BASTERIA 43: 61-80, 1979

Conchological evidence for the separate specific identity of Mytilus edulis L. and M. galloprovincialis Lam.

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INTRODUCTION

As is generally known, the question whether or not *Mytilus edulis* Linnaeus, 1758, and *M. galloprovincialis* Lamarck, 1819, are distinct species, has long been a subject of discussion and investigation. For some years I had been vaguely interested in this problem without, however, keeping up with the literature on the topic. Yet, the literature I did know, i.e. Tebble (1966: 40), Entrop (1972: 79), Lacourt (1974: 135) and the references mentioned by these authors, seemed to warrant the assumption that a clear answer to the question was still to be given. Because I wanted to see for myself anyway, I set out to seek the answer when, after a journey to Portugal, I felt that it was to be found among the shells in my collection. Only after having finished the investigation, I learned about important papers as those by Lewis & Seed (1969), Seed (1971, 1972), Lubet (1973) and Gosling & Wilkens (1977), which convinced me that the problem had already been solved in principle.

Though this made my results more or less superfluous, it nevertheless seemed worth while to publish the outcome of my investigation, because: (1), though sufficient factual information has been presented in the literature, an adequate discussion of the question whether or not we are dealing with two distinct species, seems not to have been given as yet; (2) my investigation contains a few new aspects; (3) it demonstrates the efficacy of simple, be it tedious, biometrical methods, such as can be applied by any amateur, in problems of even this size.

I am much indebted to A.C. Drinkwaard, biol. drs., of the Rijksinstituut voor Visserij-onderzoek, IJmuiden, Netherlands, to Dr. B. Métivier of the Muséum National d'Histoire Naturelle, Paris, and to Dr. R. Seed of the University College of North Wales, Bangor,

for valuable advice; to Miss A.M. Testud of the Muséum National d'Histoire Naturelle, Paris, and to Mr. G. Real of the Institut de Biologie Marine, Archachon, for presenting me with shells from the Bassin de Thau, and to my wife for forbearance.

MATERIAL

The material studied consists mainly of shells from the following localities, arranged geographically:
(1) W. ITALY, 87 specimens washed ashore at Marinella, a few km SE. of La Spezia;
(2) SE. SPAIN, 16 specimens washed ashore a few km W. of Nerja, 50 km E. of Malaga;
(3) S. PORTUGAL, 39 specimens washed ashore at Ferragudo, one km E. of Praia da Rocha;
(4) W. PORTUGAL, 28 specimens washed ashore at Peniche, 70 km N. of Lisboa;
(5) N. SPAIN, 5 specimens washed ashore at Santander;
(6) SW. FRANCE 1, 103 specimens from the Bassin d'Arcachon, taken alive from concrete supports of the easterly pier at Arcachon. These shells were collected in the intertidal zone;
(7) SW. FRANCE 2, 109 specimens washed ashore on a sandy and muddy part of the Bassin d'Arcachon, a few km E. of Arcachon;
(8) NETHERLANDS, 94 specimens washed ashore at Wassenaar, a few km NE. of Den Haag.

These samples are in my collection. A number of other samples from the Mediterranean and from the Atlantic coasts of Europe and NW. Africa (including one of 128 specimens, which otherwise is a complete duplicate of sample 6), were used to check part of the conclusions reached. Most of these samples are in the Rijksmuseum van Natuurlijke Historie, Leiden (RMNH), some are in the Dautzenberg collection, Institut Royal des Sciences Naturelles de Belgique, Brussels, and in private collections.

If the two valves of a single specimen have got separated, they may not be recognized as having belonged to one individual only. Therefore, measures have been taken that no single specimen is represented twice in the results. These measures did not preclude the examination of both shells, if present and recognized as a pair. Occasionally, this proved to be of interest, because the two shells of one individual are not always completely symmetrical as regards colour pattern, details of muscle scars etc.

METHODS AND DEFINITIONS

- The length *L* of the shells has been measured parallel to the ventral edge.
- The height *H* of the shells is the minimum distance between the tip of the dorsal angle, or of the dorsal edge if that is the higher one, and the ventral edge.
- The length *Laa* of the anterior adductor scar, and the dimensions *Lar* and *Har* of the anterior retractor scar, are those of the blue prismatic layer which stands out against the surrounding whitish nacreous layer, unless it was obvious that the limits of the scar were different.
- The internal radius *Rin* of the anterior end of the shells is a minimum value. It was measured by fitting the cylindrical part of drills with known diameter into the nose of the shells. The ratio of the diameters of two successive drills did not exceed 1.25. If the curvature of the internal edge of the nose proved to be irregular, I deviated only exceptionally from the actual minimum radius.
- The upper limit of the length *Lie* of the ligamental edge is the beginning of the dorsal angle. If this beginning is gradual, *Lie* is not sharply delimited, and cannot be established with accuracy.
- The width *Wpr* of the posterior retractor scar has been measured as close to the anterior end as is feasible. *Wpr* was measured with the help of a pair of compasses with pointed legs for transferring the measurement to the measuring scale, as were *Laa*, *Lar* and *Har*, mentioned above.
- In order to be able to distinguish between beaked shells and curved shells, the distance between the umbo and the point of contact of the tangent to the ventral edge in fig. 11 has been limited to 0.15 *L*.
- *M. edulis*-like rays were considered to be present even if only one narrow ray could be observed in but one of the shells of a specimen. Pseudo-rays are more vaguely delimited, and establishing

their presence was therefore more subjective.
- The radii *Rd* and *Rp* of the dorsal angle and of the posterior end of the shell respectively, are minimum values. They were measured by fitting the shells to drawn circles with known diameter.
- It would be tedious, and rather senseless, to discuss in detail the accuracy achieved in the measurements. Though often not high, it is manifestly sufficient for the purpose.

MAIN RESULTS

In an extensive preliminary investigation of samples 1 and 8, from W. Italy and the Netherlands respectively, those characters were selected in which both samples proved to differ most. Next, samples 2-7, from intermediate localities, were examined as regards these characters. As far as quantifiable, the observations are presented in figs. 2-26.

Obviously, it must be concluded from figs. 2-13 that (1) all samples from the Mediterranean to N. Spain belong to one form, *Mytilus galloprovincialis*[1], only, and that (2) most characters of that form are rather constant in that area. All of a sudden, however, important changes occur in SW. France 1 (Arcachon pier). *Laa/L* (fig. 3), *Rin/L* (fig. 4) and *Wpr/Lpr* (fig. 10) appear to have much larger values; the percentage of "not beaked" shells (*a* = positive in fig. 11) increases considerably; so does the percentage of rayed shells (fig. 12); the histogram of *Rin/L* (fig. 4) shows a slight bimodality, which did not disappear when I remeasured the shells, and which proved to be similarly present in the duplicate sample from the same locality.

Fig. 27 proves that there is much system in these phenomena. Two clusters can be distinguished. Nearly all beaked shells (*a* = negative in fig. 11) as well as nearly all shells without rays belong to the lower left cluster. Conversely, such shells are predominantly absent in the upper right cluster. If, notwithstanding all evidence to the contrary, these two clusters would belong to one form only, one might expect unimodality of the frequency histogram when going from lower left to upper right in fig. 27. Obviously, this is not true in sample SW. France 1, in contrast to SW. France 2, shown in fig. 28, which was obtained at only a few km east of the former sample.

The presence of two distinct clusters in sample SW. France 1 becomes even more obvious if we plot *Laa/H* and *Rin/H* instead of *Laa/L* and *Rin/L*, see fig. 29. There simply cannot be any doubt that two distinct forms of *Mytilus* are living together in SW. France 1. Obviously, those represented by the lower left cluster belong to *M. galloprovincialis*, those represented by the upper right cluster to *M. edulis*. The questions whether any individual shell can be identified convincingly, and whether the two forms should be considered to belong to distinct species, will be discussed below.

SPECIFICITY OF CHARACTERS

No more than preceding authors did I succeed in finding characters or combinations of characters which allow identification of every individual shell of *M. edulis* or *M. gallo-*

[1] As regards nomenclature, I have relied on Bucquoy, Dautzenberg & Dollfus (1890: 136), who amply discussed the problems involved.

provincialis. Yet, in my experience, good results may often be reached with the following two characters:

(1) In fig. 29 a line has been drawn which connects all points of which *Laa/H* + 1.5 *Rin/H* equals 0.25. It separates nearly all shells represented by black symbols from nearly all shells represented by open ones, which suggests that it separates *M. edulis* from *M. galloprovincialis*, or nearly so. I verified that this conclusion is strongly supported by the other important character, the colour of the shells in transmitted light, discussed sub (2).

From fig. 30 it appears that also among the other samples studied, *Laa/H* + 1.5 *Rin/H* seldom exceeds 0.25 in *M. galloprovincialis*, while the opposite is true for *M. edulis*. Fig. 31 suggests that the criterion might be slightly dependent on the length *L* of the shells, but the number of large shells is too small for conclusions. Fig. 32 shows that the dependence on the length disappears by the use of *Laa/H* + 1.5 *Rin/H* + 0.2 *Lpr/H* as a criterion. However, it should be remarked that this improvement is solely due to the large values of *Lpr/H* in sample SW. France 2, which seems to be a phenomenon of local occurrence only.

Figs. 33 and 34 show the results of an analysis of the duplicate sample of SW. France 1. Judging from the coulour in transmitted light, three shells with *Laa/H* + 1.5 *Rin/H* below 0.25, but with *Laa/H* + 1.5 *Rin/H* + 0.2 *Lpr/H* slightly above 0.322, belong convincingly to *M. edulis*. Similarly, three shells with *Laa/H* + 1.5 *Rin/H* above 0.25 and *Laa/H* + 1.5 *Rin/H* + 0.2 *Lpr/H* even more above 0.322, belong to *M. galloprovincialis*. As regards three other shells of dubious identity, the colour criterion proved to be of little use. Though fig. 34 suggests that the criterion *Laa/H* + 1.5 *Rin/H* might be somewhat dependent on the ratio *H/L*, it also shows that not much improvement is to be expected from the introduction of a correction on that account. Similarly, I verified that not much further improvement may be obtained by combining the criterion with *Wpr/Lpr*, or with *Wpr/H*.

(2) The colour of the shells in transmitted light is another important character. The usefulness, however, is seriously impaired by lack of transparency of shells from many localities. Otherwise, the general colour in transmitted light of *M. edulis* is a dull yellowish brown (or whitish if the periostracum is removed), usually with blue or deep violet blue rays. Often, more or less irregular, bluish and occasionally even purplish, background colours may be also present.

The general colour in transmitted light of *M. galloprovincialis* inclusive of the periostracum often is somewhat more reddish, from a rich brown to purplish or violet. Locally, however, the colour may be blue. In the more transparent shells, darker brown, somewhat narrow, concentric bands may often be seen, which bands are arranged rather regularly. For the remainder, shells of *M. galloprovincialis* are often notable for the homogeneity of the colour above the ridge which marks the upper limit of the ventral part.

In *M. edulis* the blue rays are sharply delineated, and continuous up to the edge of the shell. The blue colour is situated right below the periostracum, to the effect that in transmitted light the rays are more distinctly visible from the outside of the shell than from the inside. In *M. galloprovincialis* rays, if present at all, often result from density variations of the general colour of the shell (pseudo-rays), rather than from sharply delineated, differently coloured zones (*M. edulis*-like rays). Locally and/or occasionally,

M. edulis-like rays also occur in *M. galloprovincialis*. In specimens from Ria de Arosa, NW. Spain (RMNH), these rays are purplish brown, but in a specimen from the lagoon at Aveiro, 60 km S. of Porto, Portugal (my colln.), they are deep violet blue, as they are in five fine specimens from Vilanova, puerto, Barcelona, Spain (RMNH, leg. C. Altimira), and in a few specimens from Marseillan, 25 km W. of Béziers, S. France (my colln.). See also Barsotti & Meluzzi, 1968.

Also at the inside of the shells, i.e. in transmitted light more distinctly visible from the inside, blue colours may appear in both *M. edulis* and *M. galloprovincialis*. Especially in the latter, these blue colours may form a pattern of fine rays, which rays, however, always end at some distance from the posterior edge of the shell. Such non-continuous rays should not be mistaken for continuous rays at the outside of the shell, as described above.

Because of the difficulty in describing and recognizing more or less subtle differences in colour and colour patterns, and because of the local and geographical variability, the following procedure is recommended. First, the sample should be divided into two groups with the help of character (1), described above. Next, the nature and variation of the colour and colour pattern should be studied in order to decide what corrections should be made in the identification of the shells.

A few other characters may be of additional value for the identification of difficult shells:

(3) Exept for very transparent shells, the ventral part of shells of *M. galloprovincialis* is distinctly more transparent than the remaining portion of the shell. In particular the anterior end is remarkably transparent. In *M. edulis*, the transparency is about constant over the whole of the shell, only depending on the distribution of the rays. Often, the anterior end is not the most transparent part of the shells of *M. edulis*.

Usually, a dark brown spot can be seen at the ventral edge of the shells, slightly anterior of half the length *L*. This spot tends to disguise somewhat the greater transparency of the ventral part of *M. galloprovincialis*.

(4) Extremely high values of *Wpr/Lpr* of over about 0.38 (see fig. 10), seem to occur in *M. galloprovincialis* only. Both in *M. edulis* and *M. galloprovincialis*, however, this ratio is subject to considerable geographical variation.

(5) If, as occasionally happens, the posterior adductor scar changes gradually into the posterior retractor scar, as shown in fig. 25, the shell belongs to *M. galloprovincialis*.

(6) High values of *Lie/Li* of over about 1.24 (see fig. 8), seem to occur in *M. galloprovincialis* only. Values below about 1.07 seem to be restricted to *M. edulis*. Often, however, it is difficult to establish the upper limit of *Lie*, i.e. the beginning of the dorsal angle (see fig. 1) with sufficient accuracy.

A number of other characters, which are of little use for the identification of difficult shells, are well suited for obtaining a general impression of the nature of a sample:

(7) Shells with a large value of *Rin/L* (see fig. 4) belong to *M. edulis*. Such shells have a more blunt and more inflated anterior end. The beak is usually slightly dorsal to the ventral edge of the hinge plate, and the hinge plate is larger, as described and depicted by Seed (1972: 359): "..... the hinge plate too is typically much smaller in *galloprovincialis*. In *edulis* it is usually a gentle curving structure whereas in *galloprovincialis* it describes a

much tighter arc with its rear end much more clearly delimited from the adjacent ventral edge of the valve." Possibly unjustly, I did not try to measure the length of the hinge plate, because in *M. galloprovincialis* it also often seems to be too vaguely delimited for accurate measurements, necessary for the identification of difficult shells (cf. Lewis & Seed, 1969: 238).

(8) Beaking (*a* = negative in fig. 11), of course, is largely incompatible with a more dorsally situated beak of the shell, as mentioned sub (7). Particularly not if, additionally, the hinge plate does hardly or not project, see fig. 26. This explains why beaked shells are rare in *M. edulis*.

(9) Shells with small values of *Laa/L* usually belong to *M. galloprovincialis*, those with large values to *M. edulis*, see fig. 3.

In the preliminary investigation of samples 1 and 8, from W. Italy and the Netherlands respectively, these proved to differ in a number of characters which do not appear in figs. 2-26, and which, as it turned out, were of little or no specific value at other localities. For the sake of completeness, they are mentioned below:

(10) In reflected light, the colour of the inside of the shells from W. Italy is distinctly blue if the shells are fresh, with occasionally a small whitish area at the anterior end. Among the shells from the Netherlands, the inside of the anterior end is always whitish. Moreover, this whitish area tends to be considerably larger.

(11) At the inside of the anterior end, small irregular pits can be seen. These are coarser in the shells from the Netherlands than in those from W. Italy.

Finally, I counted the teeth in the hinge plate of about 170 shells from W. Italy, SW. France 1, and the Netherlands, with the outcome that:

(12) In *M. galloprovincialis* about 30% of the shells possess more than three teeth, as compared to slightly over 60% in *M. edulis*. On the average, in both forms the number of teeth in the left valve equals that in the right valve. Often, a tooth may be developed so poorly, that it is difficult to decide whether to count it or not.

DISTRIBUTION

M. edulis is definitely rare in the Mediterranean, and at the Atlantic coasts of Spain, Portugal and Morocco. I have only seen a few specimens from the Rio Tejo (Tagus), Portugal (Dautzenberg colln.), and from Algeria, Venezia, Trieste, and San Remo in the Mediterranean (all RMNH). I feel convinced that at least part of these few shells has been wrongly labelled, and that among published records, as compiled by Seed (1972: 379), mistaken identifications do occur[2]. Confirmation of the presence of *M. edulis* in the area mentioned is therefore still very much desired.

[2] Seed (1972: 372, 378) reports a small percentage of *M. edulis* among the mussels in the commercial beds of the "étangs" near Sète, and from a site near Martigues. I examined a sample of 75 specimens from commercial beds in the Bassin de Thau, S. France, collected near Marseillan, 15 km SW. of Sète (my colln.). Though Seed's and my sample most probably have been collected in the same "étang", and though in my sample also a small percentage (slightly over 6%) of shells with

In contrast to *M. edulis, M. galloprovincialis* seems to be a southerly form, which in Europe has been reliably reported as far north as NW. Ireland (Seed, 1974). It seems to be absent in the North Sea, the Irish Sea, and the eastern part of the Channel. It is widely distributed along the Atlantic coasts of France, Spain, Portugal and Morocco, and in the whole of the Mediterranean. For more details, see Lubet (1973: 2:1) and Seed (1972: 379; 1974: 17).

TWO DISTINCT SPECIES

If *M. edulis* and *M. galloprovincialis* would have been geographically separated, we would not have been in a position to know whether or not they would interbreed in case the geographical barrier would break down. In that case, we might have considered them to be subspecies, i.e. local forms of a single species. On the other hand, if we would have been justified to believe that no hybridization at all occurs in the actual overlap of the ranges of the taxa, complete reproductive isolation would have convinced us that they are distinct species. The problem is that we do not know whether hybridization occurs or not, as long as it has not been decided to what extent reports on hybrid specimens are due to difficulties in distinguishing between both taxa, rather than to the presence of true hybrids. However, it is certainly not so that there exists a more or less gradual geographical merging of both taxa. In my sample SW. France 1, i.e. from close to the southern limit of the overlap of the ranges, both taxa are present together in great numbers, without much evidence of hybridization, if any. Similarly, Seed (1972: 368) too had few difficulties in identifying the shells in the greater part of his samples from the Bassin d'Arcachon. Recently, Skibinski et al. (1978), produced genetic evidence for the natural occurrence of small percentages of F_1 hybrids in sympatric populations in SW. England. Thus, if hybridization occurs at all, it surely must have the character of a very limited transgression of the reproductive barriers which otherwise separate both taxa. Moreover, the fact that it has been possible to demonstrate the simultaneous presence of both taxa at many sites, proves that the exchange of genetic material between both taxa (introgression) is far from complete too, if present at all. Within a single species, such a complete or nearly complete genetic isolation is only conceivable between the "terminal links of a circular chain of intergrading subspecies" (Mayr, 1964: 180). This, however, seems to be excluded by the excellent dispersal facilities of the taxa involved. Moreover, it is difficult to imagine such a circular chain which is in accordance with the distribution of *M. edulis* s.l. given by Soot-Ryen (1955: 22). Thus, there simply is no choice, *M. edulis* and *M. galloprovincialis* must belong to distinct species. If hybridization does occur, this only proves that the reproductive isolation is not (yet) complete, as is also known from many other good species.

M. edulis-like rays occurs, I cannot confirm Seed's observation. I have no doubt that all shells in my sample belong to *M. galloprovincialis*. The highest value of *Laa/L* in my sample is 0.092, and in Seed's about 0.098. Though these may be high values for Mediterranean samples, they are not unusual among Atlantic ones of *M. galloprovincialis*. Obviously, *Laa/L* is subject to geographical variation, and no conclusions can be drawn from the presence of high values in variable populations in "étangs" or commercial beds. Moreover, there seems to be little or no correlation between the presence of rays and high values of *Laa/L* or *Laa/H* + 1.5 *Rin/H* in my sample. This only leaves the slight shoulder in Seed's histogram, which, in my opinion, must be accidental.

DISCUSSION

In general my findings agree well with published information on the characteristic features of *M. edulis* and *M. galloprovincialis*. Occasional different results may be due to difficulties in the identification of individual shells, resulting from the absence of completely specific characters. Because of the great, and seemingly highly parallel, geographical variability of both species, differences may, moreover, have arisen from differences in the origin of samples. In my investigation, for instance, shells from localities north of Arcachon, S.W. France, played a very minor part, except for those from the Netherlands.

I therefore will restrain myself to two remarks as regards differences which cannot be ascribed to the reasons mentioned above:

(1) The strong bimodality of the histogram of the ratio anterior adductor scar over shell length, found by Seed (1972: 376) at Arcachon Pier, proved to be absent in my sample from very much the same locality (see fig. 3). This is mainly explained by the substantially and, judging from the way I sampled myself, probably accidentally lower percentage of *M. galloprovincialis* among my sample, but it nevertheless underlines the limited specificity of the character.

(2) I did find little or no support for the specificity of the characters mentioned by Lacourt (1974: 135). Among the samples investigated by me, irregularity of the posterior retractor scar, which according to Lacourt is a new character of *M. galloprovincialis*, only occurs in a very limited number of the shells, and is at least as frequent in *M. edulis* as in *M. galloprovincialis* (see fig. 24). In addition, it is certainly not so that the nature of irregularities differs fundamentally in both species; the posterior retractor scar reminds one of the longitudinal (not "transverse", as Lacourt wrote) section of a human foetus no more often in *M. galloprovincialis* than in *M. edulis*.

In order to distinguish between both species, Lacourt used two other characters: the shells of *M. galloprovincialis* should (a) be flatter, less bulging, and should (b) be dark brown to black, as compared with violaceous or bluish in *M. edulis*. In my experience, the former character is far from specific, see fig. 16. As regards the colour of the shells, we may assume that Lacourt refers to the outside in reflected light, and with the periostracum still intact. Otherwise, no black colours can be observed, unless Lacourt denotes opaque shells as black. But opaque shells occur as often among *M. edulis* as among *M. galloprovincialis*. Now, in both species the periostracum is brown, largely disguising the colour of the prismatic layer beneath. If the colour of the prismatic layer is very pale, the shell is brown, which changes into black as the prismatic layer is darker, be it brown, purplish, violaceous or bluish. Thus, in reflected light, and as long as the periostracum is intact, violaceous or bluish colours are only to be observed in very transparent shells with rays or an otherwise bluish coloured prismatic layer. Indeed, such shells are considerably more frequent in *M. edulis* than in *M. galloprovincialis*, but in both species they are of local and/or occasional occurrence only. Thus, the colour in reflected light is a character of very limited specificity.

Notwithstanding the, in my experience, inadaquate specificity of the characters used, Lacourt does not mention any difficulties in discriminating between the shells of both species. No more does he give any information about nature, amount, or exact origin of the material studied, or about any observations as regards variability, specificity etc. of

his new character. I then tried to find at least the origin of the two characters he used in distinguishing both species. As regards colour of the shells, this, however, is not to be found among the references given by Lacourt, nor is it to be found in any other publication I know. On the contrary, Lamarck (1819: 126) described *M. galloprovincialis*, and not *M. edulis* as blue! Lubet (1976: 348) described the periostracum of *M. edulis* as "blue or brown", and that of *M. galloprovincialis* as "violet purple or blackish". A description which is rather close to that by Lacourt, but still sufficiently different to underline the inadaquacy of Lacourt's first character.

The second character, i.e. the flatter shells of *M. galloprovincialis*, is used by Jeffreys (1863: 105) and Sowerby (1887: Pl. VII, 18-21) in order to distinguish the variety *galloprovincialis* of *M. edulis*. A character, however, may be perfectly suited to describe the variability of a species, without having the specificity necessary to separate two very similar forms. Anyway, the character is not mentioned by Lubet (1976), and is not considered to be of much use by Lewis & Seed (1969) and Seed (1972, 1974). It is therefore difficult to understand why Lacourt preferred other characters than those advocated by the latter authors, unless he was not acquainted with them.

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SAMENVATTING

Conchologische bewijsvoering dat Mytilus edulis en M. galloprovincialis aparte soorten zijn

Een centrale rol bij de bewijsvoering dat *Mytilus edulis* L. en *M. galloprovincialis* Lam. afzonderlijke soorten zijn, speelt het monster SW. France 1, dat in de getijdenzone levend verzameld werd op de betonconstructie van de oostelijke pier te Arcachon, ZW. Frankrijk. Uit fig. 3, 4 en 10-12 blijkt dat, wat betreft enkele der vele onderzochte kenmerken, dit monster aanmerkelijk verschilt van de erboven afgebeelde monsters, die kennelijk alle tot *M. galloprovincialis* behoren. Uit fig. 27 en 29 blijkt duidelijk dat genoemde verschillen veroorzaakt worden door het naast elkaar voorkomen van *M. edulis* en *M. galloprovincialis*. Uit fig. 29-31 blijkt voorts dat de formule $Laa/H + 1.25\ Rin/H = 0{,}25$ een vrij scherpe grens tussen beide vormen aangeeft. Samen met de kleur in doorvallend licht bleek dit het beste kenmerk om de schelpen uit elkaar te houden. Die van *M. galloprovincialis* missen gewoonlijk de scherp begrensde, tot de schelprand doorlopende blauwe radiale banden op een afwijkend gekleurde ondergrond, en vertonen soms concentrische, tamelijk regelmatige, smalle donkerder kleurbanden. Ook zijn de ventrale delen, vooral bij de punt, vaak duidelijk meer transparant dan de rest van de schelp. De kleur van deze overige delen is vaak anders dan bij *M. edulis*, donkerder bruin, paarsachtig of violet, en vaak opvallend homogeen; alles, zoals gezegd, in doorvallend licht. Behoudens de (niet altijd aanwezige) radiale banden is bij *M. edulis* de doorzichtigheid nogal constant over de gehele schelp. Er bestaan geen kenmerken waarmee elke schelp gedetermineerd kan worden!

M. edulis is zeldzaam, of misschien wel geheel afwezig, langs de kusten van Spanje, Portugal, Marokko en de gehele Middellandse Zee. *M. galloprovincialis* is daar juist wijd verspreid, evenals langs de Atlantische kust van Frankrijk, ZW. Engeland en Ierland.

Uit het feit dat *M. edulis* en *M. galloprovincialis* blijkens het monster SW. France 1 op zijn minst plaatselijk naast elkaar voorkomen zonder dat merkbare hybridisatie optreedt, moet (in dit geval) de conclusie getrokken worden dat ze niet tot dezelfde soort kunnen behoren.

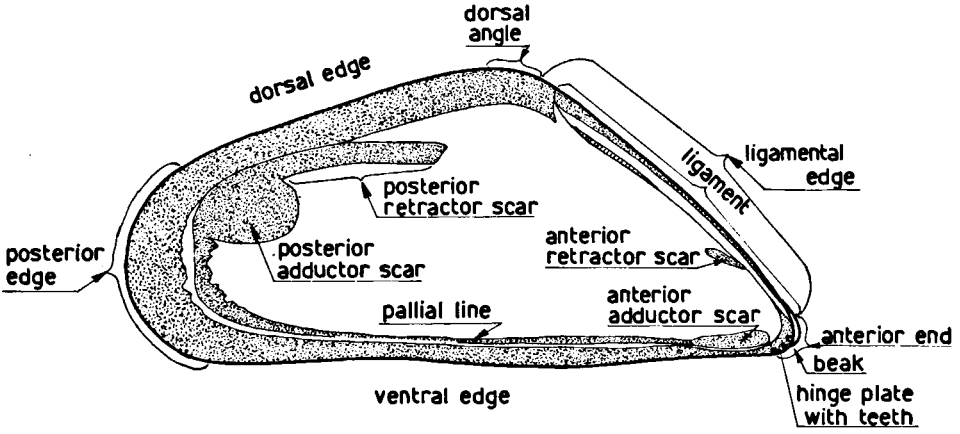


Fig. 1. View of the inside of the left valve of *Mytilus edulis*.

Figs. 2-13. Observations on *M. galloprovincialis* and *M. edulis* from eight localities, arranged geographically, and differentiated according to the length *L* of the shells, as shown in fig. 2.

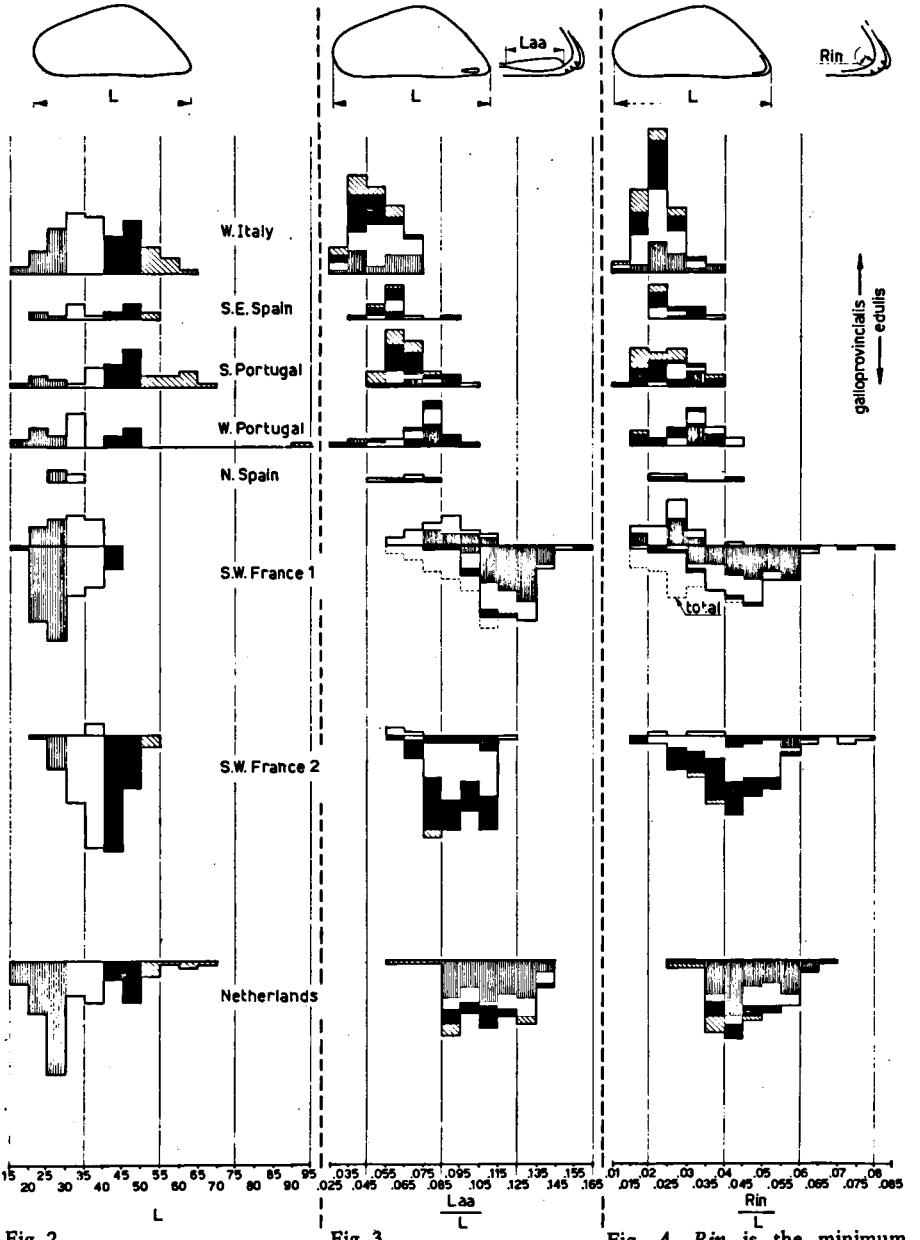


Fig. 2.

Fig. 3.

Fig. 4. *Rin* is the minimum radius of the inner edge of the hinge plate

Results differentiated according to length of shells, see fig. 2

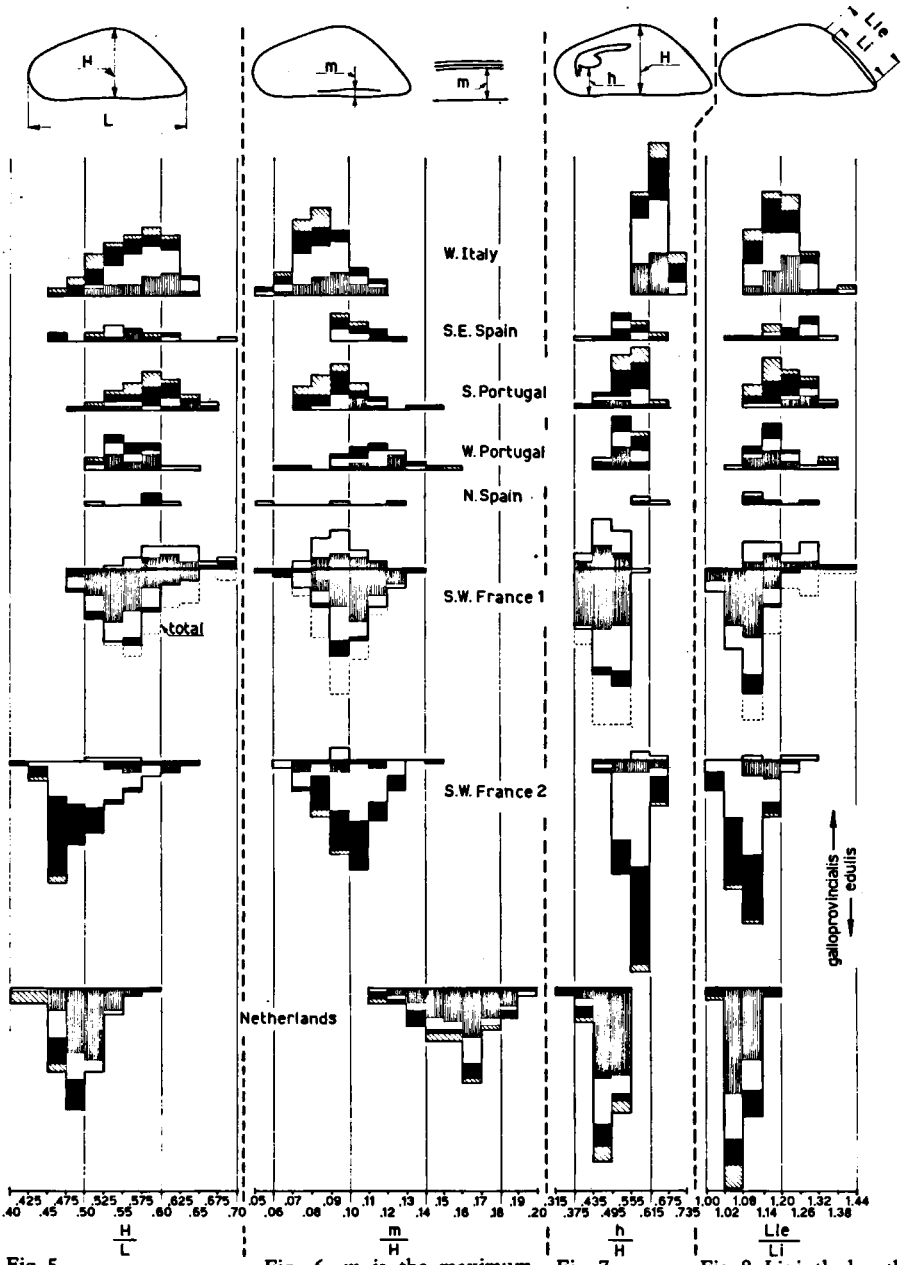


Fig. 5.

Fig. 6. *m* is the maximum distance between the ventral edge and the lower limit of the compound pallial line

Fig. 7.

Fig. 8. *Lie* is the length of the ligamental edge

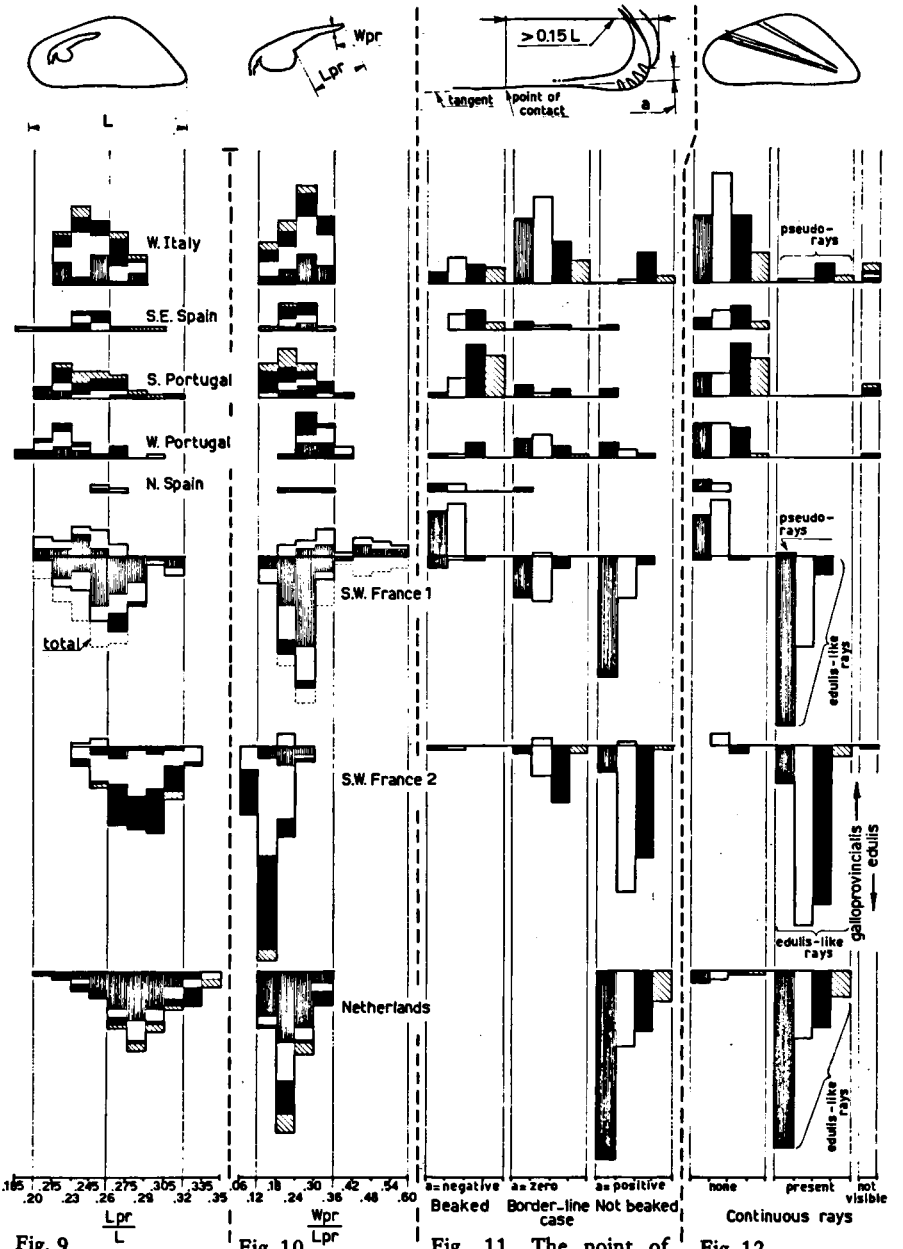


Fig. 9. Fig. 10. Fig. 11. The point of contact is chosen such as to produce a minimum, if possible negative value *a* Fig. 12.

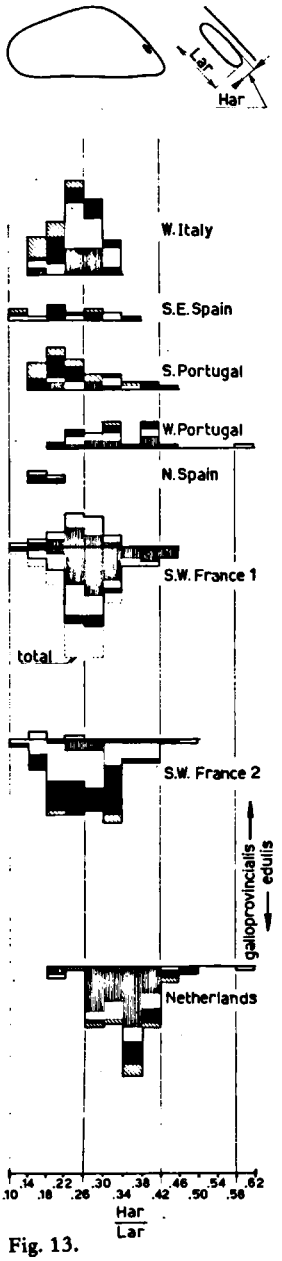


Fig. 13.

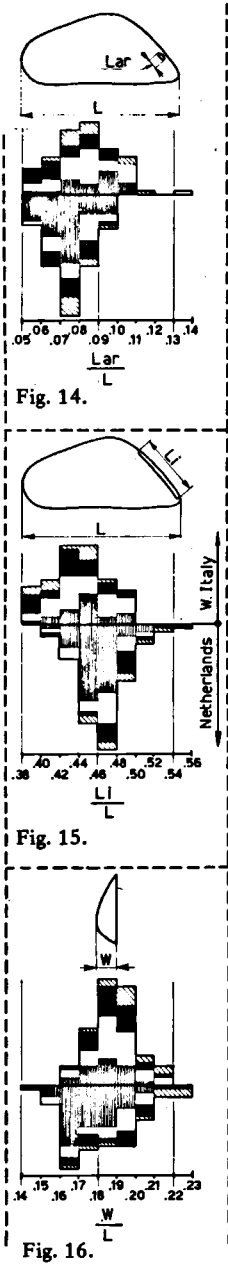


Fig. 14.

Fig. 15.

Fig. 16.

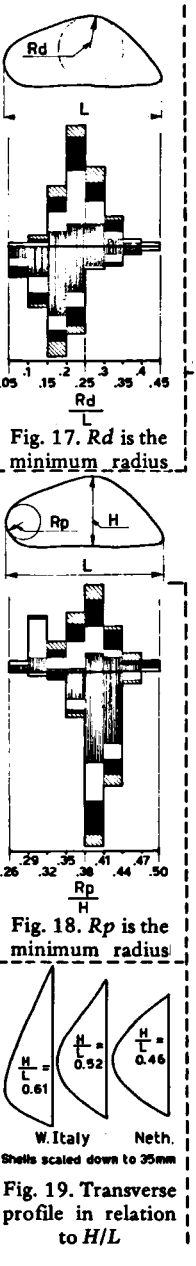


Fig. 17. *Rd* is the minimum radius

Fig. 18. *Rp* is the minimum radius

Fig. 19. Transverse profile in relation to *H/L*

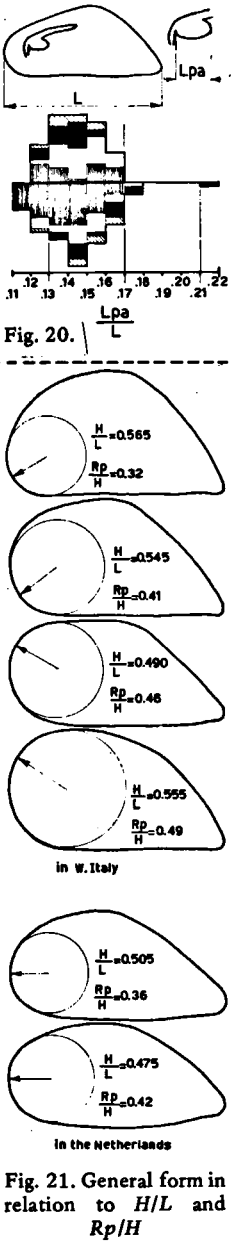
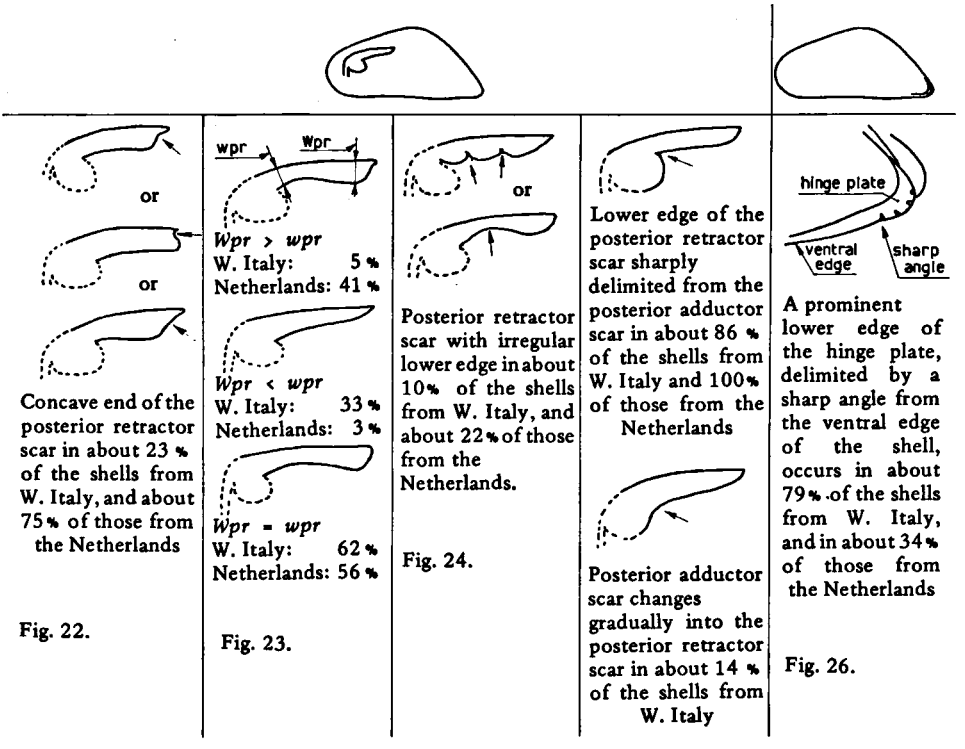


Fig. 20.

Fig. 21. General form in relation to *H/L* and *Rp/H*

Figs. 14-21. Observations on *M. galloprovincialis* from W. Italy and *M. edulis* from the Netherlands only. Differentiation according to length of shells, see fig. 2.



Figs. 22-26. Additional observations on *M. galloprovincialis* from W. Italy, and *M. edulis* from the Netherlands.

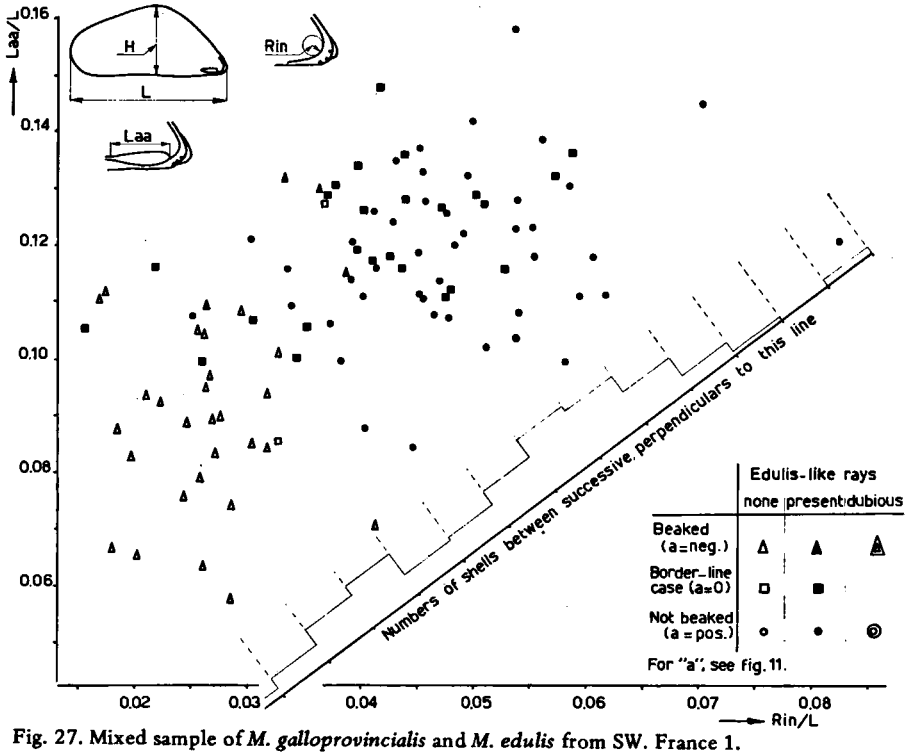


Fig. 27. Mixed sample of *M. galloprovincialis* and *M. edulis* from SW. France 1.

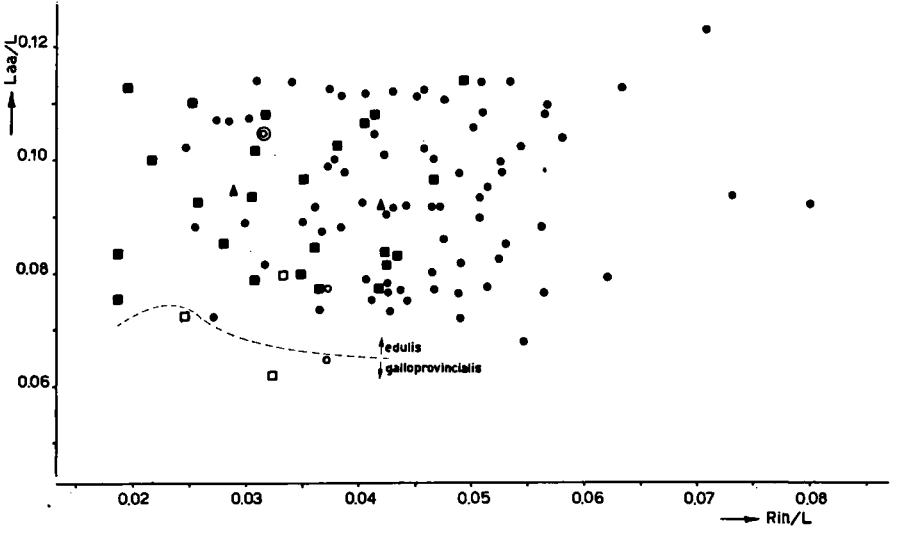


Fig. 28. Mixed sample from SW. France 2, consisting mainly of *M. edulis*.

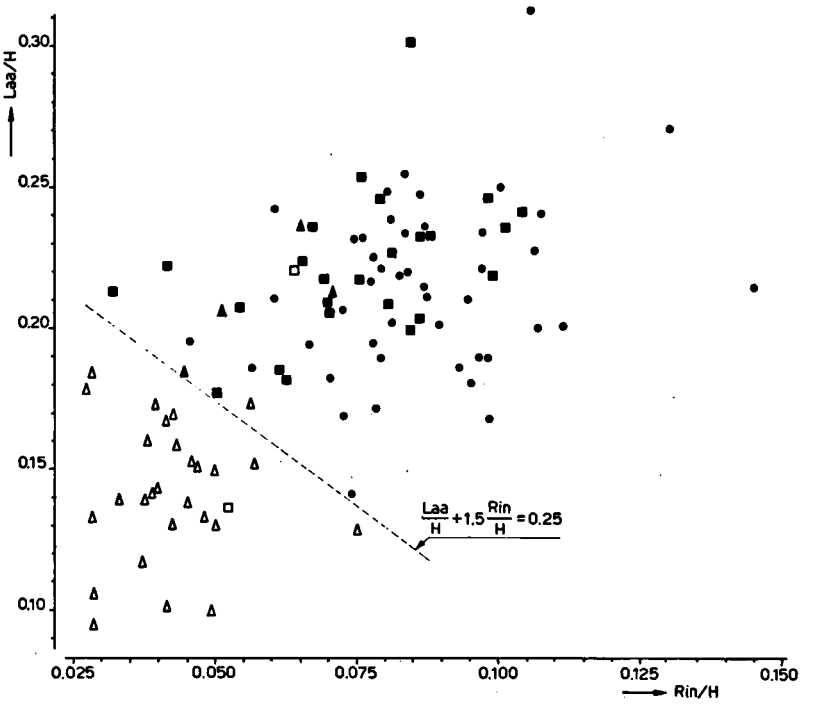


Fig. 29. Same sample as that of fig. 27, with *Laa/L* and *Rin/L* replaced by *Laa/H* and *Rin/H* respectively. Same symbols as in fig. 27.

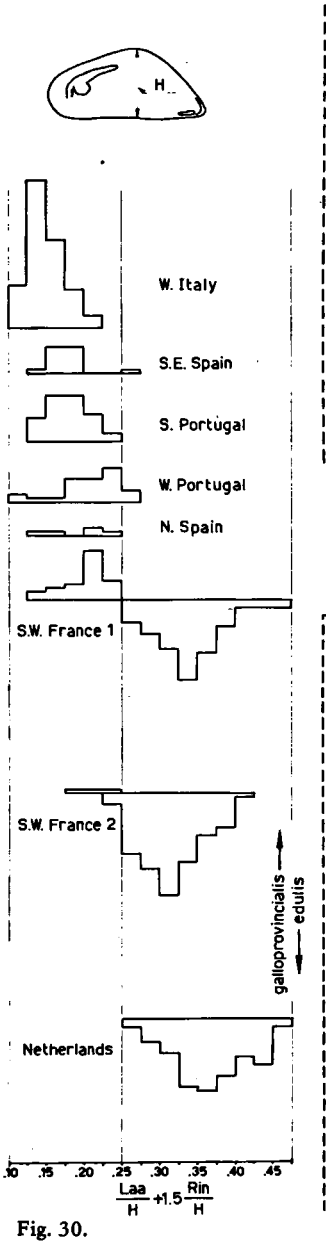


Fig. 30.

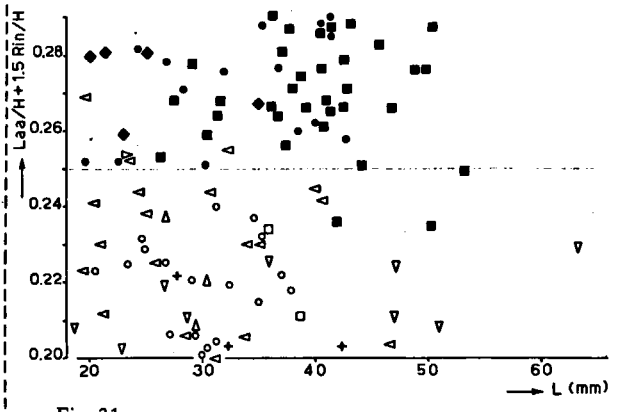


Fig. 31.

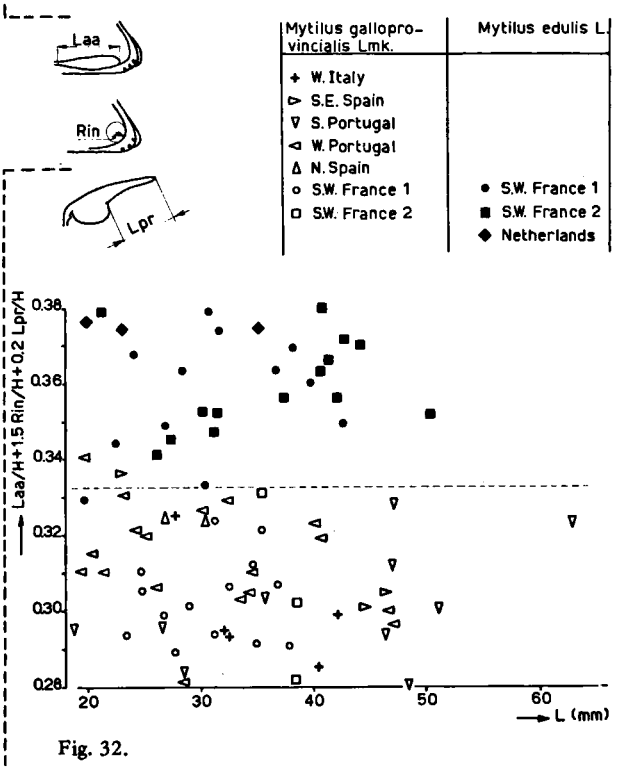


Fig. 32.

Fig. 30-32. Observations on *M. galloprovincialis* and *M. edulis* from the same localities as those of figs. 2-13.

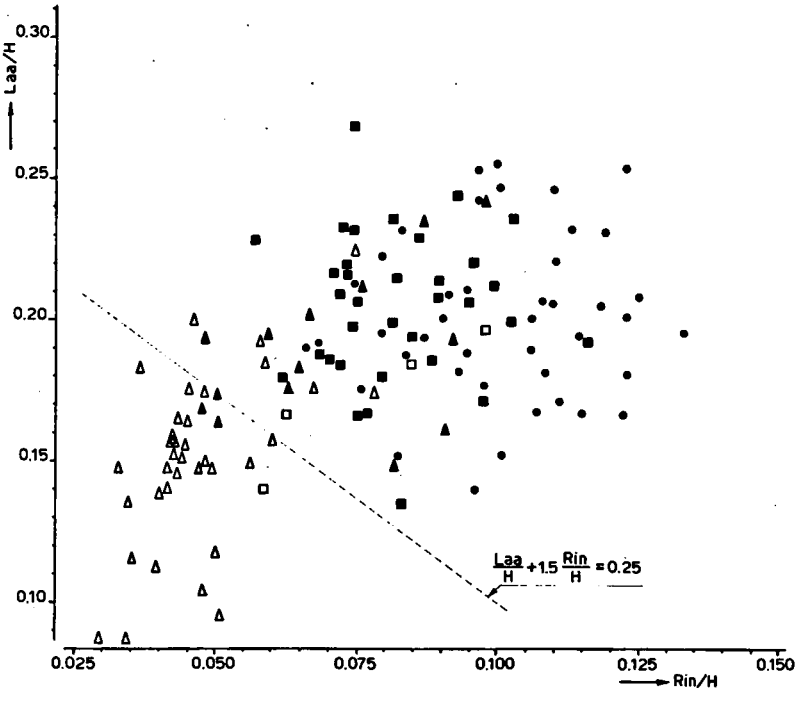


Fig. 33. Observations on *M. galloprovincialis* and *M. edulis* from SW. France 1; duplicate sample of that represented by figs. 2-13, 27 and 29-32. Symbols as in fig. 27.

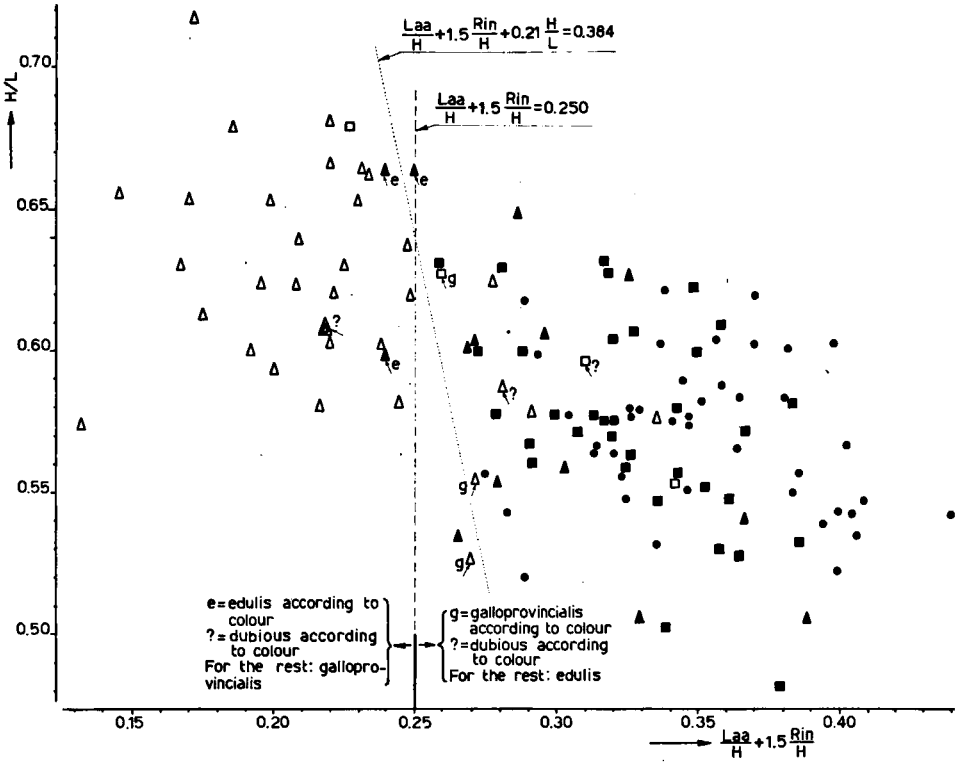


Fig. 34. Same sample as that of fig. 33. Symbols as in fig. 27.