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THE ROCKY SHORE BIOLOGY OF BANTRY BAY: A RE-SURVEY

by

J. M. Baker, S. Hiscock, K. Hiscock, D. Levell, G. Bishop,

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The rocky shore biology of Bantry Bay: a re-survey

by

J. M. BAKER, S. HISCOCK, K. HISCOCK, D. LEVELL (Field Studies Council Oil Pollution Research Unit, Pembroke).

[1]G. BISHOP (Temporary biologist for Gulf Oil Terminals (Ireland) Ltd. and Sherkin Island Field Study Centre).

[2]M. PRECIOUS (University College, Cork).

R. COLLINSON, R. KINGSBURY, [3]A. J. O'SULLIVAN (Atkins Research and Development, Epsom).

ABSTRACT

A survey of the distribution and abundance of intertidal rocky shore animals and plants of Bantry Bay was carried out in 1970 and 1971 by G. B. Crapp and published in 1973. A re-survey was carried out during 1975 and early 1976 and a number of changes were noted. In an attempt to explain these the possible effects of changing weather conditions, the occurrence of oil spillages and the use of dispersants were examined. In most cases, the changes were not obviously attributable to visible oil pollution and seem more likely to result from a variety of natural factors.

The re-survey highlighted a number of problems associated with this type of biological monitoring. The problems are discussed and some alternative approaches suggested.

INTRODUCTION

In 1968 Gulf Oil Terminals (Ireland) Ltd. opened an oil terminal on Whiddy Island in Bantry Bay. Surveys designed to provide information on the flora and fauna of Bantry Bay before possible exposure to oil pollution had by this time been carried out by workers from the Department of Agriculture and Fisheries (Dublin), the Lancashire and Western Sea Fisheries Joint Committee, the University of Durham and the Field Studies Council Oil Pollution Research Unit. An initial survey of the intertidal rocky shores of Bantry Bay was described by Crapp (1970), and this was followed by more detailed work (Crapp, 1973). The abundance of littoral animals and plants was assessed at regular vertical intervals on forty transects, and the distribution patterns of these species were described and discussed in relation to two major environmental variables: emersion and exposure to wave action. Crapp intended that this work should (*a*) be of scientific value in its own right and (*b*) serve as a 'baseline' for the detecting of future changes.

It was considered that a 1975 re-survey would be appropriate in view of oil spillages which occurred during October 1974 and January 1975. On 21st-22nd October, 1974, a spillage of Kuwait crude oil (estimated size about 2,600 tonnes) occurred at the Whiddy Island terminal, and on 10th January, 1975, a spillage of bunker or heavy fuel oil (estimated size about 460 tonnes) occurred as a tanker was being towed out of Bantry Bay. These incidents have been described by O'Sullivan (1975a and 1975b).

In addition to the biological re-survey, information was collected on location and persistence of oil on the shore and cleaning methods used. These factors can affect distribution and abundance of shore organisms. It was also considered necessary to examine meteorological data as many changes in rocky shore biology can occur as a result of changing weather conditions.

METHODS

Biological transect survey

The sites and methods used were the same as those of Crapp (1973). Basically, at each of 40 sites the abundance of about 60 intertidal species was assessed at 0.3 metre height intervals up the shore from low water spring tide mark. Where possible a belt of shore about 10 metres wide was examined. The sites surveyed are given in Table 1 and their positions shown on Figs. 1 and 2.

Abundance scales used were those given by Crapp (1973). They are reproduced in an appendix to this paper.

Except where otherwise stated, nomenclature of species follows Fletcher (1975a, b) for the lichens, Parke and Dixon (1968) for the algae, and the Plymouth Marine Fauna, Marine Biological Association, 1957, for the invertebrates.

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[1] Present address: Marine Biological Association of the U.K., Plymouth.

[2] Present address: Snave, Bantry.

[3] Present address: Advisory Committee on Oil Pollution of the Sea, 1 Cambridge Terrace, London NW1 4JL.

Other biological observations

Apart from the semi-quantitative transect studies, qualitative observations were made at a number of sites and other relevant information has been published (O'Sullivan, 1975a, Cullinane et al, 1975). These observations are summarised in the 'results' section of the paper.

Observations on oil and cleaning

Records were made of the distribution of oil while carrying out the biological transect survey and these are shown together with observations from intermediate sites and other sources on Figs. 1 and 2.

Concerning cleaning operations, observations from the literature (O'Sullivan, 1975a, and Cullinane et al, 1975) were collected and during the transect survey evidence of cleaning, (e.g. remaining dispersant drums) was noted.

Weather records

The nearest meteorological station to the Bantry Bay area is Valentia Observatory, Cahirciveen (about 50 km. N.W. of Bantry Bay). Temperature and wind records for the period 1970 to 1975 were supplied by the Irish Meteorological Service and examined to see if there were any trends which could account for observed biological changes. It should be noted, however, that the Valentia site is relatively sheltered compared to Bantry, and that sea temperatures are not available for the area.

A summary of weather conditions at the Whiddy Island terminal, from June 1968 to August 1975, was supplied by Mr T. B. Kelly of Gulf Oil Terminals (Ireland) Limited. This information was extracted from log books kept at the terminal.

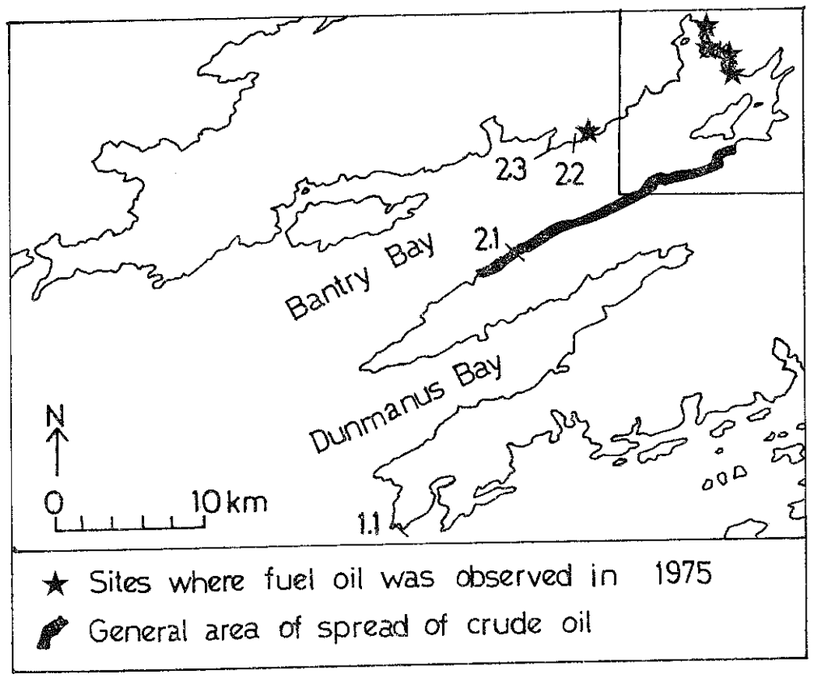

FIG. 1. Map of part of south west Ireland showing the location of the four most exposed transects (1.1 etc.) and the distribution of oil. The specific site records of oil are from the 1975 transect re-survey; the general area of spread of crude oil is from O'Sullivan (1975a) and Cullinane et al (1975). The enclosed area at the top right hand corner is shown on a larger scale in Fig. 2. Based upon the Ordnance Survey by permission of the Government (Permit No. 1833).

RESULTS

Biological transect survey

The results of Crapp's survey were presented as sets of histograms for each species, arranged according to the degree of exposure to wave action of each site. This arrangement has been followed in the present paper and Figs. 3-10 show selected re-survey histograms superimposed upon the originals. Summaries of the most noticeable changes in abundance are given in Tables 2 and 3, and the factors that have to be taken into account when interpreting changes are given in the discussion section of this paper.

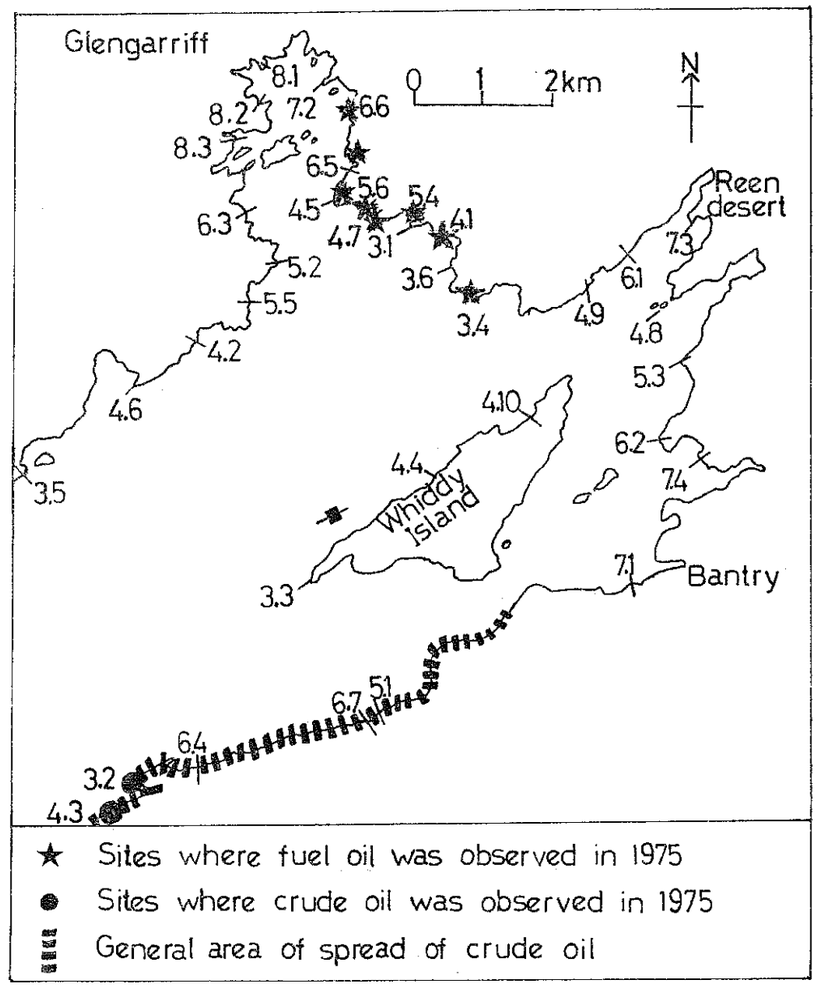

FIG. 2. Map of the inner Bantry Bay showing the locations of all but the most exposed transect sites and the distribution of oil. The specific site records of oil are from the 1975 transect re-survey; the general area of spread of crude oil is from O'Sullivan (1975a) and Cullinane et al (1975). Based upon the Ordnance Survey by permission of the Government (Permit No. 1833).

The various forms/species of *Littorina saxatilis* were considered together for the purposes of the present survey with the exception of *Littorina saxatilis neglecta* (as defined by James, 1968). This was because a recent re-classification of the group (Heller, 1975) relies on features which cannot be distinguished in the field, and the older classification proved difficult to use in some cases. In Table 3 the *Littorina saxatilis* results of 1975 are compared with Crapp's combined *Littorina saxatilis rudis*; *L.s. jugosa* and *L.s. tenebrosa* (all as defined by James, 1968) records. *Spirorbis* spp. were considered together in 1975, and compared with Crapp's combined *Spirorbis borealis* and *S. rupestris* results.

Following Crapp (1973), *Mytilus galloprovincialis* Lamark was not separated from *M. edulis* L.

Other biological observations

Preliminary work following the October, 1974 spillage indicated that immediate biological damage to intertidal rocky areas was not severe, except possibly in one area affected by spraying dispersant close to the shore, (O'Sullivan, 1975a). Further observations up to January, 1975, at Relane Point, League Point and Gerahies Harbour are reported by Cullinane et al (1975). This latter paper describes damage to seaweeds and lichens. *Fucus serratus* was reported as the most badly damaged seaweed but was recovering in December, 1974. Discolouration and large quantities of detached seaweed (several species) were seen. During the re-survey bleached *Lithothamnion* spp., *Laurencia pinnatifida, Palmaria palmata* and *Laminaria digitata* were noted in particular at site 6.3, but patches of bleached seaweeds occurred at most sites.

Cullinane et al (1975) reported observations on lichens affected by the October, 1974 spillage. Several lichen species were affected, showing discolouration, erosion, softness or sliminess, but *Xanthoria parietina* and *Caloplaca thallincola* showed signs of regeneration. Further observations on lichens were made during the re-survey at sites affected by the January, 1975 spillage. Discolouration of patches of *Ramalina siliquosa, Xanthoria parietina, Caloplaca* spp., *Ochrolechia parella* and *Lecanora atra* was noted at intervals along the coast between sites 6.6 and 3.4.

A small saltmarsh near site 2.2 (Mehal Head) was oiled following the January, 1975 spillage. When visited during May, 1975 most of the saltmarsh plants were showing signs of new growth. *Juncus maritimus* appeared to be the worst-affected species.

With animals, Cullinane et al (1975) observed limpet (*Patella* spp.) detachment and damage to saddle oysters (*Anomia ephippum*) in the League Point area between sites 3.2 and 6.4. During the transect re-survey, winkles (*Littorina littorea*) and top shells (*Monodonta lineata*) were seen crawling over weathered fuel oil on rocks at site 5.6. Some of the winkles appeared to have weathered oil on their shells and the presence of oil on and/or in the winkles was later confirmed by extraction and thin layer chromatography carried out on a ground sample of approximately 100 winkles by the Yarsley Testing Laboratories. Two further samples from Reendesert (Bantry Bay Fig. 2) and the eastern end of Dunmanus Bay (Fig. 1) were found to be oil free using this method.

Observations on oil and cleaning

Figs. 1 and 2 and Tables 2 and 3 summarise oil observations arising from the re-survey and other sources. Oil, where present, was generally stranded on the upper shore as weathering films and crusts, and concentrated mainly in west and south-west facing gullies. Tables 2 and 3 summarise information on clean-up operations. O'Sullivan (1975a) describes dispersant spraying of floating oil following the October, 1974 spillage, but the fact that the spill took place outside the tourist season meant that there was no compulsion to use dispersant on the shores. Peat moss, straw, road gully cleansers and skimmers were used to remove the oil from coastal rocks and coves. Cullinane et al (1975) reported that in December, 1974, BP 1100X was used to clean the pier and nearby shore at Gerahies Harbour, and also noted that diluted dispersant spray reached some shores from boats working close to the rocks.

Following the January, 1975 spillage, spraying of floating slicks was repeated (O'Sullivan, 1975b). Spraying equipment and empty drums were observed near site 6.6 and oil had penetrated into mud and shingle in a nearby inlet. Oil coming ashore near sites 5.6 and 4.7 was cleaned by removal in buckets, absorption onto straw and spraying with BP 100X. Oily straw was present at intervals along the coast between sites 6.6 and 3.4 and some 'clamps' of oily straw had been made above high water mark.

Weather records

Table 4 summarises information extracted by Mr. T. B. Kelly from the log books kept at the Whiddy Island Terminal. The tables are by no means exhaustive or systematic, but provide a useful guide to the main weather features experienced 1968-1975. Particular points of interest are:

1. Many of Crapp's transects were surveyed during the summer of 1971, for which prevailing low pressures are recorded.
2. Most of the re-survey was carried out during the summer of 1975 for which prevailing high pressures are recorded.
3. The winter of 1974-75, i.e. the winter preceding the re-survey, was "without a doubt the severest winter experienced since the terminal opened in 1968". This is in terms of winds and swell.

4. The summer of the re-survey was "without doubt the finest summer experienced since the summer of 1968 when records began".

The relevance of these records to a number of biological observations will be discussed later.

Data from the Valentia observatory were plotted as follows:

(a) Mean monthly temperatures (Fig. 11). These suggest that winters from 1972/73 to 1974/75 were comparatively mild.

(b) Mean monthly wind speed (Fig. 12). These suggest that comparatively high wind speeds have been experienced during the winters 1972/73 to 1974/75.

From the above it will be recognised that most of Crapp's work was conducted during the summer of 1971, which had long periods of low pressure, average temperatures and a lot of rain. The preceding winter did not have notably high mean wind speeds but was colder than the 1974/75 winter. The re-survey was done during a particularly fine summer with long periods of high pressure and much sunshine. The preceding winter of 1974/75 was comparatively mild but very windy and long heavy swells were experienced in Bantry Bay.

DISCUSSION

The superimposed histograms (Figs. 3-10) show that many apparent changes in zonation relative to Chart Datum have taken place. In some cases, it appears that plants and animals occupy zones on the shore 0.3m higher than at the time of Crapp's survey, and occasionally the apparent change is as much as 1.0 m. Some of the species involved are known to move up and down the shore to some extent (e.g. *Littorina* spp.) but others are thought to be relatively static.

This apparent difference may be explained in terms of differing meteorological conditions during the two surveys. Both surveys used predicted tidal height (Admiralty Tide Tables) as a datum for levelling. As the re-survey was mainly carried out during a prolonged high pressure period, it is very likely that actual tidal heights were lower than predicted and that consequently, when working up the shore, more transect stations were surveyed before any particular zone was reached. In particular instances, wind speeds and directions could probably enhance the difference between the levelling on the two surveys.

Another possibility is that as recent winters appear to have been particularly windy, there may be a slight increase of exposure grade and extension of the spray zone on some of the shores. Shore organisms would adjust to this over a period of years, but it seems unlikely that this is the major explanation of the apparent shifts. Milder winters since 1973 may allow an increase of some species.

None of Crapp's transects was permanently marked and some sort of permanent reference point is recommended on each transect to resolve levelling and zonation problems in the future.

Apart from apparent zonation changes, there are many abundance changes concerning most species. These have to be interpreted with great care, taking into account the following points:

1. Work in Milford Haven has shown that different workers estimating abundance on the same transect at the same time of year commonly differ by one abundance category and often by two (Baker, 1976). Possible differences of one abundance category between workers are inherent in the abundance scale method. Assuming, for example, a real value of 30% cover for a seaweed one worker may estimate slightly more than 30% and put it in the 'A' (30-60% cover) category; another worker may estimate slightly less than 30% and put it in the C (5-30%) category.
2. Crapp's sites were located using his maps and profiles but as the transects were not marked on the rock it was not always certain that exactly the same 10 m belt was being surveyed again.
3. Transects should ideally be re-surveyed at the same time of year as the original. This was not always possible, so seasonal changes (e.g. the greater abundance of seaweeds in the spring) have to be taken into account.

Tables 2 and 3 show the main abundance changes noted, after taking into account points 1 and 2 above. Considering the tables species by species, it seems that there has been an overall increase in some seaweed species, notably *Porphyra spp.* but also *Ulva lactuca, Cladophora* spp., *Fucus vesiculosus, Fucus spiralis, Gigartina stellata, Chondrus crispus, Lomentaria articulata* and *Palmaria palmata.* This could be, at least in part, a seasonal effect. It is most marked at sites 2.2, 3.2, 4.1, 4.2, 4.3, 4.8, 5.2 and 5.4 and in all these cases May records are being compared with mid-summer or mid-winter records.

Plants showing overall decreases are the seaweed *Ascophyllum nodosum* and the lichen *Lichina pygmaea.* The *Ascophyllum* could be explained in terms of the rough 1974/75 winter, as it is a large plant of sheltered conditions and is probably relatively susceptible to storm damage. Oil damaged *Lichina pygmaea* was reported by Cullinane et al (1975) but the plant is reduced in abundance on both oiled and unoiled transects. Bleaching of algae such as *Laminaria digitata,* observed at both polluted and unpolluted sites, has already been shown to occur on unpolluted rocky shores in Anglesey (Jones et al 1974) during long periods of sunny weather.

Animals showing an overall decrease are the barnacle *Chthamalus stellatus,* the limpets *Patella vulgata* and *Patella aspera* and the winkle *Littorina neritoides.* Overall increases are shown by the barnacle *Elminius modestus,* the mussel *Mytilus edulis* and the dog whelk *Nucella lapillus. Pomatoceros triqueter* and *Littorina littorea* show increases on exposed shores. The *Littorina* populations observed on these more exposed sites were mainly composed of juveniles.

These changes are difficult to explain. The decrease of *Chthamalus stellatus* (which, according to Southward, 1967, favours warmer conditions), is not consistent with the temperature data nor with the increase in *Nucella* which preferentially eat *Balanus* (Connell, 1961). *Patella* spp. are known to be sensitive to oils and dispersants (Crapp, 1970) but are not consistently reduced in abundance on sites known to have been exposed to these pollutants. Possibly they have also been affected by rough winter conditions or young settling spat have been desiccated by hot sunny periods. The increase of young *Littorina littorea* on more exposed sites is interesting in view of the rougher winter conditions although James (1968) has noted that juvenile *L. littorea* are more widely distributed than adults. Populations may presumably be maintained by the settlement of young from planktonic larvae and variations from year to year may be a result of varying seasonal settlement and winter mortalities. Temperature may be important as well as sea state. *Elminius* appears to be increasing its abundance following its probable arrival in Bantry Bay in 1966 or 1967 (Crapp, 1973).

Considering the results site by site, an overall decrease in abundance of plants was not noticed at any site, but increases were noticed at several, notably 3.2 (oiled) and 6.4 (oiled). Overall decreases of animals were found at some sites, notably 3.2 (oiled) and 4.3 (oiled) and increases were found at others, e.g. 4.5 (oiled), 5.1 (oiled) and 4.10 (unoiled). It is clear that changes in plant and animal abundance have taken place on both polluted and unpolluted transects and no very consistent pattern emerges. It may be significant, however, that sites 4.3, 3.2 and 6.4 showed relatively large numbers of changes, increased abundance of several seaweed species at sites 3.2 and 6.4 and decreased abundance of several animal species at sites 3.2 and 4.3. This group of sites was affected by the October 1974 spillage and possibly by nearby dispersant use during the subsequent clean-up.

In summary, it can be said that many differences in abundance were noted between the two surveys, but that these cannot be consistently related to known pollution episodes. Some may be related to the contrasting weather conditions preceding and during the two surveys and oil and cleaning may account for some abundance changes along the shore from sites 4.3-6.4. (Qualitative observations of damage were made in this area by Cullinane et al 1975). Large amounts of detached seaweed in this area observed during the winter of 1974/75 have to be interpreted in terms of rough weather as well as possible pollution effects.

Along the shoreline between sites 6.6 and 3.4, weathered fuel oil and discoloured lichens were observed and at site 5.6 winkles with oil on their shells were seen. The abundance of most of the littoral species recorded does not, however, appear to have been drastically or consistently affected in this area.

CONCLUSION

Many biological changes have taken place on the shores of Bantry Bay between 1970/71 and 1975. In most cases these are not obviously related to oil spillages. Some are very difficult to explain; with others, changes in weather conditions are implicated. The changes cannot be interpreted as an overall decline. Some local qualitative observations, particularly lichen discolouration, are related to oil spillages.

It is felt that the future monitoring of Bantry Bay, and other areas, would be facilitated by the fixing of permanent markers on shore transects. Difficulties encountered with the 1975 survey resulted from lack of fixed reference points for levelling and (in some cases) exact re-location of transects. It is also felt that photographic records would be useful in site re-location and the verification of abundance data.

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APPENDIX

Abundance scales used for intertidal rocky shore surveys in Bantry Bay (from Crapp, 1973).

1. Lichens and "Lithothamnia"

Ex	More than 80% cover
S	50-80% cover
A	20-50% cover
C	1-20% cover
F	Large scattered patches
O	Widely scattered patches, all small
R	Only one or two patches

2. Algae

Ex	More than 90% cover
S	60-90% cover
A	30-60% cover
C	5-30% cover
F	Less than 5% cover, zone still apparent
O	Scattered plants, zone indistinct
R	Only one or two plants

3. Barnacles (except *B. perforatus*), *Littorina neritoides*, and *L. saxatilis neglecta*

Ex	More than 5 per sq. centimetre
S	3-5 per sq. cm.
A	1-3 per sq. cm.
C	10-100 per sq. decimetre
F	1-10 per sq. decimetre, never more than 10 cm. apart
O	1-100 per sq. metre, few within 10 cm. of each other
R	Less than 1 per sq. m.

4. *Balanus perforatus*

Ex	More than 3 per sq. cm.
S	1-3 per sq. cm.
A	10-100 per sq. decimetre
C	1-100 per sq. metre
O	1-10 per sq. metre
R	Less than 1 per sq. metre

5. Limpets and periwinkles (except *L. neritoides* and *L.s.neglecta*)

Ex	More than 200 per sq. metre
S	100-200 per sq. m.
A	50-100 per sq. m.
C	10-50 per sq. m.
F	1-10 per sq. m.
O	1-10 per sq. decametre
R	Less than 1 per sq. decametre

6. Topshells, dogwhelks, anemones, and sea urchins

Ex	More than 100 per sq. metre
S	50-100 per sq. m.
A	10-50 per sq. m.
C	1-10 per sq. m. locally sometimes more
F	Less than 1 per sq. m. locally sometimes more
O	Always less than 1 per sq. m.
R	Less than 1 per sq. decametre

7. Mussels

Ex	More than 80% cover
S	50-80% cover
A	20-50% cover
C	Large patches, but less than 20% cover
F	Many scattered individuals and small patches
O	Scattered individuals, no patches
R	Less than 1 per sq. metre

8. *Pomatoceros triqueter*

A	More than 50 tubes per sq. decimetre
C	1-50 tubes per sq. decimetre
F	10-100 tubes per sq. metre
O	1-10 tubes per sq. m.
R	Less than 1 tube per sq. metre

9. *Spirorbis spp.*

A	5 or more per sq. centimetre: on 50% of suitable surfaces
C	5 or more per sq. cm. on 5-50% of suitable surfaces
F	1-5 per sq. cm. or on 1-5% of suitable surfaces
O	Less than 1 per sq. cm.
R	Less than 1 per sq. m.

Table 1. List of transect sites, with dates of surveys and Ballantine exposure grades.

No.	Name of site	Dates of 1970/71 surveys.	Dates of 1975 surveys.	*Exposure grade.
1.1	Mizen Head	17.8.71	24.8.75	1. Extremely exposed
2.1	Collack	18.8.71	23.9.75	2. Very exposed
2.2	Mehal Head	30.12.70	11.5.75	
2.3	Shot Head	31.12.70		
3.1	Lion Point	21.8.71	23.5.75	3. Exposed
3.2	Reen Point	19.8.71	8.4.75	
3.3	Whiddy Point West	6.8.71	26.8.75	
3.4	Reennagough Point	11.7.71	10.5.75	
3.5	Dereenacarrin	11.8.71	13.5.75	
3.6	Ardaturrish Point	10.7.71	22.8.75	
4.1	Yellow Rock Bay	22.8.71	23.5.75	4. Semi-exposed
4.2	Harris Cove	12.8.71	25.5.75	
4.3	Gerahies	5.9.71	27.3.75	
4.4	Carrigacloash	20.8.71	25.8.75	
4.5	Gun Point	28.2.71	24.5.75	
4.6	Muccurragh Point	26.2.71	14.5.75	
4.7	Iskanafeelna Point	24.8.71	15.5.75	
4.8	Eagle Point	4.9.71	7.5.75	
4.9	Ardnagashel West	23.8.71	23.8.75	
4.10	Reenavanny	9.7.71	25.5.75	
5.1	Cooskeen Cove No. 1	29.1.71	26.3.75	5. Fairly sheltered
5.2	Crowdy Point	13.11.70	25.5.75	
5.3	Reenydonagan Point	13.8.71	26.4.75	
5.4	Ardaturrish Bay	21.8.71	15.5.75	
5.5	Bocarnagh Bay	12.8.71	13.5.75	
5.6	Illauncreveen Bay	24.8.71	13.5.75	
6.1	Ardnagashel East	6.9.71	18.4.75	6. Sheltered
6.2	Gurteenroe Point	1.2.71	25.4.75	
6.3	Furkeal	12.7.71	27.5.75	
6.4	Coomageragh	30.1.71	7.4.75	
6.5	Derrycreigh	10.8.71	24.5.75	
6.6	Glengarriff Castle	21.7.71	25.5.75	
6.7	Cooskeen Cove No. 2	24.2.71	11.3.75	
7.1	Black Rock	7.9.71	7.5.75	7. Very sheltered
7.2	Roches Point	25.2.71	15.5.75	
7.3	Snave Bay	9.9.71	27.5.75	
7.4	Dunnamark Point	7.9.71	15.4.75	
8.1	Corriveillaun	3.9.71	14.5.75	8. Extremely sheltered
8.2	Fir Lands	8.9.71	12.5.75	
8.3	Inchintaggart	11.8.71	12.5.75	

*Exposure grades follow Ballantine (1961).

Table 2: Summary of the main changes in abundance between the two surveys: *Plants*

\+ Increase

— Decrease

· No large change

A Absent from transect on both surveys

	1.1 Mizen Head	2.1 Collack	2.2 Mehal Head	2.3 Shot Head	3.1 Lion Point	3.2 Reen Point	3.3 Whiddy Point West	3.4 Reennagough Point	3.5 Dereenacarrin	3.6 Ardaturrish Point	4.1 Yellow Rock Bay	4.2 Harris Cove	4.3 Gerahies	4.4 Carrigacloash	4.5 Gun Point	4.6 Muocurragh Point	4.7 Iskanafeelna Point	4.8 Eagle Point	4.9 Ardnagashel West	4.10 Reenavanny
Green algae																				
Enteromorpha spp.	·	·	+	·	+	·	·	·	·	·	·	·	—	·	+	+	·	·	·	·
Ulva spp.	A	—	A	A	·	+	·	·	·	+	A	·	+	·	·	A	—	·	·	·
Cladophora spp.	A	A	+	A	+	·	·	·	·	·	A	·	·	·	·	+	+	—	·	·
Brown algae																				
Himanthalia elongata	A	·	·	A	·	+	A	·	·	·	·	·	+	·	A	·	·	·	·	·
Alaria esculenta	·	·	·	·	·	A	·	·	A	·	A	·	+	A	A	·	·	A	A	·
Laminaria digitata	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Fucus serratus	A	A	A	A	A	+	A	A	A	·	·	+	·	+	+	·	·	·	·	·
Fucus vesiculosus	A	·	·	·	—	—	·	+	—	·	·	+	·	·	·	·	·	—	·	·
Ascophyllum nodosum	A	A	A	A	A	·	A	A	·	A	A	A	·	A	A	A	A	·	·	A
Fucus spiralis	A	·	A	·	·	·	·	·	·	·	+	·	·	·	+	·	·	+	·	·
Pelvetia canaliculata	A	A	A	A	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Red algae																				
Corallina spp.	·	·	·	·	·	+	·	·	·	·	+	·	+	·	—	·	·	·	·	+
Gigartina stellata	—	·	·	·	·	+	·	·	·	·	·	+	·	·	·	·	—	+	·	+
Chondrus crispus	A	A	·	A	·	+	·	·	·	·	·	+	·	·	·	·	·	+	·	+
Laurencia pinnatifida	A	·	A	·	·	+	·	·	·	+	+	·	—	·	·	·	·	+	·	+
Lithothamnion spp.	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Lomentaria articulata	A	A	A	A	+	+	A	A	A	A	+	·	+	A	·	·	A	·	·	·
Palmaria palmata	A	·	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·
Porphyra spp.	—	·	+	·	+	·	·	·	+	·	+	+	+	+	+	+	·	+	·	+
Catenella/Gelidium	A	A	A	A	A	+	A	A	A	·	A	A	A	·	A	A	·	A	+	·
Lichens																				
Verrucaria mucosa	·	·	—	·	A	+	·	+	A	·	·	+	+	A	A	—	+	+	A	A
Verrucaria maura	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Lichina pygmaea	·	·	—	·	·	·	·	·	·	—	·	·	—	A	·	·	·	—	·	·
Lichina confinis	·	·	+	·	·	·	·	—	·	·	·	·	·	·	·	·	·	·	·	·
Xanthoria parietina	·	·	·	·	·	—	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Caloplaca spp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Grey lichens	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Ramalina spp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
A oil & dispersant absent																				
O evidence of oil on or near transect	A	A	A	A	O	O	A	O	A	O	O	A	O	A	O	A	O	A	A	A
D evidence of dispersant on or near transect	A	A	A	A	A	D	A	A	A	A	A	A	D	A	A	A	D	A	A	A

Table 2: continued

	5.1 Cooskeen Cove No. 1	5.2 Crowdy Point	5.3 Reenydonagan Point	5.4 Ardaturrish Bay	5.5 Bocarnagh Bay	5.6 Illauncreveen Bay	6.1 Ardnagashel East	6.2 Gurteenroe Point	6.3 Furkeal	6.4 Coomageragh	6.5 Derrycreigh	6.6 Glengarriff Castle	6.7 Cooskeen Cove No. 2	7.1 Black Rock	7.2 Roches Point	7.3 Snave Bay	7.4 Dunnamark Point	8.1 Corriveillaun	8.2 Fir Lands	8.3 Inchintaggart
Green algae																				
Enteromorpha spp.	A	+	—	+	·	·	·	·	·	A	+	·	+	·	·	·	A	·	·	·
Ulva spp.	·	+	A	—	·	+	A	A	·	+	+	+	·	·	·	A	A	+	·	·
Cladophora spp.	+	·	—	+	+	·	·	·	·	·	+	·	—	·	·	·	·	+	·	·
Brown algae																				
Himanthalia elongata	·	A	—	A	A	·	A	A	—	A	A	A	A	A	A	A	A	A	A	A
Alaria esculenta	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Laminaria digitata	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	A	A	A	A
Fucus serratus	+	+	·	·	·	·	·	·	·	·	·	·	·	·	+	—	·	·	—	·
Fucus vesiculosus	·	·	·	·	+	·	·	·	+	+	+	+	+	·	·	·	·	·	·	·
Ascophyllum nodosum	—	A	—	·	·	·	·	—	·	—	·	·	·	—	·	·	·	·	·	·
Fucus spiralis	+	+	·	+	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Pelvetia canaliculata	·	·	·	·	·	·	·	+	·	+	·	·	·	—	·	+	+	·	—	·
Red algae																				
Corallina spp.	+	·	·	·	—	·	—	—	+	+	·	·	—	—	A	A	A	A	A	A
Gigartina stellata	·	·	·	·	·	+	—	·	·	+	+	·	+	·	A	+	+	A	A	A
Chondrus crispus	+	·	·	+	·	·	·	·	·	·	·	—	—	·	·	·	·	·	·	·
Laurencia pinnatifida	·	—	·	+	·	·	·	·	·	+	·	·	·	·	·	A	A	A	A	A
Lithothamnion spp.	·	·	·	·	—	+	·	·	·	·	·	·	·	·	·	·	—	—	—	—
Lomentaria articulata	+	+	A	+	—	·	·	·	·	+	·	·	—	·	A	A	A	A	A	A
Palmaria palmata	·	+	·	A	+	+	·	·	·	+	·	·	—	·	—	A	A	A	A	·
Porphyra spp.	·	+	·	+	+	A	A	·	A	+	A	A	·	A	·	A	A	A	A	A
Catenella/Gelidium	·	·	—	+	A	·	·	·	·	·	·	+	—	·	—	+	·	·	+	·
Lichens																				
Verrucaria mucosa	—	—	—	·	·	·	·	·	—	·	·	+	—	·	·	+	A	+	+	A
Verrucaria maura	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Lichina pygmaea	·	—	·	·	A	—	A	A	·	A	·	A	A	A	A	A	+	A	A	A
Lichina confinis	—	·	+	·	—	·	·	·	·	·	·	·	·	A	·	·	·	·	·	—
Xanthoria parietina	·	·	·	·	·	·	·	·	·	·	·	·	A	·	·	·	·	·	·	·
Caloplaca spp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Grey lichens	A	·	·	·	·	·	·	·	·	·	·	·	·	A	·	·	·	·	·	·
Ramalina spp.	·	·	·	—	·	·	·	·	·	·	—	·	·	A	·	·	·	·	A	A
A oil & dispersant absent																				
O evidence of oil on or near transect	O	A	A	O	A	O	A	A	A	O	O	O	O	A	A	A	A	A	A	A
D evidence of dispersant on or near transect	A	A	A	A	A	D	A	A	A	A	A	D	A	A	A	A	A	A	A	A

Table 3: Summary of the main changes in abundance between the two surveys: **A***nimals*

\+ Increase
— Decrease
· No large change
A Absent from transect on both surveys

	1.1 Mizen Head	2.1 Collack	2.2 Mehal Head	2.3 Shot Head	3.1 Lion Point	3.2 Reen Point	3.3 Whiddy Point West	3.4 Reennagough Point	3.5 Dereenacarrin	3.6 Ardaturrish Point	4.1 Yellow Rock Bay	4.2 Harris Cove	4.3 Gerahies	4.4 Carrigacloash	4.5 Gun Point	4.6 Muccurragh Point	4.7 Iskanafeelna Point	4.8 Eagle Point	4.9 Ardnagashel West	4.10 Reenavanny
Sea anemones																				
Actinia equina	+	·	·	·	·	—	·	·	·	·	—	·	—	·	+	·	·	·	·	+
Annelid worms																				
Spirorbis spp.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	+	A	A	A
Pomatoceros triqueter	A	·	·	·	·	+	·	·	·	·	+	·	+	·	·	·	·	·	·	+
Barnacles																				
Balanus balanoides	·	·	·	·	·	·	·	·	·	·	·	+	—	·	·	·	·	·	·	·
Elminius modestus	A	A	A	A	+	A	+	A	A	+	—	·	·	·	·	·	·	+	·	·
Chthamalus stellatus	—	·	—	·	·	·	·	—	—	·	—	·	—	·	·	—	·	·	·	·
Limpets																				
Patella vulgata	·	·	—	·	·	—	·	—	—	·	·	·	—	·	·	·	·	·	·	·
Patella aspera	·	·	—	·	·	—	·	·	—	·	—	—	—	—	·	—	—	—	—	·
Top shells																				
Gibbula umbilicalis	A	A	A	A	·	—	·	·	·	+	·	·	·	·	+	·	·	·	·	·
Gibbula cineraria	A	A	A	A	·	+	A	·	·	A	·	+	·	·	+	A	·	·	·	·
Monodonta lineata	A	A	A	A	A	A	A	A	·	+	A	A	—	·	A	A	A	·	A	·
Calliostoma zizyphinum	A	A	·	A	A	+	A	A	A	·	·	+	·	A	·	·	·	·	A	A
Winkles																				
Littorina neritoides	·	·	—	·	·	—	·	·	—	·	·	·	—	·	·	—	—	—	·	+
Littorina saxatilis	·	·	·	·	·	·	·	·	·	·	·	·	—	·	·	·	·	·	·	·
Littorina saxatilis neglecta	—	·	+	·	·	—	·	·	+	·	·	·	—	·	·	·	·	·	+	+
Littorina littoralis	A	A	A	A	·	—	+	·	—	·	—	+	·	·	+	—	·	·	·	·
Littorina littorea	A	A	A	A	·	+	+	+	+	·	—	—	·	+	·	·	—	—	·	·
Dog whelks																				
Nucella lapillus	A	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Mussels																				
Mytilus edulis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+
A oil & dispersant absent	A	A	A	A	O	O	A	O	A	O	O	A	O	A	O	A	O	A	A	A
O evidence of oil on or near transect																				
D evidence of dispersant on or near transect	A	A	A	A	A	D	A	A	A	A	A	A	D	A	A	A	D	A	A	A

Table 3: continued

	5.1 Cooskeen Cove No. 1	5.2 Crowdy Point	5.3 Reenydonagan Point	5.4 Ardaturrish Bay	5.5 Bocarnagh Bay	5.6 Illauncreveen Bay	6.1 Ardnagashel East	6.2 Gurteenroe Point	6.3 Furkeal	6.4 Coomageragh	6.5 Derrycreigh	6.6 Glengarriff Castle	6.7 Cooskeen Cove No. 2	7.1 Black Rock	7.2 Roches Point	7.3 Snave Bay	7.4 Dunnamark Point	8.1 Corriveillaun	8.2 Fir Lands	8.3 Inchintaggart
Sea anemones																				
Actinia equina	+	·	·	·	·	·	·	+	+	·	·	·	·	·	A	·	A	A	A	+
Annelid worms																				
Spirorbis spp.	·	A	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	—	·
Pomatoceros triqueter	+	·	·	+	·	·	·	·	·	+	·	·	·	·	—	—	—	·	·	·
Barnacles																				
Balanus balanoides	·	·	—	·	·	·	—	·	·	+	·	·	·	·	·	·	·	·	+	+
Elminius modestus	+	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Chthamalus stellatus	·	·	·	·	·	·	·	·	·	·	—	—	—	·	—	·	—	A	A	A
Limpets																				
Patella vulgata	·	—	—	·	—	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Patella aspera	·	—	·	—	·	—	·	·	·	+	A	A	·	A	A	A	A	A	A	A
Top shells																				
Gibbula umbilicalis	·	+	—	·	·	+	·	·	·	—	—	—	·	+	+	—	·	—	·	+
Gibbula cineraria	·	·	·	·	·	·	·	A	+	·	—	·	·	—	·	—	A	A	A	A
Monodonta lineata	+	+	A	+	·	+	—	·	+	—	A	A	—	A	·	A	A	A	A	A
Calliostoma zizyphinum	A	·	·	·	A	·	·	A	·	A	—	A	A	A	·	A	A	A	A	A
Winkles																				
Littorina neritoides	—	+	·	·	·	·	A	A	—	·	A	A	A	A	A	A	A	A	A	A
Littorina saxatilis	+	+	·	—	—	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Littorina saxatilis neglecta	·	·	·	·	+	·	·	·	·	—	—	·	—	+	A	A	A	A	A	A
Littorina littoralis	·	·	—	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Littorina littorea	+	—	·	+	·	+	—	·	+	—	·	·	A	·	·	·	·	·	·	·
Dog whelks																				
Nucella lapillus	·	·	·	+	·	+	·	·	·	·	+	+	·	+	+	+	—	·	·	·
Mussels																				
Mytilus edulis	·	+	+	+	·	+	+	+	+	+	·	·	+	·	·	·	·	·	·	·
A oil & dispersant absent	O	A	A	O	A	O	A	A	A	O	O	O	O	A	A	A	A	A	A	A
O evidence of oil on or near transect																				
D evidence of dispersant on or near transect	A	A	A	A	A	D	A	A	A	A	A	D	A	A	A	A	A	A	A	A

Table 4. Summary of weather conditions in Bantry Bay 1968-1975.
Source: Information extracted by Mr. T. B. Kelly from log books kept by Gulf Oil Terminals (Ireland) Limited, Whiddy Island.

	Summer 1968	Winter 1968—69	Spring 1969	Summer 1969	Winter 1969—70
Air temperature		Mild	Average—below average	Average	Cold
Sunshine	Long periods		Little		
Barometric pressure	High				
Wind direction	Variable	S—SW	SE—E	Prevailing SW	NE & E followed by W & SW
Wind speed	Light — moderate		Force 4—5		W—SW winds generally Force 4
Occurrence of gales	1 notable SW gale early Sept.	S—SW gales at approx 10 day intervals	Occasional SE gales	Occasional SW gales	2 notable NW gales in Feb. SW gales at times
Rainfall		Heavy rain accompanied gales	Comparatively dry	Wet	Dry
Swell	Heavy swell after gale				

	Summer 1970	Winter 1970—71	Spring 1971	Summer 1971	Winter 1971—72
Air temperature	Average	Mild	A little below average	Average	Mild
Sunshine					
Barometric pressure	Mainly high	Usually low		Low pressures prevailed throughout summer	Low at first
Wind direction	S	SW—W	W—NW	S—SW	SW—W followed by NW & NE
Wind speed	Strong		Force 3—5	Force 3—5	
Occurrence of gales	Occasional short S gales	SW—N gales at intervals	Occasional gale force winds	Occasional S & SW gales	Severe SE & SW gales in March & April
Rainfall	Periodic	A lot		A lot	
Swell		Long low swell for long periods			

Table 4: continued.

	Summer 1972	Winter 1972—73	Spring 1973	Summer 1973	Winter 1973—74
Air temperature	Average	Mild		Average	Average
Sunshine					
Barometric pressure	Mostly high		High pressures in late spring	Low at first, high in Aug. and Sept.	Mostly low
Wind direction	SE	SW—W	SE followed by E—NE	S—SW followed by W, NW & NE	SW—W
Wind speed				Light—moderate	Strong
Occurrence of gales		Gales every 10 days	Frequent SE gales		Severe gales in January, S—SW
Rainfall	In late summer and autumn	Long periods of heavy rain		Wet	Exceptionally wet
Swell		Notable swells until mid-March			

	Spring 1974	Summer 1974	Winter 1974—75	Spring 1975	Summer 1975
Air temperature	A little below average	Generally below average	Average	A little below average	Above average
Sunshine		Little			Long sunny periods
Barometric pressure	High	Generally low	Low	High	High for long periods
Wind direction	E—NE	S—SW	SW—W, S—SE	E—SE	
Wind speed	Force 3—4		Strong	Generally force 3—5	Light
Occurrence of gales	Occasional	SE gales in June & July	Severe S—SE gales in Jan.		
Rainfall	Low	Very wet			Light
Swell			Heavy long swells & the worst winter since the terminal's opening.		The finest summer since the opening of the terminal

KEY TO FIGURES 3 TO 10:

Solid lines: 1970/71 data.

Dotted lines: 1975 data.

Width of histograms proportional to abundance, from rare to extremely abundant.

Figures down vertical axis are height in metres above Chart Datum.

Figures along horizontal axis are site numbers from 1.1 (represented as $\frac{1}{1}$) to 8.3 ($\frac{8}{3}$). The upper figure in each case is the Ballantine exposure grade.

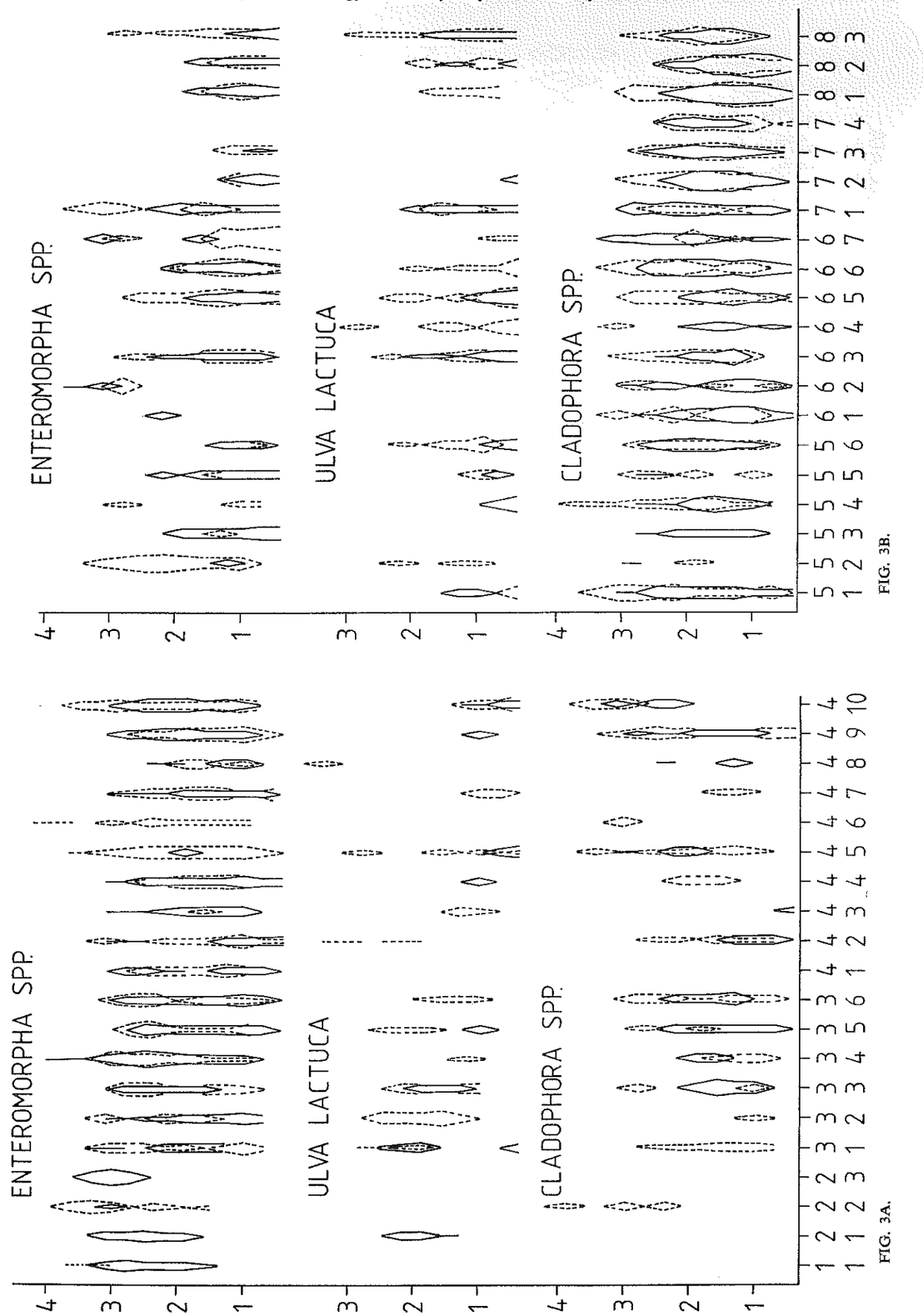

FIG. 3B.

FIG. 3A.

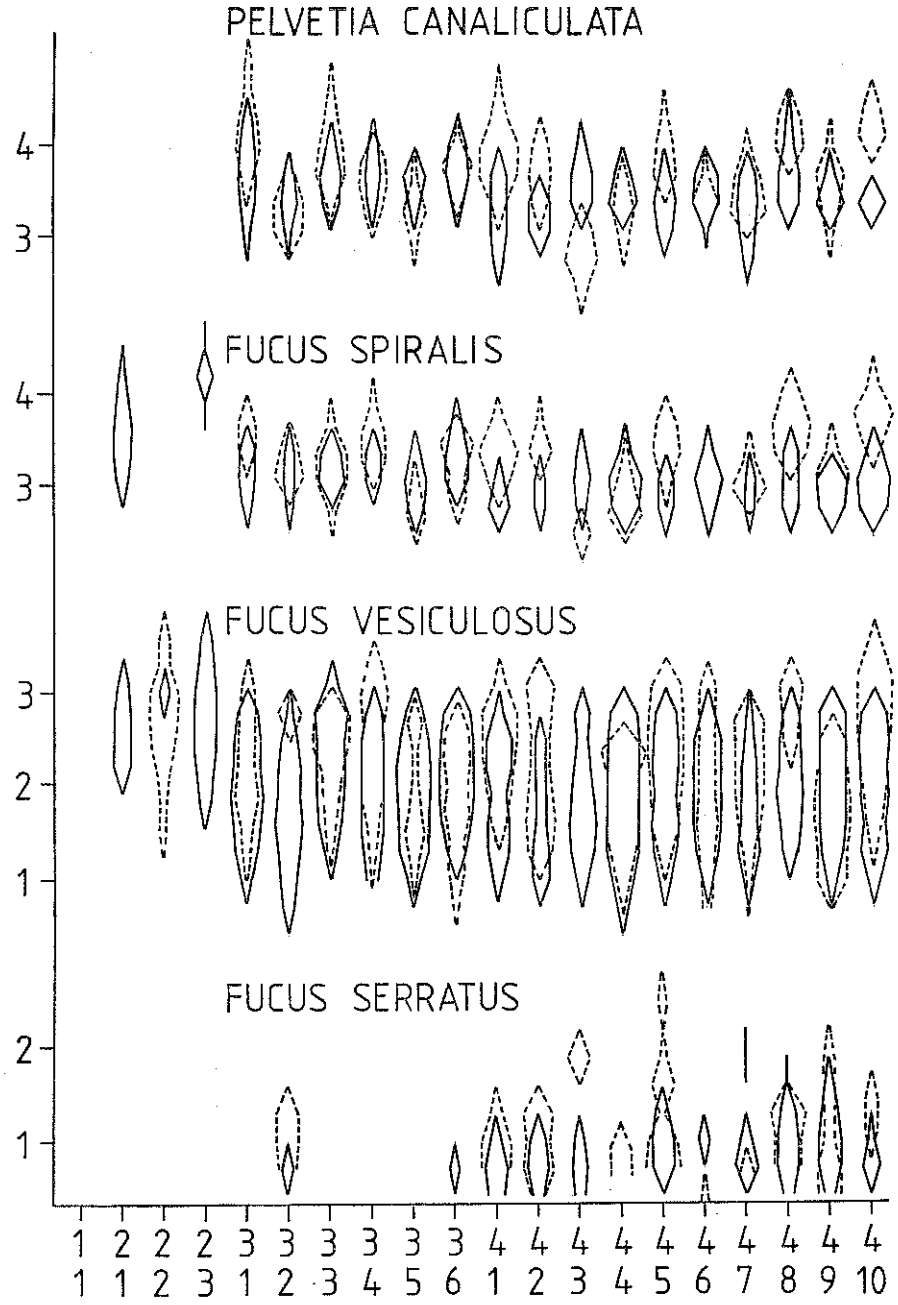

FIG. 4A.

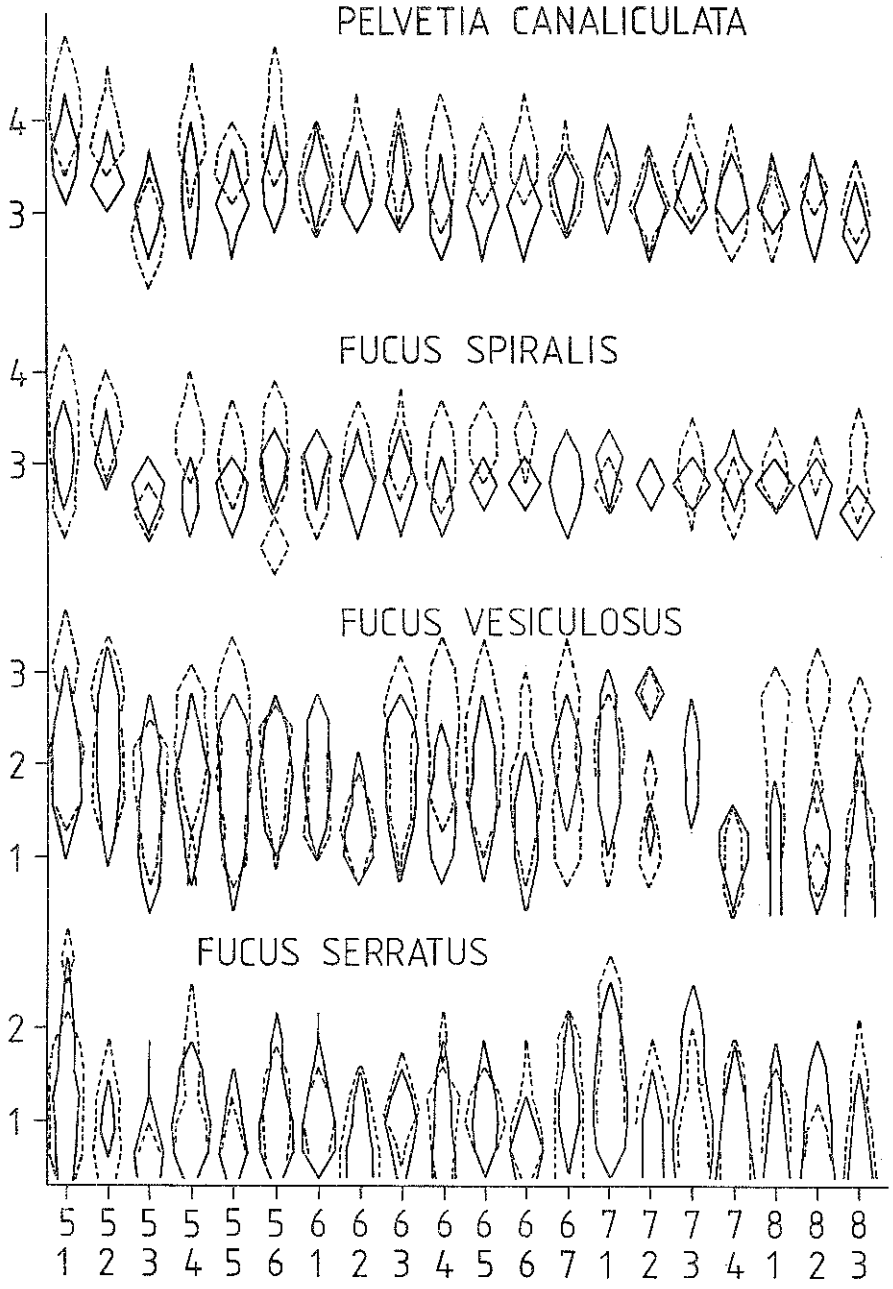

FIG. 4B.

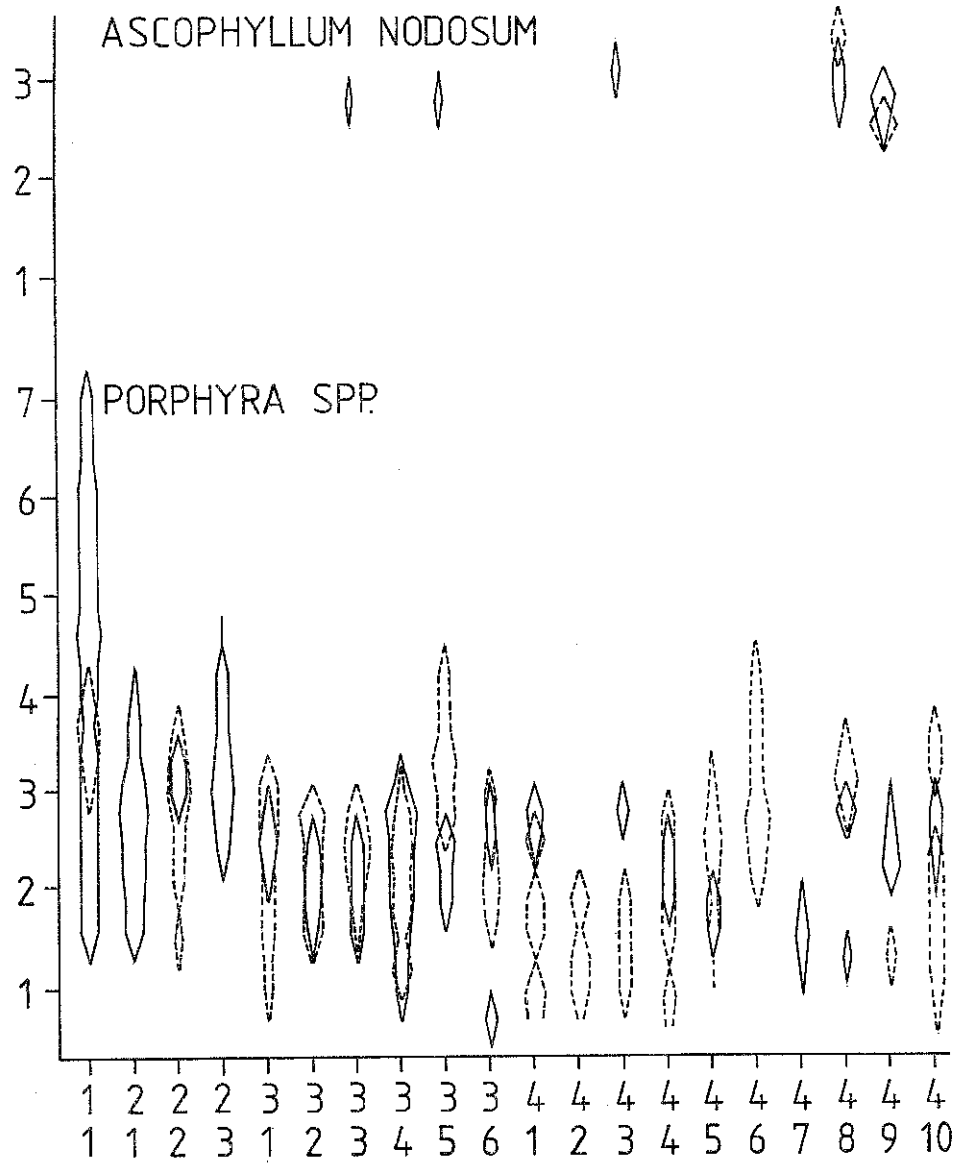

FIG. 5A.

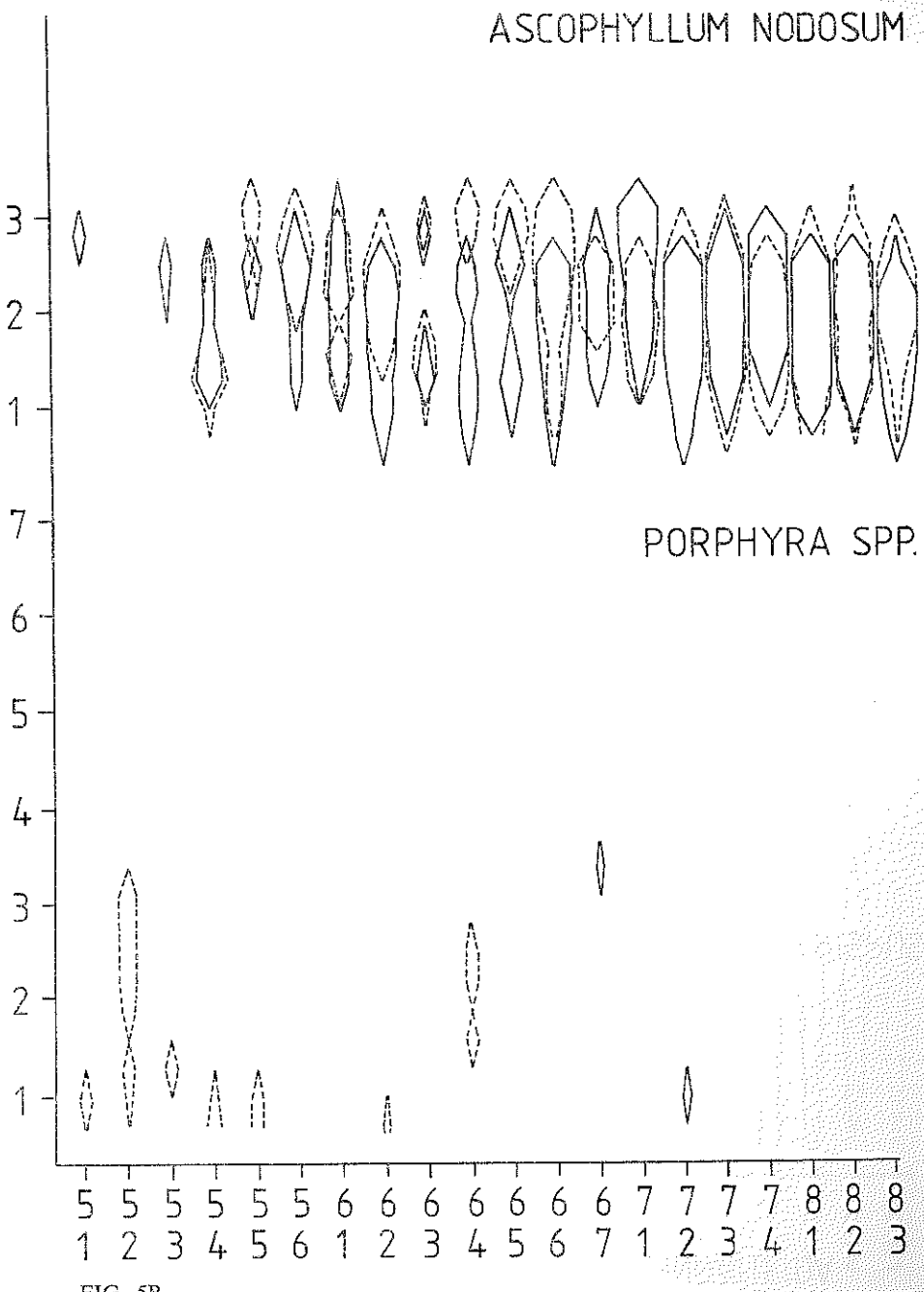

FIG. 5B.

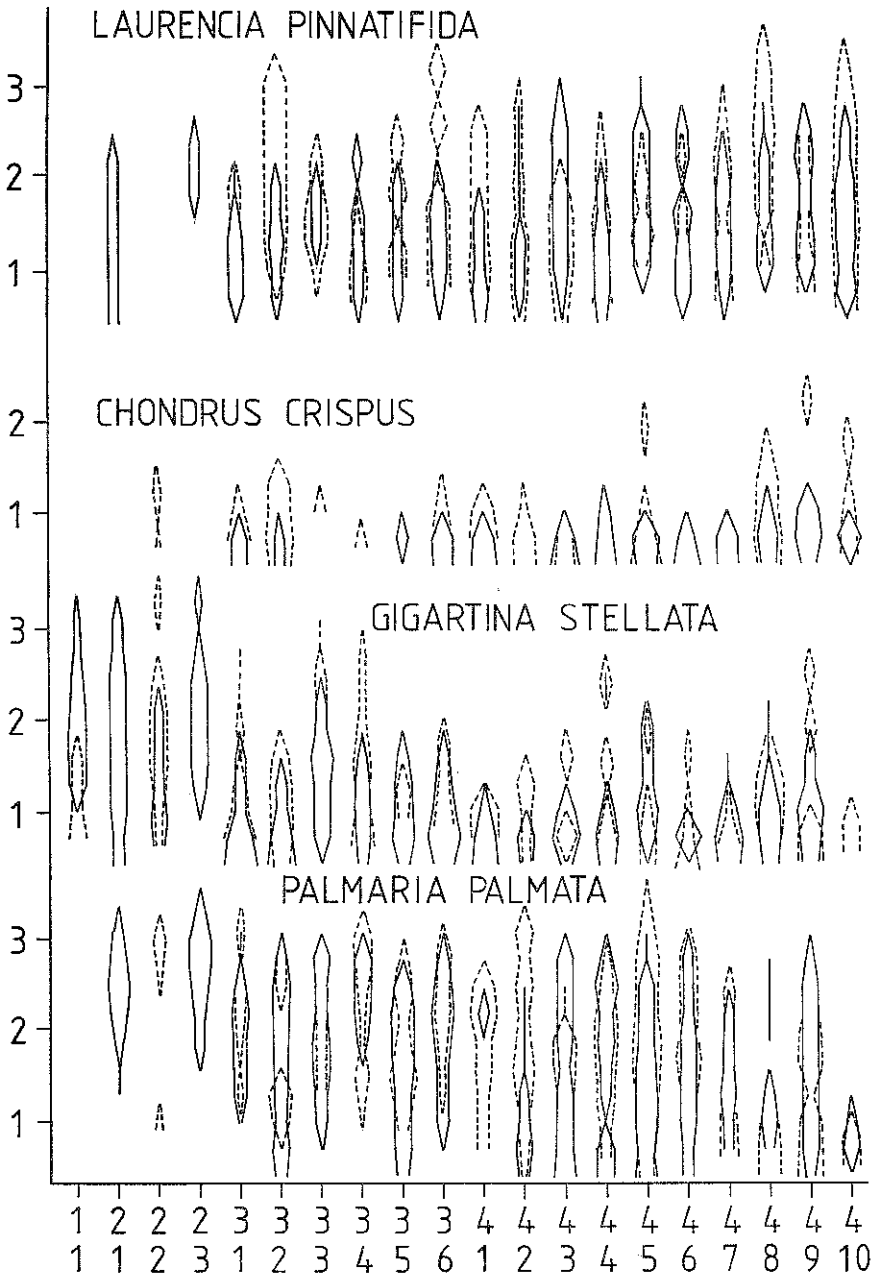

FIG. 6A.

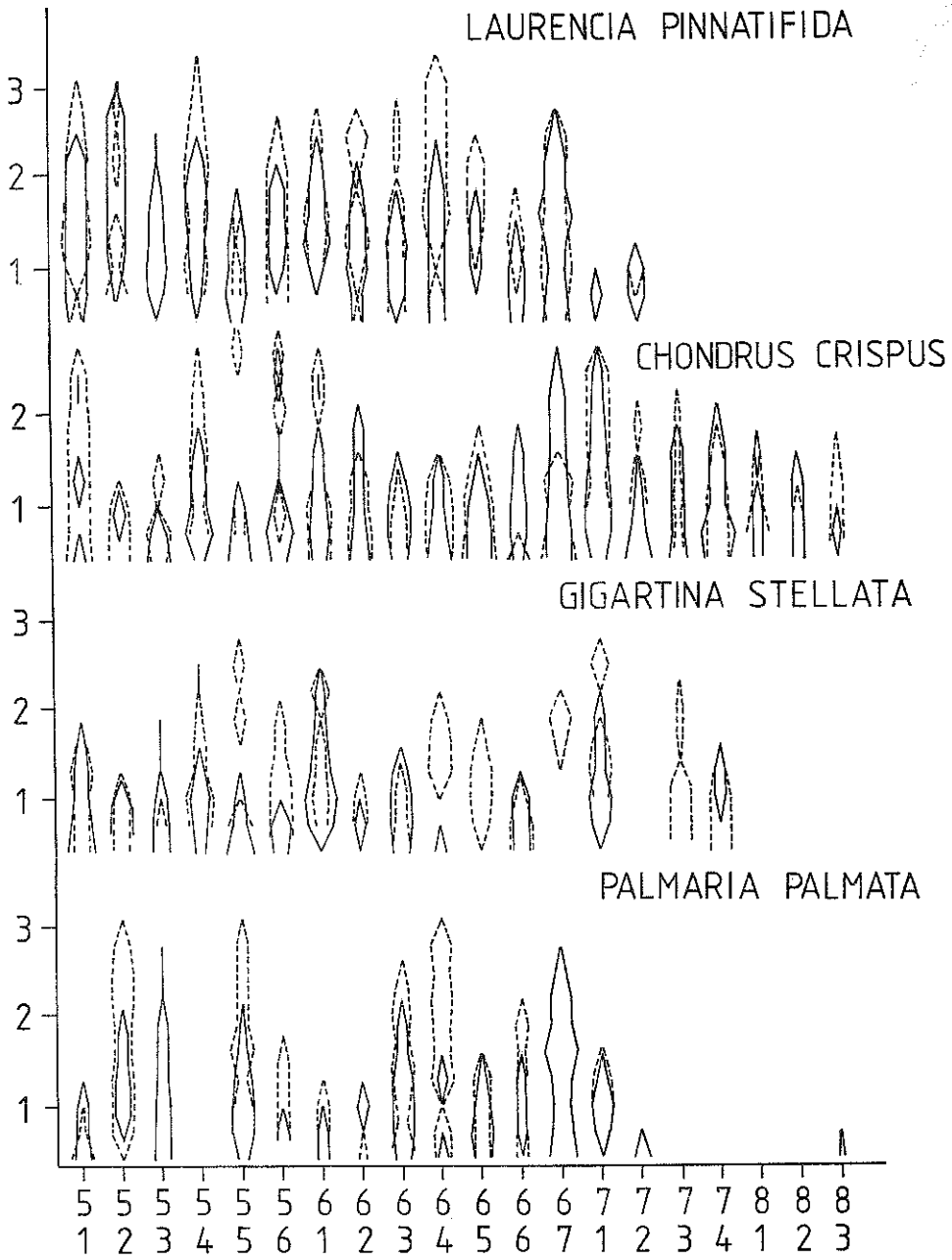

FIG. 6B.

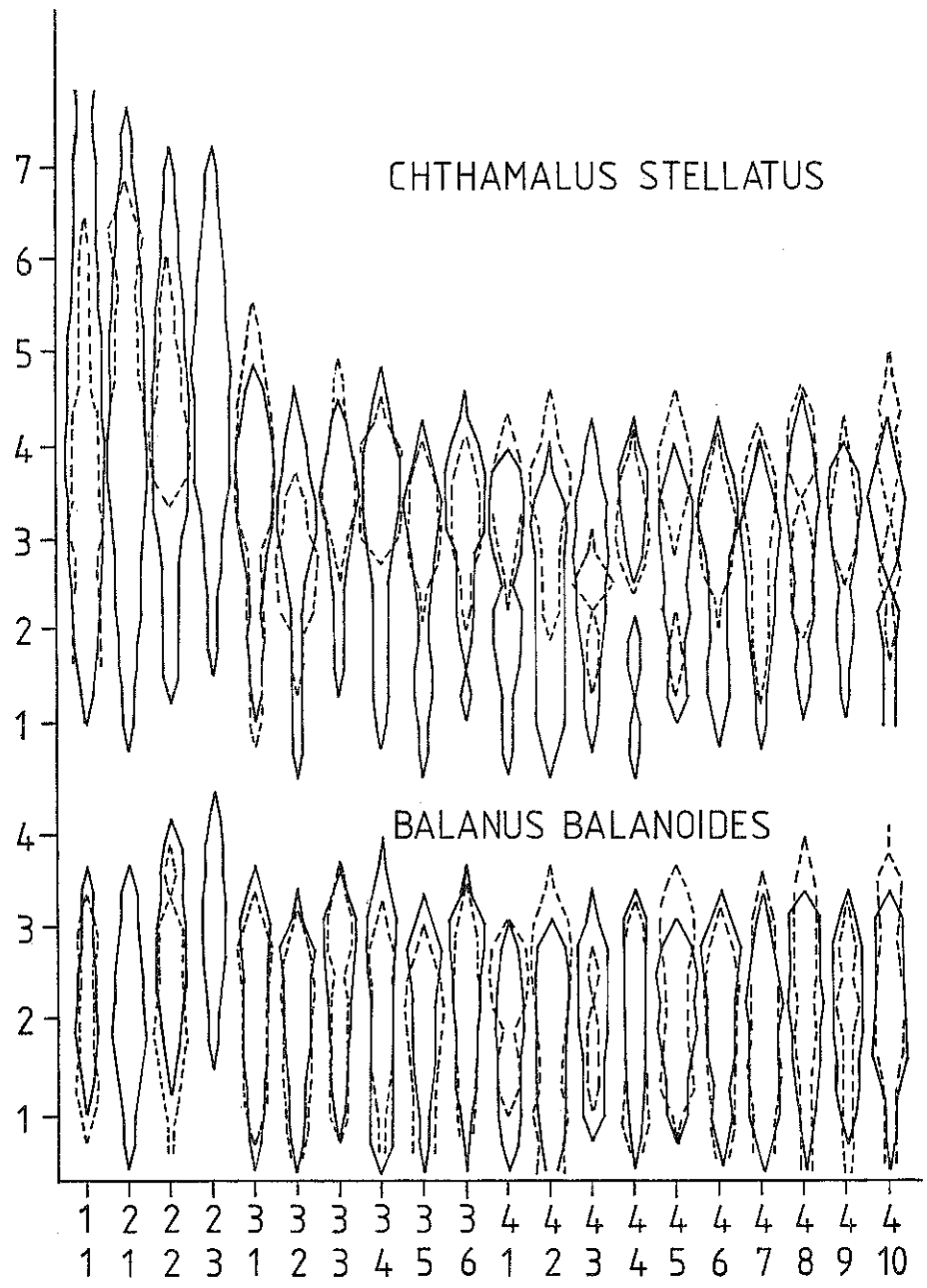

FIG. 7A.

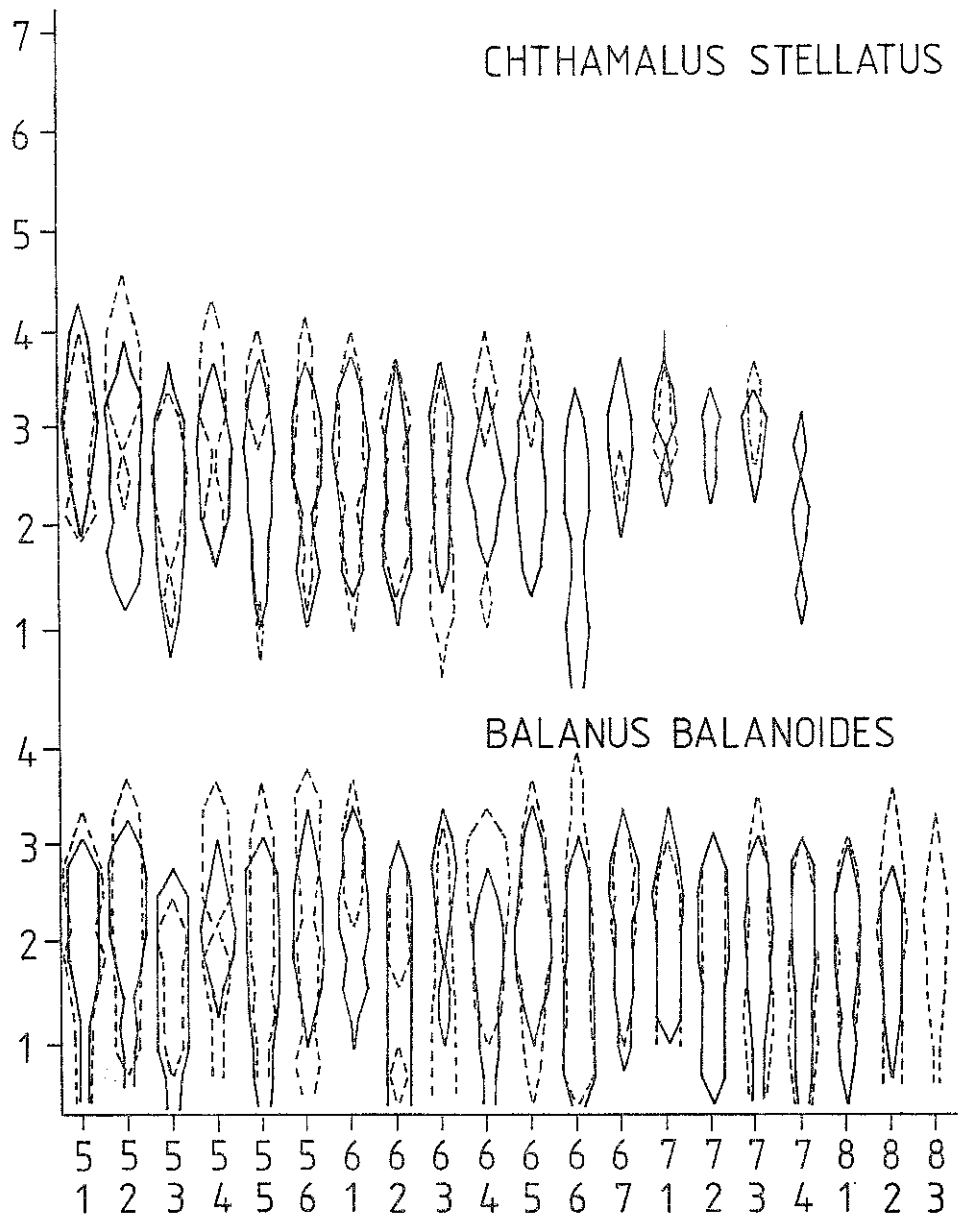

FIG. 7B.

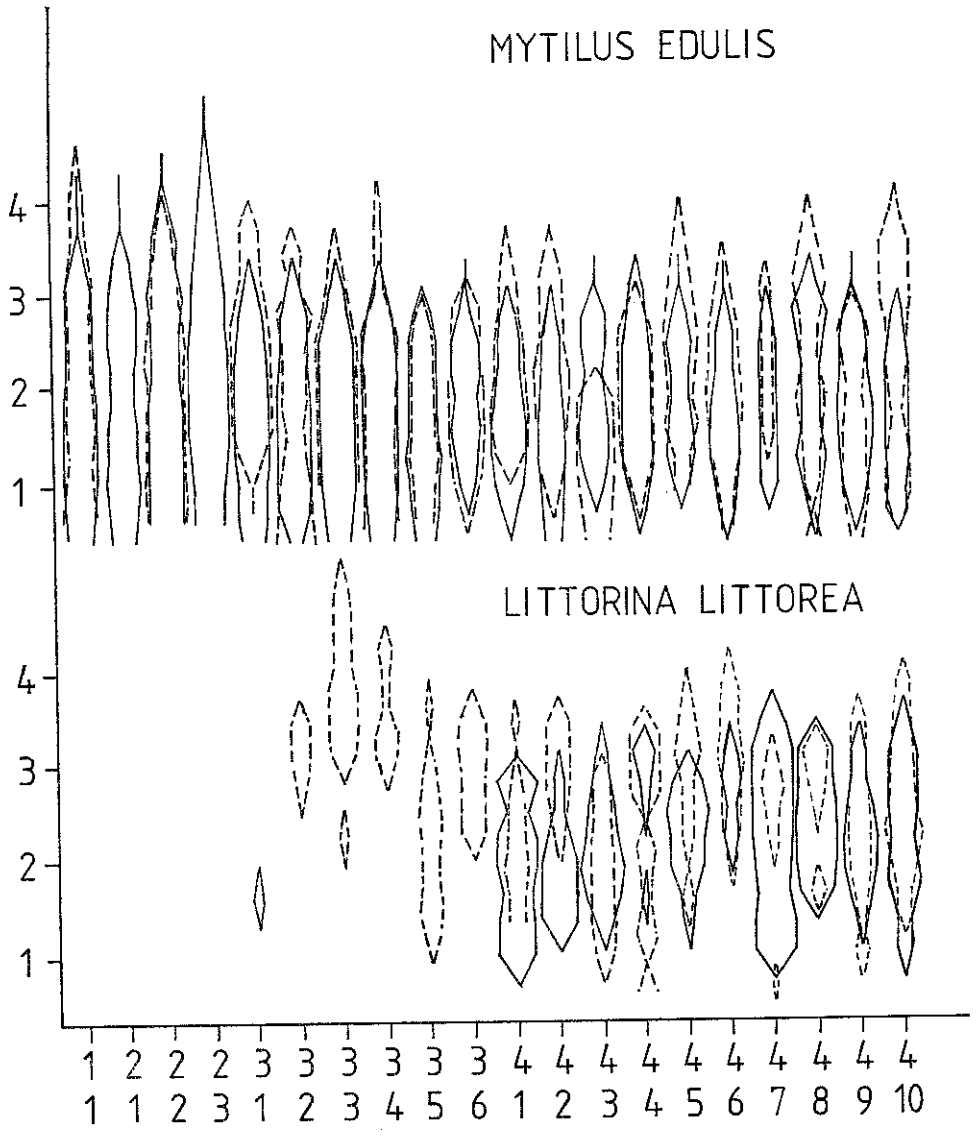

FIG 8A.

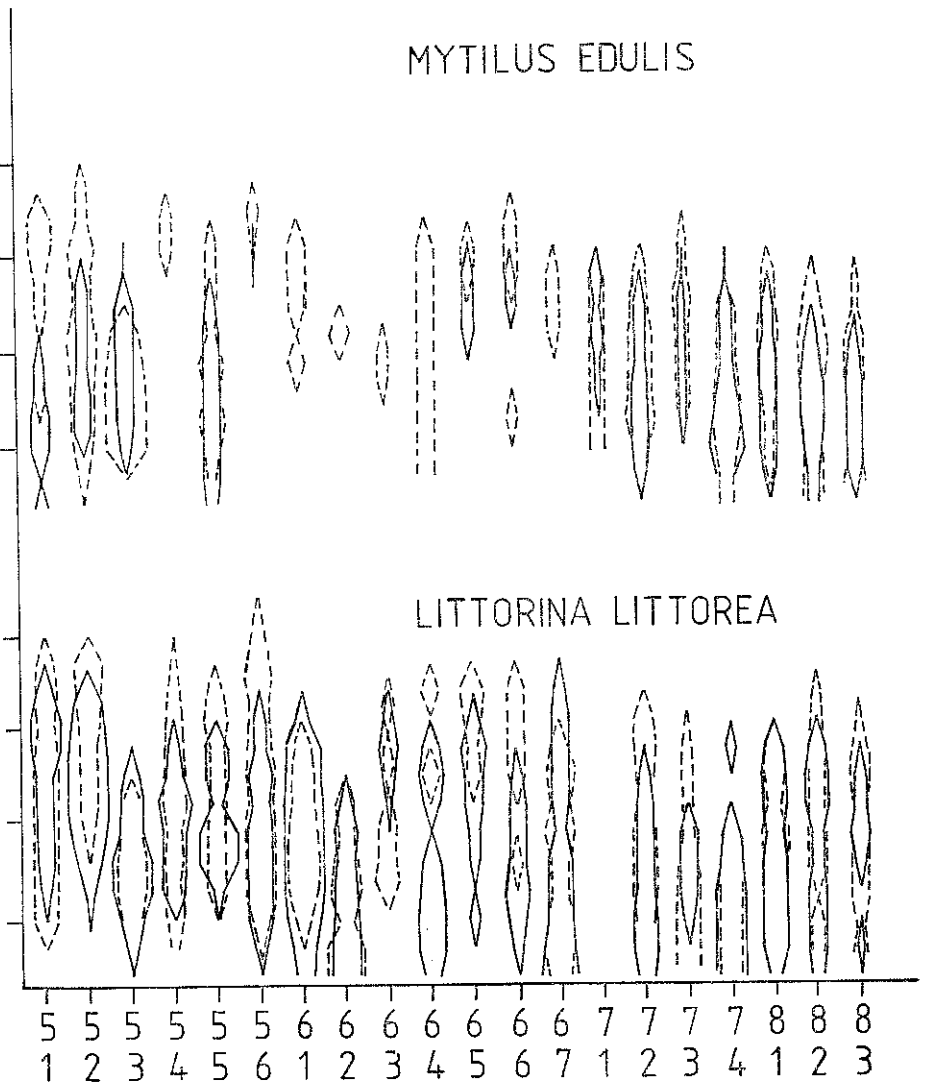

FIG. 8B.

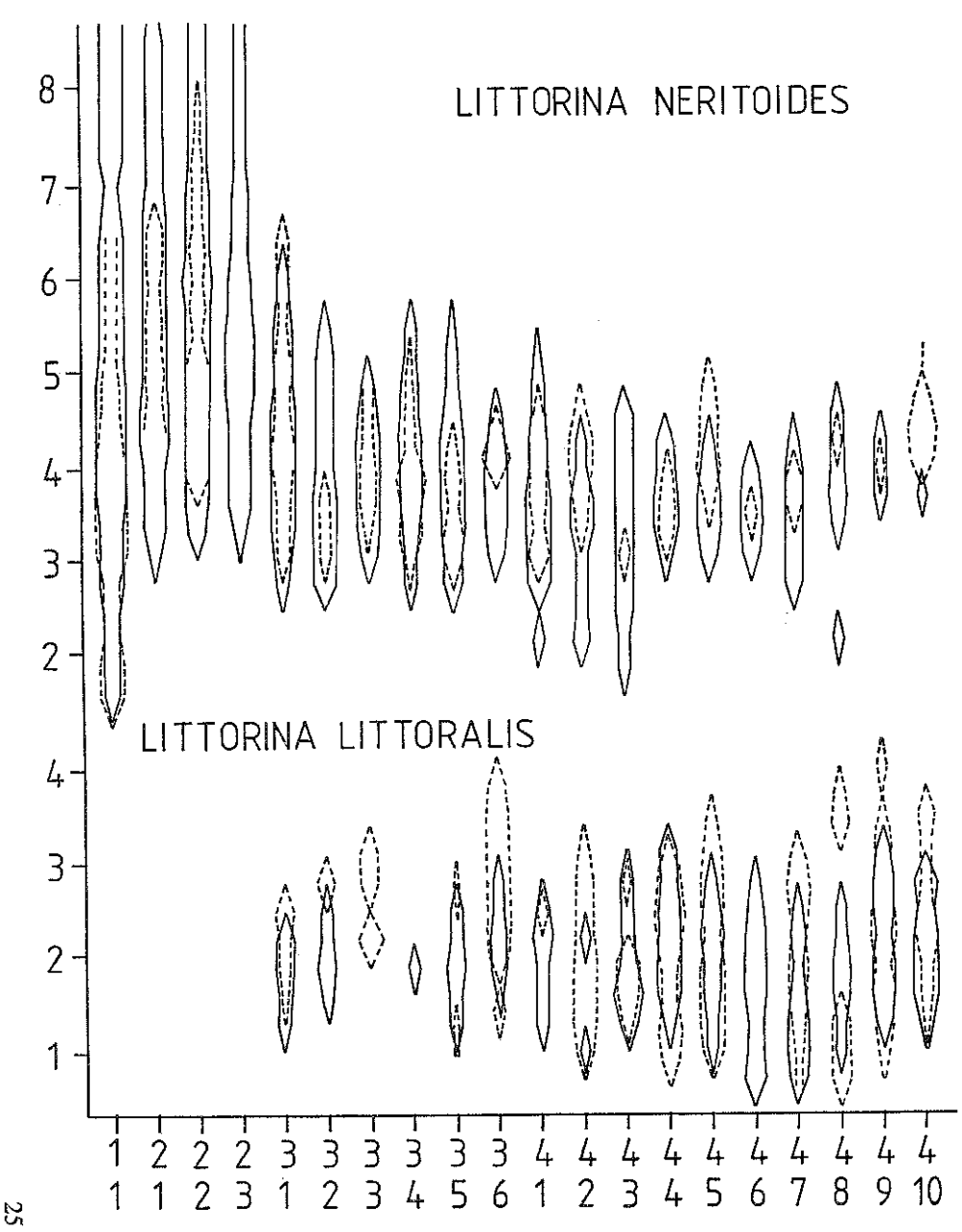

FIG. 9A.

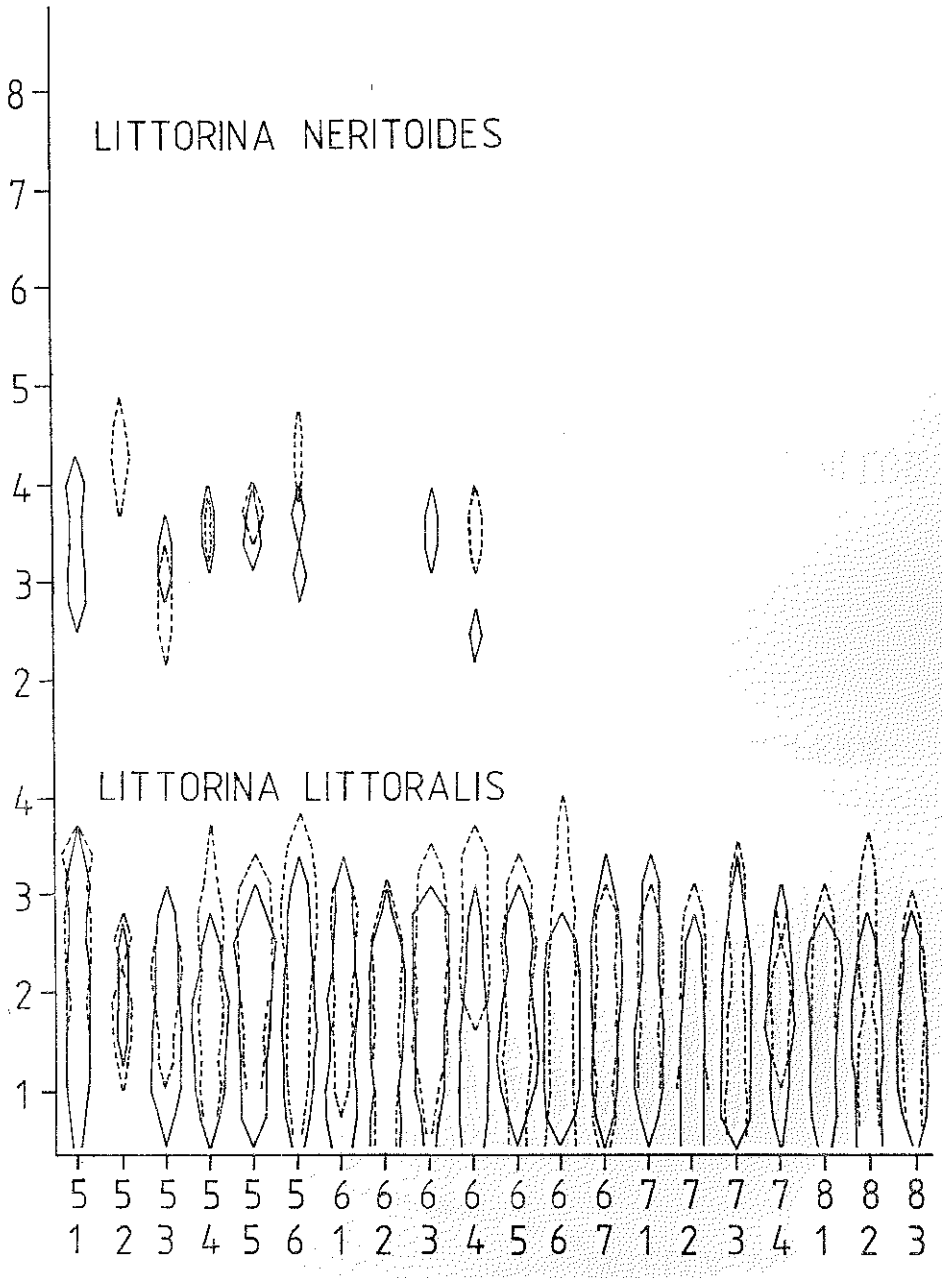

FIG. 9B.

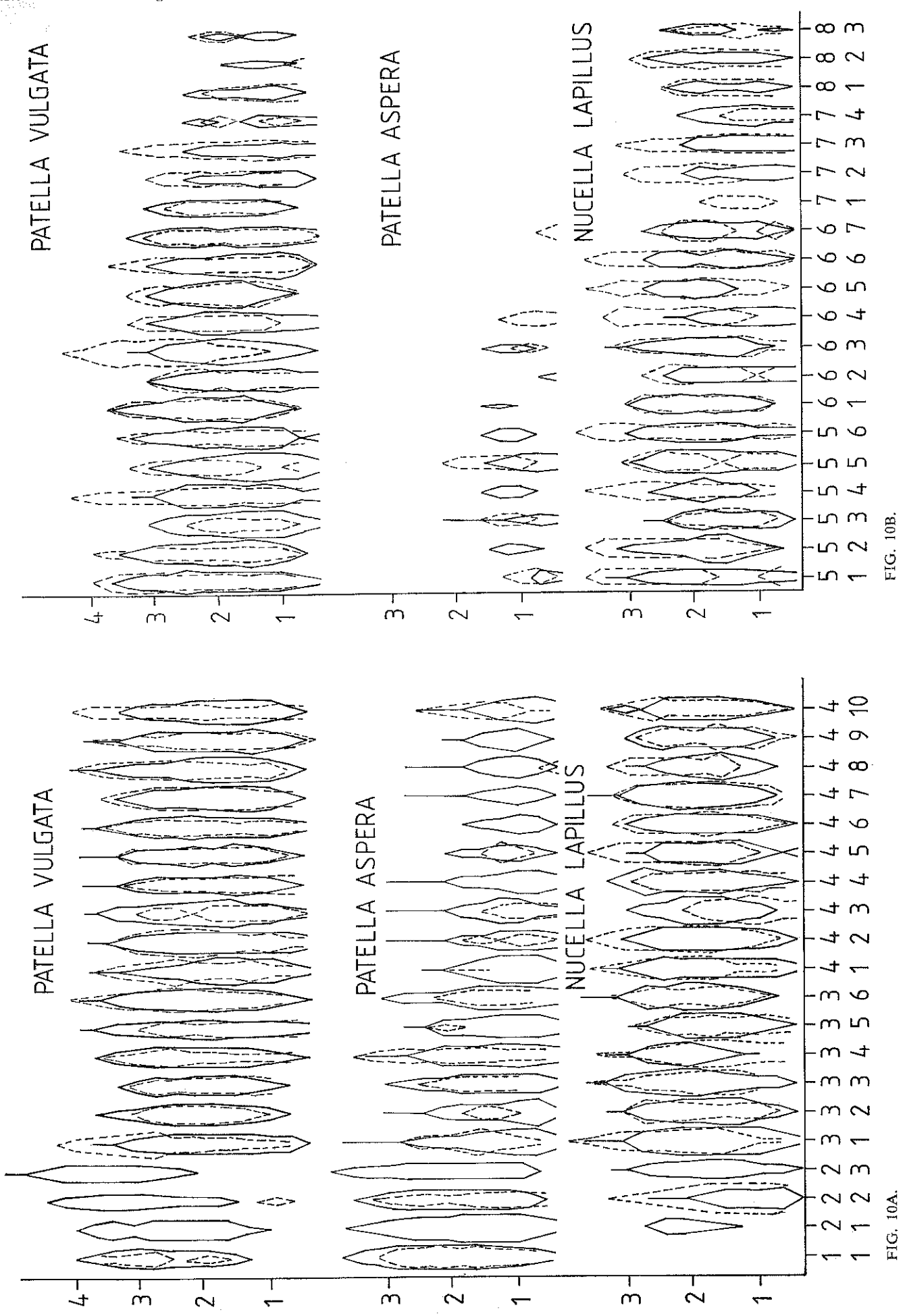

FIG. 10B.

FIG. 10A.

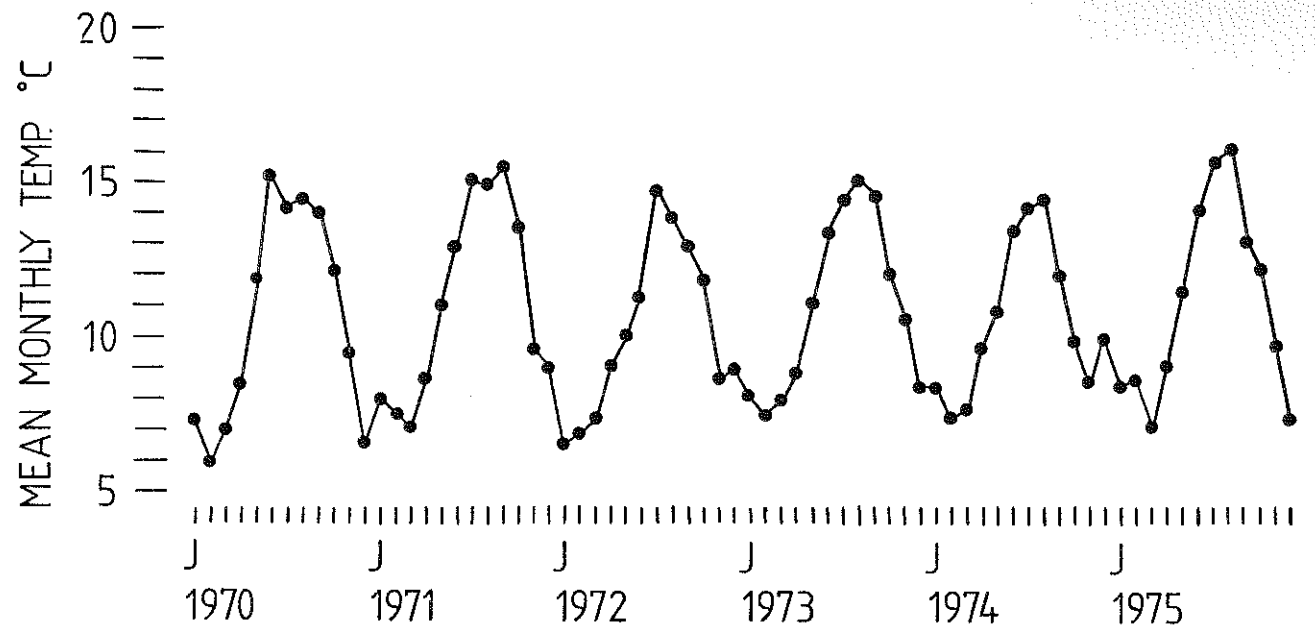

FIG. 11.

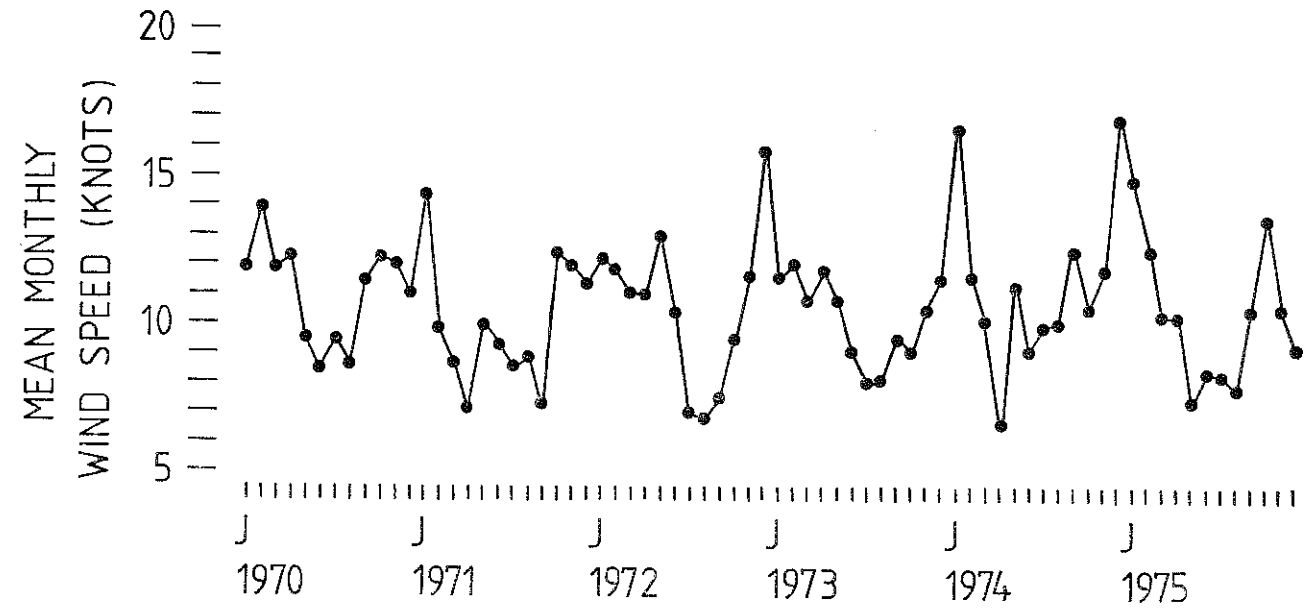

FIG. 12.

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