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Endogenous excretion of Siberian sturgeon, *Acipenser baeri* Brandt

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Abstract

The pattern of ammonia excretion was examined in the Siberian sturgeon, *Acipenser baeri*, during starvation. For different weight groups (60 g to 2 kg), this excretion decreased rapidly to reach a constant level of 32 mg NH_4-N.kg^{-1}.day^{-1} after 8 days of fast. This minimum is an estimation of the Endogenous Nitrogen Excretion (ENE). No diurnal pattern was observed in the ammonia excretion or oxygen consumption (28.6 ± 3.2 mg O_2.kg^{-1}.h^{-1}, mean ± sd) of fasted fish. These data appear to indicate that the basal metabolism is very low in the Siberian sturgeon and that the nycthemeral cycle is only the result of exogenous nutrition.

Keywords : Excretion, ammonia, oxygen, sturgeon, *Acipenser baeri.*

Excrétion endogène de l'esturgeon sibérien, Acipenser baeri *Brandt.*

Résumé

L'évolution de l'excrétion d'ammoniaque a été suivi chez l'esturgeon sibérien, *Acipenser baeri*, pendant une période de jeûne. Pour différentes classes de poids (60 g à 2 kg), cette excrétion décroît rapidement pour atteindre un niveau constant de 32 mg NH_4-N.kg^{-1}.jour^{-1}. Ce minimum représente une estimation de l'excrétion azotée endogène (ENE). Aucun cycle journalier de l'excrétion d'ammoniaque ou de la consommation d'oxygène (28.6 ± 3.2 mg O_2.kg^{-1}.h^{-1}, moyenne ± s) des poissons à jeûn n'a été observé. Ces résultats semblent indiquer que le métabolisme basal de l'esturgeon est très faible et que l'alimentation est seule responsable de l'existence d'un cycle nycthéméral.

Mots-clés : Excrétion, ammoniaque, oxygène, esturgeon, *Acipenser baeri.*

INTRODUCTION

Given the current development of sturgeon farming, it seems necessary to know with precision some zootechnical particularities of this species. In the case of nutrition, it is important to have an economic feed which respects the metabolism of the fish. Since proteins are their principal source of energy (Van Waarde, 1983), an attempt was made to find the minimum need of nitrogen for sturgeon. This can be achieved by evaluating the endogenous nitrogen excretion (ENE), defined as the minimum value of nitrogen excretion and estimated after complete starvation or a feed without proteins (Savitz, 1971; Luquet et Kaushik, 1981). The ENE corresponds to the degradation of body proteins after the utilization of reserves. This value would later help in comparisons of sturgeon with other species of fish or to test some aspects of feeding.

For this work, the ENE of Siberian sturgeon (*Aci-*

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penser baeri Brandt, 1869) was estimated for different age groups after starvation.

MATERIAL AND METHODS

This study used sturgeons obtained by artificial reproduction, weighing between 60 and 2 000 g. Experiments were performed in the CEMAGREF experimental hatchery at Donzacq (south west of France) supplied by spring water containing very low level of ammonia ($<0.02\,\mathrm{mg.l^{-1}}$) as well as an almost constant pH and temperature throughout the year.

The fish were weighed and then randomly transferred to one of four polyester tanks ($\varphi = 1$ m, 200 litres) at least eight days before the beginning of the experiment. For the fish weighing 2000 g, the tank had a diameter of 3 m and contained 6000 l. According to individual weight and the capacity of the tank, 6 to 40 fish were introduced per tank such as to obtain a density from 8 to 16 kg body weight.$\mathrm{m^{-3}}$. During this period of acclimatization to the experimental structure, the fish were fed as usual – twice a day at 10:00 and 17:00 – with artificial trout food containing 45% proteins. The feeding rate was 1.5% B.W. The renewal rate of water in each tank was approximately once every hour which is sufficient to maintain the oxygen level above 70% saturation. At the beginning of the test – day 1 –, the fish were no longer fed for the duration of the experiment (complete starvation). A double sample of water was then obtained at the input and the output of each tank, at least every 4 hours, in order to determine the concentration of ammonia with the phenol-hypochlorite colorimetric method. In a preliminary study with the same experimental conditions (tank with a diameter of 3 m) but without fish, a check was made that there was no ammonia loss due to the exchange between water and air. Determinations were made of pH (Schott-Geräte 1/100th probe), temperature (mercury thermometer), oxygen content (portable YSY oxymeter) and water flow.

The amount of ammonia excreted was calculated for a day using the following formula (adapted from Kaushik, 1980, for discontinuous measures):

$$E = \Sigma E_t \qquad E \text{ in mg } \mathrm{NH_4\text{-}N.kg^{-1}.day^{-1}}$$

$$E_t = [((C_t - C_{t-1}).V) + (F.\delta t.(C_t + C_{t-1})/2)]/W$$

with:

E_t: Excretion at t time.
C_t: Ammonia concentration ($\mathrm{mg.l^{-1}}$) at t time.
C_{t-1}: Ammonia concentration at $t-1$ time.
V: Volume of the tank in liter.
F: Flow in $\mathrm{l.h^{-1}}$.
δt: Time between two measures in hours.
W: Total weight in kg.

The existence of a nycthemeral rhythm was investigated by hourly measurements on days 0, 3, 7, 9, and 13 of starvation using the fish weighing 270 g. The consumption of oxygen was estimated during the trial with the fish weighing 2 kg using two oxygen probes (one at the inflow and the other at the outflow of the tank) and an automatic and continuous recorder (CR2M SAB600). To make sure there was no transfer across the air/water surface, the inflow and outflow of water oxygen content were measured in the same experimental conditions but without fish. Whatever the tank's size, there was never any significant difference between the two simultaneous measurements. Calculation involved use of the formula:

$$C_{O_2} = (\delta c.F)/W$$

where:

C_{O_2} oxygen consumption in $\mathrm{mg\ O_2.h^{-1}.kg^{-1}}$,
$\delta c = O_{2,\,\mathrm{inflow}} - O_{2,\,\mathrm{outflow}}$ in $\mathrm{mg.l^{-1}}$,
F and W are as previously denoted.

RESULTS

The characteristics of the water were almost stable during the experiments: pH $= 7.48 \pm 0.03$, temperature $= 17.2 \pm 0.6$°C (mean ± sd, $n > 100$).

The results of the daily variations of ammonia excretion are presented in *figures* 1 and 2. For *figure* 1, each point represents the average of 4 measures made as the sum of at least ten daily determinations of ammonia content. During the first days of starvation, the excretion decreased rapidly and then reached a plateau after eight days. At that time, the nitrogen excretion remained constant and represented an estimation of the ENE (*fig.* 1). For Siberian sturgeon at 17°C and weighing between 60 to 2000 g this ENE was approximately 32 mg $\mathrm{NH_4\text{-}N.kg^{-1}.day^{-1}}$.

For the sturgeons weighing 270 g, the postprandial augmentation of ammonia excretion rose to a maximum at around four hours after feeding (*fig.* 2). For the next days of fasting, no daily rhythm could be found. However, the variation of ammonia excretion decreased with the number of fasting days and after 9 days, the pattern of excretion was constant.

Likewise, the oxygen consumption during the 2 kg trial showed no regular cycle (*fig.* 3); in particular, there was no influence of the night period. It was noticed only (*table* 1) that the consumption of oxygen decreased between the 5th and the 11th day of fast, 44.3 and 28.6 $\mathrm{mg\ O_2.h^{-1}.kg^{-1}}$ respectively.

DISCUSSION

It must be emphasized that only ammonia excretion was determined and not the total nitrogen excretion.

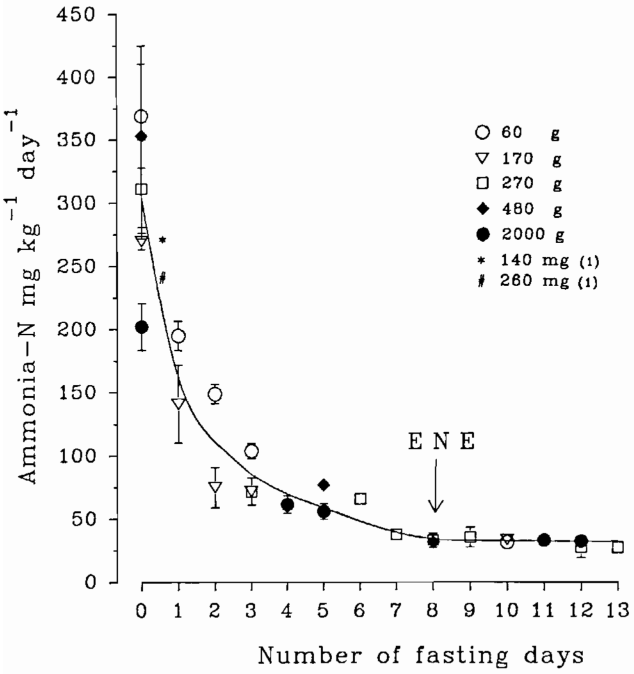

Figure 1. — Daily excretion of ammonia by sturgeon, *A. baeri*, for different weight classes during a fast. For each point: mean ± sem, $n=4$. (1) From Dabrowski *et al.*, 1987. The line was fitted by eye. ENE: Endogenous nitrogen excretion.

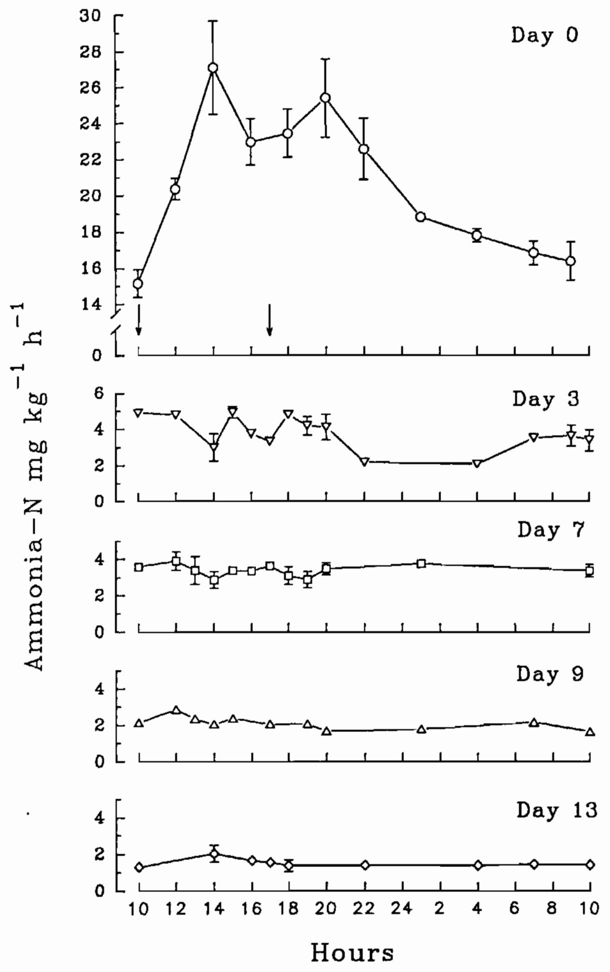

Figure 2. — Daily pattern of ammonia excretion for *A. baeri* (270 g) for 5 days out of 13 days of fast. For each point: mean ± sem, $n=4$. The two meals on day 0 are indicated by an arrow.

On the assumption that ammonia and urea represent 90% of non-faecal nitrogen excretion among which urea account for 17% in the case of stugeon (Médale, pers. comm.), a total endogenous nitrogen excretion of 42 mg $N.kg^{-1}.day^{-1}$ can be calculated. This result is very close to the data for the same species given by Médale and Kaushik, 1991. The value of ENE for Siberian sturgeon is quite low in comparison with other species of fish for which it is generally around 100 mg $N.kg^{-1}.day^{-1}$ (Brett and Zala, 1975 on *Oncorhynchus nerka;* Guérin-Ancey, 1976 on *Dicentrarchus labrax;* Kaushik, 1980 on *Cyprinus carpio* and *Oncorhynchus mykiss*). It seems that sturgeons have a low basal metabolism with an estimation of maintenance needs around 55 mg $N.kg^{-1}.day^{-1}$. This can be explained by the high contribution of fat stores in the maintenance of energy requirement in fasted sturgeon (Médale and Kaushik, 1991).

It is also interesting to note that the ENE value was the same for different individual weight classes in spite of some variation in the time necessary to reach this value. Furthermore, for young Siberian sturgeon (140 and 260 mg B.W.) fed with compound diets, the ammonia excretion after fast (14 hours) agrees well with the present results (Dabrowski *et al.*, 1987; *fig.* 1). Therefore, it seems that the evolution of ammonia excretion of fasted sturgeon can be extended to other weight classes. The absence of difference in the ENE for all weight classes was also noticed in *Dicentrarchus labrax* (Guérin-Ancey, 1976). This author obtained stable excretion after 6 days at 20°C and 8 days at 16°C (8 days at 17°C in this study). Likewise, it is necessary to maintain trout (*Oncorhynchus mykiss*) or carp (*Cyprinus carpio*) 8 days on starvation before reaching the ENE level [water temperature 16-18°C] (Kaushik, 1980). The sturgeon seems to react like other species in the mobilization of its body stores during a fasting period. It is also concluded that it is necessary to wait a sufficient time – up to 7 days – before making sure that the ENE level is really reached.

For day 0 (*fig.* 2) there is a peak of ammonia excretion 2 to 4 hours after the feeding and a reduced excretion during the night. This rhythm is still apparent during the third day of fast but it decreases rapidly afterwards. The diurnal variations are not significant after the ninth day. All experiments on the daily rhythm of excretion showed that the course of

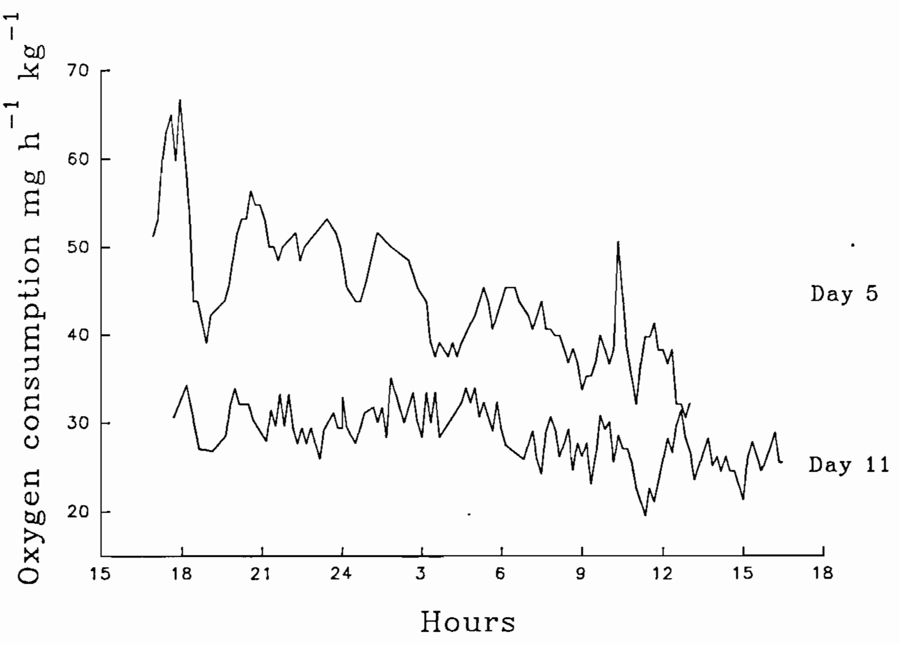

Figure 3. – Oxygen consumption for *A. baeri* (2 kg) on day 5 and 11 of starvation.

Table 1. – Oxygen consumption for sturgeon during fasting at 17-18°C.

Species	Weight (kg)	O_2 consumption ($mg O_2.kg^{-1}.h^{-1}$) mean ± sd	Fasting period (days)	References
A. baeri	2.0	44.3 ± 7.6	5	Salin and Williot, present study
A. baeri	2.0	28.6 ± 3.3	11	Salin and Williot, present study
A. transmontanus	1.9	68 ± 7	1	Ruer *et al.*, 1987.
A. baeri	1.3	62	35	Médale and Kaushik, 1991

ammonia is influenced by feeding with a postprandial augmentation 2 to 6 hours after food intake, but a regular cycle never clearly appeared during a fast (Savitz, 1971; Brett and Zala, 1975; Kaushik, 1980; Kaushik and Dabrowski, 1983; Kaushik and Gomes, 1988). It can be concluded for sturgeon, that if there is a nycthemeral rhythm for ammonia excretion, it is not the result of an endogenous phenomenon but only of exogenous feeding.

This absence of variation in the metabolism after a fast is confirmed by the quite constant value of oxygen consumption during the 11th day of fast. The values from the present work are quite low compared with other studies on sturgeon on same weight (*table* 1). However, the measures were not made using the same procedure, *i.e.* the duration of the fast was not the same and neither was the rhythm of measures (continuous or not). This may not be the only reason accounting for such a discrepancy. For example, calculation of the maximum of the consumption observed during one of the two days of measurement – day 5 between 16:00 and 19:00 –, indicates that the present result, 66 $mg O_2.kg^{-1}.h^{-1}$, is very close to those mentioned by Ruer *et al.* (1987) for *Acipenser transmontanus* with similar weight and for the same time of measurement.

CONCLUSION

The Siberian sturgeon, *Acipenser baeri*, seems to have a low basal metabolism in comparison with other fish species, especially the salmonids. However, it is not possible at present to conclude that this phenomenon is specific for this species or if it is one of the characteristics of the entire sturgeon family. It will also be interesting to verify if the excretion of the other forms of nitrogen waste (urea) decrease in a similar manner during a fast or if the respective proportion of ammonia and urea are the same during the fasting period. This work has shown that feeding is the only cause of the nycthemeral cycle for sturgeon. This result is interesting in view of future studies on feeding, like for example searches for the best distribution rhythm using ammonia excretion as a criterion.

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