Distribution and abundance of lauxaniid flies in Danish cereal fields in relation to pesticides, crop and field boundary

(Diptera, Lauxaniidae)

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Reddersen, J.: Distribution and abundance of lauxaniid flies in Danish cereal fields in relation to pesticides, crop and field boundary (Lauxaniidae, Diptera).
Ent. Meddr. 62: 117-128. Copenhagen, Denmark, 1994. ISSN 0013-8851.

In 1989-92, the effect of pesticides on adult Lauxaniidae was studied in controlled experiments in field margins of 25 Danish rotational fields. In each year in early and late June, only those 17-18 field margins with cereals were sampled. Supplementary reduced sampling was performed in mid field areas. Absolute estimates of individual and species densities were obtained using a 'D-vac' insect suction sampler.

A total of 2176 individuals in 13 species and 157 indv. in 1 species were collected in field margins and mid fields, resp. The dominant species was *Calliopum aeneum* (95%) which was collected from all localities and only *Minettia rivosa, Sapromyza quadripunctata* and *Lyciella illota* contributed more than 10 indv. (0.5%). The mean lauxaniid density ranged from 0.9 m^{-2} to 5.5 m^{-2}. No apparent patterns of regional distribution were discovered.

Individual numbers of the 3 most abundant species were negatively influenced by the mixed, variable but normal pesticide load as well as by fungicides (± herbicides) alone. Also, fewer species were caught in sprayed plots. Winter cereals held more individuals and species than spring cereals. *C. aeneum* occurred generally distributed within fields, while all other species were found in field margins only. Here, the presence of woody habitats beyond the field boundary seemed to influence positively the frequency of less numerous species.

Results are compared to the rare litterature on lauxaniids and are discussed in relation to the fungivorous feeding habits and fungicide side-effects of current agricultural practice.

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Introduction

Lauxaniid flies are known to few other than specialist dipterologists, being neither popular collectors' items nor pests. They are medium sized, stout flies, approximately of muscid relative proportions and of greyish, yellow or shiny black colouration. The yellowish tinged wing membrane with yellow venation is characteristic of the collected Danish species.

In a study of arthropods and pesticides, the Lauxaniidae was found to make up a considerable proportion of the large dipteran fauna of cereal fields (unpubl. data). Adult lauxaniids are very selective fungivores in cereal fields (Reddersen, in prep.), and are thus at risk from the fungicide sprayings becoming increasingly intensive during the 1980'ies (Anon., 1992).

This paper presents data from 25 locali-

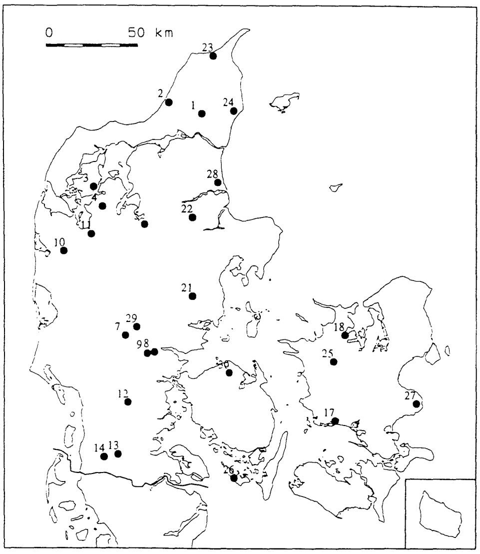

Figure 1. The distribution of the experimental fields, 1989-92. Numbers follow table 2.

Figur 1. Fordelingen af forsøgsmarkerne, 1989-92. Lokalitetsnumre følger tabel 2.

ties in 1989-92 and analyses the geographical distribution and abundance of adult Lauxaniidae from Danish cereal fields along with the local response to crop, pesticides and distance to and nature of the field boundary.

Methods and materials

Study areas and treatments:

In 1989-92, the effect of unsprayed field margins on arthropods was studied in a total of 25 fields, representing all major regions (fig. 1) and soil types of Denmark. Within each field an experimental area was placed in a homogenous field margin adjacent to a hedgerow - exceptionally to a wood or a grass ridge (cf. tab. 2, column 2). The experimental area was divided into 2x4 (rarely 2x3) permanent plots in a linear arrangement and measured 6 m (width) x 20 m (length).

Year / *År*	1989		1990		1991			1992		1989-1992	
Sampling date / *Prøvetagningsdato*	Jun12	Jun28	Jun08	Jun27	Jun09	Jun28	Jul31	Jun05	Jun25	ΣN	ΣN%
1. *Calliopum aeneum* (Fall.)	112	95	496	495	119	540	18	105	75	2055	94.4
2. *Minettia rivosa* (Mg.)	2	5	9	26		13	3		2	60	2.8
3. *Sapromyza quadripunctata* (L.)	2	4	1	12		4	3		7	33	1.5
4. *Lyciella illota* (Loew)	3		1	1		6			1	12	.6
5. *Minettia longipennis* (F.)			4							4	.2
6. *Minettia plumicornis* (Fall.)		1	2							3	.1
7. *Minettia lupulina* (F.)						2				2	.1
8. *Lauxania cylindricornis* (F.)			2							2	.1
9. *Calliopum simillimum* (Coll.)	1									1	.1
10. *Lyciella platycephala* (Loew)					1					1	.1
11. *Lyciella subfasciata* (Ztt.)						1				1	.1
12. *Lyciella descipiens* (Loew)									1	1	.1
13. *Homoneura consobrina* (Ztt.)		1								1	.1
ΣN (all species/*alle arter*)	120	106	515	534	120	566	24	105	86	2176	100
n (samples/*prøver*	127	136	134	126	134	134	60	134	140	1125	-
n (localities/*lokaliteter*)	17	18	18	17	17	17	8	17	18	25	-
N (mean/sample = indv./0.74 m^2)	.94	.78	3.84	4.24	.90	4.22	.40	.78	.61	1.93	-

Table 1. Total numbers of individuals of 13 lauxaniid species along with total numbers and mean densities per sample of all species by sampling year and date. The number of samples collected and the number of sampled localities are listed below.

Two treatments were assigned to the plots in a permanent alternating arrangement: One 'unsprayed' (control, fixed) and one 'normally pesticide sprayed' (treatment, variable). Each farmer carried out the pesticide treatments according to his local conditions and normal practice. Accordingly, pesticide treatments in 'normally sprayed' plots varied among localities and years from no treatment in a few cases to heavy pesticide loads including several applications of both herbicides, fungicides and broad spectrum insecticides. By subsequent analysis the mean pesticide load in experimental plots

Locality *Lokalitet*	Boundary *Kanttype*	Sampling *Prøvetagning*	Caen	Mriv	Squa	Lill	Others *Øvrige*	S
01. Hollensted/NEJ	H/F	2022	261		0,2			2
02. Saltum/NEJ	H/F	2202	70		0,1	1,0		3
23. Bindslev/NEJ	H/G	2200	6	0,1			$1_6 + 1_{13}$	4
24. Voerså/NEJ	H/G	2220	107	1,3	0,3		$1_5 + 1_{10}$	5
28. Als/NEJ	H/W	2201	14					1
11. Ryde/NWJ	H/F	0120	74	1,0	0,2			3
04. Balling/NWJ	H/F	2202	50	0,1	2,0		1_{12}	4
03. Kårup NWJ	H/F	2202	176	1,2	6,4			3
07. Bredsten/WJ	H/F	0222	75	1,1			1_5	3
10. Idum/WJ	H/F	2022	27		0,1	0,1		3
29. Give/WJ	H/F	2200	34					1
05. Løgstrup/EJ	H/W	2022	254	3,2	0,1	3,4	$1_7 + 1_{11}$	6
08. Højen/EJ	H/F	0222	42		2,0			2
09. Høllund/EJ	H/F	2222	86	8,7	0,1			3
21. Skanderborg/EJ	H/F	2022	9	0,1	0,1			3
22. Asferg/EJ	H/G	0200	21					1
12. Jels/SJ	H/F	2022	52	0,1		0,1	1_9	4
13. Alslev/SJ	H/F	2222	386	0,1	0,1	0,1		4
14. Løgumkloster/SJ	H/F	2022	2	1,0				2
26. Tranebjerg/F	G/F	2022	1		2,2	1,0		3
30. Otterup/F	G/F	0200	22	1,4	0,1			3
18. Hagested/NWZ	H/W	1220	107	5,5			2_6	3
25. Mørkøv/NWZ	H/F	0222	52	2,2	0,1		2_8	4
17. Nyrup/SZ	H/W	2222	44	3,1			$2_5 + 1_7$	4
27. Karise/SZ	H/F	0222	83	0,1				2
Total (♂, ♀) (individuals)			2055	27,33	12,21	5,7	16	-
Ocurrences (localities per species)			25	17	15	6	[1;3]	-

Table 2. Total number of individuals of 13 lauxaniid species by sex (excepting *C. aeneum*) and by locality (grouped by region/subregions: Jutland (J), Funen (F) and Zealand (Z) with number of species per locality (last column) and number of localities per species (last row). Column 2 lists boundary type (hedgerow (H); grass ridges (G)) along with adjacent habitats (field (F); wood (W); garden (G)). Column 3 lists the sampling occations in four successive years 1989-92 (no sampling (0); sampling on one date only (1); sampling on both dates (2)). The occurrence of rarer species are given as number of individuals with the species code as index according to tab. 1.

was found to be moderately lower than the national means (Hald et al., 1994).

In each year, only those 17-18 fields with cereals were sampled, (table 2, column 3). Thus, localities were not sampled equally, but most (17) localities were sampled in 3 out of 4 years and another 3 localities in all 4 years, while 3 localities were sampled in 2 years and 2 in only a single year (locs. 22 & 30).

Methods

The aboveground arthropod fauna was sampled twice a year, viz. early and late June, using a 'D-vac' suction sampler (model 1A, Riverside, California). The 'D-vac' consists of a motor, a suction fan unit and a flexible hose with a hard cylinder mouthpiece where a nylon collection net can be inserted and changed. During sampling this cylinder is quickly lowered to the soil surface delimiting a circular area and the vegetation above it.

At each sampling occasion one sample was collected per plot, pooling 8 separate subsamples of 0.092 m^2 each. One sample thus represented 0.74 m^2. The 8 subsample sites were dispersed regularly along the distance 5 m from the field edge avoiding a two meter transition area at the end of each plot.

In 1990-1992, a single supplementary sample was collected in the mid field (>50m from field edge) matching the 4 (rarely 3) normally sprayed field margin plots. In a few cases mid field sampling was omitted as local or temporary conditions did not allow comparison between margin and mid field.

Identification

All material was identified to species level applying Czerny (1932), Collin (1948) and Remm & Elberg (1979). All names follow Papp (1984). All individuals except some *Calliopum aeneum* were sexed.

Statistical analysis

The study was designed for the analysis of pesticide effects over a range of localities with varying pesticide load in the sprayed plots compared to paired unsprayed controls. A stratified version of the nonparametric Mann-Whitney-Wilcoxon signed ranks test, 'van Elteren test' (Lehmann, 1975), was used with 'locality' as stratum (tabs. 4 & 6) analysing within each date (n=2) and each year (n=4). Assuming independency of samples between years, supplementary analyses were conducted combining results across years within early and late June, resp. Each van Elteren test value was compared to the distribution of calculated test values based on 999 'Monte-Carlo' permutations.

Local differences in individual numbers of sprayed mid fields and matching sprayed field margin plots were tested across localities with a Wilcoxon matched-pairs signed-ranks test within dates (2) and years (3).

For the analysis of the influence of crop-types, samples were grouped into spring cereals (95% barley and 5% oats) and winter cereals (62% wheat, 19% rye, and 19% barley), resp., dividing the 1125 samples in two roughly equal subsets of 560 and 565 samples, resp. Individual numbers in spring cereals were tested against those in winter cereals using a Mann-Whitney test within each date (2), year (4) and treatment (2), analysing samples from unsprayed and sprayed plots separately.

Densities of *Calliopum aeneum* (ln(N+1) -transformed) were tentatively analysed by ANOVA analysis of variance with date, year, locality and treatment as main effects: All except date were highly significant ($P<.001$), but only ⅓ of the total variance was explained and the design did not allow the analysis of (very probable) interactions.

All statistical analyses (except ANOVA) were performed on untransformed data, and all means listed are arithmetic means.

Results

Species composition and general abundance

A total of 2176 individuals in 13 species and 6 genera was collected and identified from the cereal field margins (tab. 1). Another 157 individuluals in only 1 species, collected by the reduced sampling in mid fields, are only included in table 3.

The field margin totals correspond to an overall mean of 1.9 indv./sample or 2.6/m^2, but 95% of all individuals were *Calliopum aeneum* corresponding to 1.8 indv./sample or 2.5/m^2.

This dominance was almost universal: On single sampling occasions this species contributed from 87% (late June 1992) to 100% (early June 1992) excepting the small late July 1991 material (75%). *C.aeneum* was the only species collected from all localities (tab. 2). The species was common in samples from all localities with two exceptions, viz. locs. 26 and 14, and with moderate numbers from locs. 28, 23 and 21. Most (53%) of all *C. aeneum* were collected from 4 localities (13, 1, 5, 3). In early June 1990, a maximum of 38/m^2 occurred at loc. 13, and here also the maximum number per sample was registered, viz. 54 indv. per sample or 75 indv./m^2.

Another three species, *Minettia rivosa, Sapromyza quadripunctata* and *Lyciella illota,* were collected occasionally although in moderate numbers. They constituted 2.8, 1.5 and 0.6% of all individuals, resp. (tab. 1), and were collected from 68%, 60% and 24% of the localities, resp. (tab. 2).

In total, these 4 most common species made up 99.3% of the material. No other species contributed more than 4 individuals and occurred at no more than three localities. Among these less numerous species, only *Minettia plumicornis* occurred in more than one year (table 1), and only this species along with *Minettia longipennis* and *Minettia lupulina* occurred at more than one locality (tab. 2).

Numbers varied considerably between localities (tab. 2): 42% of *M.rivosa* was collected from two localities (9, 18), 42% of *S. quadripunctata* from two localities (3, 26) and 58% of *L. illota* from one locality (5).

No obvious pattern of geographical distribution was observed (tab. 2), neither within single species or in species number. The 4

Sprayed areas *Sprøjtede arealer*	N(margin) *N(rand)*	N(mid) *N(midt)*	Test *Test*	n(margin) *n(rand)*	n(mid) *n(midt)*
Calliopum aeneum:					
Early June, 1990	1.88	3.13	NS	56	15
Late June, 1990	2.77	3.87	NS	56	15
Early June, 1991	.57	1.69	NS	63	16
Late June, 1991	3.41	1.19	**	63	16
Early June, 1992	.30	.33	NS	47	12
Late June, 1992	.15	.17	NS	47	12
Early + Late June 1990-92:					
C. aeneum	1.48	1.69	nt	360	93
M. rivosa	.17	0	nt	360	93
S. 4-punctata	.09	0	nt	360	93
Other species	.08	0	nt	360	93

Table 3. Mean individual densities of various adult Lauxaniidae (N) and total number of samples (n) in sprayed mid fields and in the matching, sprayed field margin plots. Wilcoxon matched-pairs signed-ranks test; not significant (NS); P<.01 (**); no test performed (nt).

most numerous species appeared to be generally distributed not only between localities but also on a regional scale. Although *L. illota* was not caught east of Ærø (26), the number of individuals and localities were so low in this as well as the other uncommon species, that the observed occurrences may be purely incidental.

The sex ratios in the total material did not markedly deviate from 1:1 (tab. 2, below). A small deviation (1.17:1) was observed in the only partly sexed material of *C. aeneum* (822 ♂♂ : 700 ♀♀; significant by a χ^2-test on totals ($\chi^2 = 9.8$, df=1; P<.01)), but sex ratio may vary during the lifetime of the adult population dependent on the hatching and longevity of each sex.

Field margin vs. mid field

In late June 1991, the density of *C. aeneum* was significantly higher (P<.01) in the field margin than in the mid field (tab. 3), but this result remains uncertain as tendencies were consistently opposite on all other dates as well as in the totals. Thus, densities of *C. aeneum* did not differ greatly or systematically with distance from field margin.

No other species was ever collected in the mid fields, and calculated mean densities of any other species were thus smaller than in the field margin. This result was not tested, but appears convincingly general, although it must be noted, that the probability of an individual or a species being caught by mid field sampling was smaller due to the 3.9x smaller sampling intensity (tab. 3).

In the field margins, the presence of woody environments beyond the field boundary was positively correlated to the collective occurrence of the 9 less numerous lauxaniid species. A tentative analysis showed that while only 7 out of 25 field margins had woody or other non-field surroundings (tab. 2), 11 of a total of 16 specimens were collected here, i.e. 5x more than expected. Slightly violating the rule of $N_{expected} \geq 5$ (by 0.5) a χ^2-test confirmed this bias (P<.001, $\chi^2 = 13.1$, df=1).

Crop type

Occasionally, densities of *C. aeneum* were very high and this always occurred in winter wheat or winter rye. Generally, winter cereals had 1.4-10 times higher mean densities of *C. aeneum* compared to spring cereals in both early and late June and in all four years, although only significantly so in late June 1989 and early and late June 1992 (tab. 5). This pattern was largely parallelled in an analysis of sprayed field margins, significantly only in late June 1989 (Reddersen, unpubl. data).

The other species appeared to follow the same pattern of higher densities in winter cereals (tab. 4, below): As a whole, thrice the number of individuals and twice the number of species were collected in winter cereals, 92 indv. in 12 species, compared to

Lauxaniidae, excl. *Calliopum aeneum*	All ΣS	All ΣN	Mriv ΣN	Squa ΣN	Lill ΣN	Others ΣN	Samples (n)
Unsprayed plots	11	76	42	21	3	10	(562)
Normally sprayed plots	7	45	18	12	9	6	(563)
Total	12	121	60	33	12	16	(1125)
Winter cereals	12	92	48	25	7	12	(560)
Spring cereals	6	29	12	8	5	4	(565)

Table 4. Total species number (ΣS) and total individual number (ΣN) of all lauxaniid species (excl. *C. aeneum*) and of each of the most numerous of these species by pesticide treatment (above) and by crop type (below). Species abbreviations, cf. tab. 1.

spring cereals, 29 indv. in 6 species. Within single species, numbers were low and thus inconclusive except *M. rivosa* and *S. quadripunctata.*

Pesticides

Generally, densities of Lauxaniidae were lower in pesticide sprayed plots compared to controls. Within most single dates and years, the mean density of *C. aeneum* was lower, 9-86%, in normally sprayed compared to unsprayed plots, and significantly so in early and late June 1992 (tab. 6) and in early June ($P<.001$) and in late June ($P<.01$) across years. A small, non-significant deviation occurred i late June 1989, when the *C. aeneum* number was very low.

As a whole, other lauxaniid species followed the same pattern. The total individual number was 41% lower, viz. 45 compared to 76 individuals, and the total species number was 36% lower, viz. 7 compared to 11 species, in normally sprayed compared to unsprayed plots (tab. 4, above).

Individual numbers of *M. rivosa* were lower in normally sprayed plots on all dates, significantly so in late June 1990 ($P<.005$) and in late June across years ($P<.002$). Similarly, individual numbers of *S. quadripunctata* were lower on all dates and almost significant in late June 1992 ($P<0.07$) and in late June across years ($P<.15$). The distribution of other single species was not analysed due to low numbers.

The separate effect of fungicides (±herbicides) was studied on a reduced dataset, analysing lauxaniid numbers from localities which had been treated with fungicide(s) (±herbicides) but not with insecticides before sampling. Table 6 lists the number of localities (n) included.

In the abscence of insecticides, the mean density of *C. aeneum* remained lower in sprayed plots compared to the matching unsprayed plots (tab. 6). The difference was largely of the same size, 3-68%, as in the preceeding total analysis of 'normally sprayed' plots - with one exception of late June 1989 (100% higher, NS). This was significant in early June 1992 only but almost so on another two dates and significant in both early June ($P<0.01$) and late June ($P<.05$) across years (unpubl. analysis).The deviating result of late June 1989 coincided with a low number of *C. aeneum* and the lowest number of localities included (7), making this result particularly vulnerable to random events.

In the abscence of insecticides, individual numbers of *M. rivosa* and *S. quadripunctata* still largely remained lower in sprayed compared to unsprayed plots, but this was neither significant with *M. rivosa* (although closely so in late June 1990 ($P<.08$) and late June 1989-92 ($P<.06$)) nor with *S. quadripunctata* (test results not listed in table).

N (indv./sample)	1989	1990	1991	1992
Early June/ *Primo juni:*				
Winter cereals	1.07	4.96	1.79	1.85
Spring cereals	0.79	2.62	0.36	0.75
N_{winter}: N_{spring}	1.4	1.9	5.0	2.5
Test (P)	.15 NS	.09 NS	.08 NS	.01
Late June/ *Ultimo juni:*				
Winter cereals	1.33	5.45	5.54	2.04
Spring cereals	0.13	2.67	3.79	0.23
N_{winter}: N_{spring}	10.2	2.0	1.5	9.0
Test (P)	.0001	.10 NS	.46 NS	.007

Table 5. Mean densities per sample (indv./0.74 m^2) of *C. aeneum* in winter and spring cereals, resp., by year and date. Mann-Whitney test probabilities (P); no significance (NS).

Discussion

Lauxaniids are largely associated with woodland habitats and the larvae have primarily been reported as miners of the mesophyll in decomposing litter on which they feed (Foote in Stehr, 1991). Presumably, all lauxaniid species are univoltine in our temperate climates. Eggs are laid and hatch sometime in late summer in the upper soil layers. The species overwinter as larvae and pupate and hatch as adults in the following spring. Data from Oelerich (1988) on *M. rivosa, S. quadripunctata* and *M. lupulina* showed population hights at mid-late July and thus pointed to June and early July as the main emergence period while only *L. cylindricornis* was listed as an early species.

Only four lauxaniid species, *Calliopum aeneum, Minettia rivosa, Sapromyza quadripunctata* and *Lyciella illota* were widely distributed in Danish cereal field margins, and only *C. aeneum* was generally abundant. Another 9 species were identified, but occurred infrequently ($N \leq 4$) and thus possibly incidentally.

Potts & Vickerman (1974) and Vickerman (1992) both give D-vac data on lauxaniids in cereals but only on family level. Potts & Vickerman (op.cit., tabs. 6 and 9) reported mean lauxaniid numbers from June of 2.9 and 6.7 m^{-2} in 1970 and 1971, resp., which is in good accordance with the year means of this study ranging from 0.9 m^{-2} to 5.5 m^{-2} (tab. 1).

Only two sampling dates, viz. early and late June, represented lauxaniid populations. This adds uncertainty to the data, as fixed sampling dates may intersect the phenology curves of single species differently from year to year. The very variable climate with extremely low (1991) and high (1992) May-June temperatures, resp., makes this aspect particularly relevant.

There were, however, no indications that the short sampling period in this study greatly influenced the relative species composition. Firstly, the species composition and dominance structure were rather stable across dates and years. Secondly, due to adult phenology it is unlikely that a considerable number of additional individuals or any additional species would have resulted from extending the sampling foreward to May - apart maybe from the early species *L. cylindricornis*. Thirdly, concerning the post-sampling period, it should be noted, that the reduced late July 1991 sampling showed the lowest mean lauxaniid density recorded, consistent with a post peak population phase, but all the same showed a species composition very much like the June-data (table 1).

The variation between years seemed to reflect some general phenomena other than random variation. Mean densities were relatively high in 1990 and low in 1992, and this closely parallelled the variation between years 1989-92 within most other arthropod taxa from the samples as well as within the entire group of fungivorous arthropods in the samples (Hald et al., in prep., section 4.1).

Only *C. aeneum* can safely be considered a true inhabitant of the entire field, being the only species ever occurring in the mid field samples and at mean densities largely unaffected by distance to the field boundary. Additionally, this species has actually been reared from cereal fields: In May 26th - June 2nd 1992, 16 specimens were collected from a total of 168 0.1 m^2 emergence traps in a spring barley field 25 km NE of Aarhus (Bonde Jensen & Reddersen, unpubl. data).

At least *M. rivosa* and *S. quadripunctata* seemed to be regular inhabitants of cereal field margins. Locally and temporarily they were quite abundant in field margin samples. Further, they distributed themselves in relation to experimental treatments and crop type, which is not expected with purely incidental visitors. This is in accordance with Oelerich (1992) listing *C. aeneum, M. rivosa, S. quadripunctata* and *M. plumicornis* as characteristic of open habitats. Still, they seemed to avoid moving further into the field along with all the less numerous species.

The present study cannot reveal whether the 9 less numerous species are uncommon inhabitants of cereal field margins or true incidentals, but as a whole they occurred more frequently in field margins associated with adjacent non-field (woody) habitats. Generally, Foote (in Stehr, 1991) considered lauxaniids to be 'largely confined to woodland habitats' and Oelerich (1992) concluded that the number of lauxaniid species and individuals increased with the amount of woody habitats (incl. gardens) in the surroundings and listed *M. longipennis* and *L. platycephala* as species associated with forests. At any rate, general ecological experience also predicts higher species richness in transitional zones between different biotopes - in this case the field margin between the field and the field boundary.

Data on the lauxaniid species composition from open habitats are scarce. All studies agree on one or more of the species *C. aeneum*, *M. rivosa* and *S. quadripunctata* being dominant, but variation in species composition is considerable: Ardö (1957) and Lyneborg (1965) collected small numbers of Lauxaniidae by hand from Danish marine dunes and a heath, resp., and but only the latter listed *C. aeneum* as dominant species.

On two East Frisian islands, Oelerich (1988) identified 11 species among 3831 individuals combining coloured tray traps and sweep net catches: Two species, *S. quadripunctata* and *M. rivosa,* made up 74% and along with *M. lupulina* 96% of the total catches. *M. plumicornis, L. descipiens* and *L. cylindricornis* were among the other and less numerous species. The fact that *C. aeneum* as one of the most common Lauxaniidae of Europe were entirely missing he considered as 'incomprehensible'.

In another study of 4 semi-open habitats in Cologne, Oelerich (1992) identified 28 species among 579 individuals: Abundant species were (in descending sequence) *M. rivosa, Lyciella rorida* (Fall.), *C. simillimum, L.*

Year / *År*	1989		1990		1991		1992	
DateDate / *Dato*	Jun12	Jun28	Jun09	Jun27	Jun09	Jun28	Jun05	Jun25
Normally (all) sprayed fields (n):	17	18	18	17	17	17	17	18
N_{US} indv./sample	.92	.66	4.22	4.52	1.19	4.81	1.19	.94
ΔN (±%)	-9	+ 12	-25	-26	-51	-32	-69	-86
Test	NS	NS	NS P<.07	NS	NS	NS P<.08	*** P<.001	** P<.002
Fungicide (±herbicide) sprayed fields (n):	9	7	14	8	13	12	13	8
N_{US} indv./sample	.94	.56	4.68	7.81	1.49	5.58	1.51	.44
ΔN (±%)	-3	+ 100	-22	-29	-50	-23	-68	-43
Test	NS	NS	NS P<.14	NS P<.06	NS	NS	*** P<.001	NS P<.12

Table 6. Mean densities per sample (N) of *C. aeneum* in unsprayed (US) plots, the difference in densities (ΔN) between sprayed and unsprayed plots relative to unsprayed plots and the number of analysed localities (n) by year and date. All localities = 'normally sprayed' plots analysed above; selected localities with at least one fungicide treatment (± herbicides) but no insecticide treatments before sampling analysed below. Stratified Mann-Whitney test with 999 Monte Carlo permutations; no significance (NS).

platycephala, Peplomyza litura (Meig.), *C. aeneum, Tricholauxania praeusta* (Fall.) and *M. longipennis with M. plumicornis, L. descipiens, L. cylindricornis* and *M. lupulina* among the rarer species.

C. aeneum, M. rivosa and *S. quadripunctata* - together comprising 99% of all individuals - appeared to be negatively affected by average pesticide treatments. In the present study, the treatments as a whole were realistic as pesticide treatments varied, as effects were mixed and as mean treatment frequencies were still close to national means (Hald et al., in prep., tab. 2.4).Thus, the negative effects registered in 'normally sprayed' plots contribute important but rarely accessible experimental field data on the combined effects of the wide array of pesticides applied at the current agricultural practice.

On the other hand, exactly because treatments were variable in both time and space and were most often mixed, the present field experiments allowed little interpretation of cause and effect. However, it was clearly demonstrated that the negative pesticide response was not simply explained by negative insecticidal effects: Excluding the insecticide sprayed localities from analysis, the negative pesticide effects on lauxaniids remained largely unaltered, and were thus caused by either fungicide(s) and/or herbicide(s).

Adult lauxaniid flies are grazers on leaf microfungi (Broadhead, 1984; Reddersen, in press). In Danish cereal fields they are very selectively feeding on conidia (spores) of leaf microfungi and on conidia of the abundant saprophytic genera *Cladosporium* and *Alternaria* in particular (Reddersen, in press). Reddersen (1993) along with other authors showed that densities and conidial production of non-target microfungi such as *Cladosporium* and *Alternaria* are strongly depressed by commonly used fungicides. Therefore, it is most probable that the reduced lauxaniid numbers in fungicide (±herbicide) sprayed plots were caused by indirect pesticide effects, viz. the deterioration of fungal food resources mediated by fungicide sprayings.

The implications of massive pesticide effects on lauxaniids to lauxaniid conservation are threatening: Mean densities of *C. aeneum* were up to 83% lower in normally pesticide sprayed plots and up to 65% lower in selected fungicide sprayed plots. As a whole, the individual number and species number of the other species were 41% and 36% lower, resp., in normally pesticide sprayed plots.

The absolute size of pesticide effects are uncertainly quantified by small scale field experiments as in the present study, where sprayed and unsprayed plots were close compared to the mobility of adult lauxaniids. The higher densities in unsprayed plots compared to sprayed plots might be a mixed effect of lower mortality and net immigration (aggregation) of dispersing adults in response to richer food resources.

However, the present conclusions are qualitatively supported by (1) the large-scale experiments (farms) of Vickerman (1992), reporting on lauxaniids being less numerous in heavily sprayed areas compared to lightly sprayed areas as well as by (2) the large-scale study (farms) of Hald & Reddersen (1990), reporting on higher numbers of Lauxaniidae in organically managed cereal fields compared to matching conventionally managed fields, viz. 1.6x and 2.0x more individuals (D-vac-sampling) from late June 1987 and 1988, resp., and 3.2x more indv. (sweep net sampling) from late June 1988. Even if some of the measured pesticide effects were actually caused by redistribution in response to depleted food resources in sprayed plots, an aggregation in unsprayed areas most likely affects lauxaniid populations positively.

The main crop type was also shown to influence the number of individuals and species. The higher densities and more species encountered in winter cereals might be caused by at least two obvious facts: (1) The development of the sparse litter, of decaying leaves on the crop and of the associated saprophytic microfungi have progressed much further by June in winter cereals compared to spring cereals, causing lauxaniid food resources to be richer in winter cereals. (2) Ploughing may be very detrimental to vulnerable immature stages. Assuming that at least *C. aeneum* overwinter as larvae in the fields, ploughing may damage populations much less in winter cereals compared to spring cereals.

The individual and species numbers of lauxaniids appeared to be influenced by several factors - negatively by pesticide spraying – by crop showing higher levels in winter cereals - negatively by distance from the field boundary, excepting the only true field inhabitant *C. aeneum* - positively by the presence of woody, non–field habitats adjacent to the field boundary contributing less numerous species probably occurring as incidental visitors. The relative importance of these factors cannot be inferred from this experiment as they were not measured on the same area scale: While pesticide effects were measured on 6x20 m^2 plot scale, the effect of crop type were measured on a field-to-field scale. Differential mortality, redistribution through dispersal and aggregation might all be involved on both scales, but the role of redistribution decreases when increasing the areas compared (Jepson & Thacker, 1990).

Dansk sammendrag

Fordeling og tætheder af løvfluer (*Lauxaniidae, Diptera*) i danske kornmarker i relation til pesticider, afgrødetype og markkant

I årene 1989-92 undersøgtes pesticid-effekten på løvfluefaunaen i kornmarkers randzone i kontrollerede markforsøg på 25 danske lokaliteter. I hvert af årene blev prøvetagning kun gennemført i de 17-18 marker med vår- eller vinterkorn, og her blev der yderligere gennemført en reduceret prøvetagning i midtmarkerne i 1990-92. Absolutte estimater af individ- og artstætheder blev opnået med en 'D-vac' insektsuger.

I alt 2176 individer af 13 arter og 157 indv. af kun 1 art blev indsamlet i hhv. randzoner og midtmark. Den dominerende art var *Calliopum aeneum* (95%) som registreredes fra samtlige lokaliteter og kun *Minettia rivosa, Sapromyza quadripunctata* og *Lyciella illota* bidrog med mere end 10 individer i alt (0.5%). Den gennemsnitlige tæthed af løvfluer varierede fra 0.9 til 5.5 m^2. Ingen åbenbare mønstre i geografisk udbredelse blev iagttaget.

På individantallene af de tre talrigeste arter sås moderat til stærkt negative effekter af et blandet og varierende men totalt set normalt pesticidtryk, men også af fungicider alene. Der blev tillige registreret færre arter i de sprøjtede parceller. Vintersædsmarker havde højere individtætheder af de talrigeste arter og ialt flere arter end vårsædsmarker. *C. aeneum* forekom ligeligt i randzone og øvrige mark, mens alle andre arter udelukkende indsamledes fra randzonen. Her syntes skovprægede omgivelser at influere positivt på forekomsten af de ualmindelige arter.

Resultaterne sammenstilles med den sparsomme litteratur om løvfluer og diskuteres specielt i relation til de voksne løvfluers tilknytning til bladmikrosvampe og deraf følgende sideeffekter af fungicider i nutidig landbrugspraksis.

Acknowledgements

This paper is based on data collected within grant no. 7041-0026 from the Danish Environmental Protection Agency. Leif Lyneborg and Boy Overgaard Nielsen are acknowledged for inspiring comments. John Pedersen, Bioconsult a/s, skilfully conducted the statistical analyses.

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