN DER GOOT & GRABANDT 1970; LEEREVELD et al. 1976). In many cases it is the foraging behaviour of these flies which is responsible for effective pollination (STELLEMAN & MEEUSE 1976; STELLEMAN 1982).

From pollen analyses of the digestive tract of these flies it is clear that representatives of the M-P group are attracted to Cyperaceae particularly in Scandinavia, in the adjoining part of the USSR and in Canada (LEEREVELD 1982).

A dietary, field and SCAN study concerning the anthecology of *Scipus maritimus* L. in The Netherlands led to the conclusion that syrphid flies do act as pollinators, but to a limited extent (LEEREVELD et al. 1981); observations made along the east coast of Scotland confirm this conclusion.

Syrphids are known to make feeding visits to the following anemophiles: *Typha angustifolia* L. (WAITZBAUER 1976), *Phragmites* (Van der Goot, pers. comm.), *Rumex acetosa* L. (Leereveld) and *Sparganium erectum* L. (A. D. J. Meeuse, pers. comm.). The latter observer caught hover flies in stands of *S. erectum* in order to make pollen analyses of the digestive tract.

In the study reported here, data obtained from above-mentioned pollen analyses are combined with selectively chosen data (published and unpublished) concerning the composition of Cyperaceae pollen in the crop and intestine of syrphids. The unpublished data concern flies from The Netherlands, Madagascar,

Western Germany and Belgium; published data relate to flies from The Netherlands, Scandinavia, USSR, Canada and USA (see LEEREVELD et al. 1981 page 466, table 1: PCL 15 and LEEREVELD 1982 pages 28–32, table 2: all specimens with cyperaceous pollen).

The cyperaceous pollen is subdivided into several types, which are then assigned to species or a group of genera, according to the determination key in FAEGRI & IVERSEN (1975, page 253). In addition, eight hover flies (caught by A. D. J. Meeuse) with a fair amount of *S. erectum* pollen in their crop and gut were selected for this investigation.

Since the pollen spectrum of the crop and the intestine provides insight into the faithfulness of the syrphid flies to specific species, it is used here as a tool to estimate the efficiency of zoophilous pollination in allegedly anemophilous flowers.

2. MATERIAL AND METHOD

The Dutch specimens originated from three localities. The following specimens were selectively caught in stands of *S. maritimus* along the coast of the Province of Friesland: *Platycheirus scambus* Staeger (PCL 56–59), *P. fulviventris* Macq (PCL 55) and *Lejops vittata* Mg. The following specimens were selectively caught in stands of the Sea Club Rush in the Province of Noord-Holland, near Zaandam: *Melanostoma mellinum* L., *P. scambus* (PEL 38), *P. clypeatus* Mg., *P. fulviventris* (PEL 37, 39 and 41), *Pyrophaena granditarsa* Förster (PEL 36) and *Spaerophoria scripta* L. The following specimens were selectively caught on inflorescences of *S. erectum* along the West coast of the Province of Noord-Holland: *Episyrphus balteatus* De G., *P. granditarsa* (PDL 49) and *Syrphus ribesii* L. The place of origin of all specimens from abroad is known, but the exact location is not important in this context.

VAN DER GOOT (1970 and 1981) were consulted in connection with the determination of the syrphid flies, except for the two specimens of *M. annulipes* Macq, which were identified by B. Brugge (Amsterdam). In all cases except that of *M. annulipes* the nomenclature used is that of VAN DER GOOT (1981).

The flies used in this study were subjected to the standard procedure for extracting and subsquently mounting and counting the pollen from crop and intestine as described by LEEREVELD (1982). The determination key of FAEGRI & IVERSEN (1975) was used for the analyses of the cyperaceous pollen but not for the analyses of the type found in the crop and gut of *M. annulipes*, because these flies were of non-European origin. The northwest European pollen flora (PUNT 1976) was consulted for the determination of the *S. erectum* pollen.

3. RESULTS

Tables 1 and *2* show the results of analyses of the pollen in the crop and intestine of selected hover fly specimens. In the tables special attention is given to pollen

Table 1. Analyses of pollen in crop and gut of selected syrphids from the West coast of Noord-Holland.

Species and slide code	*Sparganium erectum*	*Plantago lanceolata*	Other types
Episyrphus balteatus			
PEL 78	48		3
PEL 79	11		18
PEL 80	25	47	
PEL 81	7%	93%	
PEL 82	13%	81%	5% grasses; 1% others
PEL 83	23		3 grasses
Pyrophaena granditarsa PDL 49	97%		3%
Syrphus ribesii PFL 2	7%		93%

types of reputedly anemophilous plants (grasses, Cyperaceae, *S. erectum* and *P. lanceolata*). If too few pollen grains were encountered for conversion to percentages, the actual number is given.

The feeding behaviour of syrphids is entirely dependent on the availability (in time and space) of attractive sources. The availability of a certain type of pollen depends on the time of day (anthesis), season and habitat. Data of this kind are omitted (in many cases such data are not available). Nevertheless, *tables 1* and *2* give an impression of the potential of some groups of anemophiles to attract hover flies. Through their way of feeding the hover flies may well act as pollen vectors.

4. DISCUSSION AND CONCLUSION

The consumption of the pollen of anemophiles or alleged anemophiles by syrphid flies is only beneficial to a plant species if one of their previous visits was to a flower or inflorescence of the same species; in such a case they will be able to transfer pollen to the stigma(s). STELLEMAN (1978) and LEEREVELD et al. (1981) showed by means of SEM studies that pollen of Cyperaceae, grasses, *P. lanceolata* and *Typha* is carried on the body of hover flies. Consequently, at least some species of syrphids may well act as potential pollen carriers for these anemophilous plants. Only if flies display a relatively high degree of faithfulness to one plant species will there be an efficient transfer of pollen. The feeding behaviour of certain species, which can be traced in the crop and intestine content, depends on habitat, season and time of day. The quantity of ingested pollen is a relative measure for the faithfulness of the flies within a certain habitat, and at one particular season and time of day. Dietary studies, performed by means of pollen analyses, are a useful tool to assess the efficiency of zoophilous pollination in anemophilous taxa under restricted circumstances. The only syrphids selected for this study were those with a fair amount of pollen of Cyperaceae or *S. erectum*

in their crop and gut.

Sparganium erectum (*table 1*)
The specimens originating from the West coast of Noord-Holland were caught under restricted circumstances: special habitat (patches of *S. erectum*), season (flowering season of *S. erectum*) and time of day (anthesis of *S. erectum*). *Episyrphus balteatus* and *Syrphus ribesii* are typically heliophilous syrphid species, although the former may be regarded as a regular visitor to *P. lanceolata* in the early morning. Seven specimens of the above-mentioned species ingested pollen of *S. erectum*; four of these specimens, however, were found to have a very limited pollen content in crop and gut. These flies were caught probably just after they had started consuming pollen. In three specimens (PEL 81, 82 and PFL 2) a low percentage of *S. erectum* pollen was found. The data indicate that the feeding visits of *E. balteatus* and *S. ribesii* were not consistent. This leads us to conclude that if *E. balteatus* and *S. ribesii* acted as pollinators, it was only to a very limited extent.

Pyrophaena granditarsa might be considered to be a syrphid species whose representatives feed on anemophiles (VAN DER GOOT & GRABRANDT 1970; LEEREVELD 1982). The large amount of *S. erectum* pollen in the crop and gut of the specimen with code PDL 49 indicates that the fly has fed solely on inflorescences of that plant. In this case, pollination might well have been effected. More information will be required before a more definite conclusion can be drawn concerning the meaning of zoophilous pollination in *S. erectum*, which is strictly protogynous. The results, however, indicate that the inflorescences are attractive to syrphid species whose representatives often feed exclusively on anemophiles (such as grasses and *Plantago lanceolata*) and field studies must show if the flies also visit inflorescences in the female phase of anthesis.

Carex-type (*table 2*, first column)
Included in the *Carex*-type is the pollen of several genera (*Carex, Dulichium, Scirpus silvaticus, Eriophorum* and *Trichophorum*) which have similar characteristics but which are not subdivided in the pollen determination key of FAEGRI & IVERSEN (1975, p. 253). *Carex hirta* L. has a different pollen type and is excluded (see *table 2*, third column). Because in many cases one cyperaceous species grows only in fairly dense populations it can be assumed that most of the syrphids that had fair amounts of the *Carex*-type of pollen in their digestive tract were faithful to one or to only a few species. This assumption is supported by the findings of large amounts of easily recognizable pollen of one species only (such as pollen of *S. maritimus* and *C. hirta*) in the crop and gut of the selected syrphids. The hover flies with the *Carex*-type of pollen in their digestive tract belong to the following species whose representatives are reported to feed on anemophilous flowers: *M. mellinum, P. scambus, P. clypeatus, P. immarginatus, P. peltatus* and *P. angustatus*. *Lejops vittata* is a species known to feed on *Scirpus maritimus* in The Netherlands. Most of the specimens originated from Scandinavia, from the adjoining part of the USSR and from Canada, a part of the world

where cyperaceous forms may occur locally in great abundance (open Arctic and sub-Arctic vegetation types).

It can be concluded that zoophilous pollination syrphids occurs in cyperaceous species which shed pollen of the *Carex*-type. The extent of this type of pollination in the anthecology of these Cyperaceae needs further investigation.

Scirpus maritimus (*table 2*, second column)

Among the pollen types of Cyperaceae, *S. maritimus* pollen is easy to distinguish. Syrphid flies which evidently fed on the inflorescences of this Sea Club Rush were caught exclusively in stands of that species in The Netherlands; unfortunately such data were not available for the Norwegian specimen (*P. peltatus*, PAL 90).

Representatives of species from the M-P group whose preference for anemophiles was noticed in earlier studies are the ones that bring about pollination of *S. maritimus*; the following species are involved: *M. mellinum, P. scambus, P. clypeatus, P. fulviventris, P. peltatus* and *P. granditarsa*. The typically heliophilous syrphid *Sphaerophoria scripta* with 27% pollen of *S. maritimus* in crop and gut consumed pollen of the Sea Club Rush only occasionally. In the restrict-

Table 2. Analyses of pollen in crop and gut of selected syrphids.

Species, slide code and country of origin	*Carex*-type	*Scirpus maritimus*	*Carex hirta* + *Schoenoplectus* type ++	Other type(s)
Mellanostoma mellinum				
PAL 32, Finland	100%			
PAL 34, Finland	100%			
PAL 36, Finland	100%			
PAL 73, Norway	100%			
PBL 34, Sweden	100%			
PEL 99, Belgium	100%			
PBL 53, Sweden	85%			15% dicot
PAL 53, USSR	70%			30% *Plantago lanceolata*
PAL 82, Norway	6%			94% grasses
PEL 40, Netherl.		100%		
Platycheirus scambus				
PAL 48, Canada	100%			
PAL 49, USA	100%			
PBL 56, Sweden	100%			
PBL 67, Sweden	100%			
PBL 57, Sweden	82%			28% *P. lanceolata*
PBL 55, Sweden	22%			70% Bryophyta; 8% grasses
PAL 41, Finland	17%			83% *Rumex*
PCL 56, Netherl.		100%		
PCL 57, Netherl.		100%		
PCL 58, Netherl.		100%		
PEL 38, Netherl.		50%		50% grasses
PCL 59, Netherl.		40%		60% grasses

Table 2. continued.

Species, slide code and country of origin	*Carex*-type	*Scirpus maritimus*	*Carex hirta* + *Schoenoplectus* type + +	Other type(s)
P. clypeatus				
PAL 37, Finland	100%			
PCL 76, W. Germ.	100%			
PCL 79, W. Germ	100%			
PBL 54, Sweden	86%			11% grasses; 3% dicots
PBL 41, Sweden	4%			49% dicots; 47% grasses
PEL 49, Netherl.		46		1 *P. lanceolata*
PBL 33, Sweden			100% +	
P. fulviventris				
PCL 55, Netherl.		100%		
PEL 37, Netherl.		100%		
PEL 39, Netherl.		100%		
PEL 41, Netherl.		44		14 grasses
P. immarginatus				
PAL 88, Norway	100%			+ grasses
PAL 87, Norway	7%			93% grasses
P. peltatus				
PAL 71, USSR	37%			66% dicots
PAL 90, Norway	+	35%	36% + +	29% dicots
P. angustatus				
PAL 50, Canada	100%			
Pyrophaena granditarsa				
PEL 36, Netherl.		100%		
Sphaerophoria scripta				
PEL 43, Netherl.		27%		73% dicots
Lejops vitata				
PCL 23, Netherl.	100%			
M. annulipes				
PEL 12, Madagascar:	100% Cyperaceaea, probably of the *C. papyrus* group			
PEL 95, Madagascar:	100% Cyperaceae, probably of the *C. papyrus* group.			

ed habitat of the stands, hover flies were faithful to the inflorescences of *S. maritimus*, which led to pollination. This confirms the results of an earlier study (LEEREVELD et al. 1981) concerning the role of syrphid flies as pollinators of *S. maritimus*.

Carex hirta (*table 2*, third column)
In one Swedish specimen of *P. clypeatus* the pollen was 100% *C. hirta*. This result supports the view that particularly hover flies of the M-P group (including *P. granditaraa* which is closely related) are faithful to one cyperaceous species only.

Schoenoplectus-type (*table 2*, third column)
Only one specimen used in this study ingested pollen belonging to this type of pollen. A local stand of one *Schoenoplectus* species is assumed.

Other anemophiles (*table 2*, fourth column)
In agreement with the results of earlier studies carried out by a research team from the Hugo de Vries Laboratorium, Amsterdam (see parts I to IV of the series: Anthecological relations between reputedly anemophilous flowers and Syrphid flies) and by VAN DER GOOT & GRABANT (1976), representatives of the M-P group can be regarded as being specialized feeders on *P. lanceolata* and grasses. Striking is the high percentage of *Rumex* pollen in the crop and gut of *P. scambus* from Finland (PAL 41). Extensive field studies performed by the above-mentioned research team have not revealed any consistent relation between species of this genus and syrphid flies. Surprising too is the 70% of spores of Bryophyta in the crop and intestine of *P. scambus* from Sweden (wrongly referred to as Pteridophyta by LEEREVELD 1982). The role syrphids play in the dispersal of spores has not yet been investigated.

It is concluded that certain species of hover flies (especially representatives of the *Melanostoma-Platycheirus* group and the related *Pyrophaena granditarsa*) may play a role as pollinators of at least some Cyperaceae.

Inflorescences of *Sparganium erectum* are visited by syrphids only occasionally and zoophilous pollination in this monoecious and strictly protogynous species seems to be limited.

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