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AGGRESSION AND GROWTH OF DIFFERENT POPULATIONS OF ATLANTIC SALMON PARR

By

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A B S T R A C T

In order to study aggression and growth of salmon parr of different populations and the possible effect of fin-clipping on these traits hatchery reared parr originating from three populations (2 Norwegian, 1 Swedish) were stocked in three aquaria with 90 unmarked fish in each. Three aquaria were stocked with a mixed group of 30 each of the populations. These fish were fin-clipped (adipose or pelvic fins) in order to enable identification of groups. Observation time was 15 min/day/aquarium, altogether 28 days of observation were made. Total experimental time was 8 weeks. Significant differences in agonistic behaviour as well as in growth ($p < 0,001$) was found between the populations. An effect of fin-clipping could also be detected in this study. At least one fish per aquarium established dominancy for part of the time. Most of the dominants in the mixed groups came from the same population.

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INTRODUCTION

Salmon parr are territorial under natural conditions (KALLEBERG 1958). A relation between aggression and growth under high densities has been proposed by BROWN (1946 a, b) and REFSTIE and KITTELSEN (1976). In experiments under crowded rearing conditions (FERNØ et al. 1976), salmon parr showed several kinds of aggressive behaviour patterns, and dominant individuals with incomplete territorial defence were established. Aggression and growth of small and large fish were estimated in different densities.

In the present paper, growth and aggressive behaviour of different populations of salmon parr have been studied using fin-clipping as a marking technique. Behavioural differences between populations could be relevant to selection experiments for growth (NAEVDAL et al. 1976) and fin-clipping as a method of marking fish has been used in several studies, possibly introducing systematic errors.

MATERIAL AND METHODS

The parr used in the experiment were second generation of hatchery reared fish from three different rivers, i.e. Lonevåg-river and Etne-river in Southwestern Norway and Skellefte-river in Northeast Sweden. The Lonevåg-river is a typical grilse river while Etne-river produces big salmon. The Skellefte-river salmon have their feeding area in Gulf of Bothnia where the water is low salinity brackish water. The Norwegian fish migrate to the Northeast Atlantic Sea. The parents of the fish used were all selected for good individual growth rate.

The eggs were hatched in the spring of 1977 at the field experiment station in Matre, near Bergen, where this experiment also was performed. The fish were about one year old at the start of the experiment in January 1978.

The aquaria used were 200 l semioval fibreglass tanks with a window pane of the same type and size as described by FERNØ et al. (1976). The water inflow was about 1.0 l/min. The

temperature was 10 + 1.0°C and the photoperiod was 12 hours starting 7.30 a.m. The source of illumination was 100 W white fluorescent lights placed on top of the aquaria. Each aquarium was stocked with 90 fish, a density which during earlier experiments had proved favourable for observing, yet not too unrealistically low for rearing conditions. At the start of the experiment, the fish were 50-99 mm long and the total weight of fish /200 l was 250 g except for an aquarium with solely Etne fish, where the weight was 200 g.

The fish were fin-clipped in order to enable identification of populations when observing. The fin-clipping was rotated in order to avoid systematical error and to detect possible effects of fin-clipping on behaviour and growth. The populations were stocked in the aquaria as Fig. 1 indicates.

Aquarium no.

1	2	3	4	5	6
90	90	90	30 S, U	30 L, U	30 E, U
U	U	U	30 L, A	30 E, A	30 S, A
L	E	S	30 E, P	30 S, P	30 L, P

Fig. 1. Number and clippings of the fish in the aquaria.

E = Etne-river U = Unmarked
L = Lonevåg-river A = Adipose fin
S = Skellefte-river P = Pelvic fin.

The observation time was 15 min/aquarium/day and the observations were made on three aquaria starting at 11.00 and on the other three starting at 16.00, i.e. 2 hours after feeding. The order was rotated. The fish were observed daily for 10 days by one person and by another person for 10 days following immediately afterwards. Then there was a pause of 2 weeks, then 4 days' observation by the first person, one week's pause and then 4 days observation by the other person, thus altogether making 28 observations in aquarium Nos. 4, 5, 6. Aquarium Nos. 1, 2 and 3 had 2 more observations. The laboratory was in darkness during the observations which were recorded on magnetic tape

and later transcribed. Unfortunately, the fish were attacked by bacterial gill disease after 5 weeks, which caused some mortality and possibly also affected behaviour during observation Nos. 20 - 24.

The fish were fed to satiation by hand at approximately 9.00 a.m. and at 2.00 and 7.00 p.m. every day during observation periods and when not observed at 8.00 a.m., 11.30 a.m. and 3.30 p.m. daily except on Sundays.

The categories of recorded aggressive behaviour were: Attack, charge, nip and chase; these terms were used as described in FERNØ et al. (1976). In this paper, however, only the sum of all categories is taken into account. The distribution of the fish and the positions of the dominant fish were recorded.

Standard statistical methods (cf. SOKAL and ROHLF 1969 and SIEGEL 1956) were used for analysing the data.

RESULTS

There was generally one dominant fish in each aquarium defending a territory which could vary in size and position from day to day. Once a fish had established dominancy it generally remained dominant throughout the experiment (8 weeks), but there could be changes in dominants and some times no dominants at all could be discriminated. The dominant fish in the aquaria with mixed groups were with few exceptions Etne parr. Table 1 shows the aggressive actions made by dominants.

Table 1. Per cent aggressive actions made by dominant fish in the different aquaria.

	AQUARIUM No.					
	Pure groups			Mixed groups		
	1	2	3	4	5	6
	30 observations			28 observations		
% aggressive actions by dominants	9.5	5.1	24.3	29.1	17.9	26.5
Total No./ aquarium	1125	1381	767	819	636	437

The pure groups of parr, i.e. aquaria 1, 2 and 3, showed differences in intrapopulation agonistic behaviour as follows:

	Etne-river	Lonevåg-river	Skellefte-river
Total number of aggressive actions	1381	1125	767

30 observations

The difference is significant ($p < 0.01$, Wilcoxon matched-pairs signed-ranks test) between Etne and Skellefte and Lonevåg and Skellefte parr, while it is nearly significant between Etne and Lonevåg parr ($p = 0.075$).
The amount of aggressive actions in the mixed populations (i.e. aquaria 4, 5 and 6 is presented in tables 2 and 3. Subject to an analysis of variance the data (number of aggressive actions per fish/aquarium/observation) revealed significant differences ($p < 0.001$) between aggressive actions made by parr of different populations and also an interaction between population and clipping. The effect of clipping alone on agonistic behaviour was not significant.

Table 2. Aggressive actions made by different categories and per cent of total amount in each aquarium. Aquarium No. in brackets. Dominants not included.

	Population									
	Etne			Lonevåg			Skellefte			N
Marking	n	%		n	%		n	%		total
Unmarked	165	51.4	(6)	158	30.3	(5)	159	27.4	(4)	482
Adipose fin	256	49.0	(5)	165	28.4	(4)	94	29.3	(6)	515
Pelvic fin	256	44.1	(4)	62	19.3	(6)	108	20.7	(5)	426
N total	677			385			361			

There was also difference in the actions received by the different categories, although they were less pronounced. The effect of fin-clipping ($p<0.05$) was more important than differences between populations in this respect.

Table 3. Number of aggressive actions received by different categories and per cent of total amount in each aquarium. Auarium No. in brackets.

	Etne			Lonevåg			Skellefte			N
Marking	n	%		n	%		n	%		total
Unmarked	163	38.0	(6)	187	29.9	(5)	313	39.8	(4)	663
Adipose fin	280	44.8	(5)	270	34.3	(4)	163	38.0	(6)	713
Pelvic fin	204	25.9	(4)	103	24.0	(6)	158	25.3	(5)	465
N total	647			560			634			

The above distribution of aggression (Tables 2 and 3) is the sum of aggressive actions during the whole observation time (420 min/aqu.). It must therefore be mentioned that there were changes between the different categories of fish during certain periods, e.g. during the attack of cacterial gill disease and the subsequent feeding with antibiotics.

There were also other differences between the populations which, although difficult to quantify, were apparent to the observers. E.g. the pure Etne group was during the whole experiment less willing to leave the bottom to take food, while the fish in the other aquaria rushed like one school to the surface when the feeding started. The Skellefte parr seemed more nervous than the others making rapid bursts around the aquarium and displaying more fright reactions than the others (50 incidents against 14 - 22 in the other aquaria).

The growth data are presented in Table 4. The differences in growth were significant ($p < 0.001$) between the pure groups of Lonevåg and Etne, and Skellefte and Etne, but unsignificant between Skellefte and Lonevåg (Student's t-test). Analysis of variance revealed no differences in growth between different markings nor any interaction between population and marking. The difference in growth between the populations was significant ($0.01<p<0.05$) also in the mixed groups.

Table 4. The growth and utilization of food during experimental period (8 weeks).

Aqu. no	Population		Mean weight g Initial ± Sd	Final ± Sd	Food conversion factor	Specific growth rate
1	Lonevåg	U	2.8 ± 1.26	5.2 ± 2.62	1.5	7.73
2	Etne	U	2.1 ± 1.11	3.3 ± 2.14	2.5	5.64
3	Skellefte	U	2.8 ± 1.26	5.0 ± 2.56	1.6	7.25
4	Skellefte	U	2.6 ± 1.16	4.4 ± 2.07		6.58
	Lonevåg	A	2.7 ± 0.96	4.7 ± 1.93	2.1	6.93
	Etne	P	2.5 ± 1.13	4.2 ± 2.48		6.48
5	Lonevåg	U	2.7 ± 1.57	4.9 ± 3.07		7.45
	Etne	A	2.9 ± 1.63	4.6 ± 3.25	1.7	5.77
	Skellefte	P	2.7 ± 1.20	4.8 ± 2.75		7.19
6	Etne	U	2.9 ± 1.92	4.7 ± 3.68		6.06
	Skellefte	A	2.7 ± 1.39	4.7 ± 3.06	2.0	6.93
	Lonevåg	P	2.6 ± 1.43	5.0 ± 3.39		8.24

U = unmarked
A = Adispose fin cut
P = Pelvic fin cut

DISCUSSION

Etne parr were more aggressive than parr from Skellefte and Lonevåg in pure as well as in mixed groups and the dominant individuals in mixed groups were with few exceptions Etne parr. This high aggressiveness might be caused by a high aggressive motivation. A relation between anti-predator behaviour and aggression was found in the three-spined stickle-back (Huntingford 1976). A genetically determined high aggressive motivation could be connected with a low predator pressure.

Etne parr grew least rapidly in both pure and mixed groups. This might possibly be correlated with their higher aggressive activity. The Lonevåg parr, which had the most rapid growth in mixed groups, were least often the object of aggressive actions, also suggesting relationship between aggression and growth. On the other hand,

in a pure group Lonevåg parr showed rapid growth, although the level of aggression was relatively high.

The effect of fin-clipping on aggression seemed to be that fish with cut pelvic fins both attacked and were attacked less frequently than other fish, which might result from:

a) Fish with cut pelvic fins have a weaker display of aggressiveness, since the pelvic fins are used in displaying agonistic behaviour.

b) Cut pelvic fins might give less swimming and manoevring ability.

c) Removal of pelvic fins might make it difficult for the fish to stay close to the bottom, which again seems to be correlated with high level of aggression.

In this experiment, however, it is not possible, perhaps due to too short experimental period, to give significant statistics for the above conclusions.

The tendency of the Etne parr to keep near the bottom in the pure as well as in the mixed groups, suggests the following relationship: High aggression - slow growth - position near bottom.

Differences in growth between parr populations have been demonstrated to be genetically based (cf. RYMAN 1971, NAEVDAL et al. 1975 and 1976).

Even if the findings in this study are not conclusive, the correlation between population, growth and aggressive activity implies that the growth differences between populations to some extent are mediated via behavioural differences. The effect of fin-clipping must be born in mind when evaluating experiments with fish marked by this method.

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