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GONAD MATURITY AND INDIVIDUAL FECUNDITY OF THE ARCTIC CHARR,
SALVELINUS ALPINUS (L.) FROM HORNSUND (VEST SPITSBERGEN)

STOPIEŃ DOJRZAŁOŚCI GONAD I PŁODNOŚĆ OSOBNICZA
GOLCA ARKTYCZNEGO *SALVELINUS ALPINUS* (L.) Z REJONU HORNSUNDU
(ZACHODNI SPITSBERGEN)

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Results of analyses of gonad maturity and individual fecundity of the Arctic charr, *Salvelinus alpinus* (L.) are presented. A total of 38 individuals caught in summer 1986 in lakes Revvatnet and Svartvatnet and in River Revelva were examined. Both males and females showed a considerable variability in gonad maturity.

INTRODUCTION

The Arctic charr, *Salvelinus alpinus* (Linnaeus, 1758), common and abundant in Svalbard waters, shows – as reported in the literature – a substantial within-population and individual variability.

A representative sample of mature fish, more or less homogenous in terms of age and length, was obtained in 1986 from lakes Svartvatnet (17 males and 21 females) and Revvatnet (1 female) as well as from River Revelva (1 female). The sample offered an opportunity to perform a detailed gonad maturity analysis and to determine female individual fecundity. What made the sample a still more interesting study material was the fact that most of the individuals were obtained from the same locality (Svartvatnet) and at a single time point on one day (20 July 1986).

MATERIALS AND METHODS

Immediately after capture, the fish were frozen and transported frozen to the laboratory in Poland.

After thawing, female gonads were removed from the body cavity, weighed, and examined. They were subsequently subjected to detailed histological analysis, with a particular reference to the state of oocytes and follicular integuments.

Gonad maturity was determined according to Maier's scale (Maier, 1939). Individual fecundity was determined in those females having gonads at stage IV–V. The lowest and highest egg diameters were found and a mean diameter was calculated.

Male gonads were weighed, examined morphologically, and their maturity stage was determined.

RESULTS

All the gonad parameters considered in females (gonad weight, external morphology, ovary maturity, oocyte development stage, oocyte size, and fecundity) and males (gonad weight, external morphology, and testis maturity) showed a substantial variability.

Females. Gonad weight was found to range from 5.48 to 144.77 g; as shown in Table 1, there was no correlation between gonad weight and body size, hence age.

Table 1
Gonad weight, gonad maturity and mean oocyte size in Arctic charr caught in the Hornsund area

No.	Specimen No.	Fish total length (mm)	Gonad weight (g)	Egg diameter : mean, min.—max. (mm)		Maturity stage
1	2	3	4	5	6	7
1	21/86	427	13.57	degenerated eggs		
2	27/86	435	5.56	1.26	1.09–1.42	II–III
3	26/86	443	5.48	1.31	1.08–1.39	II–III
4	22/86	455	17.75	1.59	1.32–1.99	III
5	18/86	460	42.87	4.29	4.06–5.01	IV–V
6	16/86	465	9.86	1.43	1.02–1.64	III
7	20/86	465	12.07	3.78	1.99–2.57	III–IV
8	14/86	466	15.36	1.82	1.38–2.40	III
9	10/86	467	30.73	3.31	1.92–4.22	III

1	2	3	4	5	6	7
10	42/86	467	85.90	3.86	2.98-4.91	IV
11	43/86	467	11.41	-	- - -	III
12	34/86	497	20.33	1.18	1.08-1.96	III
13	13/96	511	61.74	3.78	2.88-5.00	IV
14	40/86	513	67.67	3.82	3.06-4.26	IV
15	11/86	535	1.35		resorbet egss	
16	17/86	537	15.04	1.33	0.66-2.08	III
17	35/86	541	83.66	2.49	2.35-3.38	III-IV
18	5/86	550	144.77	4.60	3.99-5.52	IV- V
19	41/86	555	61.89	3.24	2.03-2.98	IV
20	6/86	559	73.00	3.12	1.36-4.48	IV



Fig. 1. Mature ovary at maturity stage IV. Photo: K. Radziun



Fig. 2. Ovary selvage with oocytes at different trophoblastic growth stages. 3x magnification. Photo: K. Radziun

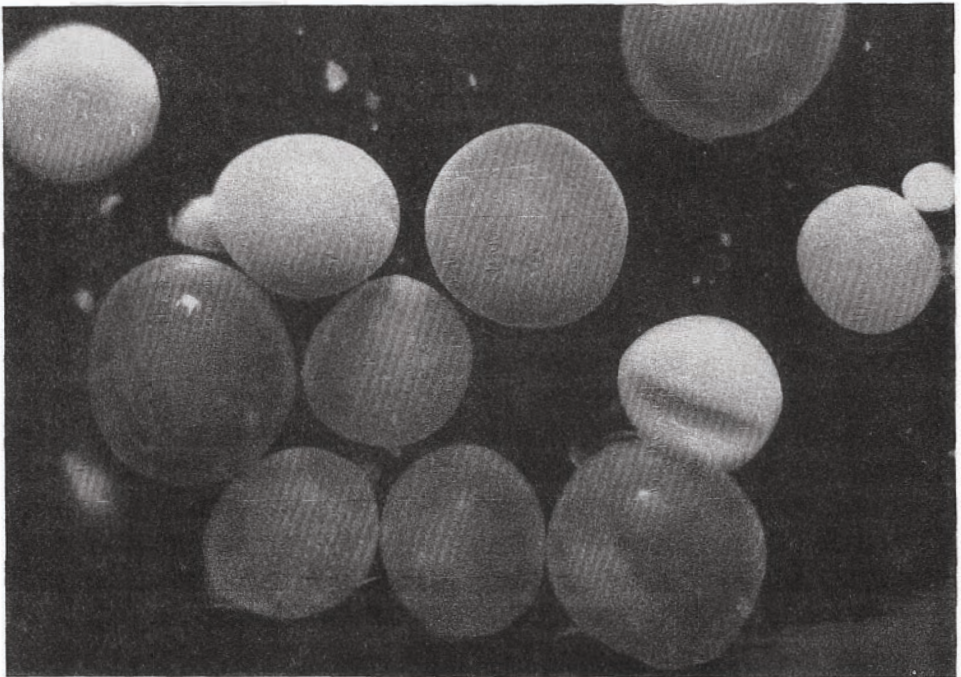


Fig. 3. Oocytes varying in size, dissected from Arctic charr ovary. About 6x magnification. Photo: K. Radziun

The Maier scale ovarian maturity stage varied considerably from individual to individual. A few females had ovaries at a stage intermediate between II and III; most gonads were at stage III; some females had gonads at stage IV, and in a few, gonads were at a stage intermediate between IV and V.

A clear relationship between ovary weight and maturity stage can be seen (Table 1). The table shows also that oocytes and eggs were equally diversified in terms of size; mean diameters for the whole sample and for an individual ranged within 1.167–4.597 mm and 1.36–4.48 mm, respectively. Those findings are illustrated by Figs. 1–4. Fig. 1 shows a mature ovary (Maier scale stage IV), large, orange in colour, with clearly separating selvages. A closer look at a section of a single selva (Fig. 2) shows easily discernible, coloured, almost mature oocytes along with colourless, immature ones at different stages of trophoblastic growth. Fig. 3 presents a still more detailed picture of oocyte size diversity; oocytes dissected out from the same ovary and follicular integuments as well as hydrated, large eggs removed from the female's body cavity are shown, the latter eggs having earlier left the ovary, but remaining in the body cavity (Fig. 4).

Individual fecundity was studied in 5 selected females. The results are shown in Table 2. The females differed by as much as 40% in their oocyte counts in both ovaries.

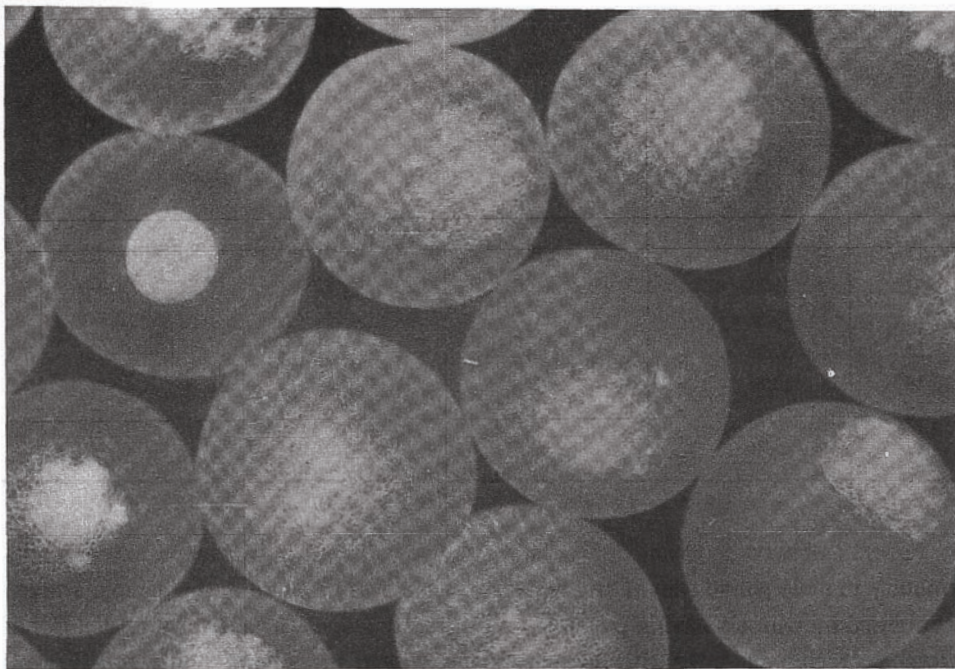


Fig. 4. Hydrated eggs found in Arctic charr body cavity. About 6x magnification. Photo: K. Radziun

Table 2

Individual fecundity of Arctic charr females

No.	Specimen No.	Total length (mm)	Gonad weight (g)	Weight of 1 egg (g)	Total number of eggs	Capture site
1	1-86	553	56.964	0.0117	4869	Revvatnet
2	2-86	574	98.400	0.0122	8065	Revelva
3	5-86	550	144.770	0.0259	5589	Svartvatnet
4	13-86	511	61.74	0.0116	5322	Svartvatnet
5	40-86	513	67.67	0.0104	6507	Svartvatnet

Table 3

Gonad weight and maturity stage of Arctic charr males in Hornsund area

No.	Specimen No.	Fish total length (mm)	Gonad weight (g)	Gonad maturity stage
1	19/86	425	0.83	I - II
2	23/86	438	0.24	I
3	8/86	466	0.98	I - II
4	12/86	467	0.88	II
5	44/86	482	42.94	V
6	15/86	491	2.42	III
7	24/86	493	0.64	III
8	25/86	498	1.01	II
9	9/86	506	1.27	II
10	33/86	512	34.08	IV
11	37/86	533	2.25	III
12	31/86	560	48.02	IV - V
13	39/86	567	43.94	IV - V
14	30/86	574	2.11	II
15	38/86	578	53.11	V
16	28/86	597	1.72	II
17	29/86	607	47.33	IV - V

Males. Observations and laboratory analyses showed a still more extensive variability in male gonad weight and maturity. As shown in Table 3, the sample studied contained individuals having gonads at all maturity stages (from I through V). Gonad weight correlated clearly with maturity stage, weight increments being considerable at stages IV and V.

DISCUSSION AND CONCLUDING REMARKS

Although the sample studied was not large, the fact that most individuals were obtained from the same water body (Lake Svartvatnet) and at the same time, and that they were adult (not the first spawners) and similar in size makes it possible to regard the sample as sufficient to form an opinion on peculiarities of Arctic charr reproduction under specific conditions of Spitsbergen. The considerable variability in both gonad weight and maturity, higher than in any other salmonid species, is an unmistakable sign of adaptation of the Arctic charr to varying, in different years and seasons, conditions it can spawn under. Given these differences in rate and timing of gonad maturation, at least some members of the population have a chance to be ready to spawn whenever the conditions are favourable for reproduction. This refers to both females and males.

This plasticity, manifest as individual gonad variability, is still more pronounced in females. As opposed to other salmonids when they are ready to spawn, gonads of the female Arctic charr house, in addition to oocytes almost ready to be released, oocytes less advanced in their trophoblastic growth which, once the mature eggs are evacuated, mature fast and become a reproductive material warranting the population's persistence.

A similar phenomenon has been observed in other fish species living under extreme conditions.

Thus the observations reported here show the Arctic charr to be highly plastic in terms of the course of its reproduction. This plasticity has been already mentioned by other workers who studied the species (Johnson, 1980; Mednikov et al., 1980; Balon, 1980), although data from Svalbard are very scanty. Apart, however, from findings published by Gullestad (1973, 1975) who pointed out that *Salvelinus alpinus* from Svalbard reaches maturity at different age, and by Greinger (1953) and Johnson (1985) who reported that the eggs (oocytes in the ovary, to be more exact) develop at different rates, there are no comprehensive studies on the species and its reproduction.

The results on individual fecundity obtained during the study reported here can be treated as an introduction to future investigations. The oocyte numbers obtained fall within the ranges found by other workers, although it is open for discussion whether both our and other workers' results should be called fecundity. The term would be adequate, if we could be sure that all the eggs produced in a given year would be evacuated from the ovary and body cavity. The peculiarities of the Arctic charr reproduction and the pattern of female reproductive cell variability indicate that such is not the case: only some of the eggs are removed from the body. It would be then more appropriate to treat the calculated numbers as a yearly seasonal potential fecundity and to determine the actual fecundity in some other way. It can be

contended even now that the other value would be less than the first. Further studies ought to show how much lower this other value is.

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STRESZCZENIE

Przeprowadzono analizę stopnia dojrzałości gonad i płodności osobniczej goliców *Salvelinus alpinus* (Linnaeus, 1758) złowionych latem 1986 roku w rejonie Hornsundu na Spitsbergenie w jeziorach Revvatnet i Svartvatnet oraz rzece Revelva. Stopień dojrzałości gonad oznaczono wg skali Meiena, natomiast płodność osobniczą określano u samic, których gonady znajdowały się w IV i V stadium dojrzałości.

Przeprowadzone obserwacje wykazały znaczne zróżnicowanie gonad badanych ryb w wartościach wszystkich parametrów jakie były brane pod uwagę: u samic — masę, wygląd zewnętrzny, stopień dojrzałości jajnika, stadia rozwojowe oocytów, ich rozmiary i płodność (tabela 1 i 2); u samców — masę, wygląd zewnętrzny i stopień dojrzałości jąder (tabela 3).

Z badań wynika, że golec arktyczny jest pod względem rozrodu rybą bardzo plastyczną. Zaobserwowane znaczne zróżnicowanie stopnia dojrzałości gonad potwierdza tę tezę i wskazuje na możliwości reprodukcji w ekstremalnych i zmiennych w czasie warunkach jakie panują na tym archipelagu.

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