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Preliminary data on gonadal development and fecundity in the Grass goby, *Zosterisessor ophiocephalus* (PALLAS, 1811) from the Venice lagoon (northern Italy)

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This paper reports a preliminary description of ovaries and oocytes characteristics in the grass goby Zosterisessor ophiocephalus *from the Venice lagoon across the breeding season. Results allowed identification of three main oocyte maturation stages occurring in different proportions across the breeding season: immature, ripening and ripe. Shape and size of oocytes change during maturation becoming more elliptical from rounded and increasing in diameter from about 0.2 to more than 0.7 mm. Completely mature ovaries were found in March and April whereas spent females with residual oocytes were present only in June. Fecundity of mature females ranged from 5000 to 26000 eggs and was positively and linearly related with body size. The relationship between number and diameter of eggs suggested a trade-off between these two parameters. Results were discussed in the light of the available knowledge on fecundity and gonadal development of repeat-spawning fishes.*

Key words: Grass goby, *Zosterisessor ophiocephalus*, oocytes, maturation stages, fecundity, repeated spawning

INTRODUCTION

The grass goby, *Zosterisessor ophiocephalus* (PALLAS, 1811) lives on seagrass (*Zostera* spp.) meadows in brackish waters of the Northern Adriatic Sea lagoons, and is particularly abundant in the Venice lagoon (NINNI, 1938). It can live up to 3 years (MILLER, 1986), with epibenthic and territorial habits. *Z. ophiocephalus* is an iteroparous species and during the breeding season, lasting from March to May, females produce more than one batch of eggs (MILLER, 1984).

The aim of this work is to give a preliminary description of oocytes characteristics and gonad development in the grass goby across the breeding season, by macroscopic observation of oocytes within the ovaries and to have preliminary data on the fecundity of this species, relating them also to egg size and female features.

MATERIAL AND METHODS

Fish were collected monthly, during the breeding season 1999 (from March to June), in the southern basin of the Venice lagoon. They were captured by means of traps (locally named "nassini") and preserved in 3.6% formaldehyde. Sex was established by examination of the dimorphic urogenital papilla (MILLER, 1984). Measurements were made on about ten females from each monthly sample. Each fish was measured for total length (*TL*), standard length (*SL*) (±0.1 cm) and total body wet weight (*TW*) (±0.1 g). Each ovary was weighed (±0.001 g) and then preserved in 2.9% formaldehyde for a few weeks. Ovarian ripeness was determined by the gonadosomatic index (*GSI*) calculated as gonads weight/*TW*x100 (ELLIOTT *et al.*, 2002). The distribution of the oocytes within the ovary was tested in March sample, by comparing oocytes size-frequency distributions (plotted with 0.05 mm class size) in two subsamples (about 0.005 g) taken from the anterior and the posterior parts of the ovary. Then the following measurements were made on a random subsample of about 0.01 g taken from the largest ovary of each female. Oocytes maximum diameter (from here 'diameter', ±0.001 mm) measurements and observations on oocyte shape were done using a stereoscope and Image Pro-Plus, a program for image analysis. Female reproductive stages (mature, immature and ripening) were identified through the size-frequency distributions of oocytes in the ovaries (VLADIKOV, 1956; MILLER, 1961; HEALEY, 1971). Batch fecundity (*F*) was measured by direct counting of the number of ripe oocytes (n_r) in the weighed subsample, and it was calculated with the formula $F = 2 \times n_r \times$ larger ovary weight/subsample weight. The relationships between fecundity and fish size (*TL* and *TW*) were tested by regression analysis, and the relationship between number and size of eggs was also studied regressing the residuals from the *F*-*TL* regression with eggs diameters, to exclude the effect of fish size.

RESULTS

The specimens showed no significant variations in body size (ANOVA: n=34, F=2.090, p=0.122 for total length; n=34, F=2.530, p=0.076 for total weight), nor in gonadosomatic index (ANOVA: n=34, F=0.302, p=0.823) among samples, and this allowed to pool data together (n=34).

The percentage of large eggs (diameter>0.35 mm) did not significantly differ between the anterior subsample of the ovary and the posterior one (MANN-WHITNEY U test: n=12, U=65.00, Z=0.404, p=0.686), with a mean value of about 30%. This result justified the choice of taking a random subsample from the ovary for the study of gonad development and fecundity.

In the ovaries three main oocyte maturation stages were identified: immature, ripening and ripe. Immature oocytes had a round shape and a diameter of 0.20 mm. During maturation, oocyte shape tends to become more elliptical and oocyte dimensions increase. Ripening oocytes had a diameter between 0.20 and 0.70 mm, while ripe eggs diameter exceeded 0.70 mm.

The size-frequency distributions of these oocytes for all the 34 females allowed to identify different ovary maturation stages and female reproductive stages (Fig. 1 and Table 1), and to have a preliminary description of gonadal development in the grass goby during the breeding season.

In completely mature ovaries (found in March and April, always in females with *GSI*>5%) ripe eggs are clearly identified as a discrete size class (with a mean diameter of 0.935 mm), while a group of ripening oocytes begins to develop from the immature ones to provide the ripe eggs for next breeding event. At the end of the reproductive period (June) most of females had spent ovaries, in which only the residual oocytes are present, destined to be reabsorbed. In March, ovaries in 'recently spawned' conditions were also identified, where, together with the immature oocytes and a group of ripen-

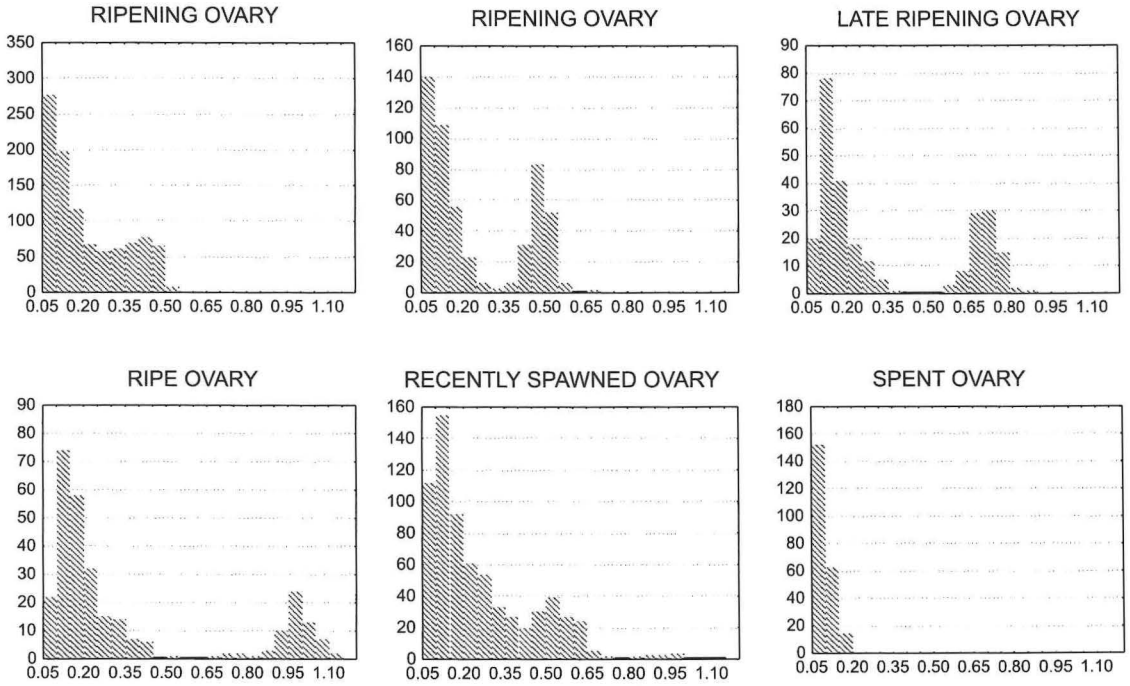

Fig.1 Size-frequency distributions of the oocytes within the ovaries subsamples of Z. ophiocephalus *at different maturation stages*

ing ones developing, also a residual group of large unshed eggs is visible.

Fecundity of females with mature (*i.e.* ripe; n=2) and late ripening (*i.e.* with eggs completing vitellogenesis, with a mean diameter of 0.670 mm; n=7) ovaries was higher in April than that of March and May (Table 1). Fecundity increased linearly with increasing total length (F = -0.0172 + 2457.8 TL, n=9, r=0.839, p=0.005) and total wet weight (F = -1041 + 633.07 TW, n=9, r=0.846, p=0.004). A negative relationship was found when considering the correlation of fecundity (measured as residuals of the F-TL regression) with egg size (residuals = 11423 - 1.58 diameter, n=9, r = -0.683, p = 0.042).

DISCUSSION

This study confirms that *Zosterisessor ophiocephalus* is a repeat-spawner, with oocytes at different maturation stages present in the ovary during the breeding season (MILLER,

Table 1. Number of females with ovaries in different maturation stages and average fecundity (number of eggs) ± standard deviation, in each sample and across all the breeding season (n = number of fish investigated)

Sample	n	ripening	late ripening	mature	recently spawned	spent	Average fecundity
March	10	7	1	1	1	0	11638 ± 2657
April	10	7	2	1	0	0	17976 ± 5941
May	10	6	4	0	0	0	12844 ± 5229
June	4	3	0	0	0	1	--
Total	34	23	7	2	1	1	14287 ± 5278

1984). The observed dimensions of the three main types of oocytes identified in the ovaries (immature, ripening and ripe) matches in general that ones described by GIULIANINI *et al.* (1994), and, as regards ripe eggs, the mean diameter of about 1 mm (0.935 mm) here observed was consistent with the results reported by PILATI (1950) and De GIROLAMO (1994) for an area in the Southern basin of the Venice lagoon. Nevertheless larger eggs were found in grass gobies of different areas located inside the Venice lagoon, with diameters exceeding also 2 mm (FRANCO, 2000). This high variability in the size of ripe eggs of *Z. ophiocephalus* within the lagoon could be due to temporal and spatial variations of the local environmental conditions (WOOTON, 1979; FLEMING and GROSS, 1990).

Fecundity values were also consistent with that ones reported by De GIROLAMO (1994) for similar sized grass gobies of an area in the Southern basin of the Venice lagoon.

The linear and positive regression found between fecundity and body length of the grass goby has been observed also for another goby, *Pomatoschistus minutus* (HEALEY, 1971), although, for the majority of gobies, as it is usual for teleosts (BAGENAL and BRAUM, 1968; ROGERS, 1988; HUSE and GJØSAETER, 1997), the positive regression of fecundity with body length is described mostly by a power (exponential) function (MILLER, 1984).

The common trade-off between egg size and clutch size (fecundity), found for other teleost fishes (WOOTON, 1979; BROMAGE *et al.*, 1990; ELGAR, 1990; L'ABÉE-LUND and HINDAR, 1990; KING, 1991; ROFF, 1992; STEARNS, 1992; BEACHAM and MURRAY, 1993; IGUCHI and YAMAGUCHI, 1994), was also observed in *Z. ophiocephalus*, after removing the effects of body size.

CONCLUSIONS

This preliminary study on gonad development and fecundity of the grass goby allowed making some observations:

1. Anterior and posterior parts of the ovary don't differ in oocyte distribution.
2. Our data on mature eggs diameters and fecundity, although preliminary, are consistent with those from samples of *Z. ophiocephalus* kept in the same area of the Southern Venice lagoon.
3. The trade-off between number and size of eggs is supported by our preliminary data.

Further investigations are necessary, enhancing the number of samples and their dimensions, in order to study gonad development and fecundity in the grass goby from the Venice lagoon.

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REFERENCES

BAGENAL, T.B. and E. BRAUM. 1968. Eggs and early life history. In: W.E. Ricker (Editor). Methods for assessment of fish production in fresh waters. International Biological Program Handbook No. 3. Blackwell, Oxford, pp. 159-181.

BEACHAM T.D. and C.B. MURRAY. 1993. Fecundity and egg size variation in North American Pacific salmon (*Oncorhynchus*). J Fish Biol., 42: 485-508.

BROMAGE, N., P. HARDIMAN, J. JONES, J. SPRINGATE and V. BYE. 1990. Fecundity, egg size and total egg volume differences in 12 stocks of rainbow trout, *Oncorhynchus mykiss* Richardson. Aquacult. Fish. Manag., 21: 269-284.

De GIROLAMO, M. 1994. Osservazioni sulla pressione di pesca nelle acque della Laguna di Venezia e sulla struttura di popolazione e biologia riproduttiva di tre gobidi (Pisces,

Teleostei). Thesis, University of Padova, pp. 37-50.

ELGAR, M.A. 1990. Evolutionary compromise between a few large and many small eggs: comparative evidence in teleost fish. Oikos, 59: 283-287.

ELLIOTT, M., K.L. HEMINGWAY, S. MARSHALL and S. DUHAMEL. 2002. Data quality analysis and interpretation. In: M. Elliott and K.L. Hemingway (Editors). Fishes in Estuaries. Blackwell Science, U.K., pp. 510-554.

FLEMING, I.A. and M.R. GROSS. 1990. Latitudinal clines: a trade-off between egg number and size in Pacific salmon. Ecology, 71: 1-11.

FRANCO, A. 2000. Stress ambientale ed ecologia riproduttiva di *Zosterisessor ophiocephalus* (Teleostei, Gobiidae) in laguna di Venezia. Thesis, University of Venezia, 97 pp.

GIULIANINI, P.G., A. DI MARCOTULLIO, E.A. FERRERO and R.A. PATZNER. 1994. Light microscopical and ultrastructural cytology of the ovaries in the sea-grass goby *Zosterisessor ophiocephalus* (Osteichthyes, Gobiidae). Boll. Zool., 61: 135-144.

HEALEY, M.C. 1971. Gonad development and fecundity of the sand goby, *Gobius minutus* Pallas. Trans. Amer. Fish. Soc., 3: 520-525.

HUSE, G. and H. GJØSAETER. 1997. Fecundity of the Barents Sea capelin (*Mallotus villosus*). Mar. Biol., 130: 309-313.

IGUCHI, K. and M. YAMAGUCHI. 1994. Adaptative significance of inter- and intrapopulational egg size variation in Ayu *Plecoglossus altivelis*. Copeia, 1994: 184-190.

KING, R.P. 1991. Some aspects of the reproductive strategy of *Ilisha africana* (Bloch, 1795) (Teleostei, Clupeidae) in Qua Iboe Estuary, Nigeria. Cybium, 15: 239-257.

L'ABÉE-LUND, J.H. and K. HINDAR. 1990. Interpopulation variation in reproductive traits of anadromous female brown trout, *Salmo trutta* L. J. Fish Biol., 37: 755-763.

MILLER, P.J. 1961. Age, growth, and reproduction of the rock goby, *Gobius paganellus* L., in the Isle of Man. J. mar. biol. Ass. U.K., 41: 737-769.

MILLER, P.J.1984. The tokology of Gobioid fishes. In: G.W. Potts and R.J. Wootton (Editors). Fish Reproduction: Strategies and Tactics. Academic Press, London, pp. 119-153.

MILLER, P.J. 1986. Gobiidae. In: P.J.P. Whitehead, M.-L. Buchot, J.-C. Hureau, J. Nielsen and E. Tortonese (Editors). Fishes of the North-eastern Atlantic and the Mediterranean, Vol III. UNESCO, Paris, pp. 1019-1085.

NINNI, E. 1938. I Gobius dei mari e delle acque interne d'Italia - Gobius ophiocephalus. R. Com. Talass. Ital., Mem. CCXLII: 149-155.

PILATI, C. 1950. Osservazioni sull'apparato riproduttore e sulla gametogenesi nel *Gobius ophiocephalus* Pallas. Arch. Zool. Ital., 35: 171-183.

ROFF, D.A. 1992. The Evolution of Life Histories. Chapman and Hall, London, 250 pp.

ROGERS, S.I. 1988. Reproductive effort and efficiency in the female common goby, *Pomatoschistus microps* (Krøyer) (Teleostei: Gobioidei). J. Fish Biol., 33: 109-119.

STEARNS, S.C. 1992. The Evolution of Life Histories. Oxford University Press, Oxford, 249 pp.

VLADIKOV, V.D. 1956. Fecundity of wild speckled trout (*Salvelinus fontinalis*) in Quebec lakes. J. Fish. Res. Board Can., 13: 799-841.

WOOTON, R.J. 1979. Energy costs of egg production and environmental determinants of fecundity in Teleost fishes. Symp. Zool. Soc. London, 44: 133-159.

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Preliminarni podaci o razvoju gonada i fekunditetu glavoča, *Zosterisessor ophiocephalus* (PALLAS, 1811) u venecijanskoj laguni (sjeverna Italija)

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SAŽETAK

U radu se daje preliminarni opis karakteristika ovarija i oocita kod glavoča *Zosterisessor ophiocephalus* u venecijanskoj laguni za vrijeme mriješćenja. Identificirana su tri osnovna stadija sazrijevanja oocita za vrijeme sezone mriješćenja: nezreli stadij, stadij dozrijevanja i zreli stadij. Veličina i oblik oocita se mijenjaju tijekom sazrijevanja, te od okruglog oblika poprimaju elipsoidni oblik, a dijametar im se povećava od 0,2 do preko 0,7 mm. U potpunosti zreli oociti pronađeni su u ožujku i travnju, dok su ženke s preostalim oocitima bile prisutne samo u lipnju. Fekunditet zrelih ženki iznosio je od 5000 do 26000 jaja, bio je pozitivan i linearan s obzirom na dužinu tijela. Odnos između broja i dijametra jaja ukazuje na uzajamni odnos ovih dvaju parametara. Rezultati su komentirani s obzirom na postojeće poznavanje fekunditeta i razvoja gonada kod riba koje više puta sazrijevaju tijekom sezone mriješćenja.

Ključne riječi: glavoč, *Zosterisessor ophiocephalus*, oociti, sazrijevanje, fekunditet, ponovno mriješćenje