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The time budget of Atlantic salmon (*Salmo salar*) held in enriched tanks

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ABSTRACT

In order to understand the impact of different experimental and husbandry procedures on fish, and ensure that the behavioural and physiological needs of fish used in research are met, it is necessary to have detailed knowledge of their behaviour. This knowledge is largely lacking for Atlantic salmon. Results from behavioural studies of rainbow trout are often extrapolated to Atlantic salmon even though this may not be correct. Pre-smolt Atlantic salmon show diurnal variation in behaviour in the wild, but there are no published descriptions of behaviour during the dark hours for salmon held in the laboratory. Thus, the first aim of this paper was to describe the time budget of singly-held salmon both during the light and dark hours on the first and seventh day after introduction to a new environment. Statistical differences in time budget between morning, afternoon and night are described. In addition, three environmental enrichments were provided, and the time spent using each resource was scored. In general, no behaviours differed in frequency between morning and afternoon registrations, but there were significant differences in the time-budget between day and night and also between day 1 and 7. Fish hid less and displayed more behaviours during the night than during the day, and also after 7 days in the tank compared to at the first day. The exceptions were bottom behaviours which were displayed with the same frequency during day and night and during day 1 and day 7, and hovering, which was unchanged at night from day 1 to day 7. Thus, different behaviours seem to be influenced by light and by the novelty of the surroundings to different degrees. Of the three enrichments included in the study, the hiding place and the inlet current were used most frequently. As far as the authors know, this is the first paper describing the daytime and night time behaviour of parr Atlantic salmon in a research facility in detail.

1. Introduction

Teleost fish, such as the Atlantic salmon (*Salmo salar*), are used as test subjects in nearly all fields of biological science (http://www.homeoffice.gov.uk, 2012). In order to evaluate the effect of experimental treatments and understand the impact of different procedures on the subjects, and to ensure that the behavioural and physiological needs of experimental fish are met, it is important to have detailed knowledge of the behaviour of the species used (Williams et al., 2009). However, there are few articles describing laboratory fish' behaviour in detail. This lack of knowledge makes behavioural data difficult to interpret and hampers the development of 'best practice' routines (i.e. stress-, fear- and pain-reducing) and the implementation of environmental enrichment for laboratory fish (Williams et al., 2009). This problem is highly relevant for research on Atlantic salmon. Salmon

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have been domesticated for a short period of time and are generally regarded as more fearful than the relative, the rainbow trout (Kittilsen, personal communication), for which slightly more knowledge about behaviour in the laboratory exists (see e.g. Sneddon et al., 2003; de Lourdes Ruiz-Gomez et al., 2008, 2011). Thus, insights gained from studies of rainbow trout behaviour are often extrapolated to Atlantic salmon, even though the interspecies variance in behaviour is not known. Atlantic salmon are anadromous. Pre-smolt stages show diurnal activity patterns in the wild (Gries et al., 1997; Valdimarsson and Metcalfe, 1999). This indicates that effects of different treatments on night time behaviour could be important, yet analysis of behaviour after dark is rarely included in experiments on salmonids. This is probably mainly due to technical difficulties, but as salmon cannot see in the infrared spectrum (Ali, 1961; Beach, 1978), use of an infrared camera should solve this challenge. In addition, it is not known whether behaviour varies between morning and afternoon, and whether time of day (during the light hours) should be taken into account when testing effects of a treatment on behaviour in salmon. Thus, the first aim of this paper was to describe the time budget of Atlantic salmon both during the light and dark hours on the first and seventh day after introduction to a new environment, and to compare the relative occurrence of behaviours during the morning, afternoon and night, and during the first and seventh day. As the physical design of the environment influences the number of behaviours a species can show, and as there is little knowledge about the use of environmental enrichment for salmonids, our second aim was to describe the use of three types of enrichments. The enrichments were chosen based on the natural habitat of salmon (Mellen and MacPhee, 2001), and included a hiding place, a water current, and a gravel box. As far as the authors know, this is the first paper describing the behaviour of parr Atlantic salmon in a research facility in detail, and also the first paper describing nocturnal behaviour in experimental aquariums.

2. Materials and methods

2.1. Animals and housing

Twenty-eight Atlantic salmon in the parr stage were used in this experiment. They were of Aquagen stock and were purchased from the University of Life Sciences at Ås, Norway. One fish died of causes unrelated to the experiment, giving a total of twenty-seven fish for analysis. They were unvaccinated and weighed 29.2 ± 8.6 grams (mean $\pm$ SD). Prior to the experiment, the salmon were group-housed in a barren 200 l tank. The temperature both in the holding tank and the experimental tanks was kept between 9 and 12 °C. The light:dark schedule was 13 h:11 h. On the first day of each of the seven replicates, four fish were moved from the common 200 L tank to the four experimental tanks (80 l: L × W × H; 75 × 30 × 40 cm) where they were housed singly (Fig. 1) for one week. Single housing was chosen as we wanted the findings to be relevant for studies in which salmon are housed singly, and because salmon are highly territorial in the freshwater stage, and fight when kept at low densities. At the opposite end of the

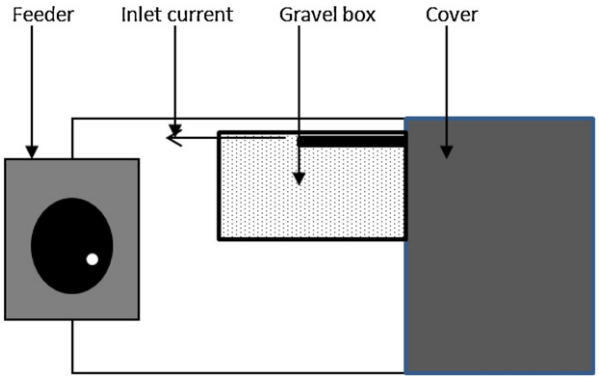

Fig. 1. An experimental tank seen from above. The position of the feeder and the three enrichments: inlet current, gravel box and cover is shown.

feeders that were mounted on the top of one short wall of the tank, one third of the tank was covered by a black pvc plate to provide a hiding-place for the fish. All experimental tanks contained a rectangular (24 × 17 × 1.5 cm) box filled with aquarium gravel. The hiding-place, the gravel box and the horizontal current from the pump inlet were provided as environmental enrichment based on features of the natural habitat of pre-smolt salmon (rivers and creeks). The fish were visually isolated from one another by black plastic covering on the sides of the tanks. Husbandry procedures included cleaning of debris by means of a manual suction pump, and putting food into the feeders and were always performed 1 h before feeding and video recording of behaviour to prevent stress associated with contact with humans from affecting the results.

2.2. Recording of behaviour

Behaviour was monitored by cameras mounted on the ceiling above the tanks and in front of the tanks. All recordings lasted for 1 h and 25 min. Daytime recordings were made twice every day, once during the morning and once during the afternoon. Infrared cameras placed in front of the tanks were used for the evening recordings which were initiated at 20:00 and ended at 21:20. The first hour of all recordings was discarded to ensure that the pre-recording presence of the human would influence the fish as little as possible. The following 20 min were kept for scoring of behaviour before feeding. At the end of the 20 min period, feeding started and lasted for five minutes, except during the night when the fish were not fed.

2.3. Scoring of behaviour

The videos were played back on the MSH video system (www.guard.lv), and scored manually for a duration of 1 s every 30 s. The fish behaviour was scored like this for 20 min prior to feeding and for 5 min during feeding. The fish were fed from an automat which was programmed to deliver pellets every 20 s. Latency to eat was scored as the latency to take the first pellet within 20 s of delivery starting from the first pellet delivery. This was done by continuous scoring. Videos giving top and front views of the tanks were played and scored simultaneously in order