Seasonal variation in agglutinated foraminiferan standing crops in the marsh and tidal flats of the River Erme, Devon

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ABSTRACT

A typical saltmarsh/tidal mudflat foraminiferal fauna has been identified in the Erme and clear zones have been defined. The high marsh is dominated by agglutinated taxa irrespective of the season, the transitional zone is only dominated by agglutinated taxa during the winter, the low marsh is dominated by calcareous species all year, and the tidal mudflat zone which is dominated by agglutinated species at the most elevated stations during the winter only.

Six euryhaline species have been identified, three agglutinated and three calcareous. Agglutinated taxa vary from 0-100% of the total foraminiferal standing crops depending upon elevation and season.

INTRODUCTION

The River Erme and other estuaries (see Fig. 1) have been selected to contribute control data in a pollution monitoring program using recent benthic foraminifera as indicators. The program was initiated in response to a large heavy metal discharge from Wheal Jane tin mine in January 1992, into the Carnon Valley (Fig. 1, box 3) river catchment which is already highly contaminated with metals from centuries of mining activity (Stubbles, 1993). As with several other river systems in S.W. England, the River Erme (Fig. 2) has been influenced by mining activity but to a lesser extent relative to the Carnon Valley (Bryan & Hummerstone, 1973a) and for a shorter duration. The Erme is, therefore, relatively unpolluted by heavy metals.

The Erme sample area is within a Site of Special Scientific Interest (SSSI) and is well conserved amid a region of arable and stock farming. Very little of the immediate area has been influenced by modern incursions, eg. residential and industrial expansion. The lower estuary area comprises sandy beaches, used for leisure and by holiday makers but it still remains relatively unspoilt.

The Erme is a ria and is macrotidal, deriving its water from Dartmoor to the north and several tributaries to the NE and NW, which ultimately flows into the English Channel. Freshwater flow varies both with season and rainfall, and, as a result salinity has widely varying ranges. Surface salinity in the high marsh area varies between 5 parts per thousand (‰) in the winter to 26‰ in the summer. The low marsh area may reach values approaching normal marine (32‰) in the summer, falling to 20‰ in the winter. A recent variable depth salinity survey has shown that the Erme is stratified with a saline wedge. During the ebb tide the channel narrows to less than 5m in the sample area, exposing extensive mudflats which grade from muddy-sand below Efford, sandy-mud at Efford and a mud-silt at Holbeton Point (Fig. 3).

METHODS

Standard intertidal sampling and processing methods have been used (see Stubbles, 1993). The same methods of collection and processing have been applied to all the estuaries featured during this current program with the same unit area, 78 cm^2 of material being removed for foraminiferal analysis. An additional sample is also collected for geochemical analysis, at seasonal time intervals. The Rose Bengal staining method (Walton, 1952) has been used with red stained individuals being regarded as living or only recently dead at the time of collection. Sample splits have been picked and analyzed for absolute and standing crop data. The standing crop values have been normalised to $10cm^2$.

FIELD DESCRIPTIONS

Two traverses, one each on the west and east sides of the Erme, comprising 19 stations have been sampled during the winter (January), spring (April), summer (July) and autumn (November) of 1993 (Figs. 4-7).

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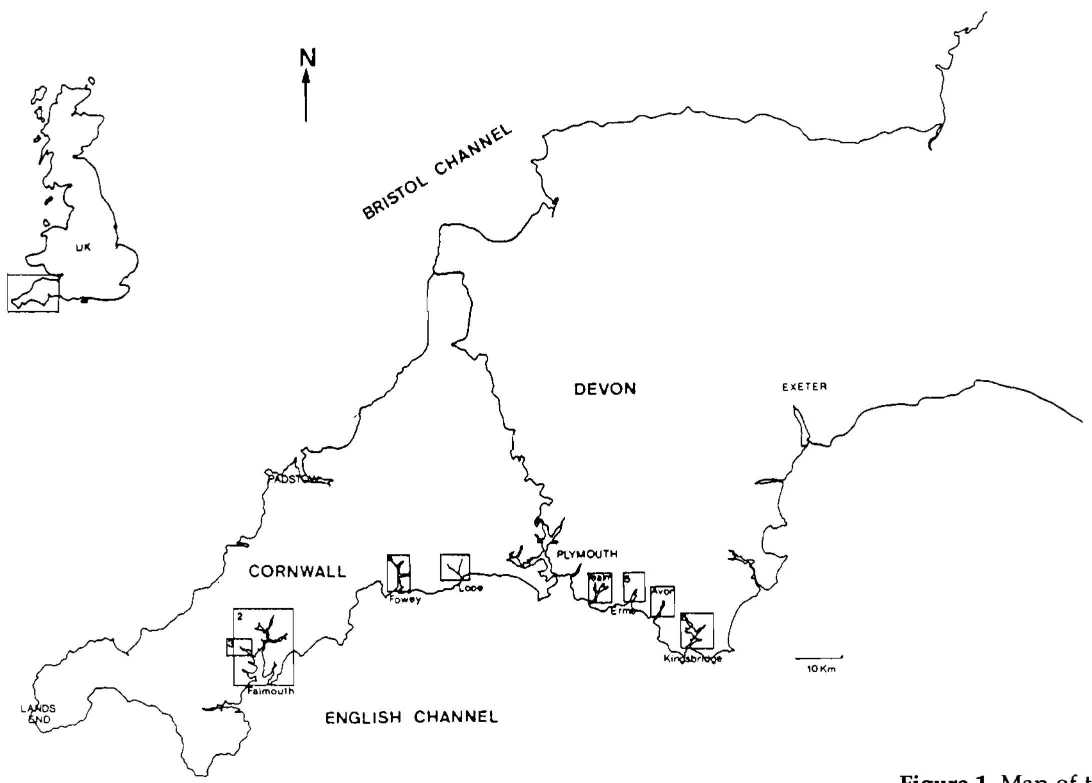

Figure 1. Map of the southwest of England, showing the sampled localities.

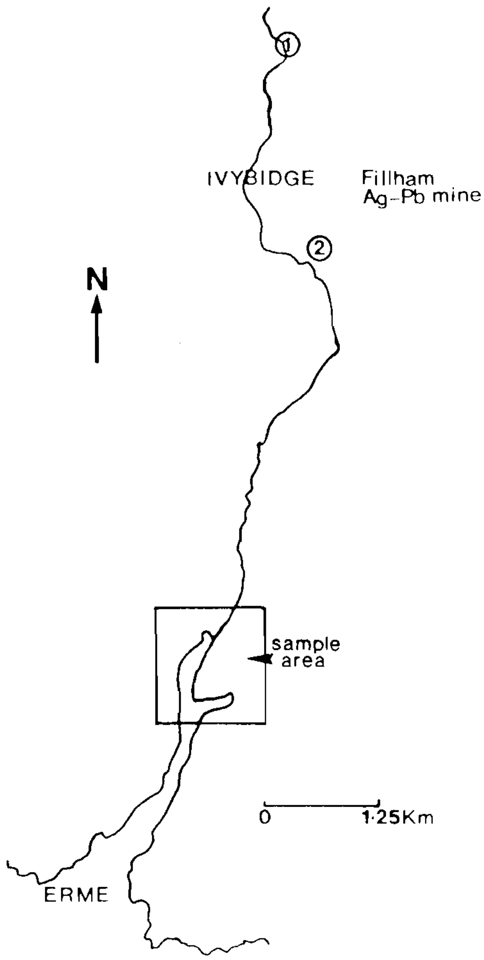

Figure 2. Map of the Erme estuary, showing the location of silver-lead mines (1, 2) including Filham.

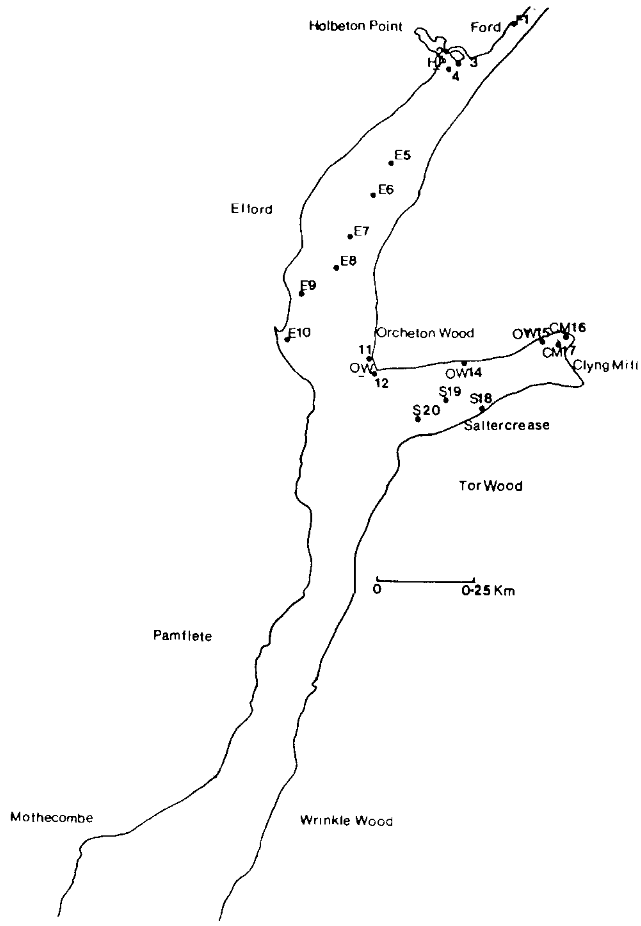

Figure 3. Map of the River Erme, with sample stations.

Traverse 1. Station F1 (Ford) is within the main channel. There is a paucity of substrate and no living foraminiferans have been found (Fig. 3). Station HP2 (Holbeton Point) has been colonised by *Spartina anglica*, *Phragmites communis* and *Puccinellia maritima* marsh flora, forming large raised areas enclosing salt pans of mud and sandy-mud. Station HP3 is a similar environment to station HP2 but is nearer to the main channel, approximately 1m away. Station HP4 is also near the main channel but 0.5m downstream of an outfall removing treated sewage from the small sewage works at the village of Holbeton. Muddy substrate predominates. Stations E5/E6/E7/E8 (Efford) are within open mudflat partially colonised by *S. anglica* and *Halimione portulacoides* marsh raised above the substrate. The substrate is of sandy-mud with abundant shell debris. Stations E9/E10 have isolated areas of *S. maritima* and *H. portulacoides* marsh as raised hummocks with coarse grass. These stations are proximal to the freshwater pond. The substrate is sandy-mud and muddy-sand with abundant shell debris. A muddy-sand bar separates these stations from the main channel.

Traverse 2. Stations OW 11/12 (Orcheton Wood) are proximal to the *S. maritima* and *P. maritima* coarse grass bank. The substrate is sandy mud. Stations OW14/OW15 are within the small mudlfat creek known as Clyng Mill. The stations are situated close to the rocky shore with saltmarsh flora being completely absent. The substrate is sandy mud. Stations CM16/CM17 are at the head of the creek below the wall and coarse grass bank separating the mudflats from the disused trout ponds at Clyng Mill Cottage. The substrate is mud. Station S18 (Saltercrease) is on the south side of the creek within the tidal mudflat. There is a mud substrate adjoining a coarse grass bank of *P. maritima* and *Aster*. Station S19 is half way between the grass bank and the stream channel within the tidal mudflats. The substrate is of sandy mud. Station S20 is beside the garden to Saltercrease House and adjacent to a coarse grass bank of *P. maritima* and *Aster*. The substrate is sandy mud.

RESULTS

Traverse 1. No living foraminiferans have been found at station F1. Stations HP2, HP3 and HP4 are generally impoverished and living specimens occur only during the winter, spring and autumn (Tables 1a-d; Figs. 4, 5, 6, and 7). The agglutinated foraminiferan *Millammina fusca* (Brady 1870) comprises 100% of the standing crops at these stations, except at HP4 in the spring, when *Elphidium williamsoni* Haynes 1973, dominates the fauna (Fig. 5). The agglutinated species present *Jadammina macrescens* (Brady 1870) and *Trochammina inflata* (Montagu 1808), are only present in very small numbers during the spring and autumn (Tables 1b and 1d). The calcareous species *Haynesina germanica* (Ehrenberg 1840) is also rare. Generally, average standing crops at these high marsh stations are lower than elswhere c. 45/10cm^{-2} (Figs. 4, 5, 6 and 7).

Millammina fusca is the dominant species at stations E5 and E6 during the winter and at E6 in the summer (Tables 1a and 1c). During the other seasons *M. fusca* is rank ordered second after *E. williamsoni*. As at other stations the other agglutinated species are present in small numbers and do not exceed 4/10cm^{-2}. *H. germanica* is ranked third. *Ammonia beccarii* (Linné 1858) is present in sample E5 during the winter, spring and summer but occurs nowhere else in traverse 1.

At station E7, *M. fusca* is ranked second to *E. williamsoni* during all seasons, but they have relatively similar standing crops in the summer (Fig. 6). At station E8 *E. williamsoni* dominates throughout the year, with *M. fusca* ranked second except in the autumn when *H. germanica* is ranked second. *T. inflata* is absent in all E8 samples, but is present in the E7 summer sample. *Jadammina macrescens* is present in the winter and autumn E8 samples, but is absent in the sample E7 for all seasons.

Millammina fusca is ranked second at station E9 except in the autumn, when it is ranked sixth (Table 1d). At station E10, *M. fusca* is only ranked second in the spring. In the summer and winter, *M. fusca* is ranked third after *E. williamsoni* and *H. germanica*, and is ranked fourth in the autumn (Table 1d). The standing crops of *J. macrescens* and *T. inflata* rise at these stations, particually in the winter and autumn.

Traverse 2. At stations OW11 and OW12, combined standing crops of the calcareous species dominate the fauna during all seasons (Figs. 4, 5, 6 and 7). *Millammina fusca* is ranked second in the winter and spring only. It is ranked third after *H. germanica* in the summer, and is absent altogether during the summer and autumn at station OW11. At OW12 it is absent during the autumn. *J. macrescens* and *T. inflata* are extremely rare in all the seasonal samples, not exceeding more than 8% in the winter and 4% in the autumn of the combined agglutinated species standing crops. *Ammonia beccarii* is less rare at stations within traverse 2. At OW11, it is present in the winter, spring and summer and at OW12 is present in the autumn only.

In the winter sample at OW14 *M. fusca* is the dominant species. During the other seasons it is ranked third after the indigenous calcareous species and is absent in the autumn sample, with *A. beccarii* ranked third. *Ammonia beccarii* is generally a minor species and is absent during the winter but it is present in the spring at OW15 and in the autumn at OW14. *J. macrescens* and *T. inflata* are absent in all the OW14 and OW15 seasonal samples. *Millammina fusca* is rank ordered second at OW15 during the winter but otherwise is ranked third after *E. williamsoni* and *H. germanica*.

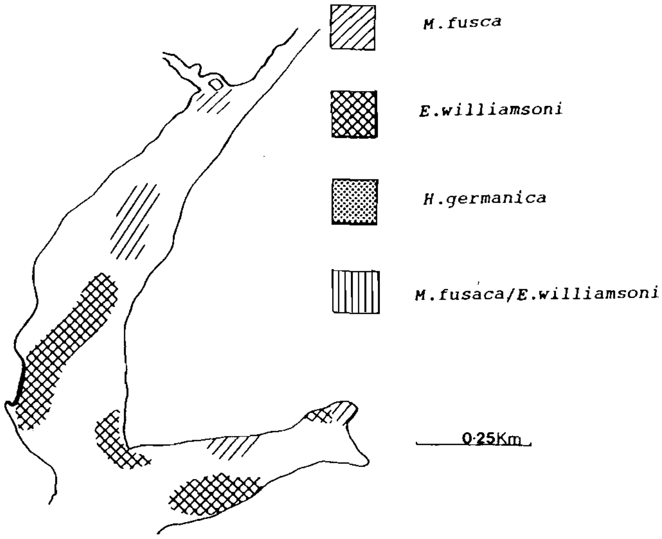

FIG.4: Species dominance during the winter.

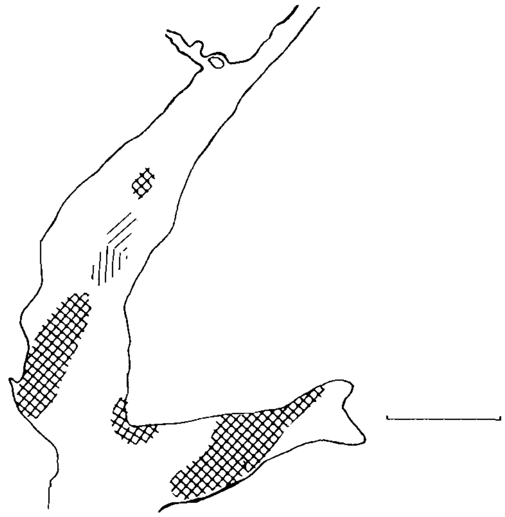

FIG.6: Species dominance during the summer.

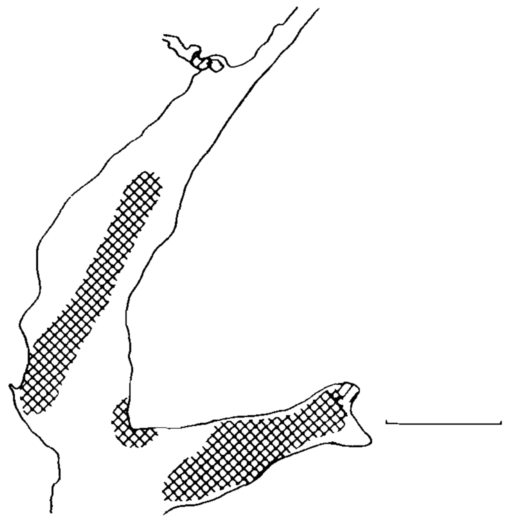

FIG.5: Species dominance during the spring.

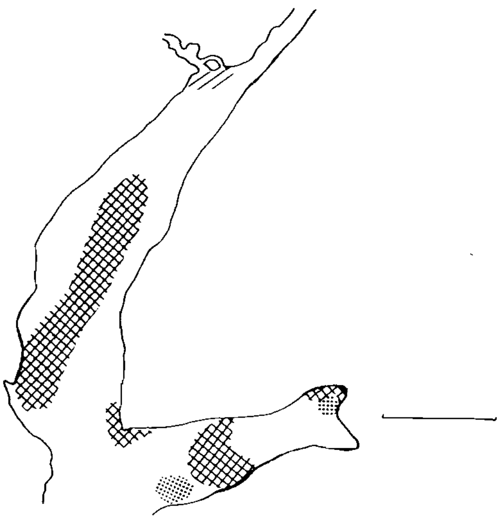

FIG.7: Species dominance during the autumn.

Millammina fusca is the dominant species during the winter and spring at station CM16 and is also dominant at CM17 in the winter. At station CM17, *M. fusca* is ranked third during the spring and autumn. No living *M. fusca* were found in the autumn CM16 sample, and only 4/10cm^{-2} have been collected from the CM17 in the autumn sample. *J. macrescens* is the only agglutinated foraminifera in sample CM16/autumn and accounts for just 7% of the agglutinated species at this station in the winter. *Trochammina inflata* and *A. beccarii* are absent at these two stations.

Millammina fusca is ranked third at S18 in the winter, spring and autumn. It is second at stations S19 and S20 in the winter and fourth at S18 in the summer. At stations S19 and S20, *Millammina fusca* is ranked third. *Trochammina inflata* is present in the summer and autumn samples of station S20, comprising 14% and 50% respectively of the combined standing crops of agglutinated taxa. *Ammonia beccarii* is present in the spring and summer samples from station S18.

SUMMARY

Faunal zonation and seasonal variation in standing crops. The absence of foraminifera at station F1 is consistent with the results of the preliminary investigation carried-out in July 1991, and no extraordinary significance is attached to this. The most reasonable conclusion accounting for this absence are the extremes in environmental conditions which are of lethal levels. Stations HP2, HP3 and HP4 comprise a predominately agglutinated taxa, which is very patchy. The dominance of the marsh indicator species *M. fusca* (Alve & Murray, 1994) defines a high marsh environment during all seasons, which extends in the winter into stations E5 and E6. The distribution of predominately calcareous species at stations E5, E6, E7 and E8 defines a transitional marsh environment. The second and third rank order (depending on the season) of *M. fusca* at E9, E10, OW11 and OW12 suggests a low marsh environment. The tidal flat environment of Clyng Mill has a predominately calcareous species distribution during all seasons except in the winter at CM16 and CM17, which are dominated by *M. fusca* and, therefore, is a transient high marsh/low marsh environment (Phlegler, 1970).

Averaged standing crops of *M. fusca* and *E. williamsoni*, vary seasonally throughout the sample area. The winter sample shows *M. fusca* (61/10cm^{-2}) and *E. williamsoni* (66/10cm^{-2}) to have near identical standing crops but in the other seasonal samples the difference in standing crop values becomes more pronounced: spring 42/10cm^{-2} to 112/10cm^{-2}; summer 22/10cm^{-2} to 87/10cm^{-2}; and autumn 19/10cm^{-2} to 71/10cm^{-2} for *M. fusca* and *E. williamsoni* respectively. This suggests *M. fusca* is a winter opportunist responding to reduced competition caused by the dormancy of the calcareous species which bloom in the spring and summer.

The standing crops of the species *M. fusca* are greatest during winter and spring in the environments of the high/saltmarsh and at stations E5 and E6 in the transitional marsh environment. During the summer and autumn, *M. fusca* is a minor component of the assemblages present in the low marsh and tidal flat environments. The agglutinated species *J. macrescens* and *T. inflata* have higher standing crops, ranking higher or equal to the standing crops of *M. fusca*.

CONCLUSIONS

The euryhaline species present in the River Erme form characteristic hyposaline/ brackish/ hypersaline faunal environments of high marsh, transitional marsh, low marsh and tidal mudflat. There is a general decrease down estuary of the foraminiferan *M. fusca*, but improved standing crop populations of *A. beccarii*, which has narrower tolerance thresholds relative to the other indigenous species. *M. fusca* remains, however, a common species. *M. fusca*, with its characteristic wide tolerance thresholds, appears to be an opportunist more suited to the elevated areas of maximum exposure and drying times which exist in the saltmarsh and, also occurring during periods of dormancy of the calcareous species.

The high variation in standing crops, in particular the rarer species, may be due to clumping (Murray, 1991) and the formation of foraminiferal micro-environments. Scott & Leckie (1980), however, suggest that the patchiness shown by marsh foraminiferans is systematic of year to year environmental variables which can only be delimited by extensive and continuous sampling over a number of years.

The findings of the Erme estuary investigation are consistent with sample data from the Fowey Estuary, presently being analyzed (Fig. 1). The Fowey sampling program is as yet incomplete but initial results show similar faunal zoning with patchiness being evident in the winter and spring. Continuous sampling will contribute sufficient data to delimit natural environmental variables and isolate metal pollution controls on foraminiferal species distribution, test condition and standing crop numbers.

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I dedicate this paper to the memory of my recently deceased supervisor Steve Caswell. He played a major supportive role as my undergraduate supervisor and continued to influence the quality of my research work.

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Tables 1a-d. Standing crops of indiginous species / 10 cm^3 (except those marked by an * which denotes total live individuals.

1A

Species	Stns.	HP2	HP3	HP4	E5	E6	E7	E8	E9	E10	OW11	OW12	OW14	OW15	CM16	CM17	S18	S19	S20
H.germanica		0	0	0	0	4	0	16	31	11	5	0	24	50	17	4	41	0	0
E.williamsoni		0	0	*2	34	90	73	59	93	117	101	181	48	124	46	72	102	84	29
A.beccarii		0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
M.fusca		0	78	15	224	124	55	31	33	6	25	25	72	66	78	280	17	14	14
J.macrescens		0	0	0	*3	0	0	4	4	3	1	0	0	0	6	0	0	0	0
T.inflata		0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0

winter

1B

Species	Stns.	HP2	HP3	HP4	E5	E6	E7	E8	E9	E10	OW11	OW12	OW14	OW15	CM16	CM17	S18	S19	S20
H.germanica		1	0	3	21	8	41	18	27	6	28	10	68	53	14	53	96	21	14
E.williamsoni		1	0	23	228	124	158	106	173	39	186	46	251	117	44	190	227	135	73
A.beccarii		0	0	0	0	0	0	3	5	0	3	0	0	3	0	0	19	0	0
M.fusca		71	0	0	137	69	114	54	71	32	74	12	14	10	51	32	35	14	8
J.macrescens		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
T.inflata		1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0

spring

1C

Species	Stns.	HP2	HP3	HP4	E5	E6	E7	E8	E9	E10	OW11	OW12	OW14	OW15	CM16	CM17	S18	S19	S20
H.germanica		0	0	0	8	10	17	33	16	14	43	105	107	77	n/d	n/d	68	62	31
E.williamsoni		0	0	0	45	51	54	607	4	35	133	48	135	25	n/d	n/d	105	197	37
A.beccarii		0	0	0	0	0	0	8	21	0	4	0	0	0	n/d	n/d	12	0	0
M.fusca		0	0	0	39	80	58	107	0	6	0	33	21	8	n/d	n/d	8	0	12
J.macrescens		0	0	0	0	0	0	0	0	0	0	0	0	0	n/d	n/d	0	0	0
T.inflata		0	0	0	4	0	4	0	0	0	0	0	0	0	n/d	n/d	0	0	2

summer

1D

Species	Stns.	HP2	HP3	HP4	E5	E6	E7	E8	E9	E10	OW11	OW12	OW14	OW15	CM16	CM17	S18	S19	S20
H.germanica		0	0	0	34	25	27	29	29	12	26	8	96	8	12	13	8	20	37
E.williamsoni		0	0	0	136	125	68	80	121	21	84	181	162	121	19	11	104	89	12
A.beccarii		0	0	0	0	0	0	8	21	0	0	8	12	0	0	0	0	0	0
M.fusca		0	107	29	108	25	43	21	1	6	0	0	0	4	0	4	1	8	2
J.macrescens		0	4	0	0	1	0	4	4	8	0	0	0	0	2	0	0	0	0
T.inflata		0	0	0	0	1	0	0	8	1	0	0	0	0	0	0	0	0	2

autumn