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Systematic position and reproduction of squid of the genus *Alloteuthis* (Cephalopoda: Loliginidae) in the eastern Mediterranean

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Squid of the genus *Alloteuthis* from the Aegean Sea and eastern Mediterranean were identified as *A. media*. It is not possible to distinguish *A. media* from *A. subulata* by relative fin length. Both 'species' are probably intraspecific forms. Egg size varied from 1.5 to 2.3 mm. Oocyte maturation in the ovary occurs in batches. The potential fecundity is some 1000–4000 eggs, most of these being released during continuous spawning accompanied by female growth.

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 and in the Mediterranean Sea (Nesis, 1985, 1987). Grimpe (1925) established the main diagnostic features allowing the separation of these species. However, a cladistic analysis showed that all three *Alloteuthis* species are taxonomic equivalents (Anderson, 1996). The systematic status and validity of these species is doubtful and should be revised (K.N. Nesis, personal communication).

The reproduction of *A. subulata* in the Mediterranean has not been studied and that of *A. media* was previously investigated only in the western part of the sea. It was found that the duration of the life cycle was 1 y, spawning takes place from March to October, egg size is 1.4–1.6 mm, and fecundity is some 950–1400 eggs (Mangold-Wirz, 1963). However, the western Mediterranean is an oceanic-like habitat whereas the north-eastern Mediterranean and the Aegean Sea, with a huge number of islands, represent a quite different environment. Moreover, in contrast to the western Mediterranean, the local ecosystem is subject to the lessepsian migration of more than 200 Indo-Pacific species of fish and invertebrates through the Suez Canal (Por, 1978). Therefore, the reproductive strategy of local squid populations could be different from that in the western part of the sea.

The aim of this paper was to investigate the female reproductive biology of *Alloteuthis* in the eastern Mediterranean region. Another task was to look at the systematic value of the main morphological features separating *Alloteuthis* species and to find whether *A. subulata*, which is considered to be rare in the Mediterranean, is present in the region studied.

MATERIALS AND METHODS

A total of 327 squid were sampled onboard the RV 'Koca Piri Reis' between 1990 and 2002. Samples were collected between January and September, but were not available from all months or all years. The squid were collected from samples taken over a depth range of 40–280 m. Female fecundity and reproductive characteristics were studied in 49 animals.

The sampling gear was a small bottom trawl (vertical opening 1.6 m, horizontal opening 10 m) with codend mesh size of 20-mm. The towing speed was 2.5 kn. Squid were preserved in 4% formaldehyde and, after about one month or more of storage, were transferred to 70% alcohol.

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 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 & Underhill, 1995) scale. Ripe egg size was measured along the major axis in the ten best preserved eggs with a perfect ovoid shape.

Fecundity was estimated using methods applied previously in other squid, including species of Loliginidae (Laptikhovsky & Nigmatullin, 1993; Laptikhovsky, 2000; Laptikhovsky et al., in press). Potential fecundity (PF) was calculated as the sum of the total oocyte number in the ovary and the egg number in the oviduct. Relative fecundity (RF) was estimated as the ratio of PF to BW. An index of potential reproductive investment was calculated as the product of RF and the weight of an individual ripe egg (Laptikhovsky & Nigmatullin, 1993).

RESULTS AND DISCUSSION

Systematic position of the eastern Mediterranean Alloteuthis

In all immature, maturing, and mature specimens studied the relative club sucker width was more than 8.5% of head width, showing that all sampled squid were *Alloteuthis media*. Neither seasonal nor size-dependent variation in this feature was found.

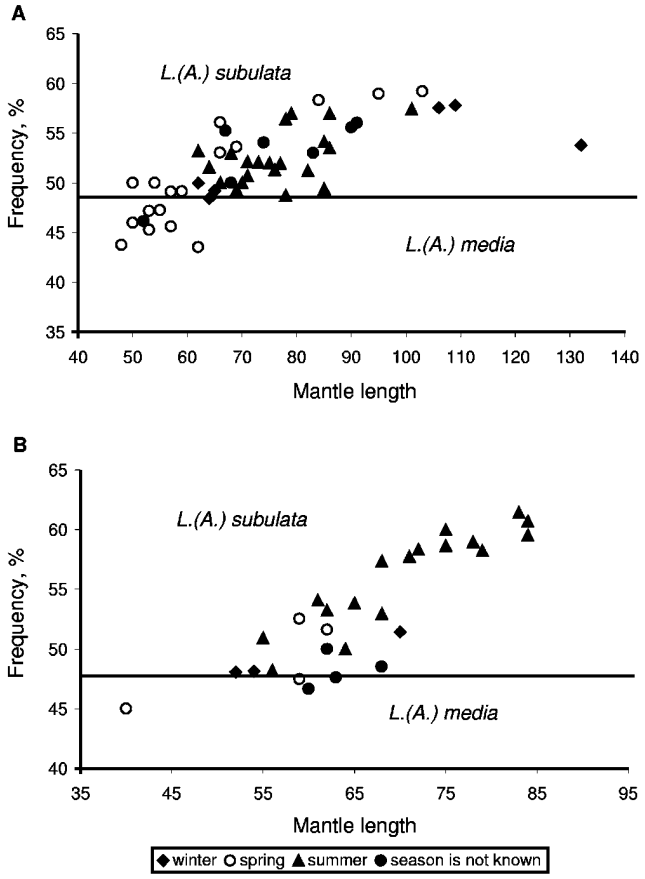

Figure 1. Relative fin length (% ML) in mature females (A) and males (B).

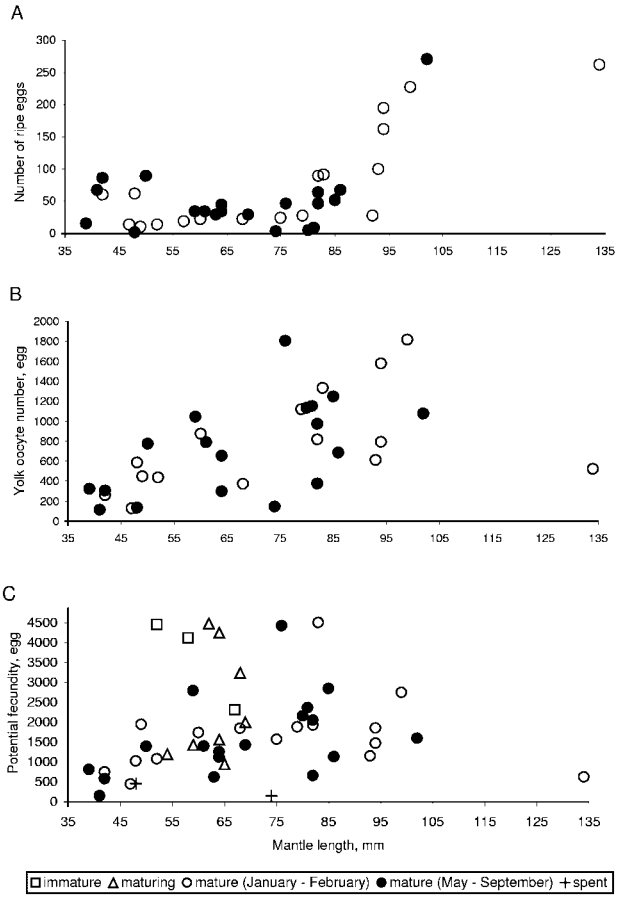

Figure 2. Fecundity of the squid *Alloteuthis media*.

The squid tail appears and grows at maturation and so, to avoid any ambiguity related to onthogenetic body changes, only mature males and females were taken into consideration (Figure 1). Relative fin length increased with body length showing no separation that might suggest the existence of two species distinguished by relative fin length. 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 recognition of the spring spawning short-tailed form '*subulata*' and autumn spawning long-tailed form '*autumnalis*' (Grimpe, 1925).

Taking into account all these findings we believe that eastern Mediterranean squids represent a single taxonomic unit and should be considered as *A. media*. The use of relative fin length for separation of these species is doubtful. It appears that these 'species' represent a range of gradual changes in body shape and are probably just ecological forms, as in salmonids and other fishes.

Maturation and spawning seasonality

Maturation of *A. media* occurs over a wide range of mantle lengths. The size of the smallest mature female was 37 mm (2.1 g BW), whereas the largest immature animal was 67 mm ML (5.1 g BW). The largest maturing female was of 68 mm ML showing that most, if not all, animals become mature on attaining about half of the maximum ML (in our sample: 132 mm ML, 25.6 g BW). A long period of maturity, during which significant growth takes place, could be a sign of long intermittent spawning.

The minimum ML of a mature male was 32 mm (1.4 g BW) and the largest immature animal was 50 mm ML (4.5 g BW). The largest maturing male was 78 mm ML (5.1 g BW), and the largest mature male 84 mm ML (6.4 g BW).

Mature females were taken in all seasons leading to the assumption that spawning occurs throughout the year.

Reproductive system maturation

Oocytes of 0.2–0.3 mm predominated in the ovaries of females at all maturity stages, the smallest being 0.1 mm. Oocyte maturation occurs in batches with a batch size of 300–500 eggs in females of 76–99 mm ML. The first oocytes with folds of follicular epithelium appear at maturity stage II, the first yolk oocytes at stage III, and the first advanced yolk oocytes, ready for ovulation, appear at stage IV.

Yolk oocytes represented from 2–37.4% (mean 23.5%) of oocyte numbers in the ovary of maturing animals and 21.1–83.2% (mean 46.2%) in those of mature females. Oocyte resorption was found in one maturing female at stage III with 24 of 4251 oocytes at different stages of atresia, and in one spent female whose ovary contained a total of 147 degenerating oocytes.

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The number of empty follicles at different stages of resorption was usually lower than the number of ripe eggs in the oviduct. This implies that this value could not be used as a tool to estimate the number of eggs released.

Egg size and fecundity

Ripe egg length on the major axis varied from 1.5 to 2.3 mm and egg weight varied from 0.68 to 2.64 mg. Larger females produced larger (r^2=0.46, P=0.011) and heavier (r^2=0.53, P=0.03) eggs. The number of ripe eggs in the oviduct varied from 1 to 270 (Figure 2).

The total number of yolk oocytes (including ripe eggs) varied from 113 to 1817, being higher in larger animals. Potential fecundity (PF) was 947–4486 oocytes in prespawning immature and maturing animals (Figure 2). In mature females, some of which were spawning, the PF was 157–4509. In two spent animals PF was 147–459. A comparison of the PF between prespawning and spent animals suggests that most of the PF (probably about 80%) is released during a long intermittent spawning period.

The relative fecundity (RF) of mature animals varied from 56 to 524 (mean 214.2 egg/g) and the index of potential reproductive investment was 0.14–0.94 (mean 0.36).

Ripe egg size in the eastern Mediterranean females was somewhat larger than in those from the west Mediterranean. Typical values of fecundity in the eastern Mediterranean (1500–2500) are higher than the maximum fecundity in the west Mediterranean (1400), suggesting higher reproductive effort in the east.

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