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Variation in fish egg size in several pelagic fish species

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ABSTRACT

*This paper presents the results of research conducted in the area of Boka Kotorska Bay in July 2006, April 2007, August 2007, April 2008, July 2008, October 2008 and January 2009. Variability in diameter of pelagic eggs of anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), round sardinella (*Sardinella aurita*), annular seabream (*Diplodus annularis*), white seabream (*Diplodus sargus*) and mediterranean rainbow wrasse (*Coris julis*) were analysed and compared with available data from literature. Although the eggs of certain pelagic fish species have a distinctive shape, determination of most species is based on the size of the horion; number, position and colour of the oil drop and pigment characteristics. Most of the fertilized eggs have no pigment characteristics, and the determination thereof is based mainly on the measurement of the diameter of the capsule, and the knowledge of the spawning season. For this reason, it is very important to know the diameter of the capsule of pelagic species of fish eggs which have a significant role in the determination of species, but may also be a signal of particular environmental changes or result of the adaptive process and maternal effect.*

Keywords: diameter of fish eggs, ichthyoplankton, Boka Kotorska Bay, South Adriatic Sea

INTRODUCTION

Many marine teleost fish species have high fecundity rate, and one female can spawn thousands, tens of thousands, even millions of eggs per year. Most have pelagic eggs that float usually near the surface of seawater. A small number of coastal fish species have demersal eggs that are usually attached to the rocks, shells and seaweed. In these type of fishes chorion is mostly sticky and allows eggs to attach to the substrate, but also to each other. Such eggs are usually found in the gelatinous masses (Gobiidae) or similar forms of aggregations.

The characters for determination of fish eggs can be divided into two categories (Ahlstrom & Moser, 1980):

1) Characters independent of embryos
2) Characters dependent on embryo

Independent characters are: egg shape and size, characteristics of chorion and yolk, attendance, absence and the number of oil droplets and the size of periviteline space. Eggs are usually round in shape (Sparidae), but can also be ellipsoidal (Engraulidae, Scorpaenidae), pear-shaped and so on. Diameter of egg range from 0.5 to 5.5 mm. The largest number of eggs is below 1 mm diameter in size, followed by ones whose diameter ranges between 1 and 1.5 mm, then from 1.5 to 2 mm, and the smallest percentage of pelagic eggs have a size larger than 2 mm. Chorion is usually smooth, and can have different structures on their surface, such as depressions, protrusions, filaments, spikes, polygonal mesh. Periviteline space is usually very narrow, in some species it is almost nonexistent, while in some species it may be very large (*Sardina pilchardus*). Oil drops are one of the most important character in the identification of eggs. A large number of pelagic eggs possess only one drop, followed by the species with no oil drop, and

at the end of those that have from two to a large number of oil droplets .
Characters dependent upon the embryo are: pigmentation of miomers, length of the gut, the position of the heart and, after hatching, the shape of yolk sac and position of oil drop in it. There are also some specific characters as elongated fins or various growths that can be specific for the species.

Classic egg size theory predicts that organisms reproducing in a given environment should divide their available resources into eggs of an optimal size (Svärdson 1949, Smith & Fretwell 1974, Einum & Fleming, 2002). Sargent *et al*. (1987) considered the importance of prejuvenile environment, including the larval stage, in relation to egg size evolution. They assumed that juvenile survival could be described by the Smith-Fretwell model (i.e., post larvae survival increases with egg size) but that, in addition, increasing egg size increases egg or larval mortality (Einum & Fleming, 2002).

The information about egg size for the fishes from Adriatic Sea are very scarce, especially from the surveys. There are some data related mostly to economically important or endangered species fish species from laboratory rared conditions (Jug-Dujaković *et al*., 1995, Kožul *et al*, 2011, Antolović *et al*., 2010).

MATERIAL AND METHODS

Ichthyoplankton surveys were carried out in July 2006, April 2007, August 2007, April 2008, July 2008, October 2008 and January 2009. Plankton samples were taken with PairOVET (modified CalVet) plankton net on 18 stations in the Bay (Fig. 1.). Diameters of net cylinders were 25 cm each, and the total mouth area was 0.098 m^2, with mesh size of 0.160 mm. Net was towed vertically at a speed of 0.5 m*sec^{-1}, from the depth of 5 m above the bottom, as the maximal depth in the Bay is 60 m. Plankton material was preserved immediately on board in 2.5% solution of buffered formaldehyde and processed in the laboratory for ichthyology of the Institute of Marine Biology, Kotor. Material was sorted and determinated using NIKON SMZ 800 binocular equiped with MOTIC camera.

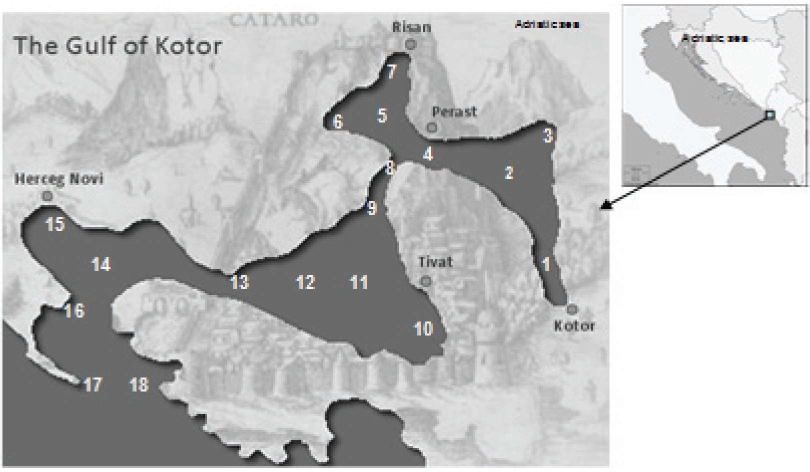

Figure 1. Geographical position of Montenegro and Boka Kotorska Bay (Investigated stations 1-18)

RESULTS

Diameter of anchovy eggs (*Engraulis encrasicolus*) (longer axis) ranged from 0.98 to 1.63 mm (Table 1).

Table 1. Diameter of anchovy eggs (long axis) in studied months.

Month	Average (mm)	Range (mm)
July 2006	1,27	1,15-1,4
December 2006	1,26	1,2-1,33
April 2007	1,34	1,07-1,62
August 2007	1,23	1,02-1,44
April 2008	1,39	1,16-1,63
July 2008	1,14	0,98-1,3
October 2008	1,25	1,19-1,32

Biggest anchovy eggs were found at the beggining of the spawning season (April 2007 and 2008), while diameter of eggs decreased towards the end of spawning season.

Diameter of sardine eggs (*Sardina pilchardus*) ranged from 1,29 to 1,66 mm, and oil drop from 0,09 to 0,17 mm (Table 2).

Table 2. Diameter of sardine eggs in studied months.

Month	Average diameter of egg (mm)	Range (mm)	Average diameter of oil drop (mm)	Range (mm)
December 2006	1,42	1,29-1,6	0,13	0,09-0,16
April 2007	1,46	1,13-1,58	0,14	0,12-0,16
April 2008	1,52	1,4-1,66	0,14	0,12-0,17
January 2009	—	1,55	—	0,15

Results showed that diameter of sardine eggs, unlike anchovies, increased as spawning season was approaching to its end (Table 2). In January of 2009 only one egg of sardine was found throughout the study area, and the size of the capsule can not be taken as valid for comparison with other investigated months.

Diameter range of round sardinella eggs (*Sardinella aurita*) was from 1.09 to 1.3 mm, and diameter of oil drop from 0.09-0.15 mm (Table 3.)

Table 3. Diameter of round sardinella eggs in studied months.

Month	Average diameter of egg (mm)	Range (mm)	Average diameter of oil drop (mm)	Range (mm)
July 2006	1.25	1.24-1.25	0.12	0.1-0.14
August 2007	1.18	1.09-1.28	0.1	0.09-0.11
July 2008	1.24	1.14-1.3	0.12	0.11-0.15

Measurements of round sardinella eggs showed similar pattern as sardine. Diameter of egg increased towards the end of spawning season.

Diameter of annular seabream eggs (*Diplodus annularis*) was from 0.64 to 0.79 mm, and diameter of oil drop ranged from 0.12 to 0.21 mm (Table 4.)

Table 4. Diameter of annular seabream eggs in studied months.

Month	Average diameter of egg (mm)	Range (mm)	Average diameter of oil drop (mm)	Range (mm)
July 2006	0.69	0.64-0.72	0.17	0.13-0.2
April 2007	0.76	0.74-0.79	0.17	0.16-0.18
August 2007	0.73	0.68-0.78	0.16	0.12-0.19
April 2008	0.76	0.73-0.77	0.18	0.13-0.21
July 2008	0.7	0.68-0.74	0.19	0.17-0.21

Diameter of white seabream eggs (*Diplodus sargus*) was in range from 0.77 to 0.91 mm, and diameter of oil drop was in range from 0.15 to 0.23 mm (Table 5.)

Table 5. Diameter of white seabream eggs in studied months.

Month	Average diameter of egg (mm)	Range (mm)	Average diameter of oil drop (mm)	Range (mm)
April 2007	0.81	0.77-0.91	0.2	0.15-0.23
April 2008	0.83	0.8-0.88	0.19	0.15-0.22
July 2008		0.8		0.21

Eggs of annular seabream and white seabream were relatively numerous throughout the period of studies. Results showed that the size of the capsule may vary widely. Unlike the previous species, it cannot be said that there is a pattern of size of the capsule depending on the length of the spawning season.

Diameter of Mediterranean rainbow wrasse (Coris julis) was from 0.55 to 0.69 mm, and diameter of oil drop was in range from 0.09 to 0.21 mm (Table 6.)

Table 6. Diameter of Mediterranean rainbow wrasse eggs in studied months.

Month	Average diameter of egg (mm)	Range (mm)	Average diameter of oil drop (mm)	Range (mm)
July 2006	0.66	0.62-0.69	0.18	0.13-0.21
April 2007	0.65	0.64-0.65	0.16	0.15-0.16
August 2007	0.59	0.56-0.6	0.14	0.09-0.18
April 2008		0.59		0.12
July 2008	0.63	0.55-0.65	0.14	0.1-0.17

Mediterranean rainbow wrasse eggs were also numerous, and results showed similar pattern as for anchovy and round sardinella eggs.

DISCUSSION

Results of this study showed certain patterns when it comes to the size of the capsules of fish eggs. In fact, at the beginning of the spawning season diameter is the largest, while it declines as the spawning season ends. This fact was confirmed by the size of the capsule of eggs of anchovy, round sardinella and annular sea bream (Tables 1, 3 and 4), while the sardines do not fit into this pattern. Size of sardine eggs increases as the spawning season ends (Table 2).

This study confirmed the earlier assumption that in species that start with the spawning season in late fall and ends in the early spring, size of the capsule increases as the spawning season ends (Chambers, 1997). Number of hypotheses was placed to explain the variation in the size of the capsule of fish eggs, especially for fish that spawns several times during the spawning season.

It is assumed that in fish of the family Clupeidae reduction in the size of the capsule may be due to the several reasons: reduction of maternal energy reserves during the spawning season, ie conversion of deposited energy into growth instead of reproduction, then the seasonal changes in the age structure of the population of spawning, or changes during oogenesis that is correlated with the temperature (Blaxter & Hunter, 1982; Chambers, 1997).

Research on eggs, larvae and postlarvae of sardines led to the assumption that there are so called "parental effects", which are manifested through variability on egg quality (and consequently larvae) during the spawning season to ensure survival in the early stages, especially postlarvae in the conditions when amount of food is limited (Riveiro *et al.*, 2000). Factors affecting the quality of eggs and larvae include the size of the eggs (Blaxter & Hempel, 1963), and size, condition and age of adult individuals (Karlovac, 1967; Kristjansson & Vollestad, 1996), and biochemical composition of eggs (Craik & Harvey, 1987, Pickova *et al*, 1997, Chicharo *et al*. 1998, 2003). Eggs spawn at the beginning of the spawning period have a higher concentration of protein which also affects the acceleration of development (Riveiro *et al*., 2000).

Values of the diameter of anchovy eggs (longer axis) showed that the biggest eggs were found during sampling that took place in April 2007 and April 2008, while the smallest diameter of the eggs was found in July 2008. This data confirms that the species that have a short lifespan produce largest eggs at the beginning of the spawning season (Regner, 1989). That is a kind of adaptation to the conditions of nutrition, which are, as a rule, very weak at the beginning of the spawning season. Larger eggs contain a larger amount of yolk and larve hatched from those eggs are larger, which gives them a greater chance of survival when environmental conditions are not satisfactory (Regner, 1989). The small size of the eggs can be a sign that the spawning season ends (Regner, 1985, Gordina *et al*., 1997). This reduction in the size of eggs when spawning season ends have been noted in other species – poor cod (*Trisopterus minutus*) (Hislop, 1975), and European and American mackerel (Ehrenbaum, 1923).

Demir (1959) compared the data on the size of eggs of anchovy from the Black, Marmara, Aegean, Adriatic Sea and the eastern part of the Mediterranean and found that the relationship between the longitudinal and transverse diameter of the egg is indicator of water quality in which the anchovy spawn. Increasing of salinity causing reduction in the size of anchovy eggs and the egg become thinner (Zaitsev, 1959, Lugovaya, 1963, Demir, 1968).

The egg diameter in Sparidae species can vary a lot (Tables 4 and 5), because in practice the egg size can differ among females of the same species, while it seems too dependent upon age, spawning time and geographical origin, and also to the nutrition (Kjorsvik *et al*., 1990).

In order to compare our results with previous data, the following tables show a comparative data on the egg size for those species for which data are available (Table 7 to 12):

Table 7. Comparative data on anchvoy (*E. Encrasicolus*) eggs size

Author	**Area**	**Period of sampling**	**Egg diameter**	**Diameter of oil drop**
Ehrenbaum (1905-1909)	North Sea	Summer	1.1-1.5	No data
Raffaele (1888)	Naples	IV-IX	1.15-1.25	No data
Varangolo (1964)	Chioggia	IV-IX	1.15-1.25	No data
	This paper	IV-VIII	0.98-1.63	No data

Table 8. Comparative data on sardine (*S. pilchardus*) eggs size

Author	**Area**	**Period of sampling**	**Egg diameter**	**Diameter of oil drop**
Raffaele (1888)	Naples	Winter	1.5-1.7	0.16
Varangolo (1964)	Chioggia	V-VI	1.65	0.16
Macchuit (1989)	Trieste	IX-V	1.37-1.75	0.12-0.17
	This paper	XII-IV	1.29-1.66	0.09-0.17

Table 9. Comparative data on *Sardinella* sp. eggs size

Author	**Area**	**Period of sampling**	**Egg diameter**	**Diameter of oil drop**
Matsuura, (1975)	Rio De Janeiro	No data	1.00-1.32	0.09-0.18
Houde and Fore (1973)	No data	No data	1.03-1.25	0.13-0.18
Ditty *et al*., (1994)	No data	No data	1.03-1.12	0.13-0.18
D'ancona, (1931)	No data	No data	1.2-1.4	—
Sardinella aurita	This paper	No data	1.09-1.3	0.09-0.15

Table 10. Comparative data on annular sea bream (*D. annularis*) eggs size

Author	Area	Period of sampling	Egg diameter	Diameter of oil drop
Divanach (1985)	No data	No data	0.71-0.81	0.18-0.22
Varangolo (1964)	Chioggia	IV-VIII	0.75-0.81	0.16-0.18
	This paper	No data	0.64-0.79	0.12-0.21

Table 11. Comparative data on white sea bream (*D. sargus*) eggs size

Author	Area	Period of sampling	Egg diameter	Diameter of oil drop
Divanach (1985)	No data	No data	0.90-1.16	0.18-0.26
Raffaele (1888)	Naples	No data	1	0.18-0.20
Kentouri *et al*. (1980)	Cultured	No data	0.98	/
	This paper	No data	0.77-0.91	0.15-0.23

Table 12. Comparative data on mediterranean rainbow wrasse (*C. julis*) eggs size

Author	Area	Period of sampling	Egg diameter	Diameter of oil drop
Ré & Meneses (2009)	No data	No data	0.6-0.7	0.12-0.16
	This paper	No data	0.55-0.69	0.09-0.21

Although there are a number of studies that indicate the correlation between the size of fish eggs with latitude (Llanos Rivera & Castro, 2004, Chambers 1997, Myers, 1991), the influence of local environmental factors (especially temperature) can have a significant impact in some fish species. Variability of environmental factors can affect not only the size of fish eggs, but the size of stock and fecundity and behaviour of females (Chambers, 1997). It is well known that the temperature is a decisive factor in the length of the developmental time of the embryo, and the experiments showed a significant role of temperature for the length of the larvae at hatching (Blaxter, 1993), ie length of larvae is smaller as the temperature of the environment increase. Pepin (1991) finds that an increase in temperature leads to a decrease in the rate of survival in the egg stage, increasing the survival of the yolk sac larvae, and that it has no effect on the larvae which actively feed. In this study the values of temperature and salinity were within limits that are acceptable to all the species that are the subject of this paper, and the impact of these factors on the size of the capsule can be neglected.

Researchs in the connections between variability of the recruitment and characteristics of the early life stages (size of the capsule and the length of the larvae at hatching) have shown that there is no significant effect on the recruitment. Einum & Fleming (2002) found that the effect of egg size on development time from egg to juvenile in fishes is weak. Pepin & Myers (1991) showed that the variability in recruitment is significantly correlated with the duration of larval period. The longer the period of larval stage is, the cumulative mortality increases (Smith, 1985, Houde 1987, Pepin, 1991), which significantly affect the variability of recruitment.

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