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Activity patterns in cultured juvenile white sturgeon (*Acipenser transmontanus Rich.*)

by

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INTRODUCTION

Sturgeon culture seems to become a promising new branch of the aquaculture industry. During the past 10 years it has developed rapidly in several European countries (Steffens et al., 1990; Rosenthal and Geßner, 1992). Various species have been introduced into Europe for culture purposes. Some of these introductions were quite risky in terms of disease transfers (Rosenthal and Geßner, 1990). Although traditional extensive pond culture and hatchery operation for ranching purposes started in the former Soviet Union, early trials in several former East Block countries were also quite successful. Rearing schemes for local species *(Acipenser transmontanus)* were also developed in the United States by Russian immigrants while studies in France concentrated on Acipenser baeri. Early investigations focussed on artificial propagation and on nutrition (Conte et al., 1988; Doroshov et al., 1983; Dabrowski et al, 1985; Binkowski and Doroshov, 1985). Most of the work provided the basis for the commercial realisation of sturgeon culture (Logan and Shigekawa, 1986; Beer, 1983; Anonymous, 1988a,b).

Studies on optimization of system design and operational strategies are just about to be realised. Sofar, most of the technology was derived from culture techneques developed for other species.

As in other species, the culture environment has a direct influence on fish health and growth (Adams and Thorpe, 1989) and the design criteria certainly determine system performance (Bjørdal et al., 1988; Lamoyeux and Piper, 1973; Leon, 1986; Meier and Horseman, 1979; Rosenthal & Murray, 1986).

Circumstantial evidence show that system design has an important bearing on disease resistance of cultivated species (Barton et al., 1986; Haywood, 1983; Peters et al., 1984) and consequently on the economic viability of the entire operation. Adequate adaptation of the technology and culture strategy to the behavioural requirements of the cultured species is increasingly considered as the key to optimum growing conditions (Rosenthal, 1989; Fernö et al., 1988). Recently, a number of studies included behavioural aspects of the species (Kils, 1986) and considered adaptive culture strategies as tools to minimize culture stress (Huse et al., 1988; Sutterlin et al., 1979).

With the development of techniques for the culture of new candidate species, behavioural aspects should be considered as equally important in research und development. This contribution describes some behavioural characteristics of *Acipenser transmontanus* under experimental culture conditions which may assist in adapting commercial production strategies. In particular, this investigation focusses on behaviour and tank design.

MATERIAL AND METHODS

Culture facilities

The experiments were conducted at Malaspina College, Nanaimo, B.C., Canada during the summer of 1989, using two-year old *Acipenser transmontanus* (Rich., 1836). Fish size in all trials was about 50 5 cm (average weight 415-980 g). The fish originated from an artificially reproduced stock from the University of California, Davis. Fish were held under different rearing conditions at two facilities:

(a) System 1: an **oval indoor** rearing tank (volume = 1.96 m3; bottom surface area = 2.06 m^2; water level = 0.60 m; stocking density = 24.1 kgm^{-3}, 14.4kg m^{-2}) which was connected to a recycling system (upflow biofilter; additional aeration). Towards the window side of the building, half of the tank was covered by a wooden panel to **reduce light intensity** during day time and also to reduce disturbances around the tank by passing personell. During dark hours the tank was illuminated at the tank surface by two 40 watt fluorescent tubes.

(b) System 2: an **outdoor circular** tank (diameter = 1.8m; bottom surface area = 2.69 m^2; water level = 1,00 m; stocking density = 11.1kgm^{-2}) equipped with a spraybar as water inlet and a standing central drain pipe (diameter 8cm). The tank was was operated as a flow-through system, and exposed to ambient light conditions. With the spraybar, current speed in the tank reached 6.3 m/sec.

(c) System 3: an **outdoor circular** (partly covered) tank system with identical dimension as used in (b). However, the tank was equipped with a point source water inlet at the surface near the tank wall. The tank was supplied with ambient seawater (flow-through system). The tangential point source inlet resulted in a current speed of about 5.6 cm/sec at the tank perimeter.Stocking density was about 6.5 kg m^{-3}.

Observations on behaviour and data analysis

Sturgeon behaviour was documented by video recordings (camera type National Panasonic VC 2022). Picture by picture analysis was facilitated by continuous time recording. The timer was programmed to record 1.0 to 2.0 minutes every hour during daylight hours.

General motility as defined by Savchenko (1977) and described as "total activity" by Fenderson et al (1971) was employed as a criterion to describe and compare activity patterns of test sturgeons in circular tanks. Total activity considers the relative number of fish actively swimming in a tank per unit time of observation. Because the video camera covered only part of the tank surface and number of fish was constantly changing, a correction factor was employed to account for those fish not recorded. In an attempt to compare motility values between tanks the data were than corrected for stocking density to facilitate this comparisons. Motility levels in Figure 4 are therefore expressed as number of active fish per unit tank area per miniute. A realistic average density of 12 fish/m^2 has been chosen as a base for comparison between tanks and all observational data on motility were recalculated on this density basis.

Environmental conditions were also monitored (temperature, light intensity in tanks, current speed, oxygen level, pH, total ammonia and nitrite). These data will be used in a later study to investigate possible relationships between water quality, micro-light climate and swimming activity.

RESULTS

The data on motility patterns in all systems suggest that sturgeons generally exhibit a bimodal daily activity which peaks around dawn and dusk. The extent of the fluctuation of these motility pattems change with environmental conditions.

The combined data sets of three 24 hour observation periods from System 1 (oval tank; low light intensity, also at night; no current) are depicted in Figure 1, indicating that the morning peak occurs between 06:00 h and 07:00 h while in the evening the highest values are obtained after 21:00 hours.

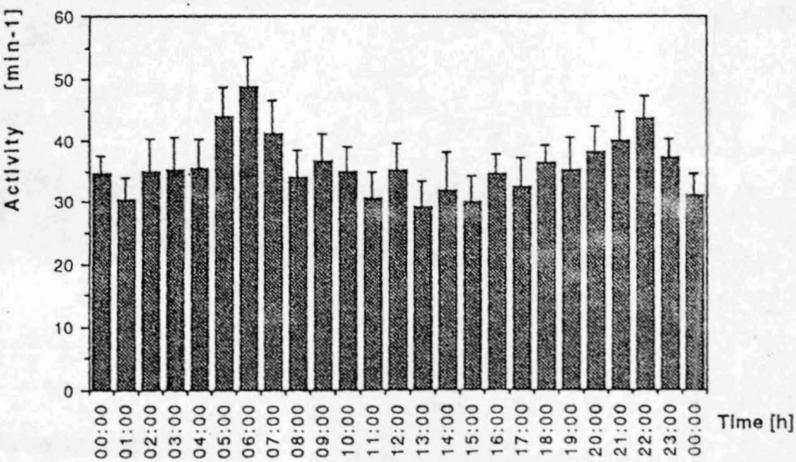

Figure 1: Motility pattern of two-year-old *Acipenser transmontanus* reared in an oval tank without noticable water current. Light intensity = 1,200 Lux; Mean temperature = 16.5°C. Columns represent mean motility values (n active fish/unit tank area/standard density/min) derived from three days of hourly video recordings. bars = standard deviation.

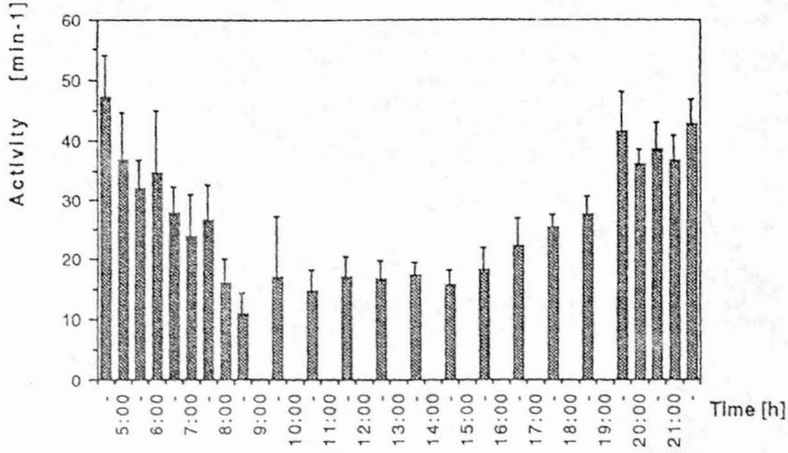

Figure 2: . Rearing of two-year old *Acipenser transmontanus* in circular tanks. Activity pattern (hourly means and standard deviation, expressed in motility units) during daylight hours and a current velocity of 6.3 cm/sec. Stocking density 11.1 fish/m^2.; light intensity = > 100,000 Lux at midday.

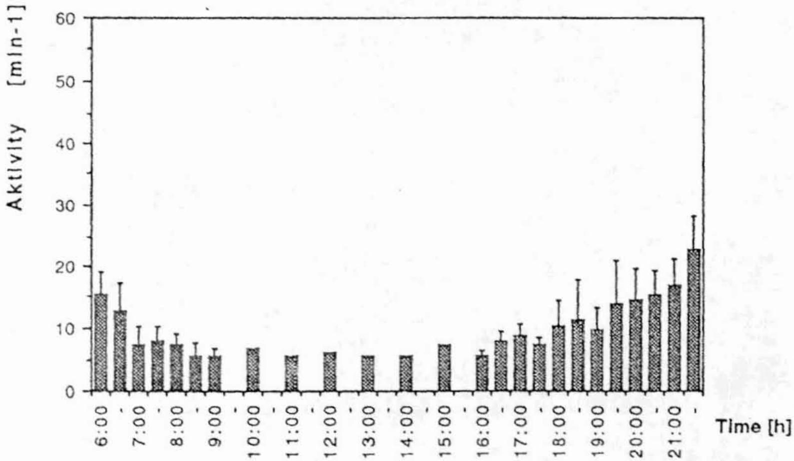

Figure 3: Changes in daily activity of two-year-old *Acipenser transmontanus* in circular tanks at low stocking density (3.9 fish/m^2). and current speeds around 5.6 cm/sec (water temperature 11.0°C; max. light intensity = 80,000 Lux

In the second system fish showed a similar daily activity patterns, however, motility of fish varied much more than in any other tank, reaching much lower values during day time. Temperature in this flow-through situation was with 15°C identical to those in system (a). The most important difference in environmental conditions was the light intensity during day time (exposure to full sunshine). This exposure may have greatly surpressed daytime activity.

System (c) showed extrem low activity over the entire observation period. In this tank, however, temperature was the lowest (11°C) and stocking density was also lowest. It may be questioned whether stocking density has influenced activity or whether the recording methodology used (partial tank coverage by video camera; reduced number of encounters per observation period) results in an underestimate of the true activity.

Motility values were, therefore, reacalculated on a basis of a standard stocking density (12 fish per m²). The resulting values are shown in Figure 4. From this graph it is obvious that similar maximum values are reached at dawn and dust under all environmental conditions in all three systems. It is only in the recycling system (system a) with reduced daytime light intensity that daytime activity remains high. In both, system (b) and (c) activtiy patterns are surprisingly similar.

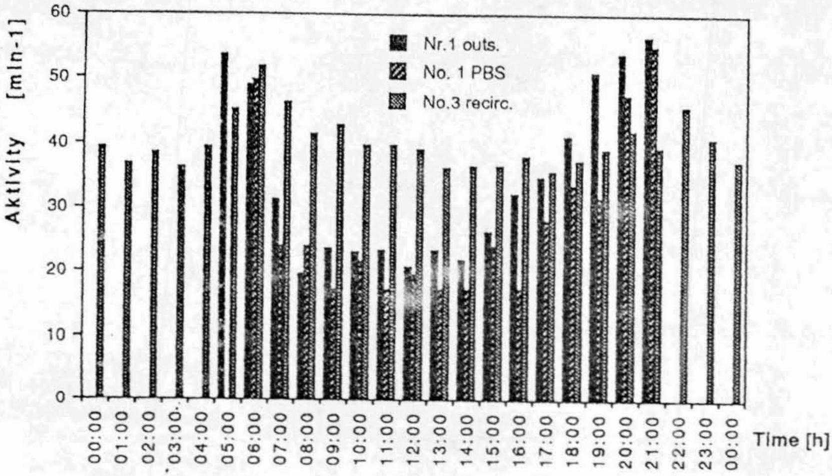

Figure 4: Commparison of the motility patterns of *Acipenser transmontanus* under different rearing conditions (recalculated for a uniform stocking density: 12 fish/m2); Details on systems (a) to (c) see Materials and Method section.

DISCUSSION

The motility of Acipenser transmontanus varies over time of day. Similar results on daily activity patterns habe been obtained for other fish species. (De Groot, 1964; Eriksson, 1978; Helfmann, 1986; Müller, 1987a,b). Olla and Studholme (1972) describe the variation in swimming speed in *Potatomus saltatrix* as similarly rhythmic over a 24 h period. Many fish species, however, show higher daytime activity than at night, while dawn and dusk activity peaks have mainly been reported for the feeding rhythms some species (e.g. eels).

Literature observations on sturgeon behaviour and activity not always confirm our findings. Manteiffel et al. (1978) abserved nighttime maximum activity in migratory juvenile sturgeons in the Volga River. There are also seasonal differences in activity and due to the short observation period, these differences cannot be shown in this study. In natural stocks, a significant increase in migratory activity is considered to be partly caused by the reduced day length.

As described for many teleost species (Hoar et al., 1957), the various life cycle stages of acipenserids also show distinct differences in behavioural responses to light intensity changes (Nikolskii, 1961; Brannon et al., 1985). It can be assumed that the capacity for adaptive behaviour is quite substantial in response to changing light conditions. This capacity can be utilized in aquaculture. For example, feeding strategies should be adjusted to the preferred motility pattern under given light regimes. It is speculated that this would lead to less feed losses and better conversion efficiencies while at the same time maintaining better water quality in the culture units. It was also reported by farmers that feed uptake peaks during early morning ours and late in the evening.

Partial cover of tanks to avoid direct sunlight seems to have a favourable, stabilizing influence on activity. Conte et al. (1988) described a generally positive effect of tank cover on sturgeon broodstock holding.

Stocking density seems not to be a critical factor that influences motility in captive sturgeons. This observation is confirmed by the study of Ruer et al (1987) when following metabolic rates at various stocking densities in Acipenser transmontanus.

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