

MORPHOLOGICAL VARIATIONS IN *MYTILUS*
FROM THE IRISH COASTS
IN RELATION TO THE OCCURRENCE AND DISTRIBUTION
OF *M. GALLOPROVINCIALIS* Lmk.

by

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Résumé

Variations morphologiques chez *Mytilus* des côtes d'Irlande, en relation avec la fréquence et la distribution de *M. galloprovincialis* Lmk.

L'existence de *Mytilus galloprovincialis* en Irlande est confirmée. L'espèce se trouve le long de la plus grande partie de la côte méridionale et se continue vers le Nord, sur la côte occidentale, jusqu'à Donegal. Cependant, sur les rivages où la salinité est réduite de manière décelable, *M. galloprovincialis* est considérablement plus rare.

M. edulis et *M. galloprovincialis* montrent tous les deux une variation morphologique nette avec l'âge et la grande variété des conditions locales de leur habitat. Le nombre anormalement grand d'individus à caractères intermédiaires dans plusieurs populations peut être, d'autre part, l'indice d'une hybridation considérable entre ces deux espèces dans cette zone particulière de leur distribution géographique.

Introduction

Recent investigations have shown that on the coasts of France and south-west England there exist two relatively distinct types of *Mytilus*: *M. edulis* L. and *M. galloprovincialis* Lmk. the Mediterranean mussel (Lewis and Seed, 1969; Seed, 1972). Although both forms show considerable variability, especially in their gross shell morphology, other features of the shell and mantle edge proved relatively more reliable taxonomic criteria.

In addition to the various morphological differences that exist between these mussels, further detailed investigations of co-existing populations from the Padstow area of Cornwall have indicated that several other differences exist which strengthen the case for regarding these mussels as distinct species at least in that part of their geographical range (Seed, 1971). These include differences in their infection with *Pinnotheres pisum* (Penn.) together with differences in their reproductive cycles, growth rates and protein electrophoretic patterns.

Whilst the occurrence and distribution of *M. galloprovincialis* in British waters have been recorded previously, e.g. Hepper (1957), few records are available of this mussel in Ireland even though as a Mediterranean species its presence might be expected, especially on the south and west coasts where climatic conditions are remarkably equable. Baird is reported by Hepper (p. 36) to have collected *M. galloprovincialis* at Castletownbere whilst its presence in the Lough Ine region of County Cork is reported by Kitching *et al.* (1959) and Ebling *et al.* (1960).

During the summer of 1970, the author made extensive collections of *Mytilus* from various localities around the Irish coasts. This paper describes the morphological variation found in these mussels, especially in relation to the occurrence and distribution of *M. galloprovincialis*.

A SUMMARY OF THE MAIN DIFFERENCES BETWEEN *M. EDULIS* AND *M. GALLOPROVINCIALIS*

Although detailed descriptions of these mussels are given elsewhere in the literature (Lewis and Seed, 1969), some of the more salient differences between them, which have previously proved to be particularly useful taxonomic characters, can be summarised as follows.

il Colour of the mantle edge:

Typically in *galloprovincialis* this is deep purple-violet in contrast to the yellowy-brown colour more usually found in *M. edulis*. Intermediate shades can, however, be encountered.

2) Size and shape of the hinge plates and anterior adductor muscle scars:

Generally reliable taxonomic characters, these structures tend to be considerably smaller in *galloprovincialis* than in *edulis* of similar shell length.

3) Raying and general shell colour:

Shells of *M. edulis* typically have longitudinal rays of deeper colour (though these may be obscured by shell erosion especially on exposed shores) whereas in *galloprovincialis* these rays are usually absent. In addition, the prismatic shell of *edulis* is frequently much deeper blue in contrast to the more purple-violet colour of *galloprovincialis*.

4) Shell characteristics:

It is in their gross shell morphology that the greatest variation between these two mussels has previously been found since these

characters appear to be most subject to phenotypic expression. Consequently, animals of almost every conceivable shape can be found from one locality to another. Considerable variation can also be observed even within the same locality according to the relative ages of the individual mussels in the population. Perhaps the most reliable external shell character is the tendency towards a more pointed and downturned anterior end in *galloprovincialis*, a feature often associated with some form of beaking (Plate 2, G7 and 12) or prominent umbo-lunule swelling (Plate 2, G9 and 11). Differences in shell height and transverse profile together with the degree of

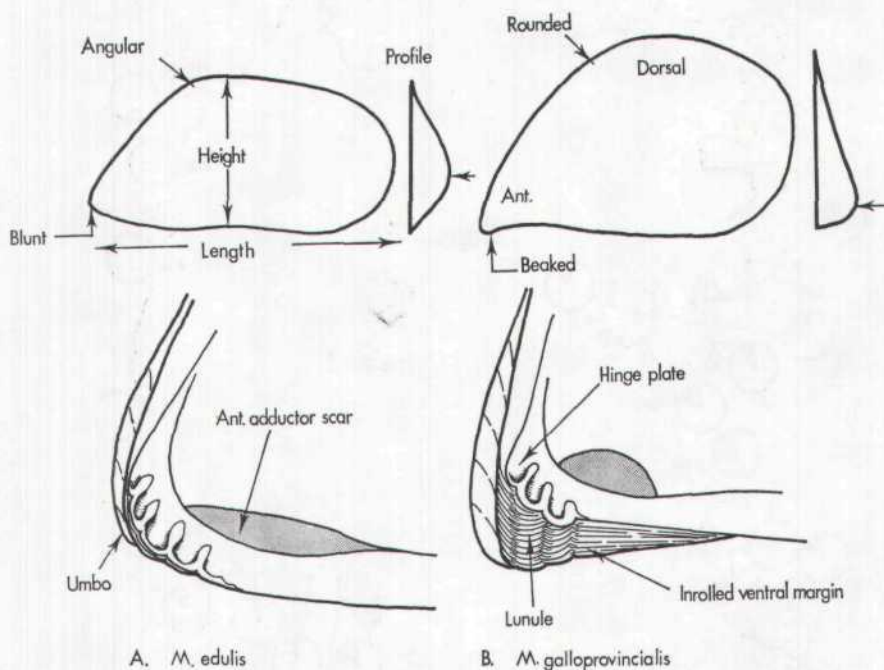


FIG. 1

Diagram illustrating some of the terminology used in the text.

angularity of the dorsal shell margin have previously proved to be of more limited value in field identifications. Some of the terminology used to describe mussel shells is illustrated in Figure 1.

COLLECTION AND TREATMENT OF MATERIAL

Figure 2 and Table 1 show the localities on the Irish coast from which samples were collected during this investigation. Although samples were taken from various types of habitats, collections were made wherever possible in sheltered harbours and estuaries, since previous experience has indicated that it is in these habitats that the

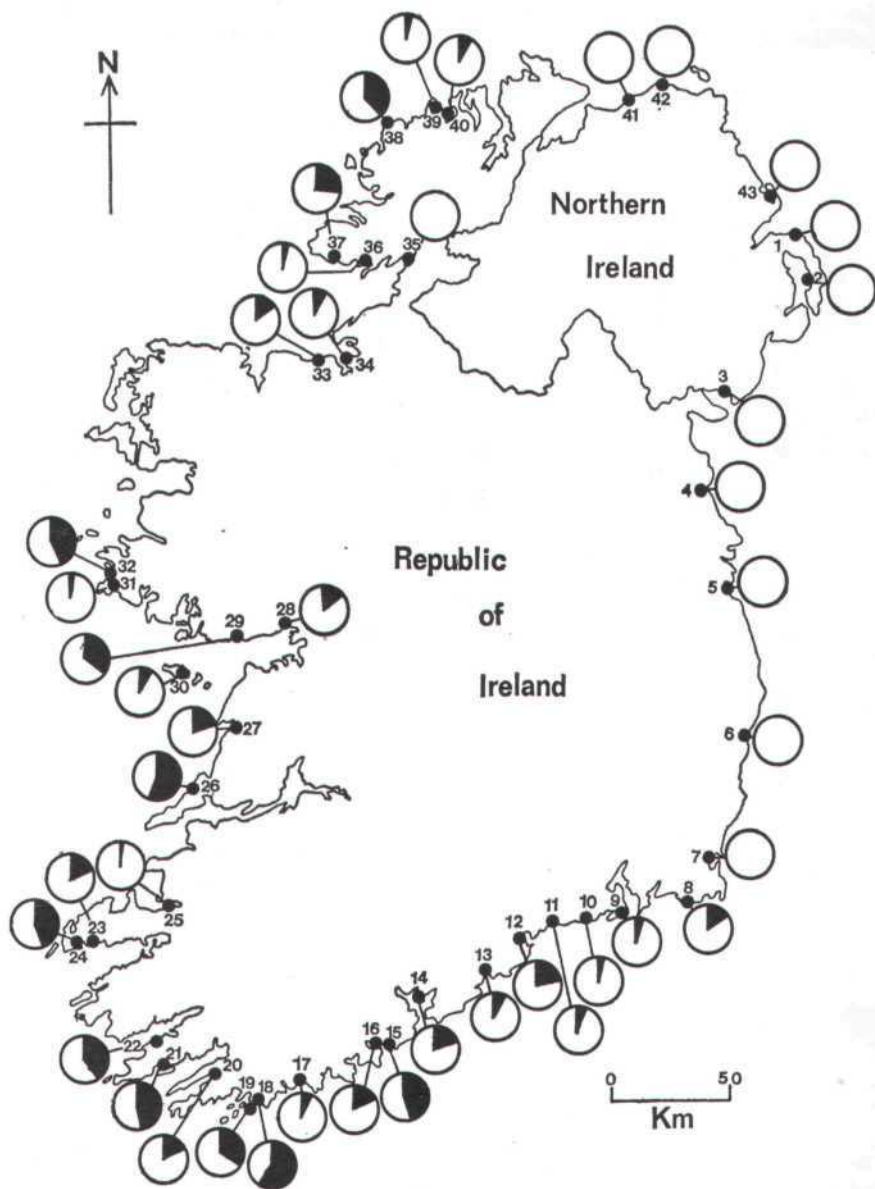


FIG. 2

Map showing the localities investigated and the relative percentage abundance of *M. galloprovincialis* (black).
For the names of the stations refer to Table 1.

various shell characters can be combined in single animals to produce mussels which are most distinctive in appearance. On exposed shores, on the other hand, especially at high tidal levels where many old individuals occur, shell characters often merge so that identification on external features alone can be difficult or even impossible. Large numbers of mussels were examined in the field and random samples

TABLE 1
Characteristic features of the shores investigated.

Station N°	Place Name	Type of Shore	Station N°	Place Name	Type of Shore
1	Bangor	Semi-exposed rock	21	Castletownbere	Sheltered harbour
2	Grey Abbey	Sheltered boulders	22	Ardgroom	Semi-exposed rock
3	Rostrevor	Sheltered boulders	23	Dingle	Sheltered harbour
4	River Boyne	Sub-littoral	24	Ventry	Sheltered stones and gravel
5	Salthill	Semi-exposed boulders	25	Tralee	Sheltered boulders
6	Arklow	Sub-littoral	26	Kilkee	Exposed rock
7	Wexford Harbour	Sheltered boulders and gravel	27	Lahinch	Exposed rock
8	Kilmore Quay	Exposed rock	28	Galway	Sub-littoral
9	Dunmore East	Exposed rock	29	Spiddal	Semi-exposed rock
10	Bor Strand	Exposed rock	30	Aran Isles	Sub-littoral
11	Annestown	Exposed rock	31	Clifden	Sheltered harbour
12	Dungarvan	Sheltered harbour	32	Clifden	Semi-exposed rock
13	Youghal	Sheltered stones and gravel	33	Aughris Head	Exposed rock
14	Cobh	Sheltered stones and gravel	34	Strandhill	Sheltered boulders
15	Summer Cove	Sheltered jetty	35	Donegal	Sheltered harbour
16	Kinsale	Sheltered bridge supports	36	Killybegs	Sheltered jetty
17	Roscarberry	Exposed rock	37	Carrick	Exposed rock
18	Lough Ine	Sheltered jetty	38	Bloody Foreland	Semi-exposed jetty
19	Carrigathorna	Exposed rock	39	Dunfanaghy	Sheltered boulders
20	Durrus	Sheltered bridge supports	40	Port-na-Blagh	Semi-exposed rock
			41	Portstewart	Exposed rock
			42	Giant's Causeway	Exposed rock
			43	Larne Lough	Sheltered boulders

each generally of between 50-150 animals brought back to the laboratory for more detailed examination.

Mussels were opened immediately after collection and separated into those with purple mantles and those in which the mantle was yellowy-brown. The soft tissues were then removed and discarded and the shells sealed in plastic bags for subsequent laboratory analyses. These shells were boiled in soda to remove the periostracum and clean the hinge plates and adductor scars. Measurements were then made of shell length, height, adductor scar and hinge plate lengths and the following ratios computed—length: height, adductor scar length: shell length (X 1,000) and hinge plate length: shell length (X 1,000). Finally, a note was made of the general shell shape and whether longitudinal rays were present.

For each of the above taxonomic characters it was possible to identify each mussel as *edulis*, intermediate or *galloprovincialis* and an appropriate score of 2, 1 or 0 could be given accordingly. Since five characters were in fact used, any mussel could score a total number of points varying from 0 (where only *galloprovincialis* characters occurred) to 10 (entirely *edulis*). A final somewhat arbitrary separation into *galloprovincialis* (0-3 points) intermediate (4-6 points) and *edulis* (7-10 points) could then be made after considering all the information available for each mussel. However, previous experience

TABLE 2
Shell characteristics of *M. edulis* and *M. galloprovincialis*.

Locality	<i>M. edulis</i>						<i>M. galloprovincialis</i>					
	Shell		L H	(1) AAS	(2) HP	Per cent Rayed	Shell		L H	(1) AAS	(2) HP	Per cent Rayed
	Length (cm)	Height (cm)		L	L		Length (cm)	Height (cm)		L	L	
Bangor	4.69	2.37	1.98	100	115	80						
Grey Abbey	5.39	2.60	2.07	98	104	75						
Rostrevor	5.25	2.58	2.03	104	104	80						
River Boyne	6.53	3.15	2.07	99	94	85						
Salthill	4.12	2.03	2.03	100	110	87						
Arklow	4.73	2.22	2.13	96	70	96						
Wexford	6.08	2.94	2.07	113	85	79						
Kilmore Quay	3.01	1.43	2.10	86	80	52	3.18	1.48	2.15	75	55	7
Dunmore	2.32	1.20	1.93	93	101	29	*2.29	1.17	1.96	93	59	0
Bor Strand	2.23	1.13	1.97	89	101	20	*2.12	1.01	2.10	58	44	0
Annestown	2.66	1.25	2.13	89	91	28	*3.15	1.48	2.13	68	59	0
Dungarvan	4.50	2.33	1.93	98	82	66	4.50	2.37	1.90	88	61	0
Youghal	5.00	2.58	1.94	95	78	74	*4.76	2.60	1.83	70	58	25
Cobh	4.58	2.42	1.89	96	74	70	4.53	2.44	1.86	78	57	8
Summer Cove	3.72	2.08	1.79	96	93	46	4.14	2.21	1.87	77	59	5
Kinsale	4.79	2.50	1.92	103	79	85	4.81	2.50	1.92	83	57	12
Roscarberry	2.29	1.11	2.06	80	84	16	*2.48	1.05	2.36	59	58	0
Lough Ine	4.19	2.21	1.90	95	80	47	4.36	2.30	1.90	78	62	13
Carrigathorna	2.87	1.32	2.17	74	80	31	2.79	1.25	2.23	62	58	3
Durrus	4.62	2.57	1.80	99	86	63	4.29	2.29	1.87	79	57	6
Castletownbere	5.24	2.81	1.86	89	80	55	5.12	2.80	1.83	73	58	4
Ardgroom	3.36	1.67	2.01	79	71	34	3.28	1.68	1.95	65	55	0
Dingle	5.19	2.97	1.75	96	83	72	4.45	2.48	1.79	79	57	0
Ventry	3.94	1.95	2.02	89	87	55	4.27	2.13	2.00	70	55	0
Tralee	4.36	2.19	1.99	88	79	91	*3.90	2.10	1.86	72	77	0
Kilkee	3.86	1.86	2.08	74	74	32	3.90	1.86	2.10	53	58	6
Lahinch	2.89	1.45	1.99	88	76	57	3.16	1.48	2.14	71	52	10
Galway	4.74	2.47	1.92	102	99	90	*3.78	2.02	1.87	85	73	0
Spiddal	3.06	1.62	1.89	85	87	37	3.10	1.66	1.87	74	58	5
Aran Island	4.48	2.36	1.90	87	83	74	*4.43	2.29	1.93	79	60	0
Clifden Harbour	5.25	2.83	1.86	91	85	81	*5.26	2.86	1.84	70	63	20
Clifden Semi-exposed	4.44	2.42	1.83	90	86	85	4.45	2.40	1.85	68	57	22
Aughris Head	2.92	1.50	1.95	86	91	28	2.99	1.57	1.90	73	58	0
Strandhill	5.37	2.71	1.98	94	85	44	5.05	2.63	1.92	72	56	0
Donegal	5.61	3.00	1.87	106	90	74						
Killybegs	5.50	2.65	2.08	89	82	81	*5.00	2.55	1.96	79	62	25
Carrick	3.19	1.52	2.10	80	73	22	3.17	1.53	2.07	60	56	0
Bloody Foreland	4.45	2.26	1.97	84	78	32	4.32	2.19	1.97	70	55	3
Dunfanaghy	6.09	3.16	1.93	97	90	65	*5.12	2.62	1.95	82	55	0
Port-na-Blagh	2.78	1.34	2.07	76	85	32	*2.60	1.25	2.08	61	57	0
Portstewart	2.93	1.47	1.99	81	87	20						
Giant's Causeway	3.04	1.48	2.05	72	77	14						
Larne Lough	5.15	2.53	2.04	101	97	83						

(*) Based on samples of less than 10 individuals.
(1) AAS = Anterior Adductor muscle scar.
(2) HP = Hinge Plate.

has shown that certain characters and combination of characters are more reliable than others. For example, gross shell morphology in both mussels is capable of considerable phenotypic expression, whilst the absence of longitudinal rays in otherwise normal *edulis* is not uncommon, especially in areas where considerable shell erosion occurs. In view of this, those animals scoring 4, 5 or 6 points were carefully re-examined in order to see whether any justification could be found for reassigning them to one species or the other.

TABLE 3

Separation of samples on individual characters together with a final separation based upon a weighted assessment of all characters.

Locality	No. in sample	Final (per cent) separation (1)		Separation on individual characters (percentage)												
				Shell characters		Rayed (edu-lis)	Hinge plate		Adductor scar		Mantle colour					
		ed	% gall	ed	% gall		ed	% gall	ed	% gall	ed	gall				
Bangor	56	98	2	0	91	9	0	80	96	4	0	73	18	9	96	4
Grey Abbey	53	100	0	0	98	0	2	75	94	6	0	89	11	0	94	6
Rostrevor	55	100	0	0	93	7	0	80	96	4	0	92	4	4	98	2
River Boyne	52	100	0	0	100	0	0	85	98	2	0	98	0	2	100	0
Salthill	55	100	0	0	100	0	0	87	98	2	0	85	11	4	98	2
Arklow	50	100	0	0	100	0	0	96	84	6	0	98	2	0	100	0
Wexford	71	99	1	0	100	0	0	79	86	12	2	95	3	2	100	0
Kilmore Quay	91	66	22	16	83	9	8	33	57	20	23	62	17	21	59	41
Dunmore	48	79	15	6	83	13	4	23	81	6	13	96	0	4	56	44
Bor Strand	54	81	15	4	85	9	6	17	80	9	11	82	11	7	81	19
Annestown	56	90	5	5	87	9	4	25	78	13	9	94	2	4	84	16
Dungarvan	105	61	16	23	71	18	11	41	49	21	30	47	27	26	73	27
Youghal	100	87	5	8	90	6	4	67	69	18	13	77	14	9	92	8
Cobh	117	68	12	20	74	15	11	50	52	20	28	58	23	19	74	26
Summer Cove	44	30	25	45	50	30	20	23	34	14	52	18	23	59	66	34
Kinsale	98	76	7	17	77	17	6	69	57	16	27	77	13	10	74	26
Roscarberry	43	74	19	7	93	5	2	12	69	12	19	79	2	19	65	35
Lough Ine	151	21	21	58	30	30	40	22	18	26	56	13	23	97	57	43
Carrigathorna	99	36	32	32	57	24	19	13	34	33	33	17	41	42	75	25
Durrus	88	64	18	18	68	22	10	45	58	12	24	45	23	32	82	18
Casteltownbere	100	31	21	48	43	26	31	22	33	17	50	17	35	48	56	44
Ardgroom	87	37	25	38	67	18	15	15	36	17	47	18	32	50	56	44
Dingle	56	70	10	20	66	23	11	57	59	16	25	34	32	34	79	21
Ventry	23	48	9	43	61	26	13	30	35	30	35	39	26	35	48	52
Tralee	54	83	15	2	92	6	2	87	74	15	11	46	39	15	96	4
Kilkee	119	21	25	54	44	45	11	13	17	23	60	9	30	61	70	30
Lahinch	103	58	22	10	77	15	8	38	43	30	27	56	22	22	72	28
Galway	50	82	4	14	78	10	12	74	76	6	18	84	8	8	—	—
Spiddal	67	45	22	33	58	25	17	21	48	15	37	28	30	42	66	34
Aran Island	31	74	16	10	84	13	3	58	52	26	22	77	23	0	—	—
Clifden																
Harbour	97	72	23	5	82	16	2	64	65	20	15	37	26	37	85	15
Clifden semi-exposed	62	44	13	43	34	32	34	55	27	15	58	18	22	60	68	32
Aughris Head	78	68	17	15	63	17	20	21	67	14	19	55	27	18	77	23
Strandhill	100	78	12	10	77	21	2	37	70	15	15	69	10	21	90	10
Donegal	77	95	5	0	92	8	0	73	87	9	4	92	7	1	94	6
Killybegs	91	88	8	4	89	8	3	74	85	10	5	84	11	5	86	14
Carrick	53	51	23	26	75	4	21	11	43	17	40	36	32	32	85	15
Bloody																
Foreland	95	39	24	37	59	20	21	16	31	29	40	38	28	34	69	31
Dunfanaghy	93	90	5	5	78	16	6	58	90	5	5	90	8	2	88	12
Port-na-Blagh	69	72	18	10	81	16	3	25	58	22	20	49	36	15	80	20
Portstewart	64	69	31	0	75	17	8	14	80	14	6	36	47	17	61	39
Giant's Causeway	52	69	31	0	94	4	2	10	61	33	6	41	38	21	71	29
Larne Lough	55	98	2	0	96	4	0	83	95	5	0	92	5	3	—	—

(1) Individuals of intermediate character.

(1) Individuals of intermediate character.

A summary of these results is given in Tables 2 and 3. Knowing the final identity of each mussel after considering all the available information, it was then possible to assess the percentage in each sample that would have been incorrectly identified using the individual characters alone. Such information, summarised in Table 4, provides a valuable indication of the reliability of the various taxonomic characters in each locality investigated as well as for *Mytilus* generally.

TABLE 4

Percentages of animals in each sample which could not be positively identified or which were incorrectly identified on individual characters. This table excludes those animals where no final positive identification was possible.

Locality	Final per cent separation			Percentage misidentified on individual characters				
	ed	?	gall	Shell characters	Hinge plate	Adductor scar	Raying	Mantle colour
Bangor	98	2	0	9	4	27	20	4
Grey Abbey	100	0	0	2	6	11	25	6
Rostrevor	100	0	0	7	4	8	20	2
River Boyne	100	0	0	0	2	2	15	0
Salthill	100	0	0	0	2	15	13	2
Arklow	100	0	0	0	8	2	4	0
Wexford	99	1	0	1	14	5	21	1
Kilmore Quay	62	22	16	23	17	20	39	25
Dunmore	79	15	6	7	2	5	66	34
Bor Strand	81	15	4	11	9	9	76	9
Annestown	90	5	5	8	13	8	68	13
Dungarvan	61	16	23	19	19	38	25	19
Youghal	87	5	8	7	21	15	25	4
Cobh	68	12	20	15	24	25	25	19
Summer Cove	30	25	45	52	9	24	24	24
Kinsale	76	7	17	20	22	19	14	14
Roscarberry	74	19	7	6	14	11	77	31
Lough Ine	21	21	58	34	19	26	23	32
Carrigathorna	36	32	32	36	28	48	37	34
Durrus	64	18	18	21	15	32	31	25
Castletownbere	31	21	48	30	14	34	20	33
Ardgroom	37	25	38	31	22	32	32	34
Dingle	70	10	20	28	16	48	22	12
Ventry	48	9	43	38	33	19	24	5
Tralee	83	15	2	2	15	46	9	7
Kilkee	21	25	54	63	26	29	24	46
Lahinch	58	22	20	20	36	24	35	30
Galway	82	4	14	8	8	12	10	—
Spiddal	45	22	33	33	17	31	38	31
Aran Island	74	16	10	12	27	23	23	—
Clifden Harbour	72	23	5	16	17	47	17	15
Clifden Semi-exposed	44	13	43	41	20	31	18	33
Aughris Head	68	17	15	18	15	31	58	20
Strandhill	78	12	10	20	14	11	42	9
Donegal	95	5	0	5	8	4	26	5
Killybegs	88	8	4	10	6	10	19	7
Carrick	51	23	26	10	29	29	51	32
Bloody Foreland	39	24	37	29	24	32	36	29
Dunfanaghy	90	5	5	17	0	6	33	7
Port-na-Blagh	72	17	10	19	19	40	60	23
Portstewart	69	31	0	11	14	50	80	27
Giant's Causeway	69	31	0	0	39	47	86	11
Larne Lough	100	0	0	3	6	10	17	0
Means:				17	16	23	33	18

THE RANGE OF SHELL VARIATION IN IRISH MUSSELS

A) Bangor-Wexford:

1. **Bangor** (Plate 1, A). Mussels were here collected from a semi-exposed rocky shore where relatively large individuals extended well into the littoral especially in pools and damp crevices. Many of these mussels were quite badly eroded and between 30-40 per cent showed some form of ventral incurvature indicative of animals of considerable age. The

majority were fairly typically *edulis* being blunt at the anterior end and rounded to slightly angular dorsally. Large hinge plates were a characteristic feature of these mussels and the mean ratio value of 115 was the highest recorded.

2. **Grey Abbey** (Plate 1, B). Situated on the east shore of Strangford Lough, this region is predominantly sandy, although relatively large fast-growing mussels are widespread on the boulders and stones which are exposed only at low water. The majority of these are rather more elongate than those from the previous site, but in all other respects are again typically *edulis*.

3. **Rostrevor** (Plate 1, C). Here mussels were again collected from low-level boulders in an otherwise mainly sandy area and the similarity between this locality on Carlingford Lough and Grey Abbey is paralleled by a remarkable similarity in the morphologies of the mussels. All again proved to be typical *edulis* with characteristically blunt umbones and dorsal margins which varied from rounded, to some that were quite markedly angular. Most were straight ventrally although a few obviously older individuals (about 5 per cent) were noticeably incurved.

4. **River Boyne estuary** (Plate 1, D). This sample of mussels from the commercial beds of the Boyne estuary were kindly sent to me by Mr. R.A. Meaney. They were the largest mussels examined during this investigation with many individuals measuring between 7 and 8 cm in shell length. They were all typical of *M. edulis* from this type of habitat where growth is extremely rapid and they showed a remarkable degree of uniformity in their external appearance. In these rather elongate mussels the ventral margin varied from straight to markedly convex, the umbones were blunt and the dorsal margins in most cases were slightly angular.

5. **Salthill** (Plate 1, E). Immediately north of Dun Laoghaire these mussels collected from semi-exposed stones and boulders were again typically *edulis*. All were extremely blunt, and whilst some were rounded dorsally most exhibited some degree of angularity. Ventrally their shells were either straight or convex, although a few were curiously incurved about half-way along their ventral margin (Plate 1, E4). Hinge plate ratios were here again amongst the highest currently recorded.

6. **Arklow** (Plate 1, F). The shores between Wicklow and Arklow are predominantly sandy, and the isolated outcrops of steep rock invariably proved to be rather barren with little else other than a few limpets and patches of stunted algae. No littoral mussels were encountered, although large numbers of brittle-shelled obviously fast-growing individuals had been washed up onto the shore where they formed extensive banks. Since these were still alive and in apparently good condition, it seemed probable that they had come from the immediate sublittoral—certainly large beds of mussels are known to occur off the coast of County Wexford some four to five miles further south (Meaney, 1970). These mussels had blunt umbones and extremely elongate shells (with a mean length-to-height ratio of 2.13) typical of animals growing in densely crowded conditions (Seed, 1968). Whilst all proved to be *M. edulis*, the hinge plate ratio of 70 is the lowest recorded for this species in the present investigation, although it is not unusually low for *edulis* in other parts of its geographical range.

7. **Wexford** (Plate 1, G). Here *Mytilus* was collected from the sheltered boulders and gravel in Wexford harbour, an area where mussels are grown commercially. This sample included some very large mussels over 7 cm in length all of which proved to be typical *edulis*. They had elongate shells with blunt umbones and the majority were slightly angular with straight to slightly convex ventral margins. The adductor scar ratio of 113 was the highest currently recorded and some of the shells were here quite badly infested with the boring sponge *Cliona*.

On the east coast of Ireland, therefore, between Bangor in the north and Wexford to the south, all the mussels examined during this investigation proved to be of the *edulis* type, many showing remarkable similarities in their external shell morphology.

B) Kilmore-Ardgroom:

1. **Kilmore Quay** (Plate 1, H). The only mussels collected in this region were those from the exposed rocks outside the harbour. These were all rather small and many were badly eroded, typical of *Mytilus* from this type of habitat. Whilst 16 per cent were finally identified as *galloprovincialis* the problem of identification is illustrated by the high percentage of intermediate animals in this sample. Externally there was very little difference between the two mussels except for a tendency towards a slightly more pointed anterior end in *galloprovincialis*. There was considerable variability in external shell morphology from some which had straight ventral margins to other much older animals that were markedly incurved (Plate 1, H²). The dorsal shell margin likewise showed a similar degree of variation.

2. **Dunmore East** (Plate 1, I). Due to unfavourable tides, the only mussels found in this region were in the middle and upper reaches of a quite severely exposed rocky shore. Apart from their smaller size these mussels were similar to those from Kilmore and many proved equally difficult to identify. Many were again badly eroded with raying of the shells discernible in less than 30 per cent of those finally identified as *M. edulis*. Although the adductor scar ratio of 93 was the highest recorded for *galloprovincialis* this figure is based only on three individuals.

3. **Bor Strand** (Plate 1, J). In this region the shores show a marked change, the predominantly sandy beaches to the east giving way to relatively steep, exposed, rocky cliffs to the west. As at Dunmore only the small, high-level mussel populations were attainable during this visit. These were once again badly eroded and many exhibited the ventral incurvature typically associated with old age. Only 4 per cent were positively identified as *galloprovincialis* (cf 6 per cent at Dunmore) and these were more pointed and distinctly beaked. *Edulis* shells were much blunter at the anterior but up to 50 per cent of the intermediate category had some indication of an umbo-lunule swelling more usually associated with *galloprovincialis*.

4. **Annestown** (Plate 1, M). Although another very exposed rocky shore, mussels were here collected from lower in the intertidal zone and were generally much larger and less badly eroded than at the two previous stations. Only 5 per cent were identified as *galloprovincialis* but these were distinctly more pointed and beaked than the generally blunter *edulis*. Mussels from this shore were rather elongate (with a mean length-to-height ratio of 2.13), a feature common in *Mytilus* grown in the densely crowded conditions one frequently encounters in this type of habitat. In addition, many of the shells had prominent growth rings suggesting—if one assumes these to be annual—an age of between 7 and 9 years for mussels measuring 3-3.5 cm in shell length.

5. **Dungarvan** (Plate 1, K). Dense clusters of quite large mussels were here found growing attached to the bridge supports in the upper reaches of the harbour. Although externally rather similar to *edulis* the majority of *galloprovincialis* in this sample were either slightly beaked or else had straight ventral margins associated with quite prominent umbo-lunule swellings. Most of the *edulis* had much blunter umbones and straight ventral margins, though a few were markedly convex and some were slightly incurved. The dorsal margin varied from some that were gently rounded to others that were distinctly angular. Whilst 25 per cent of this

PLATE 1

Mytilus from the Irish coast.

A-G *M. edulis* from : A - Bangor, B - Grey Abbey, C - Rostrevor, D - River Boyne, E - Salthill, F - Arklow, G - Wexford. H - Kilmore: 1-3, *edulis*; 4-6, *galloprovincialis*. I - Dunmore: 1-3, *edulis*; 4-6, *galloprovincialis*. J - Bor Strand: 1-2, *edulis*; 3-4, *galloprovincialis*. K - Dungarvan: 1-4, *edulis*; 5-8, *galloprovincialis*. L - Clonea: 1-2, *edulis*; 3-4, *galloprovincialis*. M - Annestown: 1-3, *edulis*; 4-6, *galloprovincialis*.



PLATE 1



R. SEED

PLATE 2

Mytilus from the Irish coast.

A - Youghal: 1-2, *edulis*; 3, *galloprovincialis*. B - Cobh: 1-3, *edulis*; 4-6, *galloprovincialis*. C - Summer Cove: 1-3, *edulis*; 4-6, *galloprovincialis*. D - Kinsale: 1-3, *edulis*; 4-6, *galloprovincialis*. E - Roscarberry: 1-4, *edulis*; 5-7, *galloprovincialis*. F - Durrus: 1-4, *edulis*; 5-8, *galloprovincialis*. G - Lough Ine: 1-6, *edulis*; 7-12, *galloprovincialis*. H - Carrigathorna: 1-4, *edulis*; 5-8, *galloprovincialis*.

sample proved to be *galloprovincialis*, a more superficial field examination of another sample from a nearby site in the harbour revealed only 7 per cent. On a semi-exposed bouldery shore at Clonea quite close to Dungarvan, a few isolated mussels were found (Plate 1, L). Of only 12 mussels examined 3 proved to be *galloprovincialis*, 7 were typically *edulis* and 2 were intermediate.

It is perhaps unfortunate that all the samples collected between Wexford and Dungarvan were from exposed shores where problems of identification are generally most acute since this region appears to represent the most easterly limit of distribution of *galloprovincialis* on Irish coasts.

6. Youghal (Plate 2, A). These quite large mussels were collected from stones and shell gravel in Youghal harbour. Although this sample contained only 8 per cent *galloprovincialis* this apparently low figure could possibly be due to the fresh-water stream which ran across the shore in the immediate vicinity of the mussel beds. *Gallopovincialis* has previously been shown to be rather less tolerant of estuarine conditions than *M. edulis* (Hepper, 1957). *Edulis* were here fairly typical, having straight to slightly convex ventral margins, slightly angular dorsal margins and blunt umbones. Whilst the *galloprovincialis* were not particularly distinctive, they did have somewhat taller shells (with a mean length-height ratio of 1.83) with rather more angular dorsal margins and they were slightly more pointed.

7. Cobh (Plate 2, B). Situated in Cork harbour, this shore was very similar to that at Youghal consisting mainly of stones and gravel. Some 20 per cent of the mussels were here identified as *galloprovincialis*, many of which had quite tall, angular shells. They tended to be rather pointed and many exhibited some form of beaking, ventral incurvature or umbo-lunule swelling. Others, however, were more difficult to separate from *edulis* on external characters alone. *Edulis* were here very similar to those collected at Youghal.

8. Summer Cove (Plate 2, C). Immediately to the east of Kinsale harbour, this sample was collected from a rather sparsely populated sheltered jetty. Some 45 per cent were identified as *galloprovincialis*, the majority being rather pointed and exhibiting some form of beaking or incurvature which in a few cases was quite pronounced. The dorsal margins varied from angular to distinctly rounded. *Edulis* were again similar to those from Cobh and Youghal, although this sample included several individuals which exhibited the ventral incurvature usually associated with old age.

9. Kinsale (Plate 2, D). In the upper reaches of the estuary, dense clusters of large, fast-growing mussels were found attached to the supports of a road bridge. Although relatively close to the previous site the numbers of *galloprovincialis* had here fallen to 17 per cent, possibly reflecting some influence of the River Bandon. *Gallopovincialis* varied from some that were rounded to the majority which showed some form of dorsal angularity, and whilst the anterior end was not particularly pointed, the majority had quite pronounced umbo-lunule swellings associated with fairly straight or even slightly convex ventral margins. Furthermore, the colour of these shells was distinctly purplish, a feature which was not as obvious in any of the *galloprovincialis* so far described. *Edulis* were browner in colour and the majority were of a fairly uniform shell shape with slightly convex ventral margins and blunt umbones—similar to this species found elsewhere.

10. Roscarberry (Plate 2, E). These mussels were collected from high tidal levels on an exposed rocky shore where densely packed clusters of small individuals were common amongst the barnacles. The majority were badly eroded (only 16 per cent of the *edulis* were rayed) and externally it was quite difficult to separate *edulis* from *galloprovincialis* though the latter tended to have slightly more pointed and downturned umbones. Only 7 per cent of the sample were finally identified as *galloprovincialis*.

11. Lough Ine (Plate 2, G). Large numbers of mussels were examined in the field at Lough Ine, where mussels of practically every conceivable shape were encountered. The majority of mussels (58 per cent) here

proved to be *galloprovincialis* and whilst many of these showed some form of beaking or ventral incurvature others were straight with quite pronounced umbo-lunule swellings. Most tended to be rather pointed and had shells like those at Kinsale which were distinctly purplish in colour. *Edulis*, on the other hand, generally had blunter umbones, and whilst some of the older individuals were slightly incurved others had ventral margins which varied from straight to convex. The dorsal shell margins in both mussels varied from some that were rounded to others that were distinctly angular.

12. Carrigathorna (Plate 2, H.) This very exposed rocky shore situated at the western entrance to Lough Ine supported densely crowded beds of rather small, elongate mussels. The majority of *galloprovincialis* were pointed, rounded or slightly angular with ventral margins that were either straight with an umbo-lunule swelling or slightly beaked. Although most of those finally identified as *M. edulis* were somewhat blunter with straight or incurved ventral margins, 32 per cent (the largest number in the present survey) were of an intermediate nature and could not be positively identified even when all characters had been considered. Although small, many of the mussels in this sample had very badly eroded shells giving an impression of exceedingly old age.

13. Durrus (Plate 2, F). Dense clusters of fairly large mussels were here collected from the supports of a road bridge towards the head of Dunmanus Bay. This site was very similar to that at Kinsale in that a considerable amount of fresh water appeared to flow over these mussels especially at low water, and it is interesting to note that approximately similar numbers of *galloprovincialis* were recorded (18 per cent compared with 17 per cent at Kinsale). Although many of these *galloprovincialis* were here rather blunt at the anterior end, the majority showed some form of beaking, ventral incurvature or umbo-lunule swelling. Many of the larger individuals were badly eroded and the dorsal shell margins varied from rounded to quite markedly angular. Many *edulis* had light straw-brown coloured shells with straight or even convex ventral margins and blunt umbones, and their external morphology showed a surprising degree of uniformity.

14. Castletownbere (Plate 3, A). On the harbour wall at Castletownbere some very large mussels were encountered, amongst which were some of the most distinctive *galloprovincialis* found during this survey. The majority of these were very pointed with noticeably beaked or incurved ventral margins—in some of the apparently older individuals this incurvature was very marked indeed (Plate 3, A9). Others, however, had relatively straight ventral margins usually associated with some degree of umbo-lunule swelling. Their shells were quite tall (giving a mean length-to-height ratio of 1.83) flat and rather angular in appearance. *Edulis* were generally less pointed and the sample included several very tall individuals, probably a consequence of the lack of overcrowding in this population. Most were straight or, in the case of older individuals, incurved with rounded or slightly angular dorsal margins.

15. Ardroom (Plate 3, B.) This semi-exposed rocky shore on the Kenmare River supported quite dense beds of small-to-medium sized mussels, many of which had very badly eroded brittle shells. Most of the *galloprovincialis*, which accounted for 38 per cent of this population, were here quite pointed and either incurved or beaked with dorsal margins varying from markedly angular to distinctly rounded. They showed a marked similarity to those previously collected from Roscoff in northern France. The majority of *edulis* had blunter umbones, and whereas the ventral margins in most cases were straight, a few were convex, whilst others, obviously older mussels, were quite markedly incurved.

C) Dingle-Strandhill:

1. Dingle (Plate 3, C). This sample was collected from the harbour wall where many large, relatively uncrowded mussels were found growing in conditions similar to those at Castletownbere. Many had relatively tall

shells and the length-to-height ratios for both *edulis* (1.75) and *galloprovincialis* (1.79) were the lowest recorded. Although not particularly distinctive, the latter was here quite pointed with rounded to distinctly angular shells and ventral margins which varied from straight to incurved. *Edulis* was generally less pointed, and the majority had straight ventral margins although a few were either convex or incurved. As many as 50 per cent of the mussels in this sample were quite badly infected with *Cliona*.

2. Ventry (Plate 3, D). This fairly small sample of mussels collected from a relatively sheltered stony shore consisted of approximately equal numbers of the two mussels. Whilst most of the *galloprovincialis* were here rounded, incurved and rather pointed, *edulis* had blunter umbones with straight to somewhat incurved ventral, and rounded or slightly angular dorsal margins.

3. Tralee (Plate 3, E). The shores in this locality at the head of Tralee Bay were predominantly sandy and this sample was obtained from the large stones and boulders in the low shore—a situation similar to that at Grey Abbey in Strangford Lough. Only one mussel in the sample was eventually considered to be *galloprovincialis* and, although this had quite blunt umbones, it was nevertheless slightly beaked and relatively angular. All the other mussels were of a remarkably uniform shell shape, exhibiting all the typical *edulis* characters one normally associates with this type of sheltered habitat.

4. Kilkee (Plate 3, F). This flat but extremely exposed rocky shore supported dense beds of apparently fast-growing mussels, many of which were extremely similar to mussels previously collected from Polzeath in south-west England. Their shells were elongate—typical of mussels growing in densely crowded conditions—and their ventral margins varied from some that were convex to others that were distinctly incurved. Externally it was impossible in most cases to separate the two types (indeed over 60 per cent would have been misidentified solely on external shell characteristics) though some of the *galloprovincialis* had quite prominent umbo-lunule swellings and were not dissimilar to *galloprovincialis* previously collected from Naples. Many of the larger mussels were badly eroded, especially around the anterior regions of the shell, and only 32 per cent of those identified as *edulis* were rayed.

5. Lahinch (Plate 3, G). Large numbers of relatively small mussels, typical of those associated with exposed shores, were here found on the outcrops or rock on what was otherwise a predominantly sandy bay. Many of the *galloprovincialis* either showed a tendency to be beaked or else had rather straight ventral margins associated with a prominent umbo-lunule swelling. Dorsally they were rounded or slightly angular. Most of the *edulis* were rather more uniform in external appearance, being less pointed, straight or slightly incurved. As at Kilkee, many were badly eroded and the sample contained a high percentage of animals of intermediate character.

6. Galway (Plate 3, J). This sublittoral sample, in which there were some quite large mussels, included 14 per cent that were finally identified as *M. galloprovincialis*. These were pointed, rounded dorsally and were either beaked (some quite markedly so) or had prominent umbo-lunule swellings. Most of the *edulis* were, in external appearances, typical of those collected from similar habitats elsewhere, though a few of the older individuals had ventral margins that were slightly incurved.

7. Spiddal (Plate 3, H). Situated on the northern shores of Galway Bay, this broken but exposed rocky shore supported quite large numbers of fairly small, often badly eroded mussels. Of the 33 per cent *galloprovincialis* in the sample, most had rather angular shells with pointed umbones and were either beaked or incurved ventrally. The majority of *edulis*, on the other hand, were very similar to those at Lahinch, exhibiting the typical features of mussels grown on exposed shores.

8. Aran Island (Plate 3, I). This small sample of sublittoral mussels were kindly sent to me by Dr. R.J. Boyd. Many of them were quite large

and had fast-growing, extremely brittle shells. Most of the *galloprovincialis* (which accounted for 10 per cent of this sample) had straight ventral margins associated with quite prominent umbo-lunule swellings and were very similar to specimens previously examined from the Mediterranean, e.g. at Sète, Marseilles and Villefranche. Their shells were rather tall and angular, and were distinctly purplish in colour. In contrast, *edulis* were blunter, and whilst some were straight, many were convex over most or part of their ventral margins. Since, as in the Galway sample, only the shells were examined, no information is available concerning the colour of the mantle edge.

9. Clifden Harbour (Plate 4, B). These rather large mussels collected from the harbour walls, were somewhat unusual, in that many of them had shells that were in parts almost devoid of pigment. Only 5 per cent of the sample were finally identified as *galloprovincialis* but once again this seemed to be a region subject to quite considerable salinity fluctuations. Although these *galloprovincialis* were not especially pointed they were slightly, and in some cases quite markedly, beaked (Plate 4, B3). The majority of *edulis* were rather uniform in shape, having generally less pointed, gently rounded or slightly angular shells and straight ventral margins. This sample contained a surprisingly large number of intermediate mussels—somewhat unusual for this type of habitat.

10. Clifden Semi-exposed rocks (Plate 4, A). Situated less than a mile from the previous site, the number of *galloprovincialis* in this sample rose to 43 per cent. These mussels were surprisingly large for this type of habitat with a few measuring up to 6.0 cm in length. *Galloprovincialis* was here more distinctive with flatter rather angular shells, pointed anteriorly and beaked or incurved ventrally. In colour, their shells were much darker blue or grey than those from the harbour. Many of the *edulis* were rather similar in external appearance but with a tendency to be less pointed and most were straight or at the most only slightly incurved ventrally.

11. Aughris Head (Plate 4, C). Many of these rather small mussels from this exposed rocky shore were quite badly eroded and only in 28 per cent of those finally identified as *edulis* was raying of the shell discernible. The *edulis* in this sample were typical of mussels from this type of habitat with rounded or slightly angular shells which were either straight or, in the case of older individuals, quite markedly incurved ventrally. Whilst *galloprovincialis* were superficially rather similar, many of them were somewhat more pointed and generally showed some degree of beaking.

12. Strandhill (Plate 4, D). These large mussels were collected from a sheltered shore of boulders and shingle at the head of Sligo Bay. Although the *edulis* in this sample showed some degree of variability in their shell morphology, none were atypical of mussels from this type of habitat. Many of the larger individuals were quite badly eroded and only 44 per cent were rayed. Of the mussels finally identified as *galloprovincialis* only two would have been regarded as such on external morphology alone. These were quite pointed and slightly beaked or incurved ventrally. The rest were impossible to separate from *edulis* on external shell characters (compare Plate 4, D1 and D3).

D) Donegal-Larne:

1. Donegal (Plate 4, E). These large mussels from the harbour wall and the stones and boulders in the river bed all proved to be typical *edulis* (apart from 5 per cent which were of an intermediate character) having blunt umbones and, in the majority of cases, straight ventral margins though a few were either incurved (Plate 4, E3) or convex (E1). Absence of *galloprovincialis* in this region could again possibly be attributed to the large amount of fresh water which ran over these mussels especially at low water. The adductor scar ratio of 106 in these mussels was amongst the highest recorded.



R. SEED

PLATE 3

Mytilus from the Irish coast.

A - Castletownbere: 1-3, *edulis*; 4-9, *galloprovincialis*. B - Ardgroom: 1-4, *edulis*; 5-8, *galloprovincialis*. C - Dingle: 1-3, *edulis*; 4-6, *galloprovincialis*. D - Ventry: 1-3, *edulis*; 4-6, *galloprovincialis*. E - Tralee: 1-2, *edulis*; 3, *galloprovincialis*. F - Kilkee: 1-5, *edulis*; 6-10, *galloprovincialis*. G - Lahinch: 1-3, *edulis*; 4-6, *galloprovincialis*. H - Spiddal: 1-3, *edulis*; 4-6, *galloprovincialis*. I - Aran Islands: 1-2, *edulis*; 3-4, *galloprovincialis*. J - Galway: 1, *edulis*; 2, *galloprovincialis*.



R. SEED

2. **Killybegs** (Plate 4, F). Only 4 per cent of this sample, collected from a jetty of concrete and boulders in Killybegs harbour, proved to be *M. galloprovincialis*. These had relatively pointed, angular shells with straight or slightly incurved ventral margins. Most of the *edulis* were somewhat more elongate (with a mean length-to-height ratio of 2.08) and of a remarkably uniform shape. They were generally less pointed and the majority were either straight or slightly convex ventrally.

3. **Carrick** (Plate 4, G). On the north-west coast of Donegal Bay many of the shores, like this one at Carrick, are severely exposed. Here dense beds of small mussels carpeted the rocks amongst the barnacles, and in this particular sample 26 per cent proved to be *galloprovincialis*. These were quite pointed and many showed some form of beaking. It was difficult in many cases to distinguish between the two mussels on external morphology although most *edulis* were less pointed and their ventral margins were either straight or, in older individuals, incurved. The difficulties of identification on exposed shores such as this are illustrated by the high percentage of intermediates in the sample. The majority of these, however, were probably *edulis*, severe erosion having obscured any raying of the shells which may have been present.

4. **Bloody Foreland** (Plate 4, H). Dense clusters of relatively large mussels were found attached to this semi-exposed jetty. Approximately equal numbers of *edulis* (39 per cent) and *galloprovincialis* (37 per cent) were recorded in this sample, although on external characters the two were remarkably similar. Many of the latter proved to be slightly more pointed and were either slightly beaked or else had a relatively prominent umbo-lunule swelling. In addition, the shells of many of these *galloprovincialis* were purplish in colour becoming brownish towards the ventral margin—a feature previously encountered in many Mediterranean mussels. As at the previous site, many mussels of intermediate character occurred here, and of the *edulis* shells only 32 per cent were rayed.

5. **Dunfanaghy** (Plate 4, J). This sheltered shore in the western corner of Sheep Haven was predominantly sandy, but extremely large mussels were found locally on boulders and gravel exposed at low tide. *Edulis* was here typical for this type of habitat, being extremely blunt with straight or convex ventral margins. In some of the older specimens, however, the ventral margin was incurved and dorsally the shells were rounded rather than angular as in the majority of these mussels. *Galloprovincialis* accounted for only 5 per cent of this population and these differed only in their slightly more pointed umbones and beaked ventral margins.

6. **Port-na-Blagh** (Plate 4, I). Whilst only 10 per cent of this sample were finally identified as *galloprovincialis*, there was very little difference between the two types on external characters. All were rather small and badly eroded and the majority had straight or incurved ventral margins. Only in a relatively few individuals were the more typical *galloprovincialis* characters discernible.

7. **Portstewart** (Plate 4, K). The only mussels found in this locality were small exposed varieties, all of which proved in the final analysis to be either *edulis* or mussels of doubtful affinity. The majority were rather blunt, straight or ventrally incurved in older individuals and rounded to slightly angular dorsally. However, a few (8 per cent) had pointed and

PLATE 4
Mytilus from the Irish coast.

A - Clifden semi-exposed: 1-4, *edulis*; 5-8, *galloprovincialis*. B - Clifden Harbour: 1-2, *edulis*; 3-4, *galloprovincialis*. C - Aghris Head: 1-4, *edulis*; 5-8, *galloprovincialis*. D - Strandhill: 1-2, *edulis*; 3-4, *galloprovincialis*. E - Donegal: *edulis*. F - Killybegs: 1-2, *edulis*; 3-4, *galloprovincialis*. G - Carrick: 1-3, *edulis*; 4-6, *galloprovincialis*. H - Bloody Foreland: 1-4, *edulis*; 5-8, *galloprovincialis*. I - Port-na-Blagh: 1-3, *edulis*; 4-6, *galloprovincialis*. J - Dunfanaghy: 1-2, *edulis*; 3-4, *galloprovincialis*. K and L - *M. edulis* from Portstewart and Giant's Causeway respectively.

somewhat beaked shells, and like some *edulis* previously found on other exposed coasts would probably have been regarded as *galloprovincialis* on external characters alone.

8. Giant's Causeway (Plate 4, L). These small mussels from this severely wave-swept, rocky shore were very similar to those described from the previous station. The high incidence of mussels of intermediate character again further illustrates the problems of identification frequently encountered in these small, old, often badly eroded mussels from exposed and semi-exposed shores.

9. Larne. All the mussels in this sample (except 2 per cent which were intermediate) proved to be of the *edulis* type and exhibited the characteristic features generally associated with this species from this type of low-level, sheltered habitat. In external shell morphology, they were very similar to mussels collected further south at Grey Abbey or Rostrevor.

DISCUSSION

This survey has confirmed the existence of the Mediterranean mussel *Mytilus galloprovincialis* in Ireland. It occurs along most of the south coast and extends northwards on the west coast as far as Co. Donegal, as will be seen from Figure 3 which shows the relative abundance of *M. galloprovincialis* at each of the stations visited. It is particularly abundant in Counties Cork, Kerry, Clare and Galway in all habitats where salinity is not appreciably reduced and, in certain localities, proved to be the dominant mussel, frequently accounting for upwards of 40 per cent of the total mussel population.

M. galloprovincialis has previously been recorded at Castletownbere by Hepper (1957) although no indication is given of its relative abundance. However, Kitching *et al* (1959) comment on the distribution of mussels at Lough Ine as follows: « ...the small *Mytilus* found at Carrigathorna are almost entirely *M. edulis* and the large ones at the north end of the Lough mainly *M. galloprovincialis*... » In another publication by these authors (Ebling *et al*, 1960) they comment, « Samples of *Mytilus* were collected from the reef immediately south of Cave Island (at the entrance to Lough Ine immediately opposite Carrigathorna) a nearly open sea position where there is a continuous intertidal belt of small specimens and from Rookery Nook in the north east of the Lough where many large *Mytilus* hang in clusters. Dr. Hepper kindly reported as follows: Cave Island Reef 34 *M. edulis* and 68 *M. galloprovincialis* (67 per cent) ; Rookery Nook 20 *M. edulis* and 66 *M. galloprovincialis* (77 per cent). » The italics within parenthesis are mine. In the present investigation, Carrigathorna and the inner basin of Lough Ine revealed 32 per cent and 58 per cent *galloprovincialis* respectively. Although it is possible that the relative proportions of the two mussels in this area may have changed between 1960 and 1970 when this survey was undertaken, it is also possible that the higher incidence of *galloprovincialis* reported by these authors could be due to the confusion of this mussel with old, "ungulate" varieties of *M. edulis* previously described by Lewis and Powell (1961) and Seed (1968).

M. galloprovincialis has also been recorded from South Wales

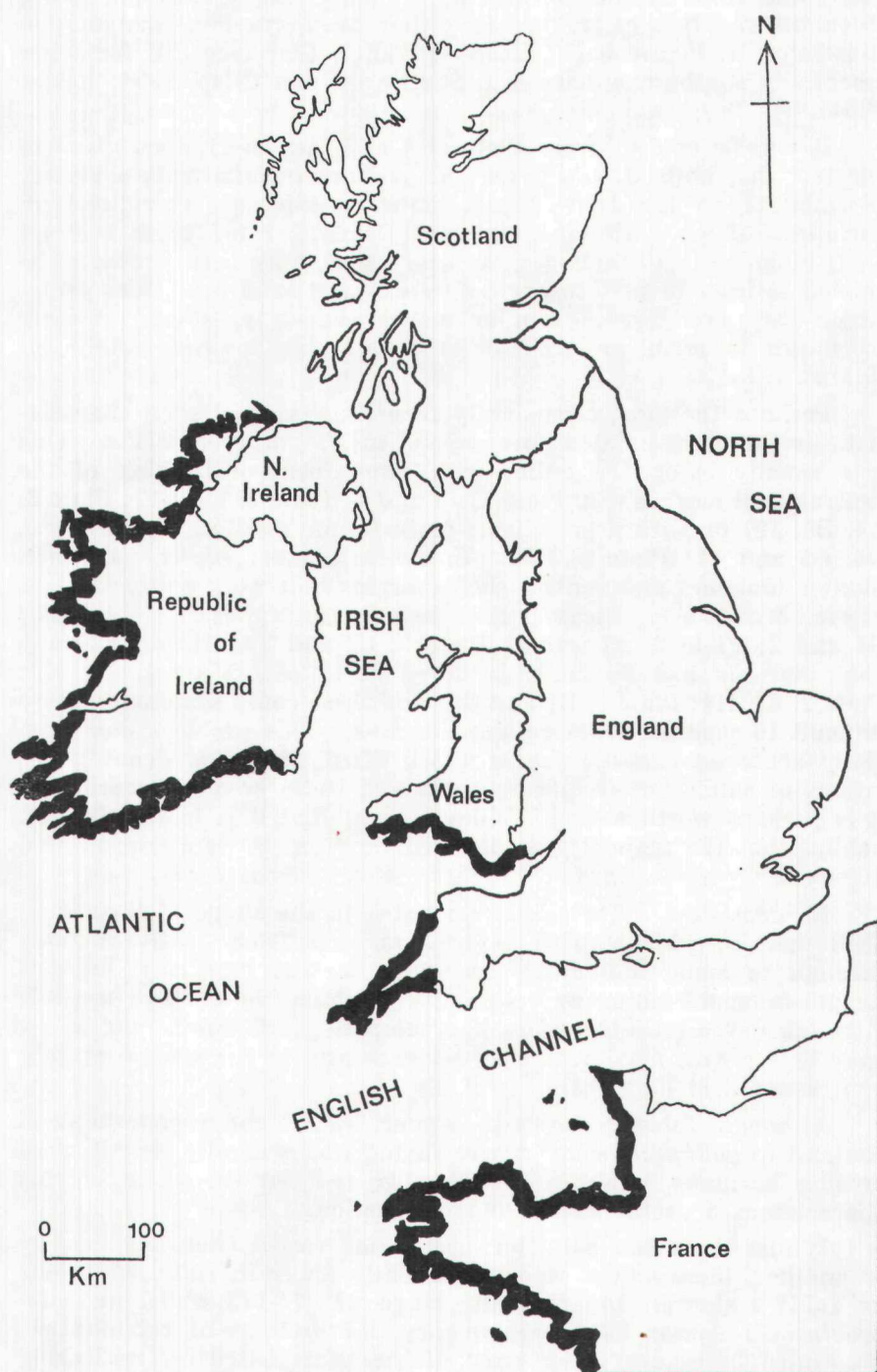


FIG. 3

Map showing in heavy outline the geographical areas in which *M. galloprovincialis* will probably occur provided local conditions are favourable.

(Hepper, 1957), south-west England (Hepper, 1957; Lewis and Seed, 1969) and from the north coast of France as far east as Cherbourg (Seed, 1972). It is clear, therefore, that its geographical distribution illustrated in Figure 3 (1) closely parallels that recorded for other essentially southern species (e.g. Southward and Crisp, 1954; Lewis, 1964).

It will be evident from Plates 1-4 and the descriptions given in the text that both *M. edulis* and *M. galloprovincialis* from a variety of habitats on the Irish Coasts show considerable morphological variation. Such variations, previously recorded for these mussels from other parts of their geographical range, have been shown to be related at least in part to age differences and local conditions under which they are grown. Similar morphological types can certainly be shown to recur in localities of comparable environmental conditions.

Perhaps the most consistently recurring external shell characteristic is the more pointed anterior end in *M. galloprovincialis*. This was usually associated either with some form of beaking of the ventral shell margin (e.g. Plate 1, J3 and 4; Plate 2, F5, G12; Plate 3, A4, B8, J2) or with a prominent umbo-lunule swelling (e.g. Plate 2, D4, G9 and 11; Plate 4, H5). In contrast, most *edulis* had much blunter umbones and ventral shell margins that were either straight or even convex over at least part of their length (e.g. Plate 1, C1 and 3; G and 2; Plate 2, A1 and 2; Plate 3, C2 and 3). However, many older animals had distinctly incurved shells (e.g. Plate 1, A2, H2; Plate 2, C2, H4; Plate 3, B1 and C1) and these could sometimes prove difficult to separate from *galloprovincialis*. This problem was especially acute on exposed shores which often supported dense populations of small, yet frequently quite old, badly eroded mussels and it is perhaps worth noting (Tables 3 or 4) that it is in this type of habitat that the majority of intermediate mussels were encountered during this survey (e.g. Carrigathorna, Kilkee, Ardgroom).

No consistent differences were noted in the shape of the dorsal shell margin, which varied in both mussels from gently rounded through to some individuals in which it was markedly angular. Length-to-height ratios were again very similar in the two mussels although several of the more characteristic *galloprovincialis* shells were flatter with maximum shell width nearer to the ventral margin as illustrated in Figure 1.

Although Table 2 shows that many *edulis* had rayed shells in contrast to *galloprovincialis* where raying was generally absent, shell erosion in many localities considerably reduced the value of this character as a useful means of identification.

Whilst the mean adductor scar ratios varied from one locality to another, these values were consistently lower in *galloprovincialis* as Table 2 shows. In *edulis* the range was 74-113 whilst in *galloprovincialis* it was 53-93. Frequency distributions of these ratios, illustrated in Figure 4, for most of the sites visited are noticeably

(1) No samples from County Mayo were examined during this investigation and the continuous distribution of *M. galloprovincialis* between Counties Galway and Sligo is in fact assumed.

different from similar analyses carried out on mussels from south-west England and France where distributions in mixed populations were generally bimodal. In the current investigation, separation on this character was much less evident and the graphs were never more

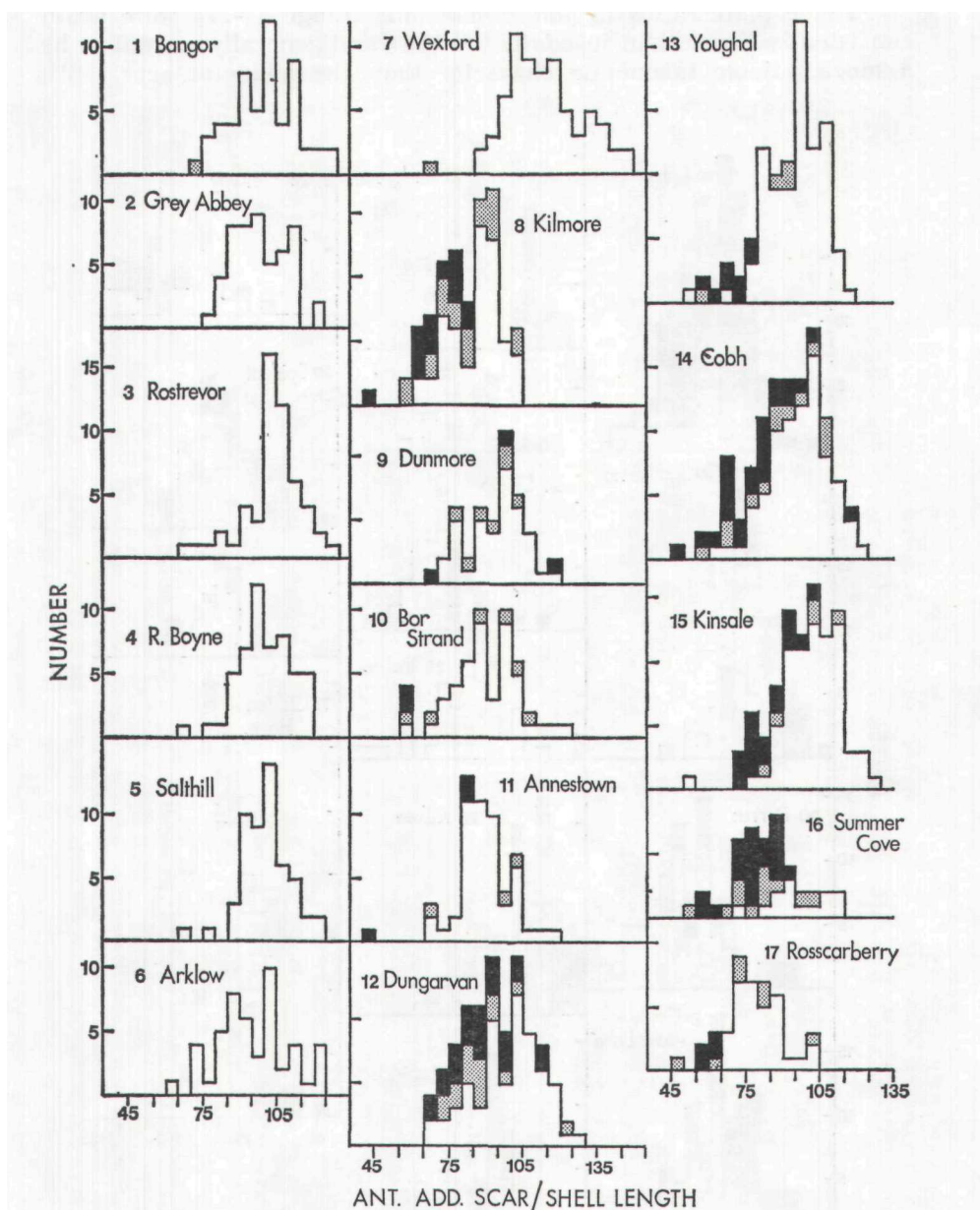


FIG. 4 A

FIG. 4 (A, B, C)

Histograms showing the frequency distributions of values for the ratio anterior adductor muscle scar length/shell length (X 1,000) in *M. edulis* (white); *M. galloprovincialis* (black); and mussels of intermediate characters (grey); from the localities investigated.

than skewed. Mussels collected from sheltered habitats generally had noticeably higher ratios than those from exposed situations and it is suggested that this may be related in some way to the richer feeding conditions in such habitats.

Hinge plate ratios in *galloprovincialis* (range 44-77) were again consistently lower than in *edulis* (70-115) and generally proved to be a more reliable taxonomic character than the adductor scar, with

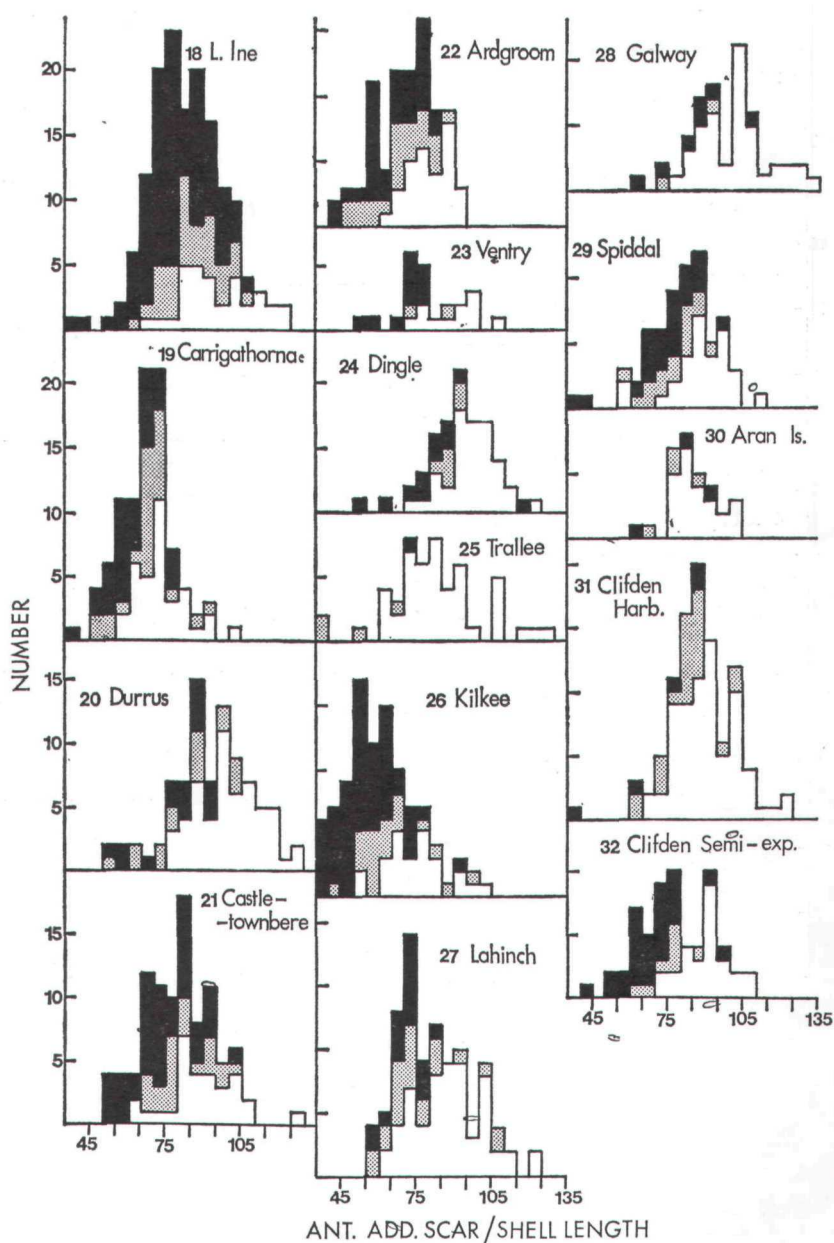


FIG. 4 B

frequency distributions in some cases quite distinctly bimodal. This is contrary to expectations, since in south-west England and France the adductor scar usually proved to be a more reliable diagnostic character. Apart from the size differences there were often additional differences between the two mussels in the shape and position of the hinge plate in relation to the umbones.

Mantle edge colour varied from pale yellowy-brown through all shades of darker brown to purple, though no really deep purple-violet mantles typical of many of the *galloprovincialis* in south-west England and France were here recorded. Although separation on this character was carried out in the field, this occasionally proved to be rather subjective and in retrospect an intermediate category for this character would have been appropriate. In addition, a number of

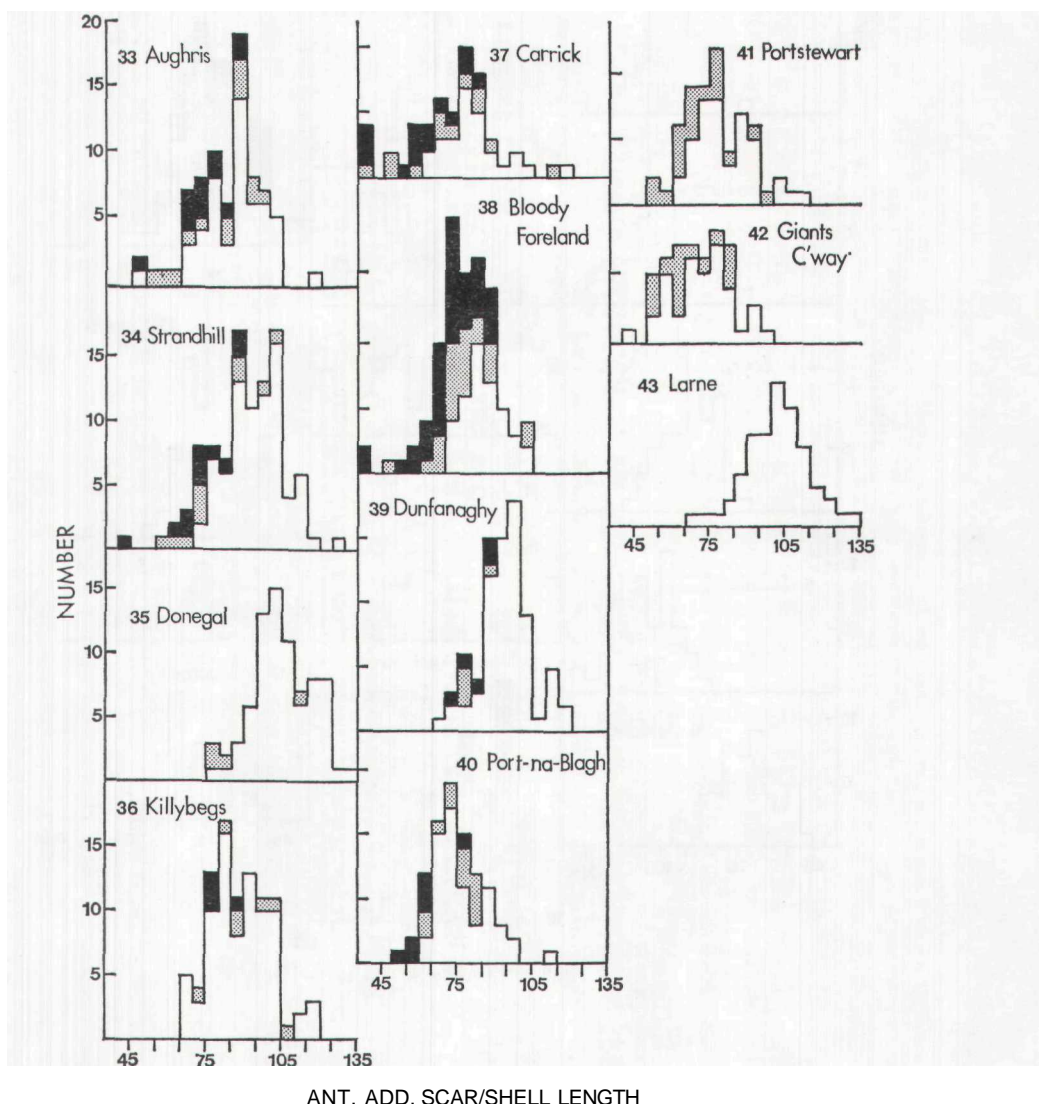


FIG. 4 C

individuals with characteristically *galloprovincialis*-like shells had mantles that were distinctly pale in colour, a combination that was rarely encountered in mussels from south-west England.

Thus, whilst quite distinctive *galloprovincialis* are to be found on the south and west coasts of Ireland, especially in the extreme

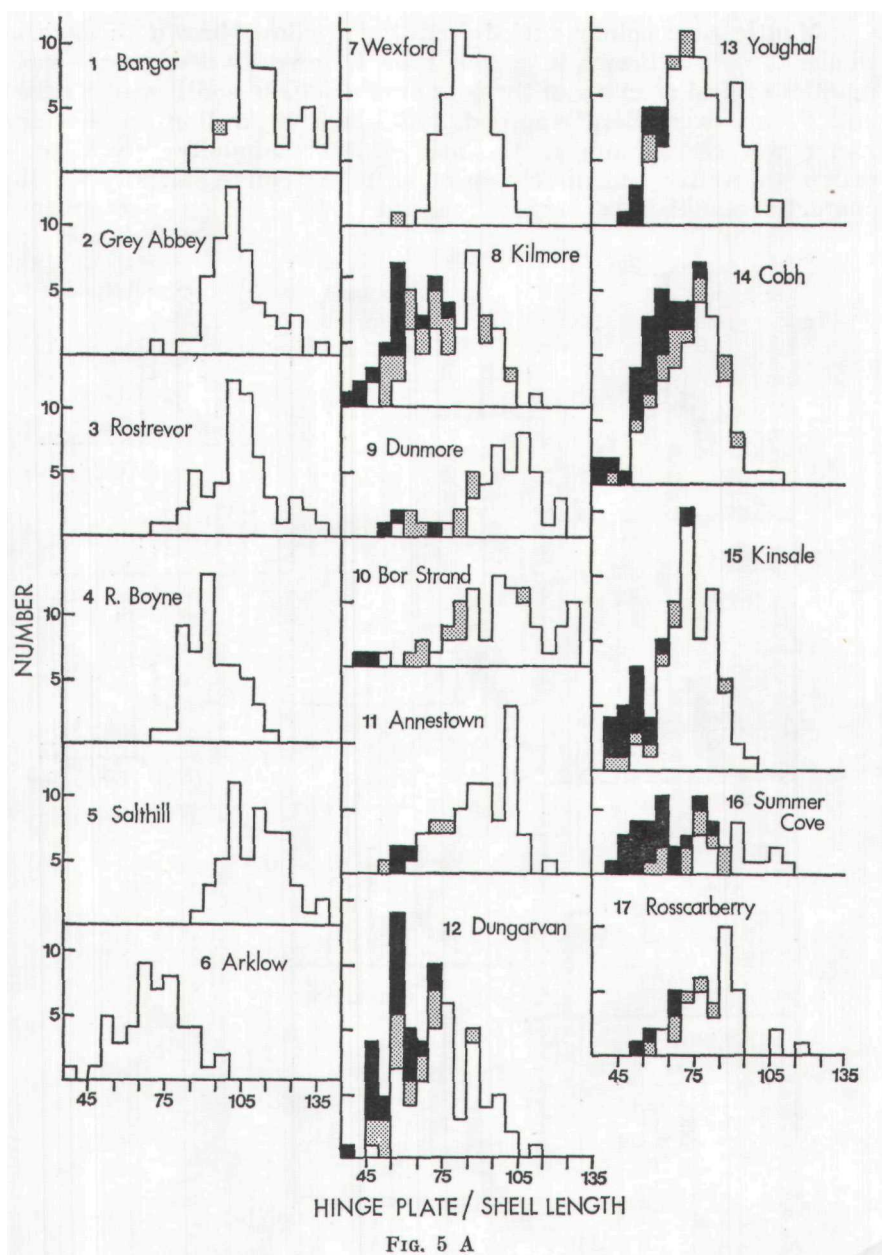


FIG. 5 A

FIG. 5 (A, B, C)
Histograms showing the frequency distributions of values for the ratio hinge plate length/shell length (X 1,000) in *M. edulis* (white); *M. galloprovincialis* (black); and mussels of intermediate characters, from the localities investigated.

south-west Counties of Cork and Kerry, in many localities intermediate forms occur where a final separation on morphological grounds is difficult or even impossible. This situation recalls that found on the north Atlantic coast of France around Concarneau and Les Sables d'Olonne, where it was suggested that overlapping spawning periods may result in considerable hybridisation. Further south along the French Atlantic coast at Arcachon, and also at Padstow in south-west

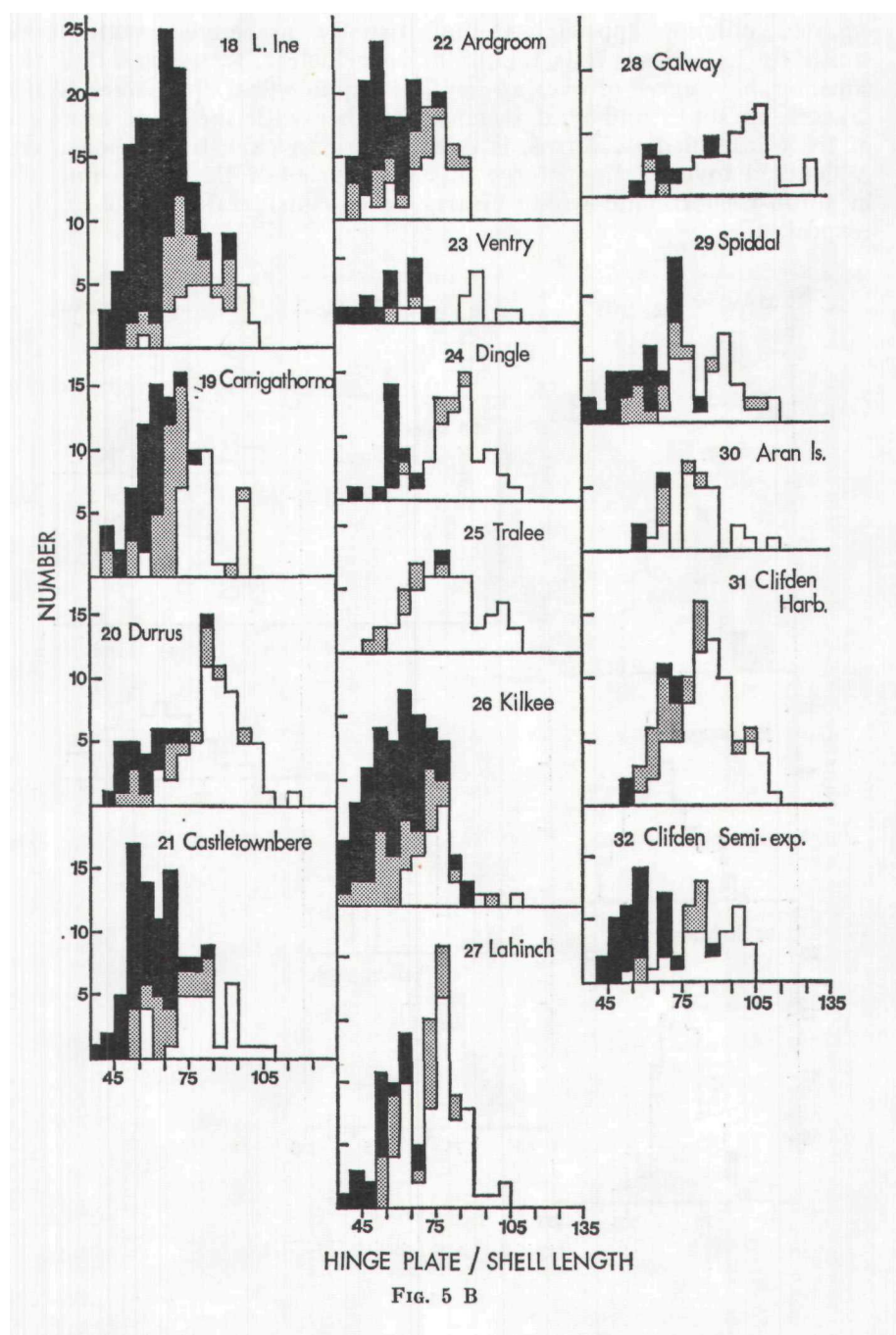


FIG. 5 B

England, both areas where these mussels are morphologically distinct, the breeding cycles are known to differ (Seed, 1971). The possible preclusion of cross fertilisation in such localities could perhaps result in the establishment of relatively genetically isolated populations. Since no detailed comparative studies have so far been made of the reproductive cycles of these mussels in the Concarneau region, the above explanation must, for the moment, remain speculative but a similar situation may exist in south and western Ireland where the equable climate approaches that usually associated with more southerly latitudes. It is tempting, nevertheless, to suggest that the considerable degree of overlap in the morphological characters of the mussels in south and west Ireland, together with the large numbers of truly intermediate forms, is due, at least in part, to hybridisation. A detailed investigation of the breeding cycles of these two mussels in south-west Ireland would clearly be of considerable value in this respect.

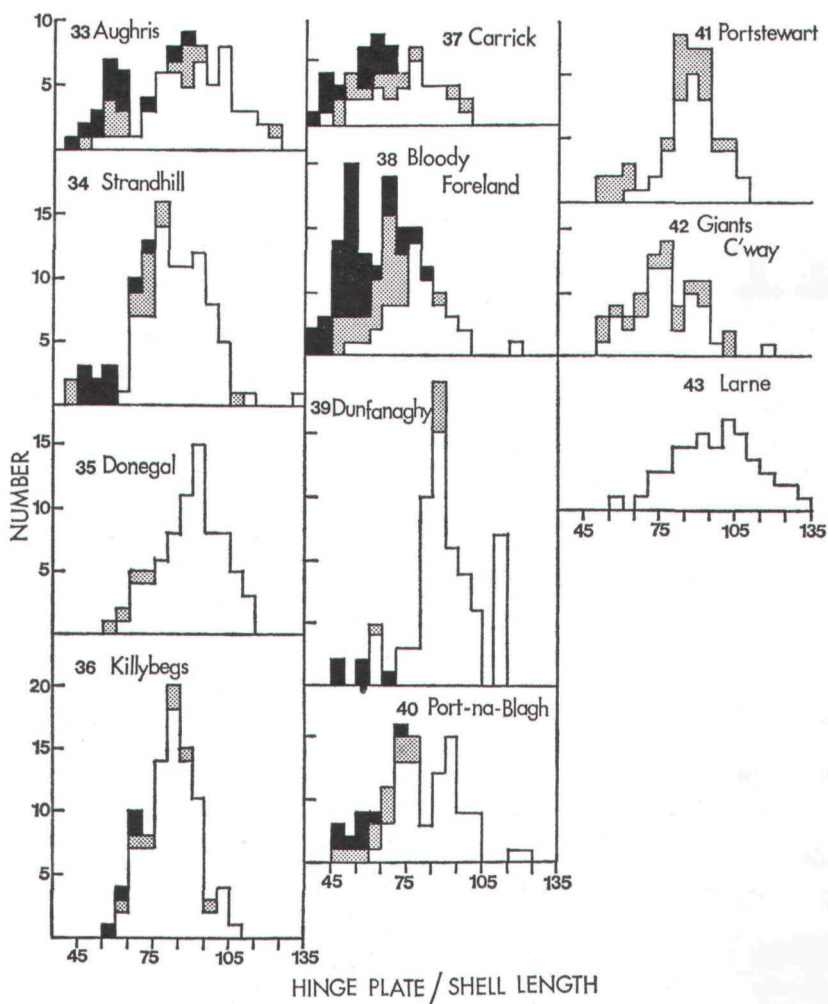


FIG. 5 C

Acknowledgements

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Summary

The presence of *M. galloprovincialis* in Ireland is confirmed. It occurs along most of the south coast and extends northwards on the west coast as far as County Donegal. However, on shores where salinity is appreciably reduced, *galloprovincialis* is noticeably less abundant. Both *M. edulis* and *M. galloprovincialis* exhibit considerable morphological variation according to their age and to the wide range of local conditions in which they occur. The unusually high incidence of individuals of intermediate characters in many populations, on the other hand, could possibly indicate that considerable hybridisation between these two mussels occurs in this part of their geographical range.

Resumen

Se confirma la existencia de *M. galloprovincialis* en Irlanda. Ocurre a lo largo de la mayor parte de la costa meridional y se extiende al norte por la costa oeste hasta Donegal. Sin embargo, en las orillas donde la salinidad se reduce perceptiblemente *galloprovincialis* es marcadamente menos abundante.

M. edulis y *M. galloprovincialis* muestran una variación considerable de morfología según su edad y la amplitud de variación en las condiciones locales en las que se encuentran. La gran frecuencia poco común de individuos de tipo intermedio en muchas poblaciones puedan indicar por otra parte que ocurre una cantidad considerable de hibridación entre estos dos mejillones en esta parte de su distribución geográfica.

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