

MORPHOLOGICAL CHANGES AT MATURATION AND SYSTEMATICS IN THE SQUID GENUS *ALLOTEUTHIS*

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ABSTRACT: Analysis of materials collected in the Aegean Sea, East Mediterranean and off Northwest Africa allows the hypothesis that the complex *A. media* + *A. subulata* may consist of two or three species, none of which perfectly fit existing diagnoses. All of the individuals studied possess features indicated for *A. media* and *A. subulata* but in different combinations, and the situation is aggravated by disappearance of the species' holotypes.

INTRODUCTION

The loliginid squid genus *Alloteuthis* comprises three nominal species. Two of these, *A. media* Linné, 1758 and *A. subulata* Lamarck, 1798, occur in the East Atlantic north of 20°N and in the Mediterranean Sea, whereas the third species *A. africana* Adam, 1950 inhabits the waters off West Africa from the south of Morocco to Angola (Nesis, 1985; 1987; Roper *et al.*, 1984). Grimpe (1925) established the main diagnostic features allowing the separation of *A. media* and *A. subulata*, which are very similar (Anderson, 1996; Laptikhovskiy *et al.*, 2002). To date the features for the species identification are as following (Nesis, 1982; 1987):

A. media – in adult squids tail length is less than 1 cm, fin length is less than ½ of the mantle length (ML), largest club suckers are 9–14% of the head width (holotype missing);

A. subulata – in adult squids tail length is up to 5–6 cm in males and up to 2 cm in females. Fin length is equal or more less than ½ of the ML, largest club suckers are 6–8% of the head width; club is narrow, pairs of median suckers are oriented at 45° to the club axis; arms are of 20–25% ML (holotype missing);

A. africana. Tail, fin and suckers as in *Alloteuthis subulata*, club is wide, pairs of median suckers are oriented perpendicularly to the club axis; arms are of 15–22% ML. Holotype is stored in Brussels.

However, their systematic status and validity is doubtful and should be revised (K.N.Nesis, personal communication). Our previous investigations (Laptikhovskiy *et al.*, 2002) showed that east Mediterranean squids represent a single taxonomic unit, which should be considered as *A. media* rather than *A. subulata*.

The aim of this paper is to investigate differences between species taking into account possible morphometric changes in relation to maturation, season, or geographic region. This study was made possible when *Alloteuthis* squid at the different maturity stages were collected both in summer and winter in two regions of the supposed species ranges' overlap: Aegean Sea and East Mediterranean (*A. media* and *A. subulata*) and Moroccan waters (all three species).

MATERIALS AND METHODS

A total of 340 squid were sampled onboard the RV “Koca Piri Reis” in different seasons between September 1990 and October 2002 in the Aegean Sea and northeast Mediterranean (Fig. 1). The squid were collected from samples taken over a depth range of 40–280 m. Mature squid were considered as winter-, spring-, summer- and autumn spawners depending on the month they were sampled in.

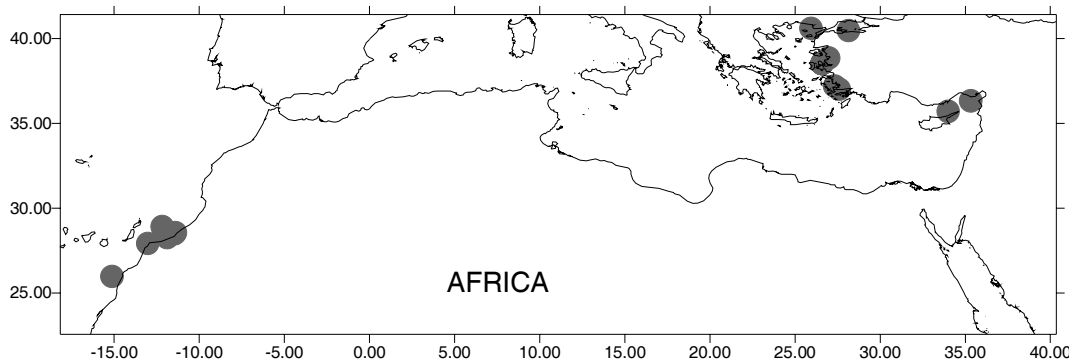


Figure 1. Position of the sampling sites.

A total of 205 *Alloteuthis* sp. (presumably a mixture of both *media* and *subulata*) and 74 obvious *A. africana* were sampled onboard RV “Dr. Fridtjof Nansen” in May–June and December 2002 off Northwest Africa between 25°58′N and 28°28′N, depth range 31–200 m. Because of the specific oceanographic seasonality off Northwest Africa, where May–June is spring and December is late autumn (Bernikov, 1969), mature animals caught in these months were considered as spring- and autumn spawners respectively. It is in accordance with data on hatching seasonality in both *A. subulata* and *A. africana* that have half-a-year life cycle off Northwest Africa with major spawning peaks in spring and autumn (Arkhipkin and Nekludova, 1993). Therefore, both major periods of the genus’ reproduction in this region were sampled.

The sampling gear onboard RV “Koca Piri Reis” was a small bottom trawl (vertical opening 1.6 m) with a codend mesh size of 20 mm. The two different “Akrahmn” pelagic trawls (of vertical opening 30 and 10 m) and one “Gisund super” bottom trawl (vertical opening of 5 m) with double mesh of 10 and 20 mm in codend had been used onboard RV “Dr. Fridtjof Nansen”.

Squid were preserved in 4% formaldehyde and, after about one month or more they were transferred into 70% alcohol. Species identification was based on the guide of Kir Nesis (1982; 1987). On examination onshore, dorsal mantle length (ML) and fin length were measured to the nearest 1 mm and body weight (BW) was measured to the nearest 0.001 g. Head width (HW) and the

width of the larger club sucker were estimated to within 0.1 mm under a binocular microscope. Maturity stage was assigned using the Lipiński (Lipiński and Underhill, 1995) scale. Data analyses were performed using MINITAB 13.

RESULTS

The systematic value of the relative largest club sucker width (% head width).

The relative club sucker width (RSW) varied from 7.8 to 14.5 (mean 10.6)% HW in the East Mediterranean animals showing increasing trend with ML ($r=0.275$, $p=0.007$) (Fig.2). All of them apart from some small animals fit the diagnosis of *A. media*. The RSW of immature animals was 8.9–10.2% HW, mean 10.2 ± 0.9 (Confidence Limit at $p=0.05$), whereas in mature squids it was 8.0–14.5% HW mean 10.75 ± 0.35 that was not statistically different ($T=-1.71$, $p=0.097$) and indicated no changes related to maturation. It was similar between animals spawning in the different seasons: 9.3–13.5 (mean 11.3 ± 0.9) in winter, 8.0–12.0 (mean 10.0 ± 0.5) in spring, and 8.0–14.5 (mean 11.1 ± 0.6)% HW.

Among the Northwest African squids, *A. africana* were considered separately from other *Alloteuthis* sp. Both groups also demonstrated a statistically significant increase of RSW with length (Fig. 2). Mean RSW was 11.34 ± 0.83 in *A. africana* vs 12.22 ± 1.57 showing no statistical differences ($T=0.97$, $P=0.137$). The sucker size of immature *Alloteuthis* sp (both seasons

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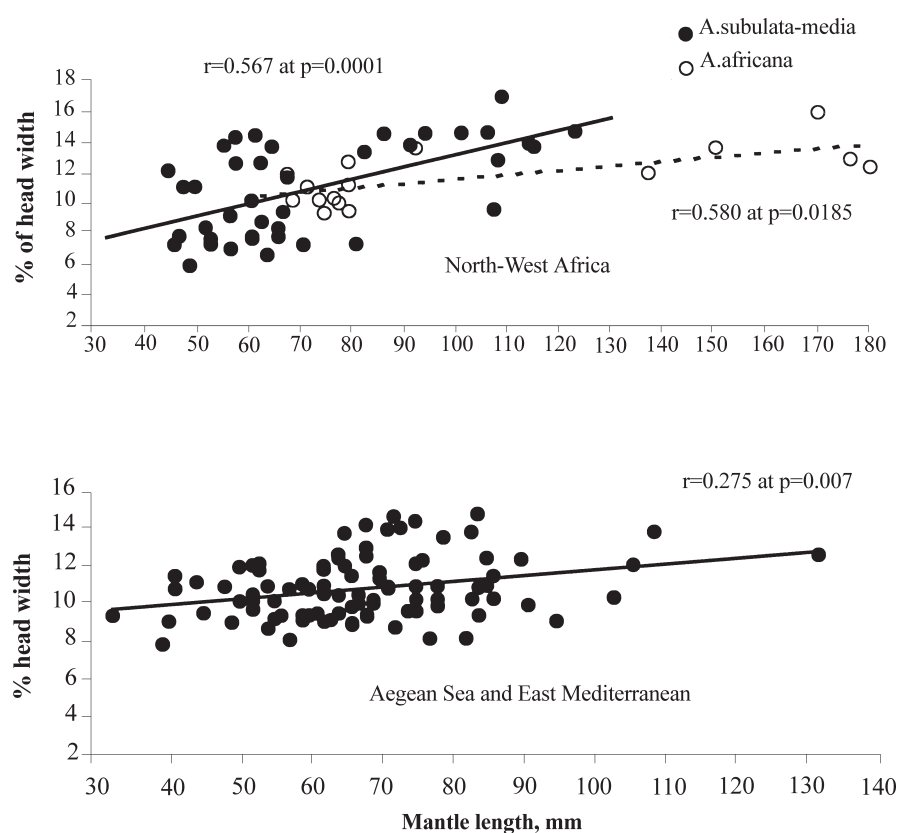


Figure 2. Relative width of the largest club sucker.

combined) was 5.8–12.0%, mean 8.57 ± 0.89 , which is more specific to the description of *A. subulata*, whereas in maturing and mature animals it was 6.4–17.7%, mean 11.83 ± 1.18 , which suits to the description of *A. media* ($T=-2.63$, $p=0.014$). The sucker size in mature spring spawners was slightly larger than in the autumn spawners (12.5–16.7, mean $14.43 \pm 1.68\%$ v.s. 6.4–14.3, mean 11.48 ± 1.86 ; $T=-2.31$, $p=0.043$).

The systematic value of the relative fin length

The tail appears in both *Alloteuthis* males and females at maturation and grows during maturity so, to avoid any ambiguity related to ontogenetic body changes, only mature males and females were taken into consideration.

In the Turkish sample the relative fin length increased with ML showing no separation that might suggest the existence of two species

distinguished by relative fin length (Fig.3). The smallest animals sampled fit the description of *A. media*, whereas the largest had the fins and tails of a typical *A. subulata*. Similar intraspecific variation was previously described in *A. subulata* with the recognition of the spring spawning short-tailed form ‘*subulata*’ and autumn spawning long-tailed form ‘*autumnalis*’ (Grimpe, 1925).

In contrast to the Turkish sample, the North African males and females of *Alloteuthis* sp. show a seasonal dimorphism in the fin length. The summer spawners have shorter fins than winter spawners: 37.55 ± 5.66 vs $59.22 \pm 2.48\%$ ML ($T=7.52$, $p<0.001$). Summer spawners suit the description of *A. media*, whereas the winter spawners have the long tail of *A. subulata*. The relative fin size increases with the ML and in such respect the *A. africana* seem to be just an “extension” of the winter spawning *Alloteuthis* sp.

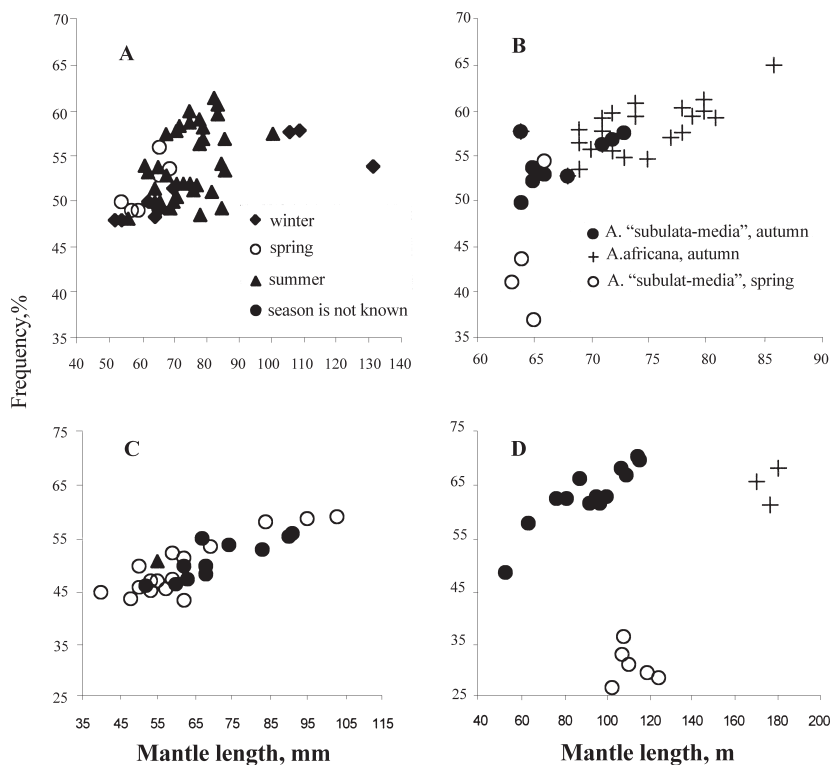


Figure 3. Relative fin length (% ML) . A – females, Turkey; B females, Morocco; C-males, Turkey, D-males, Morocco.

The systematic value of sexual dimorphism among mature squids

In the Turkish sample the maturation of *Alloteuthis* sp. occurs over a wide range of mantle lengths. The size of mature females varied from 37 mm (2.1 g BW) to 132 mm (25.6 g BW). The mature male ML was 32–84 mm (1.4–6.4 g BW). Both sexes matured in the East Mediterranean at more or less at the same size, between 30 and 60 mm (Fig 4), but males mature faster and their increase in mantle length at maturity is smaller. As a result, mature males are generally smaller than females (mean 66.3 ± 3.9 mm vs. 72.9 ± 4.5 mm, $T=-2.18$, $p=0.032$) with a 48 mm difference between the largest animals.

In the summer sample off Morocco (Fig. 5) the mature females' size varied from 60 to 71 mm (BW 5.0–7.6 g), mature males were larger, between 83–131 mm (6.7–9.9 g). Differences in lengths between both sexes was statistically significant ($T=15.54$, $p<0.001$). In the winter sample the size

of mature females was 64–73 mm (BW 5.6–6.7 g), that of males 81–116 mm (5.3–7.9 g.). Therefore, off Northwest Africa males of *Alloteuthis* sp. become mature at a larger size than females (mostly 70–100 mm vs. 60–80 mm) and attain a larger maximum size. Mean ML of mature females was 63.7 ± 2.1 mm, that of males – 106.9 ± 5.4 mm ($T=3.86$, $p<0.001$) with the difference of 58 mm between the largest animals.

DISCUSSION AND CONCLUSION

Our data show that traditional features do not allow the separation of existing *Alloteuthis* species, however, different species really do exist. Among the complex *A. subulata* + *A. media* there are at least three distinct squid forms (probably-species):

1. East Mediterranean squids. Females are larger than males. Club suckers are large

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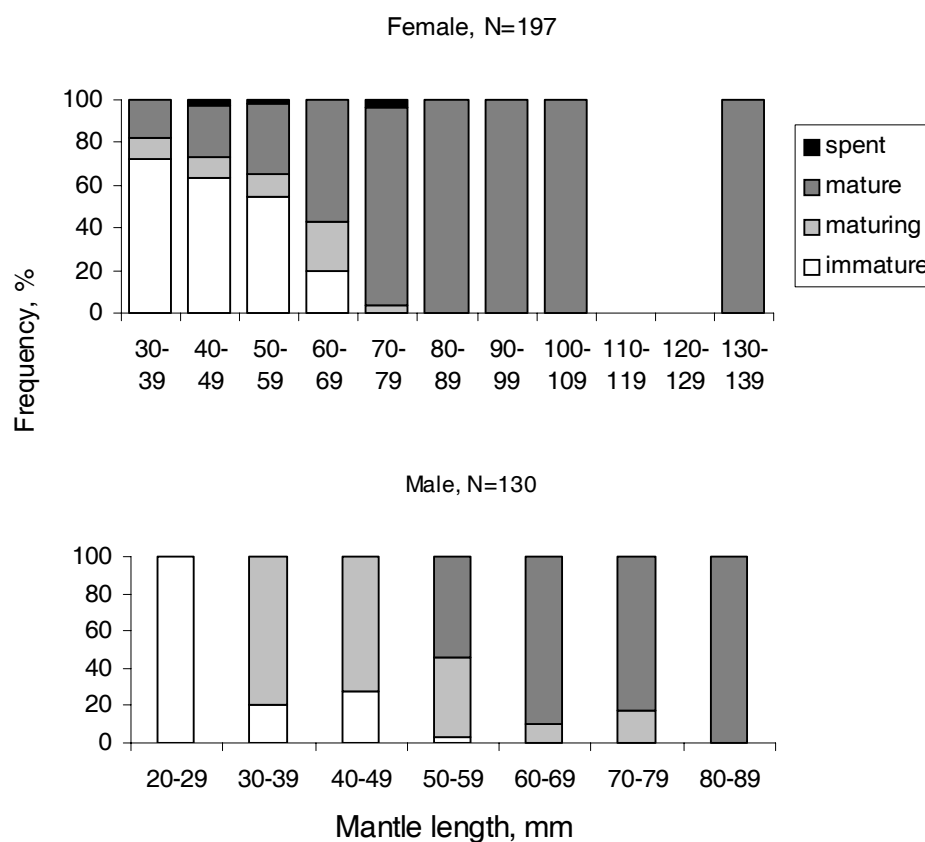


Figure 4. Maturation of the Turkish *Alloteuthis* sp.

as for *A. media* and their relative size only increases slightly at growth and maturation. The relative size of the tail increases during the maturity from the “*A. media*” pattern to that of the “*A. subulata*” and mostly suits the diagnosis of the latter species;

2. Northwest African squids sampled in summer. Males are larger than females. Club suckers in mature animals are large, their relative size shows an important increase with squid growth and maturation. The tails of mature animals are short, and basically these squids could be “proper” *A. media*, but in our sample males were larger than females. It contradicts the fact that in the Mediterranean *A. media* females are larger than males (Mangold-Wirz, 1963).

3. Northwest African squids sampled in winter. Males are larger than females. The club

suckers in mature animals are from small to large suiting both the *A. media* and the *A. subulata* descriptions, their relative size increases rapidly with squid growth and maturation. The tails of mature animals are long as they are supposed to be *A. subulata*.

On the other hand, Turkish *Alloteuthis* exhibits a fast increase of relative tail length during a prolonged period of maturity (Laptikhovsky *et al.*, 2002). It is still possible (however – highly unlikely) that the summer African samples consisted of squid that just attained maturity, whereas the winter samples consisted of squids at the end of breeding period. In such case, both (very different) Northwest African groups may turn out to be the same species.

It is obvious that additional materials from different regions of the East Atlantic are

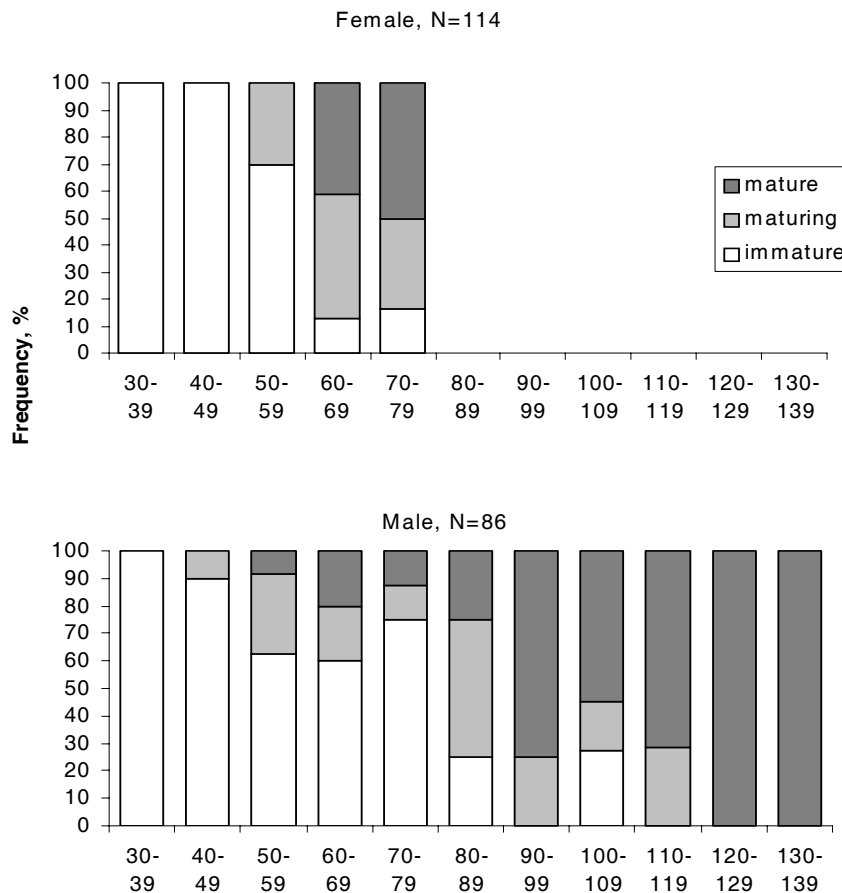


Figure 5. Maturation of the Moroccan *Alloteuthis sp* (*A. africana* are not included).

necessary for a definitive solution of the *Alloteuthis* problem. The situation is aggravated by the fact that the type specimen of *A. subulata* from the Mediterranean no longer exists, while the location given for the type specimen of *A. media* has not been recently confirmed (<http://www.cephbase.utmb.edu/dirdb/dirdb.cfm>). A comparison of samples collected in different seasons over the entire *Alloteuthis* genus range will probably help to reach a consensus about the species composition of this genus with molecular genetics methods of investigation involved. Upon genetic separation of the species it would be possible to make a detailed description of morphology of every species found and its ontogenetic changes.

ACKNOWLEDGEMENTS

We sincerely thanks The Scientific and Technical Research Council of Turkey (TÜBİTAK) for financial support of this investigation. It is impossible to underestimate the generous help of the late Dr. K.N.Nesis (Institute of Oceanology, Moscow), who formulated the problem and gave many consultations at the early stage of this work. We are thankful to Dr. Alexander Arkhipkin (Falkland Islands Government Fisheries Department, Stanley), Dr. Marek R. Lipinski (SFRI, Cape Town), Dr. Dmitry Alexeev (All-Russian Research Institute of Fisheries and Oceanography, Moscow), and an anonymous referee for valuable comments, and Dr. Paul Brickle (FIGFD) who assisted in correcting the English text.

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