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Reproductive cycle of the Common sole *Solea vulgaris* QUENSEL, 1806, in the northern Adriatic Sea

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Anatomical and cytological modifications of the ovary of Solea vulgaris *QUENSEL from the northern Adriatic Sea were studied over a one-year period. Seven stages of ovarian development were observed. The gonadosomatic index increased rapidly during the reproductive season from December to March, when the majority of oocyte growth (>200μm in diameter) occurred. Hydrated oocytes immediately before spawning reach 1360 μm. During spring, summer and autumn (from April to November) previtellogenic oocytes (<200μm) occurred.*

Key words: northern Adriatic Sea, *Solea vulgaris*, reproductive cycle

INTRODUCTION

The common sole, *Solea vulgaris* QUENSEL, 1806, is one of the most exploited species in Italian fisheries (3600 tons in 1996) (FAO, 1996), however the biological studies on local stocks from Adriatic, Ionian and Thyrrenian seas are poor (GHIRARDELLI, 1959; PICCINETTI and GIOVANARDI, 1984; VALLISNERI *et al.*, 2000). In order to increase our knowledge on the reproductive cycle of the common sole from northern Adriatic, seasonal variations of the ovary were studied through quantitative and qualitative anatomical and cytological analyses.

MATERIAL AND METHODS

Specimens random, taken live, of *Solea vulgaris* were collected monthly from the fisherman off Rimini in the Adriatic Sea (Italy) from November 1996 to October 1997. A total of 141 female was analysed. All specimens were weighed (*W*, g) and the total length (*TL*, cm) measured. The ovaries in specimens sexually mature (over 27 cm *TL*) (VALLISNERI *et al.*, 2000) were weighed (*GW*, g), fixed in 4% buffered formaldehyde. The gonadosomatic index (*GSI*) was calculated as follows: *GSI= GW/ W* *100. For histo-citometric analysis, a total of forty ovaries at different reproductive stages were prepared: after dehydration in ethyl alcohol, they were embedded in paraffin.

Ovaries from mature females were vacuum-enclosed in order to facilitate embedding in paraffin. Serial sections (7 μm thick) of the ovaries were obtained. Slides were stained using MAYER's haemalum and eosin solutions. Oocytes of three histological sections in eighty slides were measured using a semiautomatic computerized Leica Qwin imaging scanner (resolution: 1 μm=1,527 pixel). Oocytes transected through the nucleus are selected. The measurement used was the mean of the longest axis and its bisecting axis. Data were processed using Excel 4 software implemented on a Macintosh Power PC.

RESULTS

Seven stages of ovarian development were observed during the annual cycle of sexually mature females (Table1).

Table 1. Different stages of sexual maturity of common sole from northern Adriatic Sea

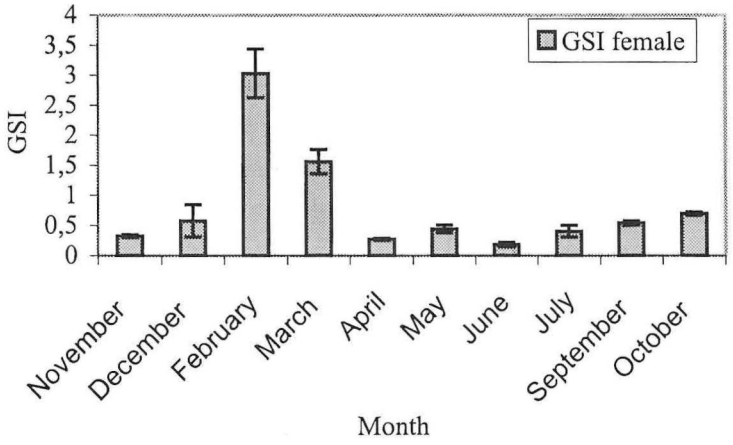
Stage	Ovary status	Macroscopic and microscopic criteria	Season
1	Immature	Ovaries like thin cord 4-5 cm long	
2	Resting	Yellowish ovaries	April-Nov
3	Recovering	Ovaries starting to extent in the body cavity, no oocytes visible by eye	Nov-Dec
4	Maturing	Ovaries take up half of the body cavity, orange-coloured oocytes	Dec-Jan
5	Mature	Ovaries fill the entire body cavity, hydrates oocytes visible by eye	Jan-Feb
6	Spawning	Ovaries running, hydrated oocytes easily stripped under pressure	Feb-March
7	Post-spawning	Ovaries spent and flacid (post-ovulatory follicles and atresic oocytes)	March

Immediately before spawning (stage 4), the ovaries were turgid and contained shiny orange-coloured oocytes. During the spawning, ovaries become more vascularized and several pouches of hydrated oocytes can be observed (stages 5 and 6). At the end of spawning (stage 7), ovaries became progressively flacid, carrying post-ovulatory follicles and atresic oocytes (Table 2).

The spawning period occurred in winter, with the *GSI* value showing a peak from December to March (Fig.1). In this period, the ovaries were mature with advanced vitellogenic and hydrated oocytes.

Table 2. Monthly variations in oocyte diameter (in μm) of common sole from northern Adriatic Sea (var.c.:mean variation coefficient; st.err.: standard error)

Month	Nov.	Dec.	Feb.	March	April	May	June	July	Sept.	Oct.
min	12	14	61	10	12	8	16	22	16	16
max	70	738	1360	520	78	115	79	174	91	91
mean	34	116	869	55	40	51	42	71	48	52
cells n°.	601	436	498	253	494	637	219	194	202	208
var.c.	35	153	26	109	38	37	36	39	38	33
st.err.	0,49	8,53	10,27	3,77	0,68	0,75	1,04	2,02	1,3	1,21



Month	GSI female	IGS male	St. err. F	St. err. M
November	0,324	0,169	0,024	0,032
December	0,575	0,094	0,269	0,024
February	3,029	0,136	0,406	0,019
March	1,56	0,193	0,2	0,088
April	0,268	0,196	0,019	0,061
May	0,441	0,144	0,063	0,092
June	0,182	0,068	0,036	0,017
July	0,4	0,023	0,097	0,011
September	0,539	0,053	0,033	0,005
October	0,695	0,063	0,03	0,003

Fig1. Gonadosomatic index during the months

Forty ovaries of mature female, at reproductive stages 1-6, were used for cytometric analysis of oocytes (Table 2). On the whole, the diameter of the germinal cells ranged from 8 μm (oogonia) to 1360 μm (hydrated oocytes). The remarkable size of these vitellogenic oocytes in stage 6 (about 1300 μm) indicates that these ovaries can be considered at a spawning stage.

DISCUSSION

Seven stages of ovarian development were observed during the annual cycle of sexually mature females, according to RAMSAY and WITTHAMES, (1996), but for different time (in the eastern English channel the majority of spawning takes place during April and May).

The *GSI* value through the annual cycle, supported by histocytological data, describe exactly the spawning period, which occurred from December to March.

The cytological study of oocyte size distribution in the mature ovaries showed only previtellogenic oocytes (diameter < 200 μm), during the period April-November, also vitellogenic oocytes (diameter > 200 μm), during the period December-March. Before the 1990's, the oocyte size distribution in the mature ovaries was rarely studied in natural populations of common soles (Le BEC, 1983; DENIEL, 1984; ROSENBOOM, 1985; URBAN, 1991) and the data obtained were often conflicting. A remarkable reproductive difference between the analysed stock populations concerns the duration of the reproductive period, which appeared shorter in the North-Adriatic populations (December-March) than in North Atlantic populations (January-June, with a peak in April-May) (RAMSAY and WITTHAMES, 1996). On

the whole, it can be suggested that local geographic temperatures and photoperiod are the most important factors affecting the spawning in common sole (HORWOOD, 1993).

In conclusion, the present anatomical and cytological study of the annual development cycle of ovaries of *Solea vulgaris* contributed to characterize the reproductive period, gonadal modifications of the common sole of northern Adriatic. Owing to the ascertained relationships between the variations in biological parameters and geographic-environmental conditions, it appears that studies on locally exploited stocks of soles are necessary and fruitful (HORWOOD, 1993; WITTHAMES and WALKER, 1995; STAGNI *et al.*, 1998).

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Reproduktivni ciklus lista *Solea vulgaris* (QUENSEL, 1806) u sjevernom Jadranu

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SAŽETAK

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