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Studies by trapping of the Empididae (Diptera) of crushed household refuse spread on an *Ulex* heathland of Central Brittany

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ABSTRACT

To study the population of Empididae in an heathland of Central Brittany, as well as those of three experimental plots spread with crushed household refuse, three sampling techniques: yellow water traps, pitfall and emergence traps, were simultaneously used.

The composition of the populations of flies, as well as their seasonal variations were studied, showing a complete transformation of the heathland population following the spreading by refuse. Several species, unknown from the area, appear on those modified biotopes; the thickness of the spreading seems to influence the colonisation by the flies.

Since sampling difficulties did not allow to investigate the larval biology, the observed modifications of the life cycles remain unexplained.

KEY-WORDS: *Empididae - Household refuse* - Ulex *heathland.*

RÉSUMÉ

Afin d'étudier le peuplement d'Empididae d'une lande à ajoncs de Bretagne centrale, ainsi que ceux de trois parcelles expérimentales où ont été épandues des ordures ménagères broyées, trois techniques d'échantillonnage ont été utilisées simultanément : pièges à eau colorés, pots de Barber et nasses d'émergence.

La composition des peuplements de mouches ainsi que leurs variations saisonnières ont été étudiées, montrant une transformation complète du peuplement de la lande à la suite de l'épandage d'ordures. Plusieurs espèces, inconnues de la région, apparaissent sur ces biotopes transformés; l'épaisseur de l'épandage semble d'ailleurs influencer la colonisation par les mouches.

En raison des difficultés d'échantillonnage rencontrées, il n'a pas été possible d'effectuer des recherches sur la biologie des larves; en conséquence, les modifications observées dans les cycles biologiques demeurent inexpliquées.

MOTS-CLÉS : *Empididae - Déchets ménagers - Lande à ajoncs.*

INTRODUCTION

In a previous paper (DUVIARD & TRÉHEN, 1981), the general transformations of the community of Arthropods in an *Ulex* heathland of Central Brittany (France) have been described, following the spreading of crushed household refuse on the soil. The particular incidence of this drastic modification of the environment on Diptera community were quite conspicuous. Even though some taxa remained as numerous as before the spreading (Mycetophilidae, Stratiomyiidae, Thecostomata), or decreased in numbers (Phoridae, Dolichopodidae), other groups of Diptera with edaphic larval

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stages were caught in increasing numbers on the modified heathland: trapped Scatopsidae, Sciaridae, Empididae, were respectively 85, 27 and 15.6 times more numerous on the spread area than on the untouched heathland.

The choice of Empididae was justified by the previous researches led on this group in the area of our laboratory as well as in other places of Central Brittany (TRÉHEN, 1971; BAILLOT & TRÉHEN, 1974; BAILLOT *et al.*, 1976).

With the aid of Pr. TRÉHEN, we proceeded to the identification of all numbers of the Empididae family. Even though this work was important, it was a necessity to identify specimens at specific level to allow a correct interpretation of our data.

METHODS AND LOCALITY

Three sampling techniques have been used: yellow water traps, pitfall traps and emergence traps, according to the pattern and timing described elsewhere (DUVIARD & TRÉHEN, 1981). The catches of Empididae obtained by these authors from both undisturbed and spread areas of *Ulex* heathland located at the Station Biologique de Paimpont were used and identified.

Another trapping experiment was conducted on two new spreadings of crushed household refuse, established on April 15th, 1981. Since 1979, when the first experiment began, the crushing plant of Gaël (Morbihan, France), which produced the crushed refuse, modified somewhat its process: broken glass and plastics were more thoroughly removed, and the average size of crushed elements decreased from 50 to 30 mm, thus giving to the so-called "compost" a more even appearance.

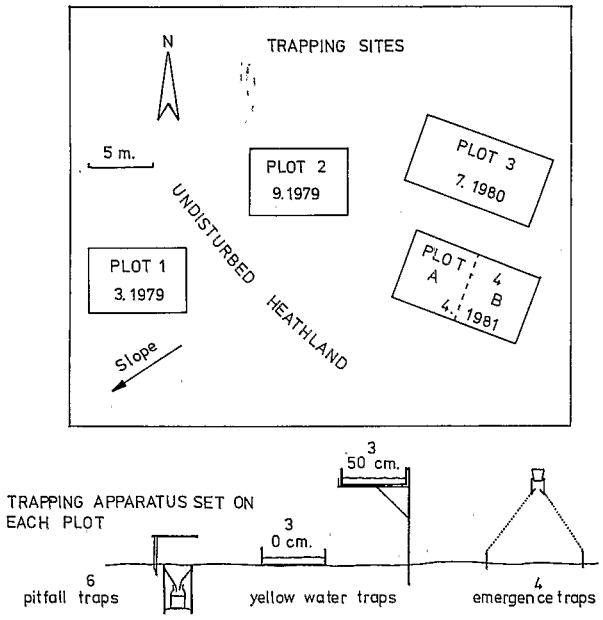

FIG. 1. — Trapping sites on *Ulex* heathland in Paimpont (France).
Upper part of the figure: situation of the spread plots and plates of spreading in the general heathland environment.

4*A*: thick spread plot: 4*B*: thin spread plot.
Lower part of the figure: the trapping apparatus used on each studied plot.

On April the 15th, 1981, a new spreading was conducted on the studied area of heathland, with day-crushed refuse, on two contiguous plots: in one plot, the refuse was spread at a 35 cm thickness, while, on the other plot, thickness was only 10 cm deep. Empididae caught on those two plots during the April to October period of 1981, according to the same device used in the 1979-1980 trapping, were identified (see fig. 1).

RESULTS

Composition of Empididae communities

The different trapping devices allowed the catch of 6,045 Empididae belonging to 29 species. Table I gives the number of trapped specimens according to species, biotopes and type of traps. The identification is based on the works of Collin (1961), Kovalev (1972) and Chandler (1978).

Several species, caught on the undisturbed heathland, have never been found in the spread plots; they are: *Amydroneura gibba*, *Empis praevia*, *Hilara manicata*, *H. pilosa*, *Hilara* sp., *Pararamphomyia geniculata*, *Tachydromia* sp. 2. The large majority of catches obtained from the different spread plots is composed by a small number of species that have not been trapped on the undisturbed heathland, such as *Crossopalpus humilis*, *C. minima* (caught in very large numbers), but also by less conspicuous species such as *Coptophlebia* sp., *Crossopalpus* sp., *Empis aestiva*, *Hilara interstincta*.

If some species are caught both on undisturbed and spread heathland, they are not observed in equivalent numbers. Some species are seldom trapped, and the signification of the observed differences is then dubious. This is the case for *Drapetis infitialis*, *Empis* sp., *Ramphomyia* sp., *Trachypeza* sp.

In some cases, catches are more numerous in the undisturbed heathland than in the spread plots; this is true for *Amydroneura erythrophtalma*, *Coptophlebia vitripennis*. But when these largely dispersed species are more numerous in the spread heathland, the difference is much more noticeable, as in the case of *Crossopalpus nigritella*, *Drapetis pusilla* or *Trachypeza nubila*.

An interesting situation is observed on the two 1981 spreadings. On those two contiguous plots, where only the thickness of the spreading differs at the beginning of the experiment, the relative importance of the three major species, all three of the genus *Crossopalpus*, is very different. *C. humilis* constitutes 92.7 % of the catches on the thick spread plot, but only 74.5 % on the thin spread one. In the case of *C. nigritella*, the catches are respectively 3.3 and 20.3 % on those two biotopes, while the case of *C. minima* is still different, with respectively 3.1 and 2.4 % of total catches.

The 1979-1980 experiment lasted 13 months, comparatively to 7 months in 1981. The importance of the three *Crossopalus* species in the 1979-1980 and 1981 communities of the spread heathland is rather stiking, as shown from table II. The 1979 yellow water traps catches have been discarded from this table.

Seasonal changes in catches

From the simultaneous use of three sampling techniques all along the 13 months of the 1979-1980 experiment, several aspects of the ecological behaviour of Empididae flies are underlined.

TABLE I. — *Catches of Empididae from*

YWT: yellow water traps; PT: pitfall traps; ET: emergence traps;

Species	Undisturbed heathland			1979 Spread plot			1981, spread plot			
							thick		thin	
	YWT	PT	ET	YWT	PT	ET	PT	ET	PT	ET
Amydroneura erythrophtalma Mg.	15			5						
Amydroneura gibba Fall.			1							
Coptophlebia vitripennis Mg.	61	11	8	7						
Coptophlebia sp.				2						
Crossopalpus humilis Frey				411	1,142	514	1,155	346	518	314
Crossopalpus minima Mg.				18	83	6	46	4	24	5
Crossopalpus nigritella Zett		7		102	362	211	38	18	194	47
Crossopalpus sp.				1					1	
Drapetis exilis Mg.	1			7		1				
Drapetis pusilla Lw.	10			61		13	10	1	13	13
Drapetis infitialis	4		1	5	1	7				2
Drapetis sp. 2					7				4	3
Elaphropeza sp.										
Empis aestiva Lw.				20					1	
Empis praevia Coll.	10		4							
Empis sp.		12	4	12	5					
Hilara interstincta Fln.				1						
Hilara manicata Mg.	3									
Hilara pilosa Ztt.	6									
Hilara sp.	2									
Pararamphomyia geniculata Mg. et Ztt.	1	1								
Ramphomyia sp.	4		1	5						
Sicodus arrogans L. et Mg.				1						
Tachydromia agilis Mg.	3								7	
Tachydromia minuta Mg.	1			12	1					1
Tachydromia sp. 1	11			11	1	1		2	1	
Tachydromia sp. 2	7									
Tachypeza nubila Mg.	1		1	3	34					
Tachypeza sp.		1			3					

undisturbed and spread plots of heathland.

T: extraction according to Tullgren's method; W: washing according to Tréhen's method.

Tréhen, 1971			Bailliot 1975		Bailliot, 1972					
Paim-pont T_1W_1	Ville-neuve Mouazé ET	Bailliot *et al.* 1975 Réguiny YWT+ET	Fréhel heatland ET	Streamside grassland YWT	Wood-land YWT	*Festuca* grass-land YWT	*Ulex* heath-land YWT	Pond NET	Brook NET	Couturier, 1973 Orchard YWT
			+ 30/m²							
×	×				+			+	+	
										spp.+
				sp. 1	+	+	+		+	
										spp.+
×		×			+	+				
	×									

TABLE II. — *Relative importance of males and females (%) of the different* Crossopalpus *species caught by the 4 types of traps on the 1979 spread plot.*

		Emergence traps		Pitfall traps		Yellow water traps			
						0 cm level		50 cm level	
		Numbers	%	Numbers	%	Numbers	%	Numbers	%
Crossopalpus humilis	♂	186	36	470	41	168	42	4	26
	♀	328	64	672	59	228	58	11	74
Crossopalpus nigritella	♂	93	44	182	48	48	50	2	50
	♀	118	56	194	52	48	50	2	50
C. minima	♂	1	17	45	54	8	53	0	0
	♀	5	83	38	46	7	47	1	100

The case of Coptophlebia vitripennis

The available data about this species are displayed on figure 2. 80 specimens of *C. vitripennis* have been caught on the undisturbed heathland, representing 41.6 % of total catches in this biotope, where it is undoubtly the dominant species. The presence of specimens in the emergence traps shows that larval stages of this species are able to grow in the soil of this biotope. Since only a small amount of catches is available, the histogram of seasonal catches is quite irregular. Nevertheless, it is interesting to point out that the more efficient trapping has been performed by yellow water traps located 50 cm above ground level, *i. e.*, during early June, just above the top of the graminaceous layer of the heathland (and more precisely just above the floral stems of the then full grown *Agrostis setacea*).

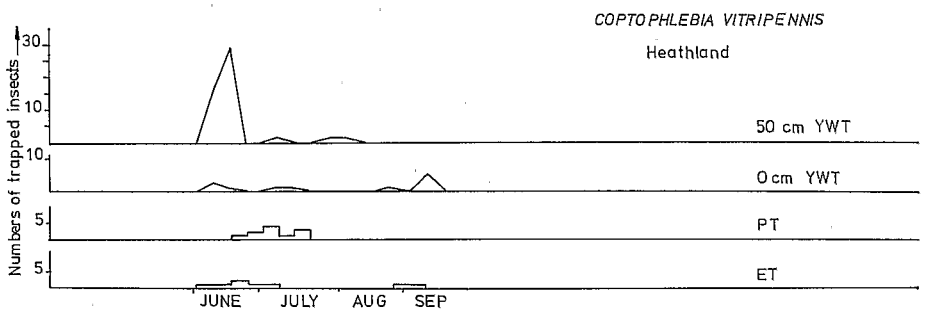

FIG. 2. — Catches of *Coptophlebia vitripennis* in heathland.
YWT: yellow water traps; PT: pitfall traps; ET: emergence traps.

The case of Crossopalpus *spp.*

Four species of *Crossopalpus: C. humilis, C. nigritella, C. minima* and *C.* sp. have been caught almost exclusively by the different traps set on the spread plots of heathland. On these biotopes, the genus is obviously dominant, totalizing 92.4 % of the

1979-1980 catches against 3.6 % on the undisturbed heathland. Newly hatched adults are collected only by emergence traps on the spread plots. Besides, pitfall traps appear to be much more efficient than yellow water traps to catch these very small flies. Using yellow water traps, *C. humilis* as well as *C. nigritella* are not common in the samples from 50 cm level traps. Meanwhile, both species are found in fair numbers in the 0 cm level traps as well, from April to October (as shown by fig. 3) and somewhat later in June-July in the case of *C. nigritella*. Rather strikingly, fair numbers of *C. humilis* have also been observed during the last week of August 1979, while a general decrease of catches was then going on.

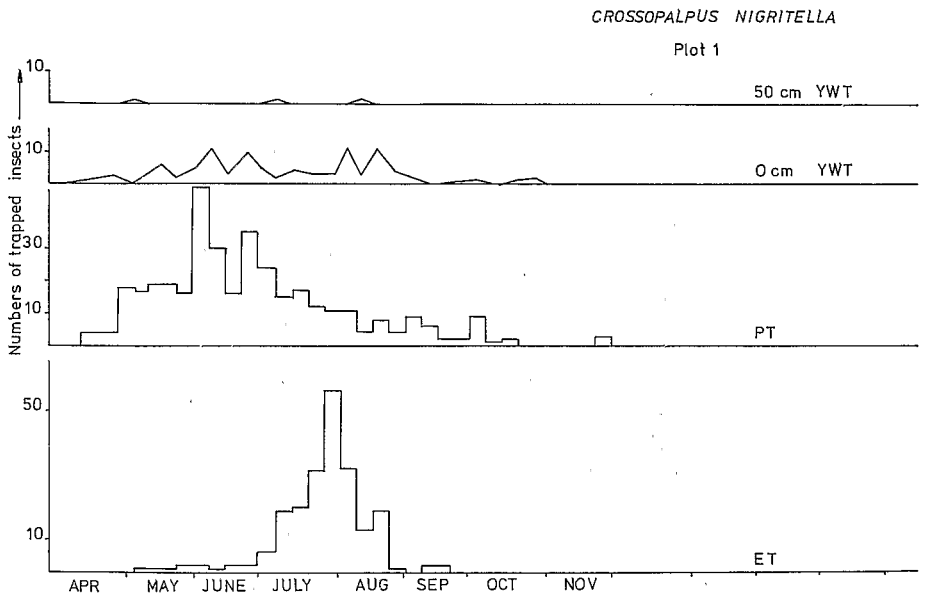

FIG. 3. — Catches of *Crossopalpus nigritella* in spread plot n° 1.
Abbreviations as in figure 1.

The data obtained from emergence traps are quite different and show the existence of a single peak for each species, occurring during mid-summer (July in the case of *C. humilis*, end of July-August in the case of *C. nigritella*).

Study of the sex-ratio of the different species shows its variation according to the sampling techniques (table II). Except for *C. minima*, the numbers of which are not high enough to allow a good discussion, it appears that pitfall traps and yellow water traps give a very similar picture of the *Crossopalpus* populations. Differences in the sex-ratio are evident in samples obtained from emergence traps and 50 cm yellow water traps, which denote a greater relative abundance of females, compared with the results obtained by other trapping techniques.

The case of Drapetis pusilla.

Although much less numerous in our trappings, this species is obviously able to reproduce in the spread plots, as shown by the data from emergence traps during

the August-September period. No catches are obtained in the pitfall traps, but *D. pusilla* seems to be fairly attracted by yellow water traps, at the two prospected levels, in the different studied biotopes (fig. 4).

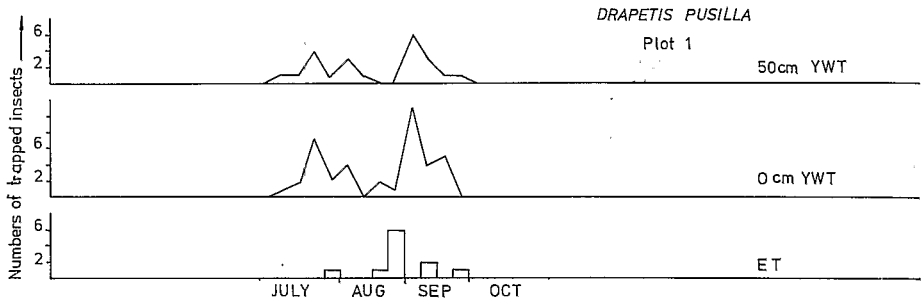

FIG. 4. — Catches of *Drapetis pusilla* in spread plot 1.
Abbreviations as in figure 1.

Comparison between different spread plots

Besides the differences in specific composition of the Empididae communities of the three spread plots of heathland, as already mentioned (see table I), the study of the seasonal catches curves from these three biotopes gives other valuable clues (see fig. 5 and 6).

The data of the emergence trapping of *C. humilis* in these three plots give very similar curves: one peak is progressively reached twelve weeks after the spreading process. The differences between the curves from the thin- and thick-spread plots of 1981 are mostly due to an earlier peak in the second situation. Meanwhile, the data obtained from pitfall traps for this species underline much stronger differences.

With pitfall traps the catches appear earlier in the season, displaying a strong peak 5 to 10 weeks after the spreading process, with an irregular decrease afterwards during another ten weeks. But only the 1979 spread plot has shown the narrow peak occurring 20 weeks after the beginning of the experiment.

Similar evidences are observed in the case of *C. nigritella;* but very strong differences appear according to the data from emergence traps: the importance of catches differ according to the different plots, and the various peaks are quite asynchronous, as shown by figure 6. These differences are also found in pitfall traps data. Catches obtained from the thin-spread plot, during the autumn of 1981, show a conspicuous twin peak, which should be compared to the *C. humilis* peak during the autumn of 1980.

Only pitfall traps catches of *C. minima* are numerous enough to allow graphical representation, but no clear pattern is shown.

DISCUSSION

Compared to the diverse Empididae populations known in Brittany, the populations of both the undisturbed and spread heathland of Paimpont show a strong originality. The comparison of their specific composition is rather striking (see table I).

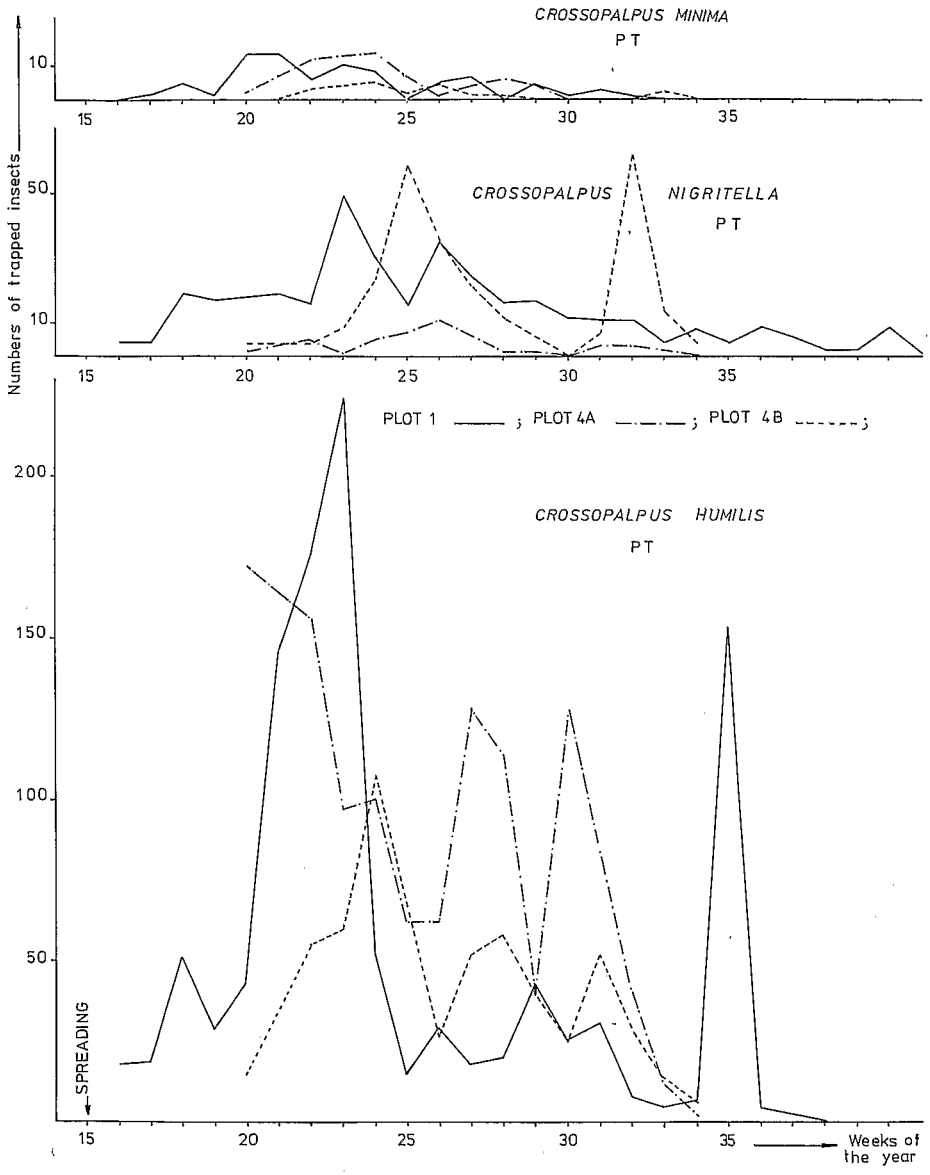

FIG. 5. — Catches of *Crossopalpus* spp. in spread plots n° 1, 4 *A* and 4 *B*, using pitfall traps only. Abbreviations as in figure 1.

The researches previously conducted in the Paimpont area itself (TRÉHEN, 1971; BAILLIOT & DELETTRE, 1972), in other areas of Brittany (TRÉHEN, 1971; BAILLIOT, 1975; BAILLIOT *et al.*, 1976), or even in the Ile-de-France area (COUTURIER, 1973), show that the Empididae populations are strictly localized, and that few species are commonly encountered in the different prospected biotopes. Distant of only a few hundreds of

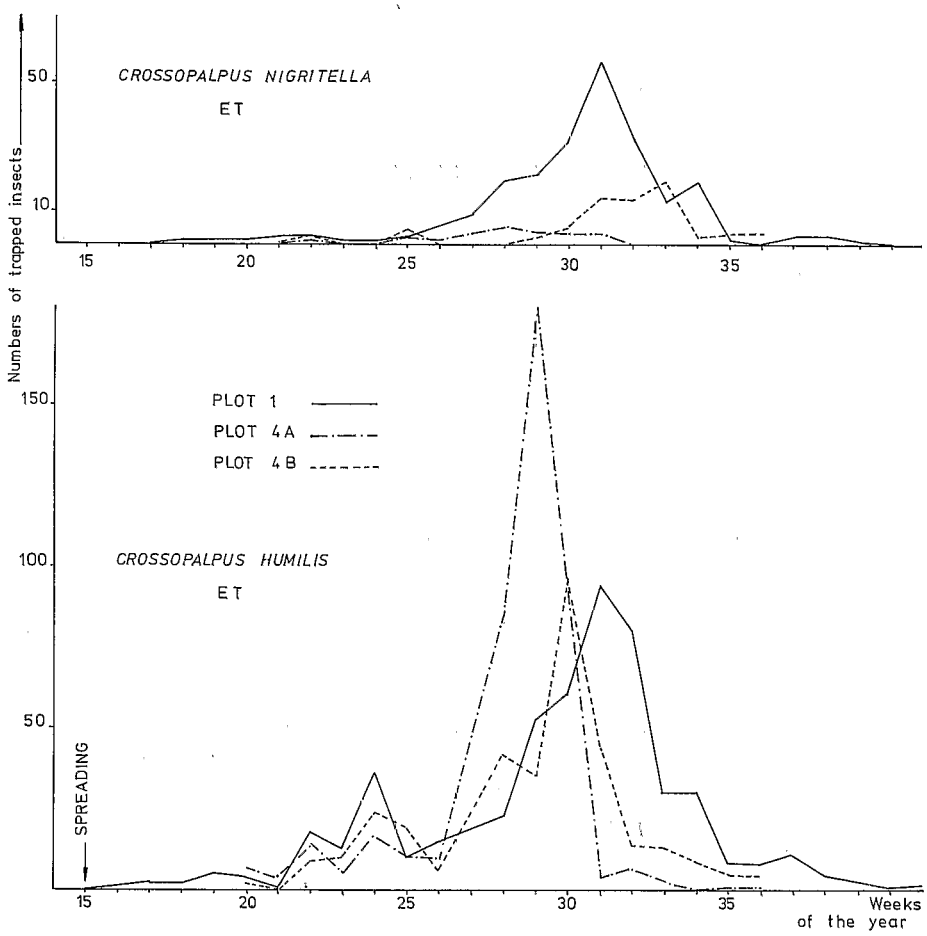

FIG. 6. — Catches of *Crossopalpus* spp. in spread plots 1, 4 *A* and 4 *B*, using emergence traps only. Abbreviations as in figure 1.

meters, the sites prospected by TRÉHEN (1971), BAILLIOT & DELETTRE (1972) and the authors of the present report, are hosts of almost completely distinct populations of Empididae. If the genuses *Hilara* and *Tachydromia* seem rather widespread, the species *C. vitripennis* seems to be characteristic of Britton heathland (Paimpont, Fréhel), while the genus *Crossopalpus* dwells strictly in biotopes rich in decaying organic matter.

The significance of catches of these insects varies from species to species, thus emphasizing the problem of geographical specificity of Empididae communities. For instance, the spread heathland may be Empididae-attractive for quite different reasons.

In the case of *Crossopalpus*, *Tachydromia* or *Sicodus* species, which are ground-level predators of micro-Arthropods, the enormous proliferation of Acari, Collembola, etc., observed in spread heathland (DUVIARD & TRÉHEN, 1981) certainly displays a very attractive part.

In the case of *Empis*, *Pararamphomyia* species, the adult flies are pollen-eaters, and may be eventual predators of small flying insects. The catch of adults over the spread plots may then be more or less automatically linked with the presence of plants producing a seeked-for pollen, such as the *Geranium* spp., which is commonly found growing on spread refuse. On the other hand, *Hilara interstincta*, a known predator of small flying insects, is often observed resting on twigs of *Salix* spp. (TRÉHEN, 1971). *Salix caprea* developped quickly on our plots of refuse-spread heathland and may then account for the presence of this fly.

Besides these particular remarks, it appears that, compared to data obtained from pitfall traps and emergence traps, the yellow water traps give a more diversified and probably more complete picture of the Empididae community among which the endemic species may not be distinguished from passing-by flies. BAILLIOT & TRÉHEN (1974) have emphasized the necessity of close attention in the interpretation of data from yellow water traps in the case of *Hilara* spp.: the efficiency of traps and the significance of trapped individuals depend strongly on the ethology and physiology of the trapped specied.

On the other hand, emergence traps and pitfall traps, by the way they catch insects on a relatively small spatial extent do probably sample a smaller fraction of the studied communities, but are more valuable on physiological and eco-ethological points of view.

Anyhow, the simultaneous use, in a given biotope, of three sampling techniques has been the only way—even if still uncomplete—to understand the eco-ethological phenomenons which affect Empididae populations in the wild.

During the period when these insects are adequately trapped (April to October), an important feature is the asynchronization of trapping results (fig. 2 to 6), mostly between emergence traps and pitfall traps, and, to a lesser extent, between pitfall traps and yellow water traps. This fact may be explained if one considers that emergence traps catch the newly hatched adults taking off for their post teneral dispersal or migratory flight (swarming behaviour so characteristic of some Empididae belong to this category of flight); that yellow water traps catch active adults either during their dispersal flights or during trivial flights; that pitfall traps catch winged adults either immediately after the teneral moult (as often observed in Sciaridae: numerous adults with uncompletely spread wings fall in pitfall traps; this does not seem a common feature with Empididae), or imagos seeking for the adequate site to mate and/or lay their eggs (and this seems very much the case of *Crossopalpus:* most females caught in this way display heavily extended abdomens full of mature eggs). Thus, the univoltism hypothesis may be drawn for the three species of *Crossopalpus* (fig. 7): following springtime dispersal flights (as observed from yellow water trapping), flies seek for reproduction sites (as observed from pitfall trapping) and females then lay their eggs in soils rich in decaying organic matter (here, the spreading of crushed refuse). The development of edaphic larvae takes place during the first weeks of summer, and newly hatched adults take off during the second half of summer (as shown by emergence trapping). A second dispersal phase occurs in late summer (as observed by the catches done by yellow water traps). These adults seem to "disappear", either by looking for other reproduction sites (which seems unlikely at this period of the year), or searching for appropriate wintering sites (but such behaviour is not yet known from Empididae), or just dying.

Anyway it is not possible to preclude the possibility of a tentative second generation: the existence in both *C. humilis* and *C. nigritella* of an occasional peak of

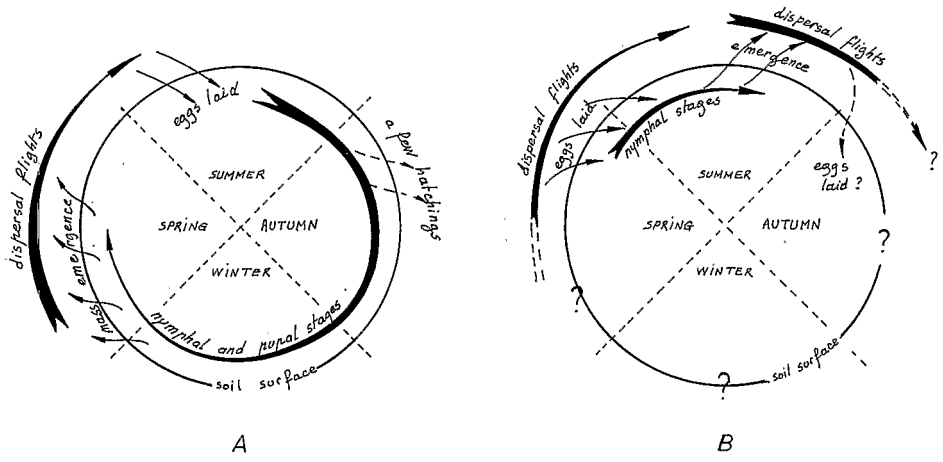

FIG. 7. — Compared life cycles of an heathland dwelling Empididae (after Tréhen, 1971) 7 *A;* and *Crossopalpus* sp. dwelling in refuse-spread heathland, 7 *B.*

pitfall trap catches at the end of summertime may be an indication of such a possibility for adults then freshly produced to seek for breeding sites. But it is doubfull if the late summer progeniture may have at all the real possibility to perform complete development: in the 1979 spread plot, not a single hatching of *C. humilis* was ever observed during autumn, winter or spring following the August 1979 peak of catches by pitfall traps.

In any case, these dubious points will not be cleared by further field research. As table III shows, an estimate density or larval population (concerning all species of Empididae) from emergence traps data gives the values of 20 larvae/m^2/year in undisturbed heathland, and 753 larvae/m^2/year in spread heathland, and weekly mean values of respectively 0.38 and 14.4 larvae/m^2/week. Extractions from samples of soil were made by BLANCHET (1981), either by direct observation or by Berlese extractor.

TABLE III. — *Estimate density of larval population of* Empididae *from data of emergence traps in the four studied biotopes.*

	Undisturbed heath land	1979 spread plot 1	1981 spread plots 4 *A*	1981 spread plots 4 *B*
Total catches of Empididae by 4 emergence traps (one square meter).....	20	753	371	385
Mean weekly value (density/m^2/week)..	0.38	14.4	23.1	24.0

The relatively high densities observed in the 1981 spread plots are biased by the fact that the trapping experiment ran during 16 weeks only, compared to the 52 weeks of the 1979-1980 experiment.

This author, working on the sites presented in the present report, used samples of 225 cm^2 of area, 10 cm deep. Using such samples (which proved to be an heavy burden at weekly intervals, especially if one considers the very poor, almost nil results registered with Empididae specimens), it appears that it would be necessary to sample each week 263 liters of heathland soil, and 7 liters of crushed refuse "compost" to obtain, in each case, *one* larva of Empididae... Thus, only laboratory cultures may perhaps allow further investigations of larval biology and ecology.

Another way to think out the problem is the examination of the species with reference to their colonisation strategies. The comparison between autochtonous species of the heathland and allochtonous species migrating on spread refuse is worthwhile. In the heathland biotope, *C. vitripennis* populations are featured by low larval density, and small numbers of individuals are caught. The fact that more specimens are caught from 50 cm level yellow water traps is altogether significant. Because of dwelling in widespread biotopes, not susceptible of quick changes, where seeking for breeding sites does not seem venturous, this rather large species (see table IV) flies actively above vegetation level, carefully avoiding places with disturbed appearance (such as the refuse spread plots). This fly is thus able to make active flights in a given aerial space to which it seems typically bound.

TABLE IV. — *Sizes and "Body area" (Lewis and Taylor, 1967) of two species of Empididae, one from the* Ulex *heathland* (Coptophlebia vitripennis) *and one from the spread plot* (Crossopalpus humilis). *Mean value from 10 specimens.*

	Coptophlebia vitripennis	*Crossopalpus humilis*
Length of wing (mm)	3.39 ± 0.4	1.67 ± 0.1
Breadth of wing (mm)	1.31 ± 0.1	0.79 ± 0.1
Wing area (mm^2)	4.44	1.32
Body length (mm)	3.82 ± 0.1	2.39 ± 0.15
"Body area", wings span × body length (mm^2)	25.89	7.98

On the other hand, *Crossopalpus* spp. populations are featured by high larval densities, concentrated on very particular habitats of restrictive area: places where large amounts of decaying organic matter have been put down. In these biotopes, the species concentrate their activities at ground level, flying low (as evident from the trapping at 0 cm level water traps), or, mostly, walking on the compost itself in quest of oviposition sites. Such a behaviour allows the concentration of eggs on adequate sites, and seems to be matched with small sized adults (table IV).

If the reproductive strategy of *C. vitripennis* clearly belongs to the *K* type (GILLON, 1976), the three species of *Crossopalpus* obviously "choosed" the *R* strategy. This does not lessen the problem of the geographical origin or the dispersal of adults bound to temporary and dispersed sites of limited extension. The small bodied, short winged *Crossopalpus* flies must then probably rely on passive dispersal mechanisms, using movements of the low atmosphere above their geographical area.

In such a changing landscape as the one of Paimpont, with its marked relief, its mosaic of closely intermingled countryscapes, its multi-directional prevailing winds, the study of this problem is not easy. At the present time, researches are going on in an island of Southern Brittany, in order to investigate this aspect of dispersal ecology.

Anyhow, the Empididae well seem to deserve attention: specific diversity, variety of ecological claims ought to help the drawing of empirical models of the eco-ethology of scavenging insects faced with the problem of managing the household refuse of our society.

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