FiskDir. Skr. Ser. HavUnders., *18:* 123–129.

AGGRESSION AND GROWTH OF ATLANTIC SALMON PARR.* II. DIFFERENT POPULATIONS IN PURE AND MIXED GROUPS

By

MARIANNE HOLM
Institute of Marine Research, Bergen, Norway

and
ANDERS FERNÖ
Institute of Fisheries Biology,
University of Bergen, Bergen, Norway

ABSTRACT

HOLM, M. and FERNÖ, A. 1986. Aggression and growth of Atlantic salmon parr. II. Different populations in pure and mixed groups. *FiskDir. Skr. Ser. HavUnders., 18:* 123–129.

The aggressive behaviour and growth of different populations of Atlantic salmon parr and the possible effect of fin-clipping on these traits were studied. Each of three 200 l aquaria was stocked with 90 unmarked hatchery parr from one of three different populations (one Swedish, two Norwegian). Three other aquaria were stocked with mixed groups consisting of 30 parr from each population. To enable identification, two of the three groups were alternately fin-clipped (adipose fin or pelvic fins). Significant differences in aggressive activity and growth were found between the populations. The population with the most aggressive parr had the slowest growth in both pure and mixed groups. Parr with cut pelvic fins both performed and received fewer aggressive acts than parr with cut adipose fin or unmarked parr. The results suggest a negative correlation between aggression and growth, and indicate that growth differences between populations to some extent may be mediated by genetically determined differences in behaviour.

INTRODUCTION

Salmon parr are territorial under natural conditions (KEENLEYSIDE and YAMAMOTO 1962). Resulting aggressive behaviour could have a negative influence on growth under crowded rearing conditions. In experiments at high densities (FERNÖ and HOLM 1986), salmon parr showed a relatively high

* This paper was first presented at the national symposium «Behaviour of marine animals» held at Solstrand, Os, Norway, 9–10 February 1983.

aggressive activity, and dominant individuals with territorial defence were established. There were also indications of a relationship between the aggressive behaviour and slow growth of small parr at the highest stocking densities.

In the present study, the growth and aggressive behaviour of different populations of salmon parr have been studied in both pure and mixed groups using fin-clipping as a marking technique. Behavioural differences between populations could be relevant to selection experiments for growth (e.g. NÆVDAL, HOLM, MØLLER and ØSTHUS 1975), and, since fin-clipping is a common means of identification in such studies, its possible influence on behaviour and growth is investigated.

MATERIALS AND METHODS

The salmon parr (*Salmo salar* L.) used in the experiment were second-generation hatchery-reared fish originating from three different rivers; namely, the Lonevåg River and Etne River in southwestern Norway and the Skellefte River in northeast Sweden. The Lonevåg River is a typical grilse river whereas the Etne and Skellefte Rivers produce big salmon.

The parents of the parr were all selected for good individual growth rate. The eggs were hatched in January 1977 at the field experiment station in Matre, near Bergen, where this experiment was performed. All parr had been reared under the standard rearing conditions at the field station. The fish were about one year old at the start of the experiment in January 1978.

The six aquaria in the experiment were 200 l semioval fibre glass tanks with a window pane of the same type as described by FERNÖ and HOLM (1986). The water inflow was about 1.0 l/min and the temperature was 10±1° C. The aquaria were illuminated from above with 100 W white fluorescent lights, and the photoperiod was 12 hrs starting 0730 hours. The fish were fed to satiation by hand with commercial dry pellets three times a day. The fish were in a healthy state throughout the experiment except for a short period with bacterial gill disease, which was cured by antibiotics. Each aquarium was stocked with 90 parr, a density that was favourable for observing, yet not unrealistically low for rearing conditions. Lengths and weights of the fish were measured at the start and end of the experiment. Initially the fish were 50–99 mm long and the total weight per aquarium was 200–250 g.

Aquaria 1–3 were stocked with single-population groups, viz. 90 unmarked parr from one population in each aquarium, and aquaria 4–6 were stocked with mixed-population groups, viz. 30 parr from each of the three populations. The fish from two of the populations in the mixed groups were fin-clipped (adipose fin and pelvic fins, respectively) to enable identification of the populations during the observations. The clipped fin of the populations was alternated

between the aquaria in order to avoid systematic error and to detect possible effects of fin-clipping on behaviour and growth.

The observations were begun four days after stocking. The laboratory was in darkness during the observations to prevent disturbances. Observations were made on three aquaria for 15 min per aquarium between 1100 and 1200 hours, and on three aquaria between 1600 and 1700 hours, with the order of observation rotated between the aquaria. There were 30 observation days for the uniform groups and 28 for the mixed groups during a total experimental period of 60 days.

A dictaphone was used for recording the observations. The aggressive behaviour was defined as the four different categories of attack, charge, nip and chase (cf. FERNÖ and HOLM 1985 for definitions). In this paper, only the sum of all behaviour patterns is considered because no significant differences were found in the relative occurence of any one behaviour pattern either between different populations or between different marking methods.

RESULTS

The aggressive activity of the fish was low at the beginning of the experiment, but then increased. One fish generally became dominant (see FERNÖ and HOLM 1986) in each aquarium, defending a kind of territory which could vary in size and position from day to day. A dominant fish generally remained dominant throughout the experiment, but sometimes challengers became dominant, and in some observations there were up to three dominant fish. The dominant fish in the aquaria with mixed groups were, with few exceptions (four observations), Etne parr.

Table 1 shows the aggressive activity of dominant and subordinate fish in the different aquaria. There were significant differences between the aquaria concerning the proportion of the aggressive acts made by dominants ($p < 0.001$, chi-square test), there being least aggression by dominants in the aquaria with highest aggressive activity. Regarding the total number of aggressive acts, Etne parr had the highest aggressive activity of the uniform groups, followed by Lonevåg parr and Skellefte parr. Significant differences were observed between Etne and Skellefte and between Lonevåg and Skellefte

Table 1. The number of aggressive acts made by dominant and subordinate fish in the different aquaria.

	Pure groups			Mixed groups		
	1 (Lonevåg)	2 (Etne)	3 (Skellef.)	4	5	6
Dominant fish	107	70	186	239	114	116
Subordinate fish	1018	1311	581	580	522	321
Total	1125	1381	767	819	636	437

Table 2. Mixed groups. Number of aggressive acts (n) made by the different categories of fish and the percentage of total in each aquarium. Aquarium number in brackets. (Dominants are excluded).

	Population						
	Etne		Lonevåg		Skellefte		
Marking	n	%	n	%	n	%	Sum
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 fins	256	44.1 (4)	62	19.3 (6)	108	20.7 (5)	426
Sum	677		385		361		1423

($p < 0.01$, Wilcoxon matched-pairs signed-ranks test), although not between Etne and Lonevåg ($p < 0.075$).

The number of aggressive actions made in the aquaria with mixed groups was generally lower than in the aquaria with pure groups. Table 2 shows the aggressive activity of the different populations in the mixed groups. There were significant differences between the populations ($p < 0.001$, ANOVAR), with Etne parr being the most aggressive. (The aggressive activity of the dominant fish was excluded from the analysis, as this would otherwise bias the data). There was also an interaction between population and fin-clipping ($p < 0.01$), with fish lacking pelvic fins being the least aggressive. The effect of fin-clipping alone on the aggressive behaviour was not significant.

There were also certain differences in the number of aggressive actions received by the different categories of fish (Table 3). The effect of fin-clipping ($p<0.05$) was more important than the population of origin. Fish with cut pelvic fins were least often the target of aggressive acts.

It is also of interest to see whether intra-population or inter-population aggression in the mixed groups was most frequent. Etne and Skellefte parr had a tendency to direct the aggressive behaviour toward members of their own population (44% and 55% respectively, $p < 0.001$, chi-square test). Lonevåg parr had no such tendency (37%).

Table 3. Mixed groups. The number of aggressive acts (n) received by the different categories of fish and the percentage of total in each aquarium. Aquarium number in brackets. (Dominants are excluded).

	Population						
	Etne		Lonevåg		Skellefte		
Marking	n	%	n	%	n	%	Sum
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 fins	204	25.9 (4)	103	24.0 (6)	158	25.3 (5)	465
Sum	647		560		634		1841

There were also other differences in behaviour between the populations, which, although difficult to quantify, were apparent to the observer. Etne parr had a tendency to keep near the bottom. During feeding they generally lay on the bottom, making short bursts to take the food particles, whereas Lonevåg and Skellefte parr generally were positioned higher in the water volume, rushing to the surface when feeding started. Parr with cut pelvic fins seemed to be positioned higher above the bottom than unmarked parr and parr with cut adipose fin.

Another observation was that Skellefte parr seemed to be more easily frightened than the parr from the two other populations. At the beginning of the experiment, Skellefte parr with submissive colouration (cf. KEENLEYSIDE and YAMAMOTO 1962) often lay in rows on the bottom. Individual Skellefte parr often made rapid bursts around in the aquarium. The homogeneous Skellefte group displayed more (50 incidents) fright reactions, with the fish swimming violently around in the aquarium, than did the fish in the other aquaria (14–22 incidents).

Table 4. The growth and food utilization of different populations and markings of salmon parr. Mean weights with standard deviations, specific growth rates and food conversion factors are given (cf. FERNÖ and HOLM 1986 for definitions). UM = unmarked, AF = adipose fin, PF = pelvic fins.

Aqua-rium	Population	Marking	Initial mean weight (g)	Final mean weight (g)	Specific growth rate	Food conversion factor
1	Lonevåg	UM	2.8±1.3	5.2+2.6	1.03	1.5
2	Etne	»	2.1±1.1	3.3+2.1	0.73	2.5
3	Skellefte	»	2.8±1.3	5.0+2.6	0.94	1.6
	Skellefte	UM	2.6±1.2	4.4+2.1	0.88	
4	Lonevåg	AF	2.7±1.0	4.7+1.9	0.91	2.1
	Etne	PF	2.5±1.1	4.2+2.5	0.80	
	Lonevåg	UM	2.7±1.6	4.9+3.1	0.99	
5	Etne	AF	2.9±1.6	4.6+3.3	0.76	1.7
	Skellefte	PF	2.7±1.2	4.8+2.8	0.92	
	Etne	UM	2.9±1.9	4.7+3.7	0.83	
6	Skellefte	AF	2.7±1.4	4.7+3.1	0.91	2.0
	Lonevåg	PF	2.6±1.4	5.0+3.4	1.07	

The data on growth are presented in Table 4. In homogenous groups, the specific growth rate of Etne parr was lower than the growth rate of Lonevåg and Skellefte parr ($p < 0.001$, Students' t-test). Lonevåg parr had a somewhat better growth than Skellefte parr, but this difference was not significant. This trend also appeared in the mixed groups, as there were significant differences between the populations ($p<0.05$, ANOVAR), with Etne parr growing most slowly and Lonevåg parr growing most rapidly. There was no significant difference in growth with respect to the different markings and no interaction

between population and marking could be detected in the ANOVAR. Table 4 also shows that the homogeneous Etne group had a poorer utilization of food than pure Lonevåg and Skellefte groups. The mortality in the experiment was generally low, with no systematic differences between populations or marking methods.

DISCUSSION

Parr from the Etne population grew slower than parr from the Lonevåg and Skellefte populations in both pure and mixed groups. The slow growth of Etne parr may be related to their frequent aggressive activity (see FERNÖ and HOLM 1986). Etne parr were more aggressive than Lonevåg and Skellefte parr in both pure and mixed groups, and the dominant parr in the mixed groups were generally from the Etne population. The high aggressive activity of this population could be genetically determined, although nothing is known about the aggressive activity under other conditions. Hereditary differences in aggresiveness are known in other fish species (see, for example, HOLZBERG and SCHRÖDER 1975).

A direct causal relationship between high aggressive activity and slow growth cannot, however, be clearly demonstrated in this study. It is also possible that the observed tendency of Etne parr to keep near the bottom could lead to a frequent occurence of aggression as well as low utilization of food and a low growth rate. Most aggression seemed to occur near the bottom, and Etne parr were positioned near the bottom also during feeding time.

A connection between aggressive activity and position in relation to bottom is also indicated by the findings that parr with cut pelvic fins had a tendency to stay high in the water volume and to perform and receive fewer aggressive actions than unmarked parr and parr with cut adipose fin.

A negative correlation between aggressive activity and growth was, however, not always found in the study. In the pure groups, Skellefte parr were least aggressive, but Lonevåg parr had a somewhat higher growth rate. This may be the outcome of a generally higher level of stress in Skellefte parr, as indicated by their frequent fright reactions.

Even if the findings in this study are not wholly conclusive, the connection between population, growth, and aggressive activity suggests that genetically based differences in growth between salmon populations (NÆVDAL *et al.* 1975) to some extent may be mediated via genetically determined behavioural differences. The effect of fin-clipping must also be considered when evaluating experiments with marked fish.

ACKNOWLEDGEMENT

We thank Miss Karin Pittman for remarks on the manuscript.

REFERENCES

FERNÖ, A. and HOLM, 1986. Aggression and growth of Atlantic salmon parr. I. Different stocking densities and size groups. *FiskDir. Skr. Ser. HavUnders., 18:* 113–122.

HOLZBERG, S., and SCHRÖDER, H.J. 1975. The inheritance of aggressiveness in the convict cichlid fish, *Cichlasoma nigrofascialum* (Pisces: Cichlidae). *Anim. Behav., 23:* 625–631.

KEENLEYSIDE, M.H.A. and YAMAMOTO, F.T. 1962. Territorial behaviour of juvenile Atlantic salmon (*Salmo salar* L.). *Behaviour, 19*: 139–169.

NAEVDAL, G., HOLM, M., MØLLER, D. and ØSTHUS, O.D. 1975. Experiments with selective breeding of Atlantic salmon. *Coun. Meet. int. Coun. Explor. Sea, 1975.* (M: 23): 1–7. [Mimeo.].

Printed 10. April 1986