SHORT NOTE

GROWTH OBSERVATIONS ON EUROPEAN *(ANGUILLA ANGUILLA* L.) AND AMERICAN *(ANGUILLA ROSTRATA* LE SUEUR) GLASS EELS.

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ABSTRACT

Comparative growth observations (13 months) of European (*Anguilla anguilla* L.) and American (*Anguilla rostrata* Le Sueur) glass eels were undertaken. Plastic containers (60 x 30 x 35 cm, volume of 30 L) were combined with a sedimentation tank and submerged, gravel, biological filter to form a recirculation system. Feeding commenced on the second day after arrival of the fish and proceeded as follows : days 1 to 50, krill hydrolysate ; days 51 to 58, krill hydrolysate mixed with a salmon starter feed ; day 59 onwards, standard salmon feed. Feed was provided at 2-hourly intervals via automatic feeders for the first 161 days of rearing, and thereafter by hand 5 times a day at a feeding rate of 5 % of the fish biomass. The average individual weight of the European eels on arrival ($\bar{x}$ = 0.266 ± 0.005 g), was significantly higher than that of the American eels ($\bar{x}$ = 0.167 ± 0.006 g). After 45 days of rearing, the weight differences between the species became insignificant. Except for the different transportation mortalities on arrival, the European and the American eels demonstrated similar mortality rates during the experiment (12.5 %), food conversion rate (2.3) and specific growth rate (0.90 and 0.99 respectively). No parasites or diseases were detected. No differences were observed in general behaviour and feeding between the two species.

Key-words : *Anguilla anguilla, Anguilla rostrata,* culture, glass eels, growth comparison.

OBSERVATIONS DE LA CROISSANCE DES CIVELLES EUROPÉENNES (*ANGUILLA ANGUILLA* L.) ET AMÉRICAINES (*ANGUILLA ROSTRATA* LE SUEUR).

RÉSUMÉ

Des observations de la croissance comparée des civelles européennes (*Anguilla anguilla* L.) et américaines (*Anguilla rostrata* Le Sueur) ont été réalisées. Des récipients en plastique (60 x 30 x 35 cm, d'un volume de 30 L chacun) ont été combinés avec un bac de sédimentation et filtre biologique de gravier pour former un système de recirculation.

L'alimentation a été donnée à partir du deuxième jour après l'arrivée des poissons, selon le protocole suivant : jours 1 à 50, hydrolysat de krill ; jours 51 à 58, hydrolysat de krill mélangé à une nourriture de démarrage pour saumon ; à partir du jour 59, nourriture standard de saumon. La nourriture est donnée toutes les 2 heures avec un système d'alimentation automatique pendant les 161 premiers jours, puis à la main 5 fois par jour, à un taux de 5 % de la biomasse de poisson. Le poids individuel moyen des anguilles européennes ($\bar{x}$ = 0,266 ± 0,005 g) était à l'arrivée significativement plus élevé que celui des anguilles américaines ($\bar{x}$ = 0,167 ± 0,006 g). Après 45 jours, la différence de poids entre les espèces est devenue non significative. Excepté la mortalité à l'arrivée, durant l'expérience, les anguilles européennes et américaines ont montré des taux similaires de mortalité (12,5 %), de même pour les taux de conversion de la nourriture (2,3) et de croissance spécifique (0,90 et 0,99 respectivement). Aucun parasite n'a été détecté. Aucune différence dans le comportement général et la prise alimentaire n'a été détectée entre les deux espèces.

Mots-clés : *Anguilla anguilla*, *Anguilla rostrata*, culture, civelles, croissance.

INTRODUCTION

The European eel, *Anguilla anguilla*, and the American eel, *Anguilla rostrata*, belong to the commercially valuable species. While the European eel is cultured in aquaculture operations in Europe and other countries and traded worldwide, the American eel, *A. rostrata*, has rarely been reared in America. In recent years, however, because of the enormous rise in prices of glass eels, the *A. rostrata* has attracted much attention. Nowadays, *A. rostrata* glass eels are shipped from USA and Canada, mainly to the far east, to be used as seedlings in aquaculture operations. Resulting from intensive research work on *A. anguilla*, including applied aspects, large numbers of publications are available on feeding and rearing of the European glass eels (KASTELEIN, 1983). *A. rostrata* has been the subject of much scientific research, yet little attention has been paid in the past to the applied aspect. Growth data of these two species are valuable to aquaculture, particularly when the two species are reared simultaneously under identical conditions, as in the present study.

MATERIALS AND METHOD

European glass eels *(Anguilla anguilla* L.) and American glass eels *(Anguilla rostrata* Le Sueur) (5,000 of each species) were reared under controlled conditions for 13 months. The European eels arrived at our laboratory from England in good condition (transportation time ~10 hours) ; simultaneously the American eels arrived from Maine (USA) suffering around 50 % mortality, presumably resulting from transportation stress (transportation time ~24 hours). The glass eels had all been netted using hand-dip nets in rivers and were transparent on arrival. The experimental facility consisted of 5 plastic containers (60 x 30 x 35 cm, active volume of 30 L), combined with a water purification unit consisting of a sedimentation tank to remove suspended particles, and a submerged gravel biological unit, together forming a recirculation system. Each container had a constant water flow and aeration. The following water parameters were maintained in the system throughout the experiment : temperature : 25 ± 1°C ; dissolved oxygen : 50-60 % of saturation ; ammonia < 0.3 mg/L (Nessler) ; nitrite : < 0.6 mg/L (spectophotometric).

Eels of each species were divided into two experimental groups and were stocked into two of the four rearing containers at a density of approximately 2,000 fish in each (approximately 14 g of biomass/L) ; the remainder of the fish were stocked in the fifth container.

Feeding commenced on the day after arrival and proceeded as follows : days 1 to 50, minced krill hydrolysate (frozen) ; days 51 to 58, krill hydrolysate mixed with a standard salmon starter (producer : Ewos) at a reducing proportion of the krill and increasing proportion of salmon starter ; day 59 onwards, standard salmon starter (16 % fat and 52 % protein [producer : Ewos]). Feed was provided at 2-hourly intervals via automatic feeders. After 161 days, automatic feeders were too small to provide sufficient feed and therefore fish were fed manually 5 times a day at a feeding rate of 5 % of the fish biomass.

At intervals of 3 weeks, 100 fish were randomly sampled from each container to determine their individual mean weight (Figure 2). Total biomass in the containers was weighed periodically to adjust feeding rate. We recorded Specific Growth Rate « SGR », denoting the average daily growth as a percentage of the initial weight, calculated as follows :

$$SGR = [\{LnWt - LnWO\}/t] x 100$$

Wt = wet weight of fish at time t,
WO = weight of fish at time 0,
t = time in days,

and Food Conversion Rate « FCR », calculated as follows :

FCR = Food intake (dry weight g)/Body weight gain (wet weight g)

Dead fish in each container were counted, removed and accumulated mortality (%) was calculated. Parametrical Student's (T-test), Fisher's (F-test) and non-parametrical (rank-criteria) tests were used to evaluate the differences between the experimental groups.

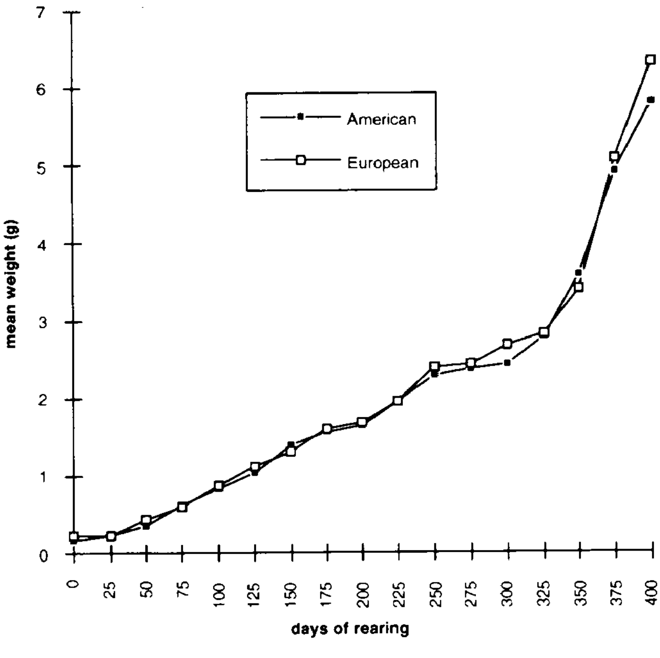

Figure 2
Growth of European and American eels.

Figure 2
Croissance des anguilles européennes et américaines.

RESULTS

The average individual weight of the European eels on arrival was ($\bar{x}$ = 0.266 ± 0.005 g) around 35 % greater than that of the American eels ($\bar{x}$ = 0.167 ± 0.006 g). Apart from the heavy loss of approximately 50 % on arrival among the American eels, resulting from lengthy transportation, there was no significant difference in mortality rate between American and European eels in the course of the experiment. Mortality rates of both species were 12.5 %, either of non-feeding individuals or occasionally resulting from technical losses. In spite of the initial smaller size of the American eels, after 45 days the differences in weight between the species became negligible (Figure 2). Specific growth rates were : 0.99 % for American eels and 0.90 % for European eels. Food conversion rate in both groups was comparable (Figure 3), as was the general behaviour, particularly feeding behaviour.

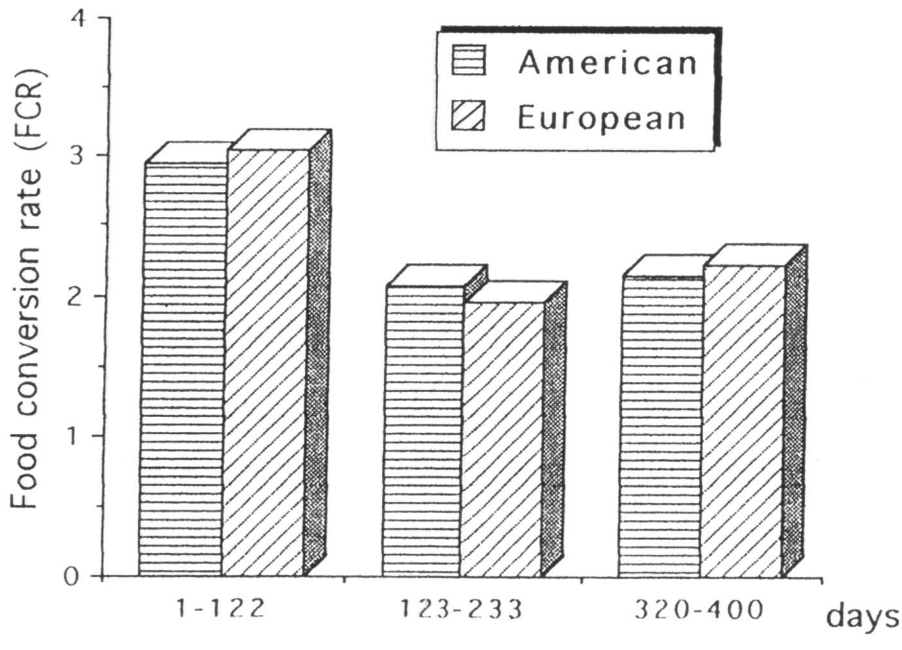

Figure 3
Food conversion rate (FCR) of European and American eels.

Figure 3
Taux de conversion de la nourriture (FCR) des anguilles européennes et américaines.

DISCUSSION - CONCLUSION

As American eels entering the American continent from the Sargasso Sea have a much shorter route than those migrating to the European continent, it is not surprising that the former are possibly younger and certainly smaller when caught as glass eels up-stream and in river mouths. In all known data, American glass eels are smaller in size than their European counterparts. There is no direct evidence that the eel species in our observation were of the same year class, other than that they were all in the non-pigmented, transparent stage. However, the results showed that when both were kept as glass eels in the same growing system, the American species, in spite of their significantly smaller size, were able to reach the size of their European counterparts within 2 months, and thereafter grew at a similar rate. BOËTIUS and HARDING (1985) estimate length increase in the first year for *A. anguilla* at 0.177 mm/day and 0.187 mm/day for *A. rostrata*. KLECKNER and McCLEAVE (1985) calculate a faster daily growth rate of 0.24 mm/day for *A. rostrata*, which could explain the faster growth rate for American eels found by us. Furthermore, it is possible that the heavy losses suffered by the American eels through transportation stress left stronger individuals that grew better than average American eels would have grown. This possibility should be re-examined in a further experiment.

EHRENBAUM and MARUKAWA (1913) found that scales in *A. anguilla* appear when the eel has attained a length of 16-20 cm. FROST (1945) noted that in the European eels, scales developed from the second to the sixth year in freshwater. RASMUSSEN (1952) showed that scale formation in *A. anguilla* starts in the fourth year after the elver stage. SMITH and SAUNDERS (1955) found that *A. rostrata* develop scales at a length of 12-16 cm ; they estimated this « scale length » to be reached during the third or fourth year in freshwater. BOËTIUS and BOËTIUS (1967) recorded that Bermuda eels, *A. rostrata*, develop scales during the first year after becoming elvers. From the above-mentioned data, it appears that glass eels of the American species develop at some stage faster than the European eels. This might be an additional explanation for the differences in growth observed at the beginning in favour of *A. rostrata*.

The initial decrease in weight of *A. anguilla* shown in Figure 1 has previously been observed by us and others (HOLMGREN *et al.*, 1991), and can be regarded as a common phenomenon caused by the time needed for the eels to complete their metamorphosis and to adapt to their new environment. TESCH (1983) describes an initial reduction in length and weight of European glass eels in aquaria, fed or unfed, while pigmentation advances. The specific growth rate found in the present experiment is comparable to other figures given in the literature for *A. anguilla* reared indoors (KOOPS and KUHLMANN (1980), 0.8 % ; KASTELEIN (1983), 0.99 % ; HOLMGREN *et al.* (1991), 1.01 to 1.15 % ; HENDRIKSEN (1992), 1.3 % ; APPELBAUM *et al.* (1996), 0.90 %).

The general understanding is that *A. rostrata* appears to be a suitable species for aquaculture operations. This can be supported by the results of this study which clearly indicate that *A. rostrata* are not inferior to *A. anguilla* in terms of growth. However, a scientific evaluation of the suitability of *A. rostrata* compared to *A. anguilla* can be achieved throughout a longer term experiment (18-14 months) at the end of which not only growth and survival rate can be determined, but also the male to female ratio of commercially viable individuals and the uniformity of the entire stock can be established.

Unlike the European eel, the American eel may need a shorter period for its physiological development prior to seeking freshwater. The American eel, at entry into the freshwater, is of a significantly smaller size than the European eel : the latter needs both a longer development and migration period.

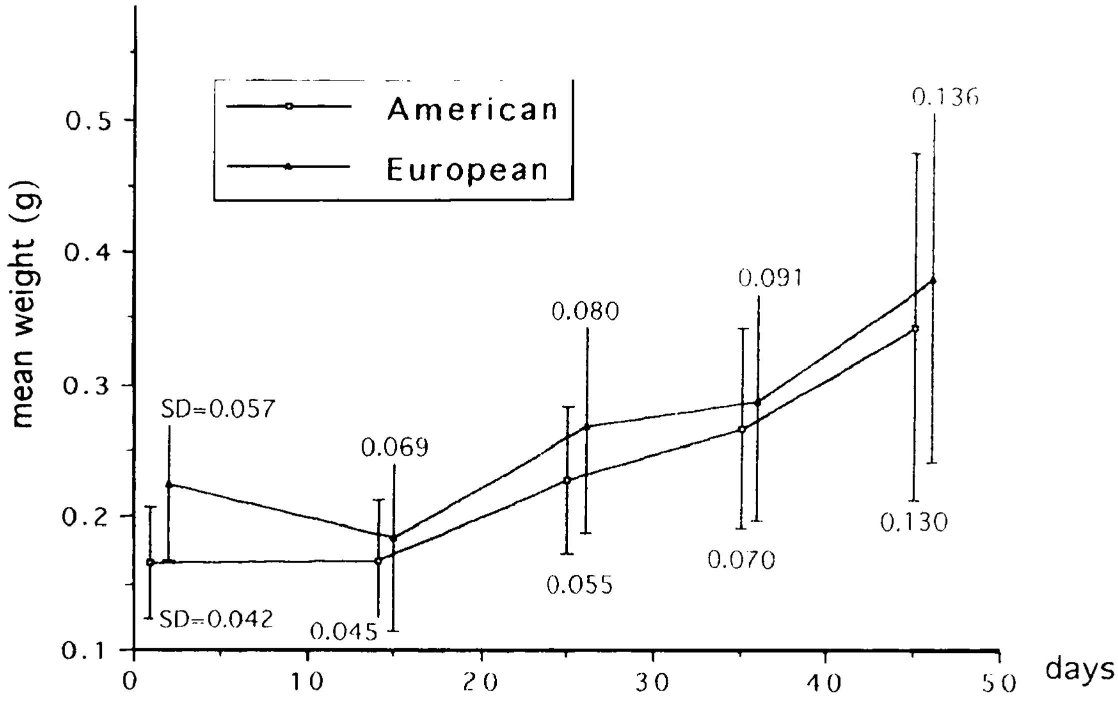

Figure 1
Initial growth of European and American glass eels.

Figure 1
Croissance initiale des civelles européennes et américaines.

Our assumption is that while the European eel shows a reduction in size before completion of metamorphosis, the American eel, which is smaller that the European, does not undergo such development before completing its metamorphosis, but rather continues to grow. Evidently, the American species starts to feed in captivity at a smaller size : whether its glass eel stage starts to feed in nature earlier than the European remains to be investigated.

We are not aware of other published data of comparisons in growth between simultaneously reared European and American glass eels. This is possibly the first report on the subject.

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