and extends forward to end along the lateral portion of the anterior margin of the secondary postnotum. Thus a sac-like structure is formed which may be taken as the membranous portion of the secondary postnotum (c1). The two such sacs of the two sides together form one extensive sac. However, their separate entites can be justified by a median septum (c2) separating them.

It can be concluded that metathoracic tergum of *S. mauritia* assumes a conspicuous shape due to the development of secondary structures. The latter extend as endoskeletal components into the lumina of the metathorax and the first abdominal segment. These structures become sites for attachment of segmental as well as intersegmental muscles. This is the first time that such complex secondary structures of the metathoracic tergum have been reported in the *Lepidoptera*. Their appearance seems to be a consequence of the development of tympanal organs within the segment, full details of which will be published later.

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SPECIES-COMPOSITION OF THE DIPTEROUS FAUNA IN VARIOUS TYPES OF FOOD-PROCESSING PLANTS IN CZECHOSLOVAKIA

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The *Diptera* present a continual source of sanitary problems in food-processing industries. No less important are economic losses, which are caused by larvae feeding on raw materials and end-products, by transmission of micro-organisms reducing the quality of raw materials and end-products, by the presence of larval or imaginal bodies in end-products, and by flies disturbing livestock or even troubling employees.

So far, comparatively little attention has been paid to the importance of *Diptera* to the food-processing industries. Among the gaps in our knowledge is the lack of data on the species-composition of dipterous fauna of food-processing plants, particularly in its correlation with the type of plant. An extensive study of the dipterous fauna of more than 500 plants was therefore carried out as a part of the entomological survey of Czechoslovak food-processing industries accomplished by this Department. The aims of the present paper are to report the species-composition of the dipterous fauna in various food-processing industries and to a certain extent the relative richness in individuals, and to show which species, including those which are not noted for their notorious synanthropy, are typical of food-processing industries.

Review of published papers

Up to the present time, no general review of the dipterous fauna of food-processing industries as a whole has been published. A series of papers supplies names of dominant species, or even rather detailed faunal lists, but these pertain only to certain types of food-processing plants or to specific groups of *Diptera*.

More detailed data on species-composition of the dipterous fauna in slaughter-houses and meat-processing, curing and rendering plants are included in the papers by Bishop (1917), Green (1951a, 1951b, 1953), Dicke & Eastwood (1952), Parkin (1952), Savage & Schoof (1955), Judd (1956), Gregor & Povolný (1960), Greenberg et al. (1963) and Greenberg & Bornstein (1964). Single records are supplied by Riley (1880), Mail & Schoof (1954), Syčevskaja (1956), etc.

The dipterous fauna of poultry farms was studied by Tanada et al. (1950), Anonym (1954), Savage & Schoof (1955), Tilden & St. Germaine (1955), Tilden (1957), Niko & Ogata (1958), Anderson (1964) and Anderson & Poorbaugh (1964). Single species are mentioned in numerous papers, e.g. in Bishop et al. (1915), Kilpatrick & Quarterman (1952), Steve (1960), etc.

There are many published papers dealing with the dipterous fauna of canneries and fruit-and-vegetable packing-houses. Sampson (1950) and Tilden (1957) offer a review of the most important species of flies presenting a problem in canneries. Ditman et al. (1936), Bickley & Ditman (1954), Bickley (1956), and Collins (1956) dealt in detail with the species-composition of the fauna of *Drosophila* in canneries. Further data on the occurrence of various species of flies in this branch of the food-processing industry, mostly involving various species of *Drosophila*,

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are supplied by DeCoursey (1925), Simmons & Dove (1942), Michelbacher & Middlekauff (1954), etc.

Lindner (1928) studied the flies in a dairy; limited and scattered information on the flies of dairies is also available in Murtfeldt (1893), Riley (1918, 1919), Zich (1[illegible]), etc.

The dipterous fauna of fish-processing plants has been studied by Savage & Schoof (1955); other data may be found in Sacharov (1918, 1921), Derbeneva-Uchova (1952), Černov (1959, 1965), etc. In wine-factories, the fauna of *Drosophila* was studied by Penrose & Womeldorf (1962); further records are available (Štakel'berg, 1956). There is very little information concerning the flies occurring in mills and bakeries. Gould (1948) published a detailed study of *Diptera* of two maize-processing plants. The occurrence of *Musca domestica* in bakeries is mentioned by Hewitt (1915), Mellor (1919), Austen (1928), etc.; that of *Drosophila melanogaster* in vinegar plants by Štakel'berg (1956).

With regard to the tobacco industry, Engel (1930) reports *Meoneura obscurella* causing damage to snuff.

There are only a few papers dealing with the *Diptera* of food-processing plants in Czechoslovakia. Havlík & Bařová (1961) supplied a review of dipterous species found in a big slaughterhouse and packing plant. Laštovka & Pulpán (1963) contributed a list of the species of *Drosophilidae* occurring in a bakery heavily infested with these flies. Laštovka & Zuska (1965) and Zuska & Laštovka (1965) studied the occurrence of various species of *Piophilidae* in food-processing plants. Zuska (1965, 1966, 1967) supplied some data on the families *Sepsidae*, *Chloropidae*, and *Ulidiidae*.

METHODS

Collecting sites and methods

The present paper is based on the material of flies collected in food-processing plants in Czechoslovakia from 1962 to 1964. Adult flies only were collected. The material represented a total of 55,430 individuals. Supplementary observations of the biology of both adults and pre-imaginal stages were made during collecting activities.

Altogether, 547 plants with extremely varied kinds of production were visited. In addition to food-processing industries (including detached storages and poultry farms), a few tobacco-processing factories were also inspected. The plants selected for visiting were chosen so that all branches of food-processing industries might be represented, and so that the plants of each group might as far as possible be evenly spread all over the country. Small, medium, and large plants of each kind were included, and when possible visited at various times of the year.

The great majority of plants were visited during the period from March to October of the years 1962 to 1964, though some plants were inspected in the winter months (Table 2). Because of the necessity of visiting as many plants as possible, most of them were inspected only once. However, one large plant representing each of the more important or dipterologically interesting food industries was visited regularly, either monthly or every three months.

Flies were collected intensively in each of the plants visited, with the aim of discovering species present there, and also to get any information possible on their relative quantity. When comparatively few individuals were present, virtually all observed flies were collected; in those cases where enormous quantities of flies occurred, only sufficiently large samples were taken. Flies were collected with help of an aspirator, a vial, etc., or by bulk methods, particularly with a butterfly net. No traps, either baited or mechanical, or sticky tapes were used (see Discussion, p. 213).

Classification of food-processing plants

The visited plants differed substantially from each other as far as both the type and the extent and complexity of production were concerned. To make it possible to draw some conclusion from the data available, the inspected plants were divided into groups on the bases of processed, produced or refuse material and other biological characteristics.

They were not classified with respect to administrative grouping, technological associations with other plants, or size, age, etc. The differences in elevation and geographic position of the various plants were considered to be factors of little or no significance. The plant as a whole (i.e. the whole complex of buildings, outdoor premises, refuse, fences, walls of adjacent buildings, closest vegetation, etc.) was considered as the basic environmental unit, without concern for the exact position where the species in question was collected.

The plant groups with their abbreviations, and the most typical substances utilized by developing *Diptera* in each of them, are reviewed in Table 1.

Table 1

Classification of food-processing plants

Group abbreviation	Types of food-processing plants included	Typical substances utilised by developing dipterous larvae
BAK	Bakeries producing bread, rolls, sweetrolls, and doughnuts, dough plants, plants combined with mills	Residues of dough, wet residues of various products, jams, eggs, sweet mixtures
BAN	Storage of bananas	Rotten bananas
BLD	Plants producing livestock food from animal blood	Blood, wet end-products
BRW	Breweries (including those producing their own malt)	Brewery waste, wet malt, wet and germinating barley
BSW	Bakeries of sweet cakes, cookies, biscuits and crackers	Residues of dough, wet residues of products, jams, molasses, syrups, eggs, sweet mixtures
CAF	Canneries and packing plants processing fruit and vegetables, plants producing fruit syrups and non-grape wines	Decomposing and waste fruit and vegetables, syrups, pulps, jams, broken jars with preservos
CAM	Canneries processing same as preceding group, and also meat for ready-made meals	Same as preceding group, and also meat refuse, bones, dried vegetables and mushrooms
CAS	Sausage etc. casing plant	Viscera
CHE	Cheese storage	Cheese
COL	Colagen plants	
CON	Confectionaries (mainly processing chocolate)	Molasses, agar, jam mixtures, syrups
DAI	Dairies of all types (incl. those producing cheese and/or dried milk)	Fresh and sour milk, curd, cheese, yoghurt, dried milk, casein
EGG	Egg storage	Eggs
FAT	Animal fat processing plants	
FEA	Feather storage	Feathers
FIS	Marine fish packing plants	Fish, fish waste, fish products, vegetables, crushed eggs, egg shells
FLA	Artificial flavouring plants	
FRZ	Frozen-food plants	Meat, bones, fruit and vegetable waste
HID	Storages of hides	Hides

Table 1 (cont.

Group abbreviation	Types of food-processing plants included	Typical substances utilised by developing dipterous larvae
LQR	Liquor plants and distilleries	Fermenting fruit, pulps, syrups
MAL	Malt-producing factories	Wet malt, wet and germinating barley
MEA	Meat factories, packing and curing plants, pure meat-canning plants etc., all without abattoirs	Fresh meat, meat products, meat refuse, bones
MIL	Flour mills (including one mill processing peas, soya, sunflower seed and rice)	Wet grain, wet residues of flour
OIL	Factories producing and utilizing seed-oil and derivatives (always large and complex plants)	
PCT	Pectin factories	Fruit skins and fruit residues
POU	Poultry farms, hatcheries	Offal (parts of bodies), viscera, blood, stored and waste feathers, carcasses, spoiled wax used for feather removal, eggs and egg shells, dung, excrements, wet poultry food
SGR	Storages of grain, maize, rice, and pulse	Wet stored produce
SLH	Slaughterhouses, combined plants with abattoirs, rendering plants	Fresh meat, meat products, viscera, hides, bristles, horns, hooves, bones, raw fats, blood, offal (parts of bodies), contents of stomachs and intestines, dung
SOU	Soup flavouring and dried soup factories (incl. one coffee-substitute plant)	Fresh and dried meat, bones, dried vegetables and mushrooms, wet raw materials for coffee-substitutes
SSM	Storages of subsidiary raw materials for bakeries	Jams
STA	Potato-starch factories	
STF	Storages of flour	Wet residues of flour
SUG	Sugar factories and refineries	
TOB	Establishments for tobacco storage and processing	Wet tobacco (exceptional)
VIN	Vinegar plants	
WIN	Wine-factories, wine-cellars	Grapes, fresh and fermenting grape juice

Evaluation of results

The carefully labelled mate[illegible] was identified, evaluated numerically and tabulated. Numerical evaluation of the material was [illegible]ried out for each species and plant group. The results are expressed with the help of the following coefficients.

Incidence is the percentage of the plants of each group where a species was ascertained. It is expressed by the following scale:

1 – less than 10%	6 – 50.1 to 60%
2 – 10.1 to 20%	7 – 60.1 to 70%
3 – 20.1 to 30%	8 – 70.1 to 80%
4 – 30.1 to 40%	9 – 80.1 to 82%*)
5 – 40.1 to 50%	

Frequency is the total number of individuals found in all plants of a certain group, divided by the number of plants of that group where the species in question was ascertained. It is expressed by the following scale:

A – less than 2 individuals per plant;	C – 6.1 to 50 individuals per plant;
B – 2.1 to 6 individuals per plant;	D – 50.1 and more individuals per plant.

The limits of particular categories were chosen on the basis of a preliminary quantitative evaluation of species-occurrence.

Thus, for example, *Lucilia sericata* has the coefficient 5D in the plant group POU. This means that the species was found in 40.1 to 50% of all visited plants of the group POU, and that more than 50 individuals were collected, on average, in each inspected plant where it was found.

Plants visited regularly (monthly or every three months) were regarded as current plants. For the purpose of frequency computation, the total number of individuals of a species found in such a plant was divided by the number of visits. The numerical evaluation was applied only in those groups where at least 5 plants were inspected. In other groups, the findings are merely recorded as affirmative, and are indicated only by the abbreviation of the particular plant group.

RESULTS

The collected material was composed of 356 items**). A review of more abundant species found and of their coefficients of incidence and frequency is supplied by Table 3; those species which did not reach higher coefficients than 1A or 1B in any group, and those which were only found in plant groups not evaluated numerically, are listed below:

Trichoceridae: *Trichocera hiemalis* (DeG.) (DAI); *Trichocera regelationis* (L.) (SLH); *Trichocera saltator* (Harr.) (POU, BRW, SSM);
Tipulidae: *Tipula nigra* L. (CAM); *Tipula paludosa* Meig. (DAI); *Tipula peliostigma* Schumm. (BAK); *Nephrotoma cornicina* (L.) (SLH);
Limoniidae: *Limonia lecontei* Alex. (CAM); *Limonia macrostigma* (Schumm.) (SLH, POU); *Limonia maculipennis* (Meig.) (EGG); *Limonia modesta* (Meig.) (POU); *Limonia tripunctata* (F.) (DAI); *Ormosia* sp. (DAI);
Psychodidae: *Pericoma nubila* (Meig.) (POU); *Psychoda moravica* Vaill. (POU); *Psychoda severini severini* Tonn. (POU);
Culicidae: *Anopheles messeae* Faller. (BRW); *Aëdes vexans* Meig. (SOU);
Chironomidae: *Macropelopia nebulosa* (Meig.) (CAF, STA); *Psectrotanypus varius* (F.) (MIL, CAF); *Procladius* sp. (CAF); ? *Orthocladius oblidens* (Walk.) (MIL); *Cricotopus sylvestris* (F.) (SOU); *Cricotopus* sp. (MIL, SLH); *Rheocricotopus* sp. (MIL); *Microcricotopus bicolor* (Zett.) (SLH); *Limnophyes* spp. (POU, CAM, STA); *Metriocnemus* spp. (POU, STA); *Smittia stercoraria* (DeG.) (SLH, POU, CAF); *Smittia* sp. (POU); *Chironomus plumosus* (L.) (BAK, FEA); *Chiro-*

*) Maximum incidence, found in *Drosophila hydei* and *Drosophila melanogaster* in the group CAM.

**) By "items" we mean the items of Table 3 and of the list of species on this page. These are mostly species but, in very few cases, higher taxa, subspecies, or females of those taxa where only males could be identified to species (in which case males are given as separate items). Thus the number of items is very close, but apparently not quite equal, to the number of species contained in the material evaluated.

nomus sp., group *Ch. thummi* (KIEFF.) (POU, CAF); *Cryptochironomus* (s.str.) sp. (MIL); *Polypedilum nubeculosum* (MEIG.) (DAI); *Polypedilum scalaenum* (SCHR.) (MIL); *Polypedilum* sp. ♀♀ (SLH); *Micropsectra atrofasciata* KIEFF. (STA); *Micropsectra* sp. (POU); *Tanytarsus* sp. (STA);

TABLE 2

Number of plants visited and species found

Group	No. of plants visited														No. of species found
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Reg[a]	Total	
POU	–	–	–	1	8	1	6	8	–	5	2	3	1	35	195
SLH	–	–	1	5	17	5	16	9	9	12	–	2	1	77	181
DAI	–	2	–	5	9	6	8	12	5	3	3	2	1	56	115
CAM	–	–	–	1	–	1	2	1	2	2	–	1	1	11	103
CAF	–	–	1	1	3	–	3	–	2	5	2	1	–	18	63
EGG	–	–	–	2	5	2	2	3	3	–	–	1	–	18	58
MIL	–	–	1	3	4	–	2	11	5	1	–	–	–	27	54
BAK	–	12	16	10	23	6	18	23	16	4	3	11	1	143	53
SOU	–	1	1	–	–	–	–	–	–	–	–	–	2	4	51
MEA	–	–	3	3	3	2	6	4	–	–	–	1	–	22	43
FIS	–	–	–	–	1	–	–	–	1	1	1	–	1	5	30
BRW	–	5	7	5	6	–	3	3	–	2	1	–	1	33	29
FEA	–	–	–	–	1	–	–	–	–	1	–	–	–	2	21
LQR	–	–	1	–	1	–	1	1	–	2	1	1	–	8	20
MAL	–	1	–	1	2	–	3	–	–	1	1	2	–	11	18
FRZ	–	–	1	–	–	–	1	1	–	1	1	–	–	5	18
STA	–	–	–	–	–	1	–	2	–	–	–	–	–	3	17
VIN	–	–	–	–	1	–	–	1	1	–	–	–	–	3	16
BSW	–	3	1	–	3	1	–	3	3	–	–	1	–	15	12
HID	–	–	1	–	–	–	1	1		–	–	–	–	3	12
CON	–	1	1	1	2	–	1	1	–	–	–	–	1	8	9
OIL	–	–	–	–	2	–	1	2	–	–	2	–	1	8	9
TOB	–	–	–	2	1	1	2	–	–	1	–	–	–	7	6
WIN	–	–	5	–	–	1	–	–	1	–	–	–	–	7	5
PCT	–	–	–	1	–	–	–	–	–	–	–	–	–	1	4
SSM	–	–	2	1	–	–	–	–	–	–	–	–	–	3	3
BAN	–	–	–	–	–	–	1	–	–	–	–	–	–	1	3
SUG	–	–	–	–	–	–	1	–	–	1	1	–	–	3	1
FAT	–	–	–	–	1	–	–	1	–	–	–	–	–	2	1
SGR	–	–	–	2	–	–	–	–	–	–	–	–	–	2	0
STF	–	–	–	–	–	1	–	–	–	–	–	–	–	1	0
CAS	–	–	1	–	–	–	–	–	–	–	–	–	–	1	0
BLD	–	–	–	–	–	–	–	–	–	1	–	–	–	1	0
CHE	–	–	–	–	–	–	1	–	–	–	–	–	–	1	0
FLA	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0
COL	–	–	–	–	–	–	–	–	–	–	1	–	–	1	0
Total	0	25	43	44	94	28	79	87	48	43	19	26	11	547	356

[a] Reg – selected plants visited regularly (monthly or every three months).

Simuliidae: *Boophthora erythrocephala* (DEG.) (SLH); *Gnus ibariense* ŽIVK. & GREN. (POU); *Odagmia ornata* (MEIG.) (SLH);

Anisopodidae: *Sylvicola cincta* (F.) (DAI);

Bibionidae: *Bibio hortulanus* (L.) (SLH);

Mycetophilidae: *Sciophila hirta* MEIG. (POU); *Sciophila lutea* MACQ. (BAK); *Mycomya wankowiczi* DZIEDZ. (FEA);

Sciaridae: *Sciara flavimana* ZETT. (POU); *Schwenckfeldina carbonaria* (MEIG.) (DAI); *Lycoriella auripila* (WINN.) (POU, CAM); *Lycoriella solani* (WINN.) (STA); *Bradysia* sp. [*brunnipes* (MEIG.) or *bicolor* (MEIG.), BAK, POU); *Scatopsciara vitripennis* (MEIG.) (POU, CAF); *Scatopsciara* sp. ♀♀ (MIL, SLH, POU, BRW);

Scatopsidae: *Scatopse picea* MEIG. (CAF); *Swammerdamella brevicornis* (MEIG.) (MIL, SLH, POU, SOU);

Cecidomyiidae: *Campylomyza* sp. (POU); *Lestremiinae* genn. spp. (POU); *Trisopsis* sp. (DAI); *Cecidomyiinae* genn. spp. (MIL, BAK, POU, SOU);

Stratiomyidae: *Sargus cuprarius* (L.) (SLH); *Sargus iridatus* (SCOP.) (POU); *Microchrysa polita* (L.) (POU, SOU);

Tabanidae: *Chrysops relictus* MEIG. (POU); *Haematopota pluvialis* (L.) (POU, CAF); *Tabanus bovinus* LOEW (SLH); *Hybomitra solstitialis* (MEIG.) (SLH, DAI);

Therevidae: *Thereva graeca* KRÖB. (POU, DAI);

Scenopinidae: *Scenopinus fenestralis* (L.) (MIL, BAK, SLH, MEA, POU);

Empididae: *Hilara* sp. 1 (DAI); *Hilara* sp. 2 (POU); *Empis livida* L. (DAI); *Drapetis assimilis* (FALL.) (POU); *Crossopalpus minima* (MEIG.) (POU); *Crossopalpus nigritella* (ZETT.) (SLH); *Platypalpus flavicornis* (MEIG.) (POU); *Platypalpus pictitarsis* (BECK.) (SLH);

Dolichopodidae: *Dolichopus claviger* STANN. (MAL, DAI); *Dolichopus latelimbatus* MEIG. (POU); *Dolichopus longicornis* STANN. (MIL); *Dolichopus nitidus* FALL. (SLH); *Dolichopus ungulatus* (L.) (POU); *Poecilobothrus infuscatus* (STANN.) (POU); *Hercostomus rusticus* (MEIG.) (SLH); *Medetera ambigua* (ZETT.) (SLH); *Medetera diadema* (L.) (MIL, SLH, POU, SOU); *Medetera micacea* LOEW (BAK); *Medetera tenuicauda* LOEW (MIL, POU, CAM, DAI, STA); *Medetera truncorum* MEIG. (POU, DAI, SOU); *Rhaphium commune* (MEIG.) (POU, DAI); *Diaphorus winthemi* MEIG. (DAI); *Chrysotus* sp. (EGG); *Sympycnus annulipes* (MEIG.) (POU);

Phoridae: *Anevrina urbana* (MEIG.) (SLH); *Dohrniphora cornuta* (BIG.) (SLH, DAI); *Conicera fallens* SCHM. (SLH); *Phora* sp. (POU); *Megaselia angusta* (WOOD) (POU); *Megaselia bovista* (GIMM.) (CAM, DAI); *Megaselia furva* SCHM. (POU, EGG); *Megaselia pleuralis* (WOOD) (SLH, STA); *Megaselia tumida* (WOOD) (SLH);

Syrphidae: *Syrphus corollae* F. (POU); *Epistrophe balteata* (DEG.) (CAM, DAI); *Epistrophe umbellatarum* (F.) (BAK); *Melanostoma mellinum* (L.) (POU); *Platycheirus angustatus* (ZETT.) (POU); *Platycheirus clypeatus* (MEIG.) (POU); *Xylota segnis* (L.) (DAI); *Syritta pipiens* (L.) (SLH, POU, SOU); *Eristalis pertinax* (SCOP.) (CAM); *Myiatropa florea* (L.) (POU, BRW);

Micropezidae: *Compsobata cibaria* (L.) (POU);

Ulidiidae: *Euxesta pechumani* CURR. (SLH);

Tephritidae: *Tephritis bardanae* (SCHR.) (POU, EGG);

Sepsidae: *Themira lucida* (STAEG.) (SLH, POU); *Themira minor* HALID. (SLH, POU), *Themira superba* HALID. (SLH); *Nemopoda nitidula* (FALL.) [may include ♀♀ of *N. pectinulata* LOEW] (MIL, SLH, POU, EGG); *Nemopoda speiseri* (DUDA) (SLH, POU); *Sepsis cynipsea* (L.) ♂♂ (SLH); *Sepsis punctum* (F.) (POU);

Lauxaniidae: *Calliopum aeneum* (FALL.) (CAM); *Lyciella rorida* (FALL.) (POU);

Piophilidae: *Piophila nigricornis* MEIG. (SLH); *Protopiophila latipes* (MEIG.) (SLH); *Mycetaulus bipunctatus* (FALL.) (DAI);

Pallopteridae: *Palloptera ustulata* FALL. (EGG);

Lonchaeidae: *Lonchaea chorea* (F.) (MIL, BAK, SLH, POU, CAM, DAI); *Lonchaea tarsata* FALL. (POU);

Sphaeroceridae: *Copromyza atra* (MEIG.) (SLH); *Copromyza costalis* ZETT. (SLH); *Copromyza equina* FALL. (SLH); *Copromyza sordida* ZETT. (SLH); *Sphaerocera parapusilla* DUDA ♂♂ (CAM); *Sphaerocera parapusilla* + *pusilla* ♀♀ (SLH, POU, EGG, CAM, DAI, SOU); *Leptocera acutangula* (ZETT.) (SLH); *Leptocera appendiculata* (VILL.) (POU); *Leptocera aterrima* (HALID.) (SLH, POU); *Leptocera claviventris* (STR.) (EGG, DAI); *Leptocera denticulata* (DUDA) (SLH); *Leptocera flavipes* (MEIG.) (SLH, DAI); *Leptocera fontinalis* (FALL.) (EGG); *Leptocera fungicola* (HALID.) (DAI); *Leptocera humida* (HALID.) (POU); *Leptocera leucoptera* (HALID.) (CAF); *Leptocera limosa* (FALL.) (SLH); *Leptocera lugubris* (HALID.) (SLH); *Leptocera luteilabris* (ROND.) (MEA, POU, DAI, FEA); *Leptocera ochripes* (MEIG.) (SLH, POU, EGG); *Leptocera palmata* (RICH.) (SLH, POU, CAM); *Leptocera pectinifera* (VILL.) (SLH); *Leptocera penetralis* (COLL.) (POU, EGG, CAF, SOU); *Leptocera pilosa* (DUDA) (SLH); *Leptocera racovitzai* (BEZZI) (MIL); *Leptocera zosterae* (HALID.) (SLH, MEA, POU, DAI);

Tethinidae: *Pelomyia* sp. (SLH, POU);

Milichiidae: *Leptometopa latipes* (MEIG.) (SLH); *Desmometopa sordida* (FALL.) (POU, CAF); ? *Meoneura vagans* (FALL.) (SLH, POU);

Ephydridae: *Discocerina nigrithorax* BECK. (POU); *Hydrellia griseola* (FALL.) (MIL); *Lamproscatella sibilans* (HALID.) (SLH); *Scatella stagnalis* (FALL.) (MIL, POU, DAI); *Scatophila caviceps* (STENH.) (POU);

Drosophilidae: *Gitona distigma* MEIG. (MIL, BAK, MEA, POU); ? *Drosophila kuntzei* DUDA (BAK); *Drosophila testacea* ROSER (BRW);

TABLE 3

Occurrence of *Diptera* in food-processing plants (species with maximum coefficients 1A or 1B not included)

Species	MIL	BAK	BSW	SLH	MEA	POU	EGG	CAM	CAF	LQR	BRW	MAL	DAI	CON	OIL	FIS	WIN	FRZ	TOB	Others
Trichoceridae																				
Trichocera maculipennis MEIG.	–	–	–	–	–	–	2C	1A	–	–	2B	–	–	–	–	–	–	–	–	
Psychodidae																				PCT
Psychoda alternata SAY	2C	1B	–	1C	–	2C	2B	3C	3B	–	1B	1A	5B	–	–	–	–	–	–	PCT, VIN
Psychoda cinerea BANKS	1A	1A	–	1A	–	1A	–	2A	2B	2A	2B	1A	3B	–	–	–	–	–	–	
Psychoda severini parthenogenetica TONN.	–	1B	1A	1B	–	2C	2C	2A	2A	–	3B	5B	2B	–	–	–	–	–	–	STA
Culicidae													1A	–	–	–	–	–	2A	
Aëdes spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2A	–	
Culiseta annulata (SCHR.)	–	–	–	1A	–	–	–	–	–	–	–	2A	–	–	–	–	2C	2A	–	STA
Culex pipiens L.[a]	1A	1A	–	1B	–	2C	2A	1A	4C	2A	3B	4A	2B	–	–	–				
Chironomidae																				
Chironomus spp.	–	1A	–	1A	–	–	–	–	2A	–	–	–	1A	–	–	–	–	–	–	
Anisopodidae																				
Sylvicola fenestralis (SCOP.)	–	1A	1C	–	–	1A	2B	3B	3A	5B	1A	–	2A	–	–	–	2C	–	–	STA, VIN, PCT
Sciaridae																				STA
Lycoriella sp. ♀♀	1C	1B	–	1A	–	1A	1A	2B	1A	–	2A	2A	1A	–	–	–	–	–	–	
Bradysia caelicera FREY	–	–	–	–	–	–	–	–	–	–	–	–	–	2B	–	–	–	–	–	
Bradysia sp. ♀♀	–	–	–	1A	–	1B	1A	2A	1A	2A	–	–	1A	–	–	–	–	–	–	
Scatopsidae																				SOU
Scatopse fuscipes MEIG.	2C	1B	–	1B	–	2B	–	1A	3C	–	–	–	1B	–	–	–	–	–	–	
Scatopse notata (L.)	1A	1A	–	1C	–	2B	2A	–	2C	–	1A	–	1B	–	–	2A	–	–	–	SOU
Scenopinidae																				
Scenopinus glabrifrons MEIG.	2B	1A	–	1A	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	
Lonchopteridae																				
Lonchoptera furcata (FALL.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2A	–	
Phoridae																				
Megaselia rufipes (MEIG.)	1A	–	–	1A	–	1A	2B	2A	1A	–	1A	1A	1A	–	–	–	–	–	–	
Syrphidae																				
Neoascia podagrica (F.)	–	–	–	1A	–	2A	–	–	–	–	–	–	1A	–	–	–	–	–	–	
Eristalis arbustorum (L.)	–	–	–	1B	–	1A	–	–	–	–	–	–	1A	–	–	2A	–	–	–	
Eristalis tenax (L.)	–	–	–	1B	–	1A	–	–	–	2A	–	–	1A	–	–	–	–	–	–	SOU
Lathyrophthalmus aeneus (SCOP.)	1A	–	–	1A	–	–	–	1A	–	2A	–	–	1A	–	–	–	–	–	–	
Ulidiidae																				
Physiphora demandata (F.)	1A	1A	–	2A	–	1A	–	2B	–	2A	–	–	–	–	–	–	–	–	–	SOU
Tephritidae																				
Rhagoletis cerasi (L.)	–	–	–	–	–	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	
Sepsidae																				
Themira nigricornis (MEIG.)	–	–	–	1B	1B	1C	2A	1A	–	–	–	–	1A	–	–	2A	–	–	–	
Themira putris (L.)	1A	–	–	1C	–	3C	–	–	1A	–	–	–	1A	–	–	–	–	–	–	
Meroplius stercorarius (R.-D.)	–	–	–	1A	–	1A	2A	–	–	–	–	–	–	–	–	–	–	–	–	
Sepsis biflexuosa STR. ♂♂	–	–	–	2B	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	SOU
Sepsis fulgens HGG.	–	–	–	4B	1B	2A	–	1A	–	–	–	–	1A	–	–	–	–	–	–	SOU
Sepsis violacea MEIG.	1A	1A	–	5C	2B	3C	2B	2A	–	–	–	–	2B	–	–	2A	–	–	–	
Sepsis spp. ♀♀[b]	–	–	–	4B	1A	2A	–	–	–	–	–	–	1A	–	–	–	–	–	–	
Piophilidae																				SOU, HID
Piophila casei (L.)	–	1A	–	8D	3C	2B	1B	2C	1A	–	–	–	2B	–	–	4A	–	–	–	
Piophila nigriceps MEIG.	–	–	–	6C	1A	2B	1A	1A	–	–	–	–	–	–	–	–	–	2A	–	
Piophila nigrimana MEIG.	–	–	–	4B	1A	1A	2A	–	–	–	–	–	–	–	–	–	–	–	–	
Piophila varipes MEIG.	–	–	–	4C	2A	2C	–	–	–	–	–	–	1A	–	–	–	–	–	–	HID
Piophila vulgaris FALL.	–	–	–	2B	1A	2A	2A	1A	–	–	–	–	1A	–	–	–	–	–	–	
Sphaerocoridae																				
Sphaerocera curvipes LATR.	–	–	–	3C	1A	2B	1A	1A	2A	–	–	–	1A	–	–	2B	–	–	–	
Sphaerocera pusilla (FALL.) ♂♂	–	–	–	2A	–	1A	1A	1A	–	–	–	–	–	–	–	–	–	–	–	SOU
Leptocera aloma (ROND.)	–	–	–	1A	–	1B	–	1C	–	–	–	–	–	–	–	–	–	–	–	SOU
Leptocera bifrons (STENH.)	–	–	–	3B	–	1B	–	1A	–	–	–	–	1A	–	–	–	–	–	–	
Leptocera caenosa (ROND.)	–	1A	–	1A	–	2B	–	1A	1A	–	2A	2A	2B	–	–	–	–	–	–	FEA, STA
Leptocera clunipes (MEIG.)	–	–	–	2B	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	HID
Leptocera ferruginata (STENH.)	–	–	–	6D	1D	1B	–	1A	–	–	–	1A	1A	–	–	–	–	–	–	
Leptocera fuscipennis (HALID.)	–	–	–	1B	–	1A	–	–	–	–	–	–	1C	–	–	–	–	–	–	

Table 3 (cont.)

Species	Plant groups																			
	MIL	BAK	BSW	SLH	MEA	POU	EGG	CAM	CAF	LQR	BRW	MAL	DAI	CON	OIL	FIS	WIN	FRZ	TOB	Others
Leptocera heteroneura (HALID.)	–	–	–	1A	–	1C	–	1A	2B	–	–	1A	1A	–	–	–	–	–	–	
Leptocera hirticula (COLL.)	–	–	–	2B	–	1C	–	–	–	–	–	–	–	–	–	–	–	–	–	
Leptocera hirtula (ROND.)	–	–	–	1A	–	2B	–	–	–	–	–	–	1A	–	–	–	–	–	–	
Leptocera mirabilis (COLL.)	–	–	–	1C	–	1B	–	1A	1A	–	–	–	1A	–	–	–	–	–	–	
Leptocera silvatica (MEIG.)	–	–	–	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	–	–	
Leptocera spinipennis (HALID.)	–	–	–	2C	–	1A	–	–	1A	–	–	–	–	–	–	–	–	–	–	SOU
Leptocera vaguns (HALID.)	–	–	–	5D	1A	1B	–	–	–	2A	1A	–	–	–	–	–	–	–	–	
Milichiidae																				
Madiza glabra FALL.	3B	1A	–	2B	1B	3B	1C	1A	1A	–	–	–	1A	–	2A	–	–	–	–	SOU, VIN
Desmometopa M-nigrum (ZETT.)	–	–	–	1A	–	1A	–	–	–	2A	–	–	–	–	–	2A	–	–	–	
Meoneura obscurella (FALL.)	1B	–	–	3B	1A	2A	–	–	–	–	–	–	1A	–	–	–	–	–	–	SOU, HID
Ephydridae																				
Mosillus subsultans (F.)	–	–	–	1C	1B	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	SOU
Drosophilidae																				
Drosophila ambigua POM.	–	1B	–	–	–	1A	–	1B	4B	2A	1A	–	1A	–	–	–	–	–	–	SOU
Drosophila bifasciata POM.	–	–	1A	–	–	–	–	1A	2A	–	–	–	–	–	–	–	–	–	–	
Drosophila busckii COQ.	–	1A	–	1B	–	2C	2B	7D	5C	–	1B	1A	4B	–	–	–	–	2B	–	VIN, BAN SOU
Drosophila funebris (F.)	2B	3B	–	2B	–	2B	2B	6D	5C	3C	3B	2A	5C	2C	–	2A	5A	–	–	SOU, BAN, FEA, VIN, SSM
Drosophila hydei STURT.	1A	3C	1C	1A	–	1A	–	9D	4C	5C	1A	2A	5C	2A	–	–	–	2A	–	SOU, BAN VIN, PC
Drosophila immigrans STURT.	–	–	–	1A	–	–	1A	3C	3B	3C	–	–	1A	–	–	–	2A	2A	–	SOU
Drosophila littoralis MEIG.	–	1B	–	–	–	1A	–	2C	1C	–	–	–	1A	–	–	–	–	–	–	
Drosophila melanogaster MEIG.	–	3C	1B	1A	1A	1C	–	9D	7D	5D	1B	2A	4C	3C	–	–	2B	4C	–	SOU, VIN
Drosophila repleta WOLL.	1A	3C	1B	–	–	1A	–	3B	1A	–	1B	–	2B	2B	2A	–	–	–	–	
Drosophila subobscura COLL.	–	–	–	–	–	–	–	1A	2A	–	–	–	–	–	–	–	–	–	–	SOU
Scaptomyza graminum (FALL.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2A	–	
Scaptomyza pallida (ZETT.)	1A	–	–	1B	–	1B	–	2B	1B	–	1A	–	2B	–	–	–	–	2C	2A	
Heleomyzidae																				
Heleomyza captiosa (GOR.)	–	1A	–	1B	–	1A	2B	–	–	–	–	–	–	–	–	–	–	–	–	
Scatophagidae																				
Scatophaga stercoraria (L.)	–	–	–	2C	–	1A	–	1A	–	–	–	–	–	–	–	2B	–	–	–	
Anthomyiidae																				
Delia platura (MEIG.) ♂♂	–	–	–	1A	–	–	–	1A	–	–	–	–	1A	–	2A	2A	–	–	–	SOU
Delia spp. ♀♀																				
+ *Pegohylemyia fugax* ♀♀[e]	1A	1A	–	1A	–	1B	–	2A	2B	–	–	–	1A	–	2A	4A	–	–	–	SOU
Paregle cinerella (FALL.)	–	1A	–	3B	1B	2B	–	1A	–	–	–	–	2B	–	–	2A	–	–	–	HID
Paregle radicum (L.)	1A	–	–	3B	1A	2B	1A	1A	1A	–	–	–	1A	–	–	2A	–	–	–	SOU
Anthomyia pluvialis (L.)	–	–	–	1A	1A	2A	1A	2A	–	–	–	–	–	–	–	–	–	–	–	
Muscidae																				
Helina punctata (R.-D.)	–	–	–	–	–	1B	–	–	–	–	–	–	–	–	2C	–	–	–	–	
Fannia canicularis (L.)	3B	2B	2B	5C	2B	6C	4A	6B	4B	2A	1A	1A	5C	2A	2C	2B	–	2B	2B	SOU, VIN, FEA, HID
Fannia incisurata (ZETT.)[d]	–	–	–	1C	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	
Fannia leucosticta (MEIG.)	1A	–	–	2B	–	1B	2A	–	–	–	–	–	1A	–	–	–	–	–	–	SOU
Fannia manicata (MEIG.)[d]	–	1A	1A	3B	1A	2B	2A	–	1A	–	1A	–	1A	–	–	2B	–	–	–	VIN, FEA, HID
Fannia scalaris (F.)[d]	1A	1A	–	5C	2B	5C	4B	4B	3B	–	–	–	2B	–	–	4C	–	2A	–	SOU, VIN, FEA, STA, HID
Hydrotaea armipes (FALL.)	–	–	–	2B	–	1A	–	1A	1A	–	–	–	1A	–	–	–	–	–	–	
Hydrotaea dentipes (F.)	–	–	–	4C	1A	4B	3B	4A	–	–	–	–	1B	–	–	2B	–	–	–	SOU, FEA
Hydrotaea occulta (MEIG.)	–	–	–	2A	–	1A	–	–	–	–	–	–	1A	–	–	2A	–	–	–	SOU
Ophyra leucostoma (WIED.)	–	–	–	6C	2B	5C	3C	3A	1A	–	–	–	1A	–	2A	4B	–	–	–	SOU, STA, FEA, HID
Muscina assimilis (FALL.)	–	–	–	1A	–	1A	–	2A	–	–	–	–	1A	–	–	–	–	–	2A	FEA
Muscina pabulorum (FALL.)	–	–	–	1A	1A	1A	–	2A	–	–	–	–	1A	–	–	–	–	–	–	FEA
Muscina stabulans (FALL.)	2A	1A	1A	5B	2B	4B	2A	8B	2A	–	–	–	2B	–	2A	2B	–	2C	–	SOU, VIN
Graphomyia maculata (SCOP.)	–	–	–	1A	–	–	–	2A	–	–	–	–	–	–	–	–	–	–	–	
Morellia hortorum (FALL.)	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	2A	–	–	–	

Table 3 (cont.)

Species	MIL	BAK	BSW	SLH	MEA	POU	EGG	CAM	CAF	LQR	BRW	MAL	DAI	CON	OIL	FIS	WIN	FRZ	TOB	Others
	Plant groups																			
Musca autumnalis DeG.	–	–	–	2B	–	1A	–	1A	–	2A	–	–	1B	–	–	–	–	–	–	
Musca domestica L.	2B	5C	4A	8C	6C	8D	3A	6A	3C	3A	1A	1A	7C	4A	2A	4B	–	8B	–	SOU, VIN, SSM, FAT FEA, STA
Stomoxys calcitrans (L.)	1A	1A	–	2A	–	2B	1A	1A	–	–	1A	–	1B	–	–	–	–	–	–	
Calliphoridae																				
Lucilia caesar (L.)	–	1A	–	4B	1B	2B	1A	1A	–	–	–	–	1A	–	–	2B	–	–	–	FEA
Lucilia illustris (Meig.)	–	–	–	6C	2B	4C	2A	1A	1A	–	–	–	1A	–	–	2B	–	–	2A	VIN, FEA
Lucilia sericata (Meig.)	–	1A	–	8D	2B	5D	2B	5B	1A	–	1A	–	2B	–	–	4C	–	2A	–	SOU, HID, FEA
Calliphora uralensis Vill.	–	–	–	5C	1A	2B	2A	3B	2A	–	–	–	1A	–	–	4B	–	2A	–	SOU
Calliphora vicina R.-D.	1A	1B	–	6D	3C	4C	2B	4C	–	2A	–	1A	1B	–	–	4B	–	2A	2B	SOU, VIN, FEA, STA
Calliphora vomitoria (L.)	–	–	–	4C	–	2B	2A	2B	–	–	–	–	1A	–	–	4B	–	–	–	
Pollenia atramentaria (Meig.)	2A	1A	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	
Pollenia dasypoda Portsch. ♂♂	–	–	–	–	–	–	–	2A	–	–	–	–	–	–	–	–	–	–	–	
Pollenia rudis (F.)[e]	3A	1A	1A	1A	–	2B	1A	5B	1A	2A	1C	–	1A	2A	–	–	–	–	–	SOU, VIN, FEA
Phormia regina (Meig.)	–	–	–	3C	3B	2C	1A	2A	–	–	–	–	1A	–	–	–	–	–	–	
Phormia terraenovae R.-D.	–	1A	1A	8D	4B	6D	3C	3B	1A	2A	–	–	1B	2B	–	2C	–	2C	–	SOU, VIN, HID
Sarcophagidae																				
Bercaea haemorrhoidalis (Fall.)	–	–	–	1A	–	1A	–	3A	–	–	–	–	1A	–	–	–	–	–	–	
Sarcophaga carnaria carnaria (L.) ♂♂	–	–	–	–	–	–	–	2A	–	–	–	–	–	–	–	–	–	–	–	
Sarcophaga (s. str.) spp. ♀♀	1A	–	–	–	1A	1A	–	2A	2A	–	–	–	1A	–	–	–	–	–	–	SOU
Parasarcophaga argyrostoma (R.-D.)	–	–	–	1A	–	1A	–	–	–	–	–	–	1A	–	–	2A	–	–	–	

[a] May include *Culex pipiens molestus* Forsk., [b] *S. biflexuosa*, *S. cynipsea*, perhaps some *S. fulgens* and *Sepsis* spp., [c] *D. florilega*, *D. platura*, *P. fugax*, perhaps some *Delia* spp., [d] Females of these species can be identified only tentatively, [e] a very limited number of females may belong to *P. dasypoda*, *P. vagabunda* or to other closely related species.

Chloropidae: *Oscinella frit* (L.) (SLH); *Oscinella pusilla* (Meig.) (POU); *Tricimba humeralis* (Loew) (BAK, POU, CAM, DAI); *Aphanotrigonum fasciella* (Zett.) (SLH); *Aphanotrigonum femorella* Coll. (SLH); *Siphunculina aenea* (Macq.) (SLH); *Thaumatomyia notata* (Meig.) (BAK, POU, DAI);

Agromyzidae: ? *Agromyza albipennis* Meig. (BAK); *Agromyza cinerascens* Macq. (SLH); *Phytomyza affinis* Fall. (POU);

Clusiidae: *Acarthophthalmus nigrinus* (Zett.) (POU);

Heleomyzidae: *Tephrochlamys rufiventris* (Meig.) (MIL, SLH, POU, CAF, FEA); *Tephrochlamys tarsalis* (Zett.) (MIL, BAK, SLH, POU, CAM, DAI, FEA); *Aecothea fenestralis* (Fall.) (EGG); *Eccoptomera pallescens* (Meig.) (EGG); *Acantholeria cineraria* (Loew) (SOU); *Heleomyza brachypterna* (Loew) (SLH, POU); *Heleomyza modesta* Meig. (SLH);

Trixoscelididae: *Trixoscelis obscurella* (Fall.) (MIL);

Anthomyzidae: *Anthomyza* sp. (SLH);

Chyromyidae: *Chyromya flava* (L.) (MIL, POU); *Chyromya oppidana* (Scop.) (POU, DAI);

Scatophagidae: *Scatophaga lutaria* (F.) (SLH); *Parallelomma albipes* (Fall.) (POU);

Anthomyiidae: *Myopina myopina* (Fall.) (MEA, POU); *Hylemya lasciva* (Zett.) (POU); *Hylemya variata* (Fall.) (SLH); *Hylemya* sp. [aff. *variata* (Fall.)] (CAM); *Hylemya* sp. [*strigosa* Fabr. or *nigrimana* Meig.] (POU); *Delia florilega* (Zett.) ♂♂ (POU, CAM); *Pegohylemyia fugax* (Meig.) ♂♂ (POU, CAM, CAF); *Pegomya silacea* (Meig.) (SLH); ? *Hydrophoria caudata* (Zett.) (CAM); *Leucophora sociata* (Meig.) (SOU);

Muscidae: *Coenosia humilis* Meig. (POU); *Helina duplicata* (Meig.) (SLH, POU, CAF); *Hebecnema vespertina* (Fall.) (SLH, DAI); *Myiospila meditabunda* (F.) (SLH); *Fannia* spp. ♀♀ [different from species given in Table 3] (MIL, POU, CAM, DAI); *Azelia* spp. ♀♀ (SLH, POU); *Hydrotaea bimaculata* (Meig.) (POU); *Hydrotaea irritans* (Fall.) (SLH); *Hydrotaea meteorica* (L.) (SLH); *Hydrotaea velutina* R.-D. (SLH, DAI); *Ophyra capensis* (Wied.) (SLH, POU, CAM); *Alloeostylus simplex* (Wied.) (CAM); *Dendrophaonia querceti* (Bché) (SLH, MEA, POU, CAF); *Phaonia goberti* (Mik) (CAM); *Phaonia variegata* (Meig.) (SLH); *Morellia simplex* (Loew) (SLH); *Pyrellia cadaverina* (L.) (SLH); *Musca larvipara* Portsch. (SLH); *Musca vitripennis* Meig. (SLH); *Haematobia irritans* (L.) (SLH);

Calliphoridae: *Lucilia richardsi* Coll. (SLH, POU, DAI, HID); *Lucilia silvarum* (Meig.) (SLH, MEA, POU, CAM); *Onesia* sp. (EGG); *Melinda caerulea* (Meig.) (CAM, CAF); *Melinda* spp. ♀♀ (POU, CAM); *Cynomya mortuorum* (L.) (BAK, SUG); *Pollenia vagabunda* (Meig.) ♂♂ (DAI, FEA); ? *Pollenia varia* (Meig.) ♂♂ (CAM); *Protocalliphora azurea* (Fall.) (CAM); *Chrysomyia albiceps* (Wied.) (SLH);

Sarcophagidae: *Sarcophaga carnaria lehmanni* Müll. ♂♂ (CAM); *Sarcophaga subvicina schulzi* Müll. ♂♂ (POU, DAI); *Sarcophaga subvicina subvicina* Rohd. ♂♂ (SLH); *Bellieria melanura* (Meig.) (SLH); *Parasarcophaga similis* (Pand.) (DAI); *Parasarcophaga* sp. (SLH, MEA); *Perretia* sp. (POU);

Rhinophoridae: *Frauenfeldia trilineata* (Meig.) (POU, SOU);

Tachinidae: *Mintho rufiventris* (Fall.) (POU, CAM); *Bigonicheta setipennis* (Fall.) (CAF); *Macquartia grisea* (Fall.) (POU); *Blondelia nigripes* (Fall.) (CAM); *Exorista rustica* (Fall.) (DAI); *Siphona cristata* (F.) (SOU); *Pales pavida* (Meig.) (SLH); *Nemorilla floralis* (Fall.) (POU); *Lydella grisescens* R.-D. (POU); *Phryxe nemea* (Meig.) (CAM).

Seasonal occurrence and sex ratio, as found in the collected material, of more important species of *Diptera* in food-processing industries as a whole are shown in Table 4.

DISCUSSION

Analysis of methods used

Mechanical methods of collecting *Diptera* (trapping, etc.) are relatively accurate if comparisons are to be made of the abundance of a certain species at various times or of several species at the same time and under identical conditions. For our purposes, i.e. particularly for ascertaining the species-composition of dipterous fauna in various food-processing plants with often extremely different and incomparable properties, use of a trained collector seemed far preferable to any of these objective methods. This enabled us to obtain practically all species present in the inspected plant, but also to gain some data on the approximate frequency of each species.

TABLE 4

Seasonal occurrence and sex ratio of the most abundant species[a]

Species	Month: Jan b m e	Feb b m e	Mar b m e	Apr b m e	May b m e	Jun b m e	Jul b m e	Aug b m e	Sep b m e	Oct b m e	Nov b m e	Dec b m e	Sex ratio ♂/♀
Psychoda alternata	+ +	+	++	++	+++	++	+++	+++	+++	+++	++	++	0.62
Psychoda cinerea		++	++	++	+++	+++	++	+ +	+++	+++	+++	++	0.54
Psychoda severini parthenogenetica	+ +	++	++	+++	++	+++	++	+++	+	+++	++	++	–
Culex pipiens		+	+ +	++	++	+	++	+++	+++	+++	+++	+	0.06
Sylvicola fenestralis	+		+	++	++	+++	++	+ +	+++	+++	++	++	0.64
Scatopse fuscipes					++	+++	++	+++	++	+++			1.16
Scatopse notata	+			+++	++		+	++	++	+++	+	+	0.93
Themira putris					++	+++	+++	+++	+	+			0.54
Sepsis fulgens				+	+	+++	+++	+++	+++	+			0.42
Sepsis violacea				++	++	+++	+++	+++	++	++			0.80
Piophila casei			+	+	++	+++	+++	+++	+++	+++	++	++	2.24
Piophila nigriceps					++	+ +	+++	+++	++	++			0.67
Piophila nigrimana				+	++	+ +	++	+++	++	++			0.15
Piophila varipes					++	+	+++	+++	++	++			0.23
Sphaerocera curvipes				+++	+++	++	+		++	+++			1.30
Leptocera caenosa			+	++	+++	+++	++	+++	+++	+++	+	+	0.74
Leptocera ferruginata		+		+++	++	+++	+++	+++	++	+++			0.[illegible]
Leptocera vagans				++	++	+++	+++	+++	++	+++			0.[illegible]
Madiza glabra				+++	++	+++	++	+++	+++	+			0.26
Meoneura obscurella		+	+	+ +	++	+ +	++	+++	++	+++	+	+	0.49
Drosophila buscki				+	++	+++	++	+++	+++	+++	+++	+	0.70
Drosophila funebris	+	+	++	+++	+++	+++	++	+++	+++	+++	+++	+++	1.19

Table 4 (cont.)

Species	Month[a]: Jan b m e	Feb b m e	Mar b m e	Apr b m e	May b m e	Jun b m e	Jul b m e	Aug b m e	Sep b m e	Oct b m e	Nov b m e	Dec b m e	Sex ratio ♂/♀
Drosophila hydei		+	+	+	+++	+++	++	+++	+++	+++	+++	+	1.31
Drosophila melanogaster			+	+	++	+ +	++	+++	+++	+++	+++	+	1.16
Drosophila repleta		+	++	++	++	+	++	+++	+++	+++	+	+	0.70
Paregle cinerella					+	+++	++	++	+++	++			0.05
Paregle radicum				+	++	+ +	+++	+++	++	++			0.37
Fannia canicularis			+	+++	++	+++	++	+++	+++	+++	++	+	[illegible]
Fannia manicata			+	+	+++	+++	++	+++	++	++			0.14
Fannia scalaris				+	++	+++	++	+++	+++	+++	+		0.15
Hydrotaea dentipes					++	+++	++	+++	++	+++			0.05
Ophyra leucostoma					+	+++	++	+++	++	+++			0.07
Muscina stabulans				+++	++	+++	++	+++	+++	+++			0.65
Musca domestica	+ +	+	+	+++	+++	+++	+++	+++	+++	+++	+++	+++	0.80
Stomoxys calcitrans				++	++	+++	+++	+++	++	+++	+	+	0.78
Lucilia caesar					+	+++	++	+++	++	++			0.07
Lucilia illustris				+	++	+++	++	+++	++	+++			0.05
Lucilia sericata				+	++	+++	+++	+++	+++	+++	+		0.11
Calliphora uralensis				+	++	+++	++	+++	+++	+++			0.20
Calliphora vicina	+ +	+	+	+	++	+++	+++	+++	+++	+++	++	+	0.75
Calliphora vomitoria			+	++	++	+	+	+ +	++	+++		+	0.03
Pollenia rudis		+	++	+++		+ +	++	+++	+++	+++		+	1.11
Phormia regina				+	+	++	++	+++	++	+			0.19
Phormia terraenovae			+	+++	++	+++	+++	+++	+++	+++	++		0.52

[a] b — 1st decade, m — 2nd decade, e — 3rd decade of each month; + — found in a food-processing plant.

Because the data on frequency are only approximate, they are presented in a simple, four-point scale. The data on incidence are much more reliable. Nevertheless, incidence (and, of course, also frequency), as given in Table 3, is somewhat inaccurate. Most plants were necessarily visited only once; this must have caused some inaccuracies in our data on the seasonal occurrence of adult flies (Table 4), and also in the computed coefficient of incidence and frequency (Table 3). It probably was not possible either to capture all dipterous species associated with a given plant or to exclude the influence of such factors as weather, time of the year, period elapsed since last cleaning of plant or application of insecticides, etc. Our results were also unfavourably influenced by the differences in age of the buildings, type and construction of the premises, size of the plants, adopted technology, and possible technological association with other industrial or agricultural units.

Weather was not of primary significance, particularly when the plant in question was composed predominantly or entirely of enclosed or even heated areas. The influence of the season was also partly reduced in such cases. To some extent, it was possible to reduce the effects of the above-mentioned factors by regular visits to selected plants. This meant, however, that these plants became somewhat heterogeneous elements in the series of singly-visited plants.

The different number of plants visited in each group (see Table 2) caused the results, particularly in Table 3, to be unequally significant. In general, both the statistical significance of the coefficients of incidence and frequency and the absolute numbers of atypical species must vary directly with the number of inspected plants in each group.

Species-diversity and species-composition

Diptera are unevenly distributed in establishments of food-processing industries. Most species were found by us in the groups POU, SLH, DAI, and CAM. It is possible to define these as groups noted for excess of protein substances, with sufficient supply of moisture, and (perhaps with the exception of the group DAI) with particular diversity of environment and food substances.

The group POU has the most diverse fauna as to species, and is also quite rich in individuals. This is possible to explain by reason of the many kinds of food substances and by the diversity of outdoor and indoor biotopes. The only moderate richness in individuals is perhaps caused by the smaller quantity of particular substances, their rapid circulation and their restricted accessibility.

The group SLH resembles the preceeding group in species-composition, although the incidence of most species is greater. Several species reach a remarkable degree of incidence here; they apparently occur in practically every plant of this group. The multiformity of outdoor and indoor biotopes and the variety of food substances, as well as their relative abundance and stability, are typical of this group. All of these factors combine to produce favourable conditions for the development of great quantities of sarcophagous and coprophagous species of *Diptera*.

The group DAI does not comprise very heterogeneous biotopes or food substances. Indoor premises are mostly used; refuse matter is kept in closed tanks, and the sanitary aspects of dairy production are emphasized more

than in other food-processing industries. Yet numerous *Diptera* occur here, though, with a few exceptions, they have low frequency. The species-diversity may be due in part to both high biological value and great attractiveness of available food substances.

The group CAM also has a particularly rich dipterous fauna. Because of the relatively small number of plants of this group which was visited, the species-diversity probably is even greater than shown in the present paper. The apparent causes of species-diversity here are the excesses of food substances characteristic of such plants, the fact that different varieties of foods are processed in different seasons each year, and the great diversity of biotopes. The dipterous fauna is related to that of the group CAF as well as of groups SLH and MEA, because similar food substances are available.

The spectrum of dipterous species in other food industries is substantially smaller. Plants in these industries almost always have much less diversity of biotopes, and much less variety of available food substances.

Among these groups, comparatively more species were found in plant groups CAF, EGG, MIL, BAK, SOU, and MEA. With very few exceptions, the species found there did not show higher incidence or frequency. Yet the species-diversity of the group SOU is remarkable. Theoretically, this group is exceptionally rich in species, because of its great variety of food substances. Unfortunately, our results were somewhat limited because of the very few visits we were able to make.

The rest of the groups have a very poor fauna of *Diptera*; 30 or fewer items were found in each of them. The most important common feature of these industries is shortage or unavailability of suitable food substances. The premises serve more as shelter with stable temperature and darkness for adults than suitable environments for the development of larvae. The group FIS is somewhat similar to the groups SLH and MEA, yet the number of species found is far smaller. Also in this case the results are supposedly somewhat distorted because of the small number of inspected plants in this group; the fauna of *Diptera* is evidently richer in species than those actually found.

From our observations and results it follows that species-diversity is directly dependent upon the diversity of environment of the food-processing plant in question. Large combined plants that include rather complementary technological units usually have a conspicuously more diverse fauna than plants which are large but offer uniform environment. It is also apparent that larger plants have a more diverse fauna than smaller plants of the same technological type; this is because larger plants offer the possibility of more food being accumulated and a greater variety of other factors.

The most important factor determining the species-composition and relative frequency of the dipterous fauna of food-processing plants is food. Our results clearly show that plants processing protein materials have, on average, a more diverse fauna of *Diptera* than others. Moisture probably is a limiting factor for practically the whole fauna of *Diptera* in an environment that may, in some cases, be quite suitable nutritionally; this seems to be true of many plants in the groups FAT, CON, etc. High moisture of food and environmental substances is a primary condition of existence for some flies (e.g. *Psychodidae*, *Anisopodidae*). It is typical of food-processing plants that some favourable or unfavourable factors are very ephemeral. Ability

to make use of briefly exposed food substances is a condition of success of dominant species.

The species which show highest incidence in a particular type of plant almost always have also high frequency. They are associated with substances typical of food-processing industries in their development; they show a very high degree of synanthropy though not all of them are generally known as notorious synanthropes. They are by far the most numerous as to individuals, but represent only a very small part of the total of species. They belong mainly to the families *Calliphoridae*, *Muscidae*, *Drosophilidae*, *Piophilidae*, and *Sphaeroceridae*. The most important species, having the coefficient of incidence 9 or 8, are *Drosophila hydei*, *Drosophila melanogaster*, *Musca domestica*, *Lucilia sericata*, *Phormia terraenovae*, *Piophila casei*, and *Muscina stabulans*.

Another series of species includes those which do not have nutritional associations with substances typical of food-processing plants. They may also show a high degree of synanthropy, but develop in substances not exclusively characteristic of the food-processing industries, e.g. in strongly polluted water, wet debris, moulds, etc. *(Psychodidae, Trichoceridae, Anisopodidae, Phoridae)*; these species are currently found anywhere in corresponding places.

Highly specialized species normally living only in certain specific habitats in nature present a special case. Thus, for example, *Leptocera fuscipennis*, living along the marine shoreline or in inland salt marshes, was found in slaughter-houses on hides preserved with salt, and in dairies in vats with salty water for maceration of fresh cheese bricks.

Many species of flies occur in food-processing plants, and in human environments generally, mainly because they are negatively phototactic, stenothermal, and hygrophilous. They prefer cellars, basements, dark storerooms in stone buildings, etc. To this category belong *Trichocera* spp., *Sylvicola fenestralis*, *Culex pipiens*, *Meoneura obscurella*, *Leptocera caenosa*, and some other species. Nutritional reliance in these cases ranges from very strong *(Meoneura obscurella)* to non-existent *(Culex pipiens)*.

The majority of species, however, are atypical species, which penetrated into food-processing installations by chance only. They were always represented in our material by single or very few individuals and belong to a variety of families.

SUMMARY

1. In dipterological inspection of 547 food-processing plants of various types in Czechoslovakia, 356 species (or species groups) of *Diptera* were found. Both incidence and frequency were determined for each species and plant type.

2. The industries that were richest in species of *Diptera* were poultry farms (195 species), slaughter-houses and packing plants combined with abattoirs (181 species), dairies (115 species), canneries processing meat in addition to fruit and vegetables (103 species), and canneries processing exclusively fruit and vegetables (63 species). Large numbers of species were also found in egg storages, mills, bakeries, soup flavouring and dried soup factories, and in meat packing plants not combined with abattoirs. None or very few *Diptera* were found in some industries.

3. *Calliphoridae*, *Muscidae*, *Drosophilidae*, *Piophilidae*, and *Sphaeroceridae* are families with the largest numbers of species showing high incidence and frequency.

4. Species typical of food-processing plants represent only a small proportion of the total number of species found. The most important species, i.e. those with the highest degrees of incidence and frequency, are *Drosophila hydei*, *Drosophila melanogaster*, *Musca domestica*, *Lucilia sericata*, *Phormia terraenovae*, *Piophila casei* and *Muscina stabulans*.

5. The greatest number of species found occur in food plants only by chance, showing very low incidence and frequency.

6. The most abundant species found in food-processing plants do not occur there during the winter months, nor do they occur in heated premises in winter. Probably only very few species continue their development during that time.

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