SIZE AT THE ONSET OF SEXUAL MATURITY IN 7 BIVALVE SPECIES IN EGYPTIAN WATERS

SUMMARY

Egyptian beaches have extended over long distances and it has become necessary to look at how the exploitation of bivalves inhabiting these beaches. Onset of sexual maturity for 7 bivalve species in 4 sites of Egyptian waters was reported. Specimens were collected during summer and winter seasons. A total of 1870 individuals belonging to 4 families were examined under the microscope. The trend of decreasing size at maturity with increasing water temperature was reported. The trend of increasing size at maturity with decreasing latitude was much less clear in this study. The size at 50% maturity (SM₅₀) varied between 9.2 mm SL (for Cerastoderma glaucum in summer) and 16.6 mm SL (for Venerupis aurea in winter), and showed an average value of 12.7 mm SL (± 2.4 S.D.) for 5 commercial clams.

INTRODUCTION

The shell length at which the gonad begins to develop from rudimentary virgin state (undifferentiated or juvenile gonad) to the state at which the gonad is sexually differentiated is, usually, taken to be the size at onset of sexual maturity. The size at onset of maturity is important as it provides a minimum size limit for the control of exploitative fishing of young individuals (Agostinho, 2000). It also indicates population changes caused by pollution, overfishing or others (Weng, 1994).

Not all members of a species mature at the same size (length) and many species reach sexual maturity at a particular age which corresponds to a broad range of individual lengths. Therefore, the estimation of the size at onset of maturity is important as it gives a particular size which represents the maturity size of the species. Weng (1994) and RoA et al. (1999) reported that the size at onset of maturity is commonly accepted as the “average size at which 50% of a population is mature”.
The onset of sexual maturity varies in the different species and in the same species under different ecological conditions (Yankson, 1986; Darrigran et al., 1999). Water temperature is thought to be the major factor in the regional and seasonal differences in the size at maturity.

Family Veneridae represents the most abundant and successful group of bivalves in Lake Timsah (Fouda and Abou-Zied, 1990; Ghobashy et al., 1992; Mohammed et al., 1992). The most common Veneridae in the Lake are Venerupis aurea (Gmelin, 1791) and Tapes (= Ruditapes) decussata (Linnaeus, 1758). The two species are indigenous to the Mediterranean Sea and successfully colonized Lake Timsah by penetrating the Suez Canal (Fouda and Abou-Zied, 1990). V. aurea was first recorded from Lake Qarun by El-Shabrawy (2001). Both V. aurea and T. decussata are of great economic importance; being consumed in large quantities in the Suez Canal region and exported to some European countries (Kandeel, 2006).

Donacidae inhabit exposed intertidal sandy beaches and form the largest group living in such highly dynamic environments (Brown and McLachlan, 1990). Donax variabilis (Say, 1822) and D. trunculus (Linnaeus, 1758) spreading in the Mediterranean coast of Egypt are the favorite food among the populations of the coastal cities (El-Ghobashy et al., 2011).

The lagoon cockle Cerastoderma glaucum (Poiret, 1789) (Family: Cardiidae) represents one of the historically most dominant species of the macrobenthos of Lake Qarun, Fayoum Depression (Fishar, 2000; El-Shabrawy, 2001) and Lake Timsah, Suez Canal (Mohammed et al., 1992; 2006). C. glaucum plays an important direct and indirect role in nutrient cycles. It is eaten by human and considered as a very cheap resource due to their occurrence in high densities. The indirect role is by sharing in food chain as some marine animals prey upon them (Kandeel et al., 2017).

Mussels living in salt or brackish water are classified in the family Mytilidae which includes many genera such as Modiolus, Brachidontes and Mytilus (Seed and Suchanek, 1992). Two Indo-Pacific mytilids; M. arcuatulus (Hanley, 1843), and B. variabilis (Krauss, 1848) were found in high densities and create most of the fouling problems in the Suez Canal (Ghobashy et al., 1992; Mohammed et al., 1992). The study of the size at onset of maturity may provide information for future researches in biofouling of these mussels.

This study reports the onset of sexual maturity for 7 bivalve species in the Mediterranean coast (Damietta shore), Lake Timsah, the Great Bitter Lake and Lake Qarun. The possible role of water temperature was discussed, also.

**MATERIALS AND METHODS**

Damietta shore (Mediterranean coast) and three lakes: Lake Timsah, Great Bitter Lake, Lake Qarun (supporting information online at https://www.in-
gimage.com) were sampled to collect 7 species of bivalves belonging to 4 families (Table 1).

*Venerupis aurea* and *Tapes decussata* were collected using quadrate measuring 25 x 25 cm. Quadrates were dug to a depth of 10 cm and sieved in the field through 1-mm screen. *Donax variabilis* and *D. trunculus* were sampled using a specially designed hand dredge (75 cm wide) similar to that used by local fishermen but incorporating a smaller mesh size bag (3 mm) to collect enough samples of juveniles. *Cerastoderma glaucum* was collected using 20 x 20 cm stainless steel grab sampler randomly placed in the substratum at about 2 m depth. *Brachidontes variabilis* sampling was carried out by quadrates; each measuring 10 x 10 cm. Mussels inhabiting the area of the quadrate were scraped from the rock surface using a sharp knife. For *Modiolus arcutulus*, core samples of sediment were taken from the surface of the mussel bed using 14 cm diameter circular plastic pipe. Samples were washed out carefully in situ through one mm size sieve. Collection of samples was carried out in summer (July/August) 2015 and winter (January/February) 2016. Collected samples were kept in labeled containers filled with 6% formaldehyde-seawater solution and then transported to the laboratory.

In the laboratory, shell lengths (SL; maximum distance on the anterior-posterior axis) of the entire specimens were measured to the nearest 0.1 mm by using a Vernier caliper. Smears of the sexual products (growing or mature oocytes in females and morphologically ripe spermatozoa in males) were examined under the microscope. Each specimen was categorized as immature (juvenile) or mature (adult). For each species, the percentage of sexually mature individuals was plotted against shell length. The length at which 50% of the populations are sexually mature (SM$_{50}$) was then estimated by fitting a logistic curve to the percentage mature by size using the methods discussed in Somerton (1980) and Torroglosa and Giménez (2016). The length at maturity was estimated for the samples collected during the two seasons.

**RESULTS**

Sample descriptive statistics and parameters of logistic curves of 7 bivalve species belonging to 4 families and collected from Egyptian waters are reported in Table 1.

*Venerupis aurea*

The minimum size at maturity for *V. aurea* collected from Lake Timsah was 12 and 15 mm shell length during summer and winter seasons, respectively (Fig. 1). Estimated sexual maturity (SM$_{50}$) was 11.0 and 16.4 mm SL, respectively. For samples collected from Lake Qarun during summer and winter, the
The smallest mature clam was 12 and 15 mm SL and SM$_{50}$ were 12.1 and 16.6 mm SL, respectively (Fig. 2).

Fig. 1. The percentage of maturity plotted against shell length (mm) of *V. aurea* collected from Lake Timsah during summer and winter seasons. The size at 50% maturity (11.0 and 16.4, respectively) is demonstrated. N = number of individuals examined.

Fig. 2. The percentage of maturity plotted against shell length (mm) of *V. aurea* collected from Lake Qarun during summer and winter seasons. The size at 50% maturity (12.1 and 16.6, respectively) is demonstrated. N = number of individuals examined.
**Tapes decussata**

The smallest mature specimens of *T. decussata* collected from Lake Timsah during summer and winter were 10 and 13 mm SL, respectively. The maximum size of immaturity was 13 and 17 mm SL and the SM$_{50}$ was 11.1 and 15.2 mm SL for the two seasons, respectively (Fig. 3).

![Graph showing percentage of maturity against shell length for Tapes decussata](image)

Fig. 3. The percentage of maturity plotted against shell length (mm) of *T. decussata* collected from Lake Timsah during summer and winter seasons. The size at 50% maturity is demonstrated (11.1 and 15.2, respectively) is demonstrated. N = number of individuals examined.

**Donax variabilis**

*D. variabilis* collected from Damietta shore reached sexual maturity at a smaller size during summer than that reported for samples collected during winter (Fig. 4). The minimum size of maturity was 11 and 13 mm SL and SM$_{50}$ were 12.2 and 14.7 mm SL for the two seasons, respectively.

**Donax trunculus**

The smallest mature *D. trunculus* collected from Damietta shore during summer and winter were 11 and 13 mm SL, respectively. The maximum size of juveniles was 13 and 15 mm SL and the SM$_{50}$ were 12.4 and 14.8 mm SL for the two seasons, respectively (Fig. 5).

**Cerastoderma glaucum**

The minimum size at maturity for *C. glaucum* collected from Lake Timsah was 8 and 10 mm SL during summer and winter seasons, respectively (Fig. 6).
Fig. 4. The percentage of maturity plotted against shell length (mm) of *D. variabilis* collected from Damietta shore during summer and winter seasons. The size at 50% maturity (12.2 and 14.7, respectively) is demonstrated. N = number of individuals examined.

Fig. 5. The percentage of maturity plotted against shell length (mm) of *D. trunculus* collected from Damietta shore during summer and winter seasons. The size at 50% maturity (12.4 and 14.8, respectively) is demonstrated. N = number of individuals examined.
Estimated SM$_{50}$ was 9.2 and 11.1 mm SL, respectively. For samples collected from Lake Qarun during summer and winter, the smallest mature clams were 9 and 7 mm SL and SM$_{50}$ was 9.8 and 11.1 mm SL, respectively (Fig. 7).

![Fig. 7. The percentage of maturity plotted against shell length (mm) of C. glaucum collected from Lake Timsah during summer and winter seasons. The size at 50% maturity (9.2 and 11.3, respectively) is demonstrated. N = number of individuals examined.](image)

**Brachidontes variabilis**
The smallest mature specimens of *B. variabilis* collected from Great Bitter Lake during summer and winter was 7 mm SL (Table 1). The maximum size of immaturity was 10 and 11 mm SL and the SM$_{50}$ was 8.3 and 9.2 mm SL for the two seasons, respectively (Fig. 8).

**Modiolus arcutulus**
The minimum size at maturity for *M. arcutulus* collected from Great Bitter Lake was 4 and 6 mm SL during summer and winter seasons, respectively. Estimated SM$_{50}$ was 4.6 and 6.2 mm SL, respectively (Fig. 9). For samples collected from Lake Timsah during summer and winter, the smallest mature mussel was 4 mm SL. The SM$_{50}$ was 4.6 and 4.4 mm SL and the maximum size of a juvenile were 5 and 6 mm SL for the two seasons, respectively (Fig. 10).
Fig. 7. The percentage of maturity plotted against shell length (mm) of *C. glaucum* collected from Lake Qarun during summer and winter seasons. The size at 50% maturity (9.8 and 11.1, respectively) is demonstrated. N = number of individuals examined.

Fig. 8. The percentage of maturity plotted against shell length (mm) of *B. variabilis* collected from The Great Bitter Lake during summer and winter seasons. The size at 50% maturity (8.3 and 9.2, respectively) is demonstrated. N = number of individuals examined.
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<th>Longitude</th>
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<th>T\text{L}</th>
<th>N</th>
<th>L\text{min}</th>
<th>SM\text{50}</th>
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Tab. 1. Sample descriptive statistics and parameters of the onset of sexual maturity of 7 bivalve species collected from Damietta shore (Mediterranean coast) and 3 Lakes of Egyptian waters. T\text{H}, mean water temperature; L\text{L}, size limit at onset of maturity; N, number of individuals examined; L\text{min}, minimum size at maturity; SM\text{50}, the size of 50% maturity; L\text{max}, maximum size of immaturity.

Fig. 9. The percentage of maturity plotted against shell length (mm) of M. arcutulus collected from The Great Bitter Lake during summer and winter seasons. The size at 50% maturity (4.6 and 6.2, respectively) is demonstrated. N = number of individuals examined.
Fig. 11. The percentage of maturity plotted against shell length (mm) of *M. arcutulus* collected from The Great Bitter Lake during summer and winter seasons. The size at 50% maturity (4.6 and 4.4, respectively) is demonstrated. N = number of individuals examined.

DISCUSSION

Temperature is considered the main environmental factor which regulates bivalve reproduction (Sastry, 1979). In venerid clams like *Venerupis japonica* (Holland and Chew, 1974), *Mercenaria mercenaria* (Manzi et al., 1985) and *Tapes philippinarum* (Meneghetti et al., 2004) a clear relation between temperature and gonadic activity has been established. Ojea et al. (2004) observed a positive relationship between temperature and gonad condition index (GCI) in *Ruditapes decussatus*. Laruelle et al. (1994) reviewed data on reproductive patterns in *R. decussatus* throughout its geographical range and concluded that temperature has a positive effect on gametogenesis that may directly affect the metabolic rate of the animal, or indirectly affect the availability of the food.

*Venerupis aurea* and *Tapes decussata* exhibited remarkable reproductive effort and spawned several times in Lake Timsah (Kandeel, 2006). Continuous gamete production and repeated spawning bouts have also been documented for the mytilides *Modiolus arcutulus* and *Brachidontes variabilis* in Suez Canal Lakes (Kandeel, 2002) and the cardiids *Cerastoderma glaucum* in Lake Qarun (Kandeel, et al., 2013). Continuous gamete production may refer to the availability of food in Suez Canal Lakes and Qarun Lake through the
year. Also, it seems that the relatively moderate water temperature in winter (monthly mean =16.3 °C) and warm in summer (monthly mean = 29.3 °C) are both within range of the clam’s and mussel’s normal metabolism. For this reasons enough samples of juveniles (N = 1870) were examined in the present study.

For the studied species, samples collected during summer season reached sexual maturity at a size smaller than that reported for samples collected during winter. Also, the trend of increasing size at maturity with decreasing temperature was observed. Early maturation in warm environments and delayed maturation in cold environments were, also reported for the majority of ectotherms (ANGILLETA et al., 2004). Venerupis aurea collected from Lake Timsah, Suez Canal (approximately 30° 33’ - 30°35’ N latitude) matures at a relatively smaller size (SM₅₀ = 11.0 and 16.4 mm SL for summer and winter, respectively) than do individuals from Lake Qarun, Fayoum Depretion (approximately 29° 25’ - 29° 34.0’ N latitude). SM₅₀ was 12.1 and 16.6 mm SL for the two seasons, respectively. However, the trend of increasing size at maturity with decreasing latitude was much less clear in all studied species. A distinct latitudinal variation in the patterns of shell growth and sexual maturation was detected in the venerid bivalve Phacosoma japonicum (Reeve) in the Japanese coast (SATO, 1994).

Juveniles of C. glaucum from Lake Timsah (MOHAMMED et al., 2006), M. arcutulus from Great Bitter Lake and Lake Timsah and B. variabilis from Great Bitter Lake (KANDEEL, 2002) are capable of spawning in the same year in which they themselves were spawned. YANKSON (1986) reported that juvenile clams of C. glaucum mature and spawn within the same spawning season from which they themselves originated. However, additional studies are necessary to detect the accurate age at the onset of sexual maturity in the studied species.

REFERENCES


