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Variation in *Cavolinia inflexa* (Lesueur, 1813) (Gastropoda: Pteropoda: Euthecosomata)

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Key words: variation; taxonomy; distribution; *Cavolinia*; Pteropoda.
Cavolinia inflexa (Lesueur, 1813) proves not to be composed of subspecies or formae, or to show clinal variation. Maximum shell length varies between 4 and 7 mm, shell width between 2 and 4 mm, length/width ratio between 0.51 and 0.81. A geographic pattern in the occurrence of different length/width ratios, on which the subdivision of this species was always based in literature, could not be found. Frequency analyses of length for all samples combined did not show subdivision in local populations and length/width ratios over all samples did show only a pattern of shell growth. There is no valid ground for the subdivision of the species into different taxa.

Introduction

More detailed studies of variable species usually bring to light more differences and discriminating characters. Zooplankton species with a distribution over all oceans between 40°N and 40°S show usually longitudinal or sometimes latitudinal variation. This variation is frequently correlated with environmental parameters, and thus geographic in character so that clinal variation or infraspecific taxa can be recognised (van der Spoel & Heyman, 1983). For at least one species this does not hold; *Cavolinia inflexa* (Lesueur, 1813) proves not to be composed of subspecies or formae (sensu van der Spoel, 1969), as was previously postulated (Boas, 1886; van der Spoel, 1967; Rampal, 1975) nor to show clinal variation. It seems as if local populations vary by hazard. To clarify this problem specimens of this species from localities all around the world were studied. Putting together the shell shape variation from localities around the world proved to be an inadequate approach so that the present paper focuses on meristic data throughout, with the result that any subdivision of the species in lower taxa proves to be impossible.

Material

From the collections of the Zoological Museum, Amsterdam, and those of the Dana Expeditions, preserved in the Zoological Museum, Copenhagen, 45 samples from around the world were studied. Twenty-two of these, with enough specimens were selected for the meristic study and presented in fig. 1. The measurements taken, shell length (A), shell width (B), length above the spines bases (C) and distance closing mechanism to spine bases (D) are indicated in fig. 2. In total 184 specimens were measured. Only full-grown shells were taken for the measurements with a 'Wild' dissecting microscope with a magnification of 25 ×.

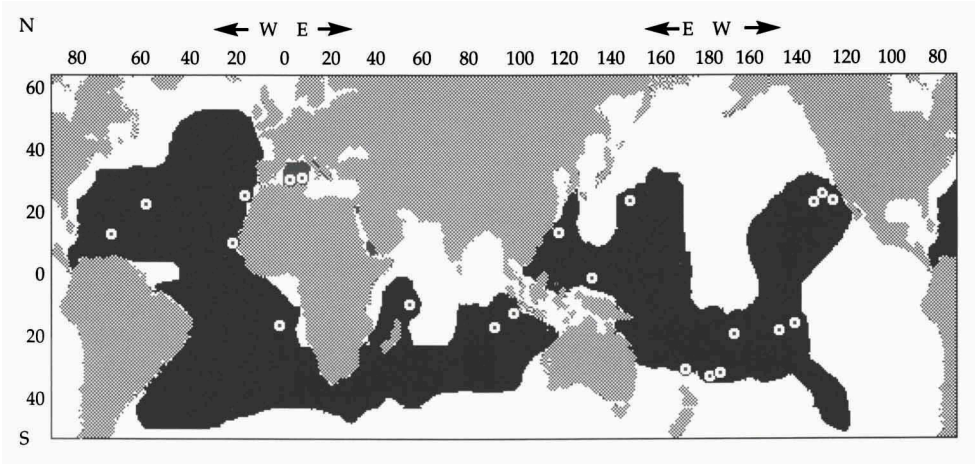

Fig. 1. Distribution of *Cavolinia inflexa* with localities of material studied indicated by circles.

Results and discussion

The maximum shell length varies between 4 and 7 mm, shell width varies between 2 and 4 mm. The length/width ratio varies between 0.51 and 0.81. A geographic pattern in the occurrence of different length/width ratio's, on which the subdivision of this species was always based in literature, could not be found (figs 3 and 4). The approximate level which should, according to literature, divide the lower taxa, are indicated with dotted lines. Since the other characters measured (width, length of shell above lateral spines and distance between lateral spine and closing mechanism, fig. 5) show variation completely comparable with that of the length/ width ratio, it was concluded that local populations showing different sizes represent an at random variation in growth. That growth is the most important vector for the variation is also shown in the North-South variation where the smallest specimens and the smallest length/width ratios occur in areas with lower productivity at 25°N and 18°S. Frequency analyses of length for all samples combined did not show any subdivision in local populations and length width ratios over all samples did show only a pattern of shell growth (fig. 6).

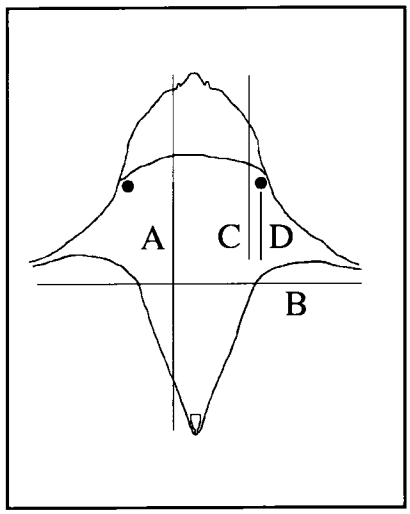

Fig. 2. Diagrammatic representation of the shell of *Cavolinia inflexa* from ventral with the measured sizes indicated, A = length, B = width, C = length above the lateral spines, D = distance lateral spine-closing mechanism.

Pfeffer (1880), Boas (1886) and Tesch (1913) were the first to pay special attention to the variation in *C. inflexa*. Pfeffer (1880) considered this species to be composed of three nominal species *C. inflexa* (Lesueur, 1813), *C. labiata* (D'Orbigny, 1836) and a new species *C. imitans* (Pfeffer, 1880) from the W. Indian and Atlantic Oceans.

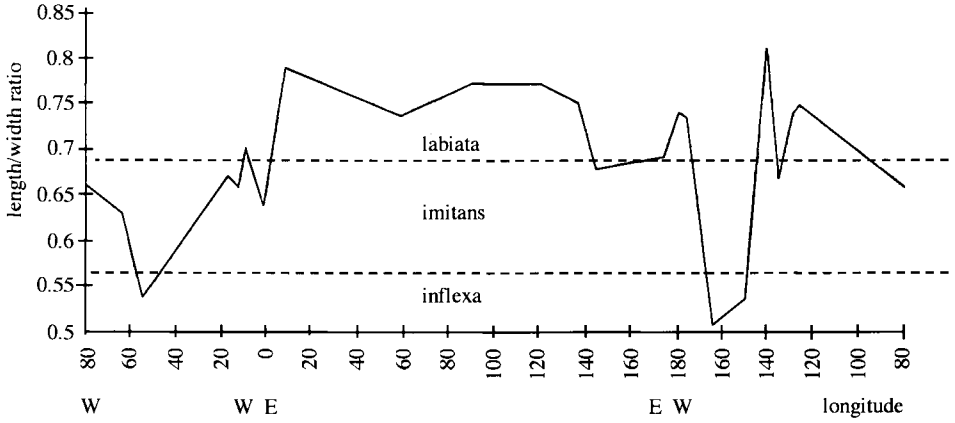

Fig. 3. Geographic west to east variation of the average length/width ratio per station.

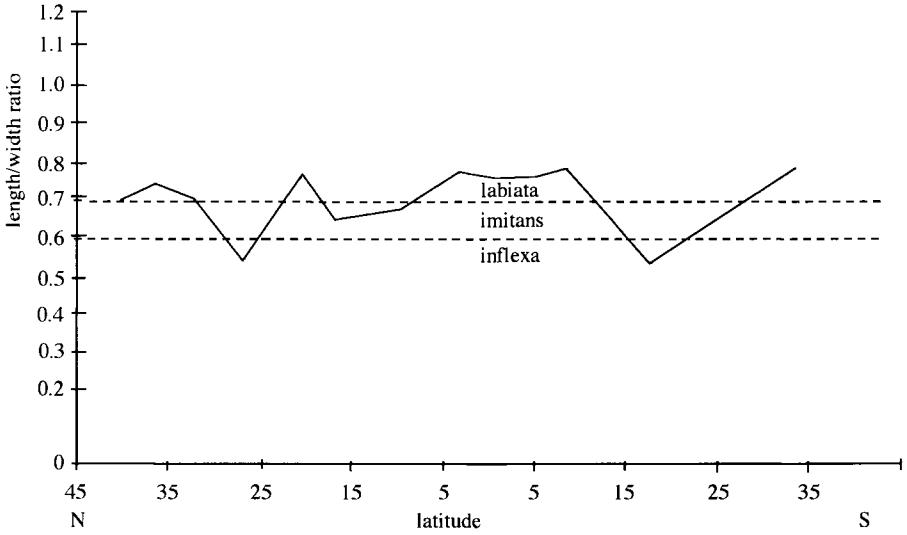

Fig. 4. Geographic north to south variation of the average length/width ratio per station.

This idea is not in accordance with the present data. Boas (1886) distinguished only two varieties *longa* (= *inflexa*) from the Atlantic and *lata* (= *labiata*) from the Indo-Pacific. Apparently the illustration of the variation in the present species by Boas misled most scientists. In that figure the specimens are arranged in morphological sequence, but not in any geographic order, suggesting a clinal variation which in reality does not exist.

If clinal variation would be present in a species with a 40°N-40°S distribution like the present species has, one is inclined to compare the variation with that described by Fleminger (1973) for the copepod *Eucalanus subtenuis* Giesbrecht, 1888. Typical for

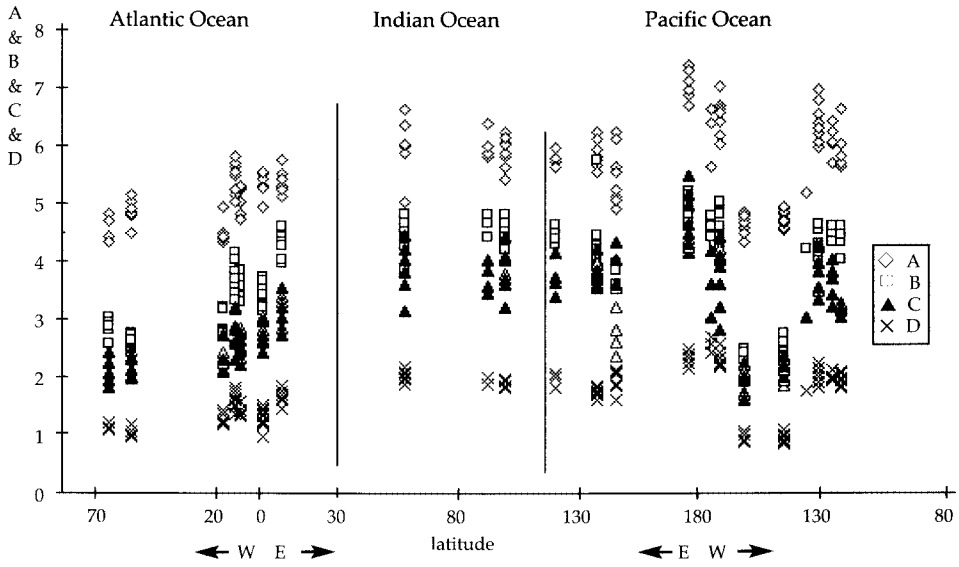

Fig. 5. Geographic west to east variation of all measured sizes (cf. fig. 2).

this cline is the gradual change in characters from east to west with the greatest changes only near inter-ocean connections. In *C. inflexa* the variation is not gradual but fluctuates and the most pronounced changes occur near inter-ocean connections as well as in the centre of oceans.

Tesch (1948) considered *C. inflexa* to be composed of two subspecies: *C. inflexa* in the N. Atlantic and E. Pacific and *C. labiata* in the S. Atlantic and Indo-Pacific. More recently, van der Spoel (1967, 1996) followed Tesch (1913) in the main lines but gave the taxa the level of formae and considered *imitans* a valid taxon. Rampal (1975) again considered the three taxa as subspecies in her accurate study of the variation, ending up with a distribution map presenting *C. inflexa* as a cold water species of the N. and S. Atlantic, *C. imitans* as an E. Pacific and Atlantic taxon and *C. labiata* as occurring in the S. Atlantic, Indian and W. Pacific Oceans.

The concepts presented by Rampal (1975) and van der Spoel (1967, 1996) seem very dubious as a) the distribution in both the Atlantic and E. Pacific of one taxon (Rampal, 1975, fig. 38) is very unusual (cf. van der Spoel & Heyman, 1983) and b) allopatric occurrence of geographic subspecies is unacceptable.

When there are no grounds for the acceptance of *C. inflexa* to be composed of different species or at least genetically well isolated subspecies, character displacement as postulated by van der Spoel, 1985, is also impossible.

In conclusion we have to consider the variation in *C. inflexa* to be generated only by differences in growth and available food; to be non-geographic in nature, although a vague resemblance with east-west variation was found. Thus there is no valid ground for the subdivision of the species into different taxa.

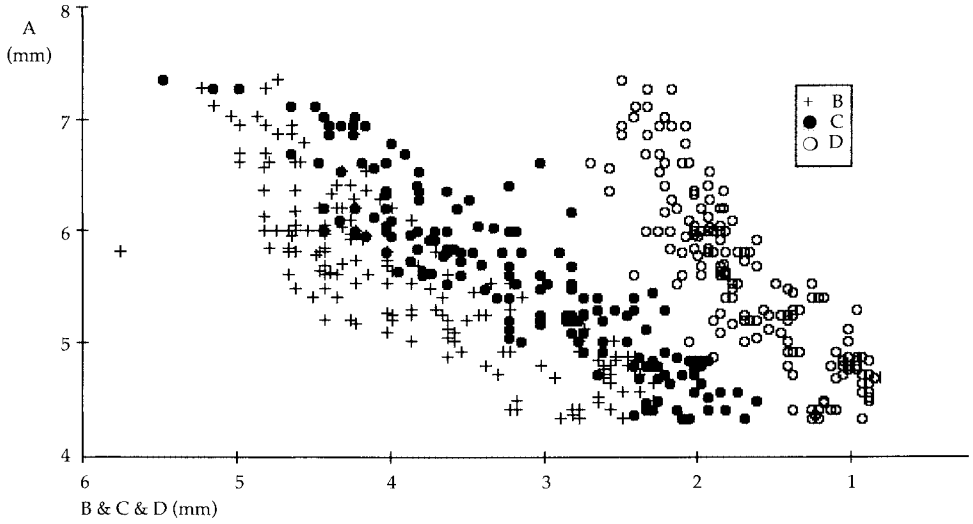

Fig. 6. Width (B), length of upper shell half (C) and distance lateral spine-closing mechanism (D) in relation to length (A) for all specimens examined.

Summary

On the basis of meristic data from about 200 specimens of 22 localities in the world oceans it was concluded that no clinal variation nor subspecific divisions could be made in the species *Cavolinia inflexa*. For the formae or subspecies described in literature no geographic pattern could be found.

Acknowledgements

It was in 1965 that Dr Vervoort warned us, stating: "be very careful in describing new taxa". We hope to have learned his lesson now, so that we dare dedicate, with thanks, this small note to our teacher and colleague.

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