FISHING METHOD AND SEASONAL OCCURRENCE OF GLASSEELS (ANGUILLA ANGUILLA L) IN THE RIO MINHO, WEST COAST OF THE IBERIAN PENINSULA

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ESTUAIRE DE MINHO
PÊCHE DE CIVELLES
DONNÉES STATISTIQUES
DONNÉES BIOLOGIQUES
MIGRATION

RÉSUMÉ. — La pêche expérimentale des civelles a été entreprise de novembre 1981 à avril 1983 dans l'estuaire du Minho en incluant 2 saisons de pêche régulière au moyen du filet « Hamen ». Les statistiques officielles de l'Espagne et du Portugal sont données mais sont probablement sous-estimées. Les données biologiques de poids et taille, les relations matière sèche et matière organique sèche/poids humide sont discutées en tenant compte des lieux de capture, des phases de la lune et des époques de l'année.

MINHO ESTUARY
GLASSEEL FISHERY
STATISTICS
BIOLOGICAL DATA
MIGRATION

ABSTRACT. — In the Minho estuary experimental fishery of glasseels was carried out between November 1981 and April 1983, including two regular fishing seasons, by means of the locally used "Hamennet". Official statistics of Spain and Portugal are given but are supposed to be underestimates. Biological data on length, weight and relations of dry and organic dry weight to wet weight are discussed with consideration to catchsite, moon's phase and time of the year.

INTRODUCTION

Concerning the fishery of glasseels, the Rio Minho became recently one of the most important rivers of the Iberian Peninsula. An analysis of the glasseel ascent (see e.g. Elie, 1979; Cantrelle, 1981) which provides the natural basis for the fishery, seems therefore necessary. This paper provides results of an experimental glasseel fishery in the estuary of the river and data on the captured glasseels including development stage, length and weight.

THE COMERCIAL FISHERY

With a length of 340 km the Minho has a hydrographic area of 17 081 km^2 and forms over the last 75 km the northern border between Portugal and Spain (fig. 1).

The Portuguese fishery regulations from 26.11.1981 (Dec. Lei 316, Art 55 º) permit the utilization of a "Hamennet" for catching glasseels during the period between 1 November and 1 April with the following maximum dimensions : length of floatlines 2 × 10 m, kept at the surface by means of 10-20 litre buoys, net height 8 m, leadline 15 m, width of the netend 2.5 m, meshsize 2 mm (square-mesh) (fig. 2).

Fishing from the riverbank by means of a dipnet with meshsize of 2 mm and a diameter which should not surpass 1.5 m is limited to the period 1 October to 1 April. Both regulations apply to Spain also.

The glasseel fishery is always performed at night around new moon. The catch extends over a period of three hours from the beginning of the rising tide onwards depending on current speed and yield.

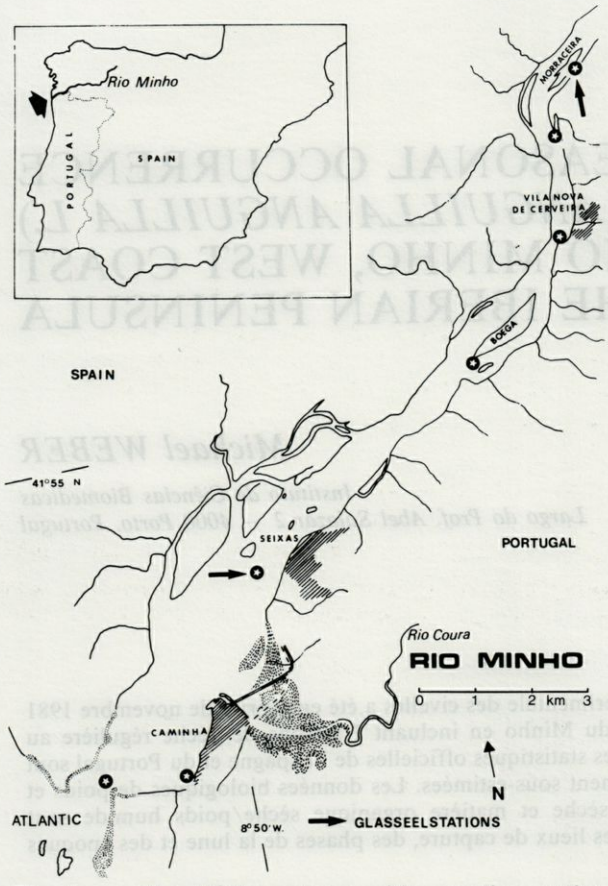

Fig. 1. — The Minho estuary with sampling stations (arrows).

Maximum yield can be up to 40 kg per boat per night within the three hours with a value of 100 000 Escudos (in 1983/1984 the price per kg varied around 2 500 Escudos). Minimum yield was seldom more than 100 g.

When the tide is rising a marked buoy is thrown overboard followed by an anchor belonging to it. Then the boat is moved across the river up to 20-30 m in order to drop a second anchor with a buoy. The net is then released, normally carried by the current, forming a funnel against the now faster flowing tide and held by the two anchors. The end is fastened with two lines to the boat which drifts diagonally to the current. The depth of water at the fishingsite and the location of the anchors determine the opening area of the net ($\sim 50\ m^2$).

Using a lamp, the concentration of glasseels, elvers and other organisms is scooped out of the netend with a small dipnet at frequent intervals. The dipnet is emptied into a sieve mounted to a wooden frame with a meshsize of 4-5 mm. Other fish, floating debris and elvers remain on it while the glasseels wind themselves through the meshes to drop into a second sieve of a smaller meshsize (1 mm).

After cleaning the catch, quantities of 4-5 kg are stored in wooden boxes. Back at the riverside the glasseels are delivered to a buying agent who takes care of weighing and further transport. Principal customer of the Portuguese glasseels is Spain where 90 % are provided for human consumption.

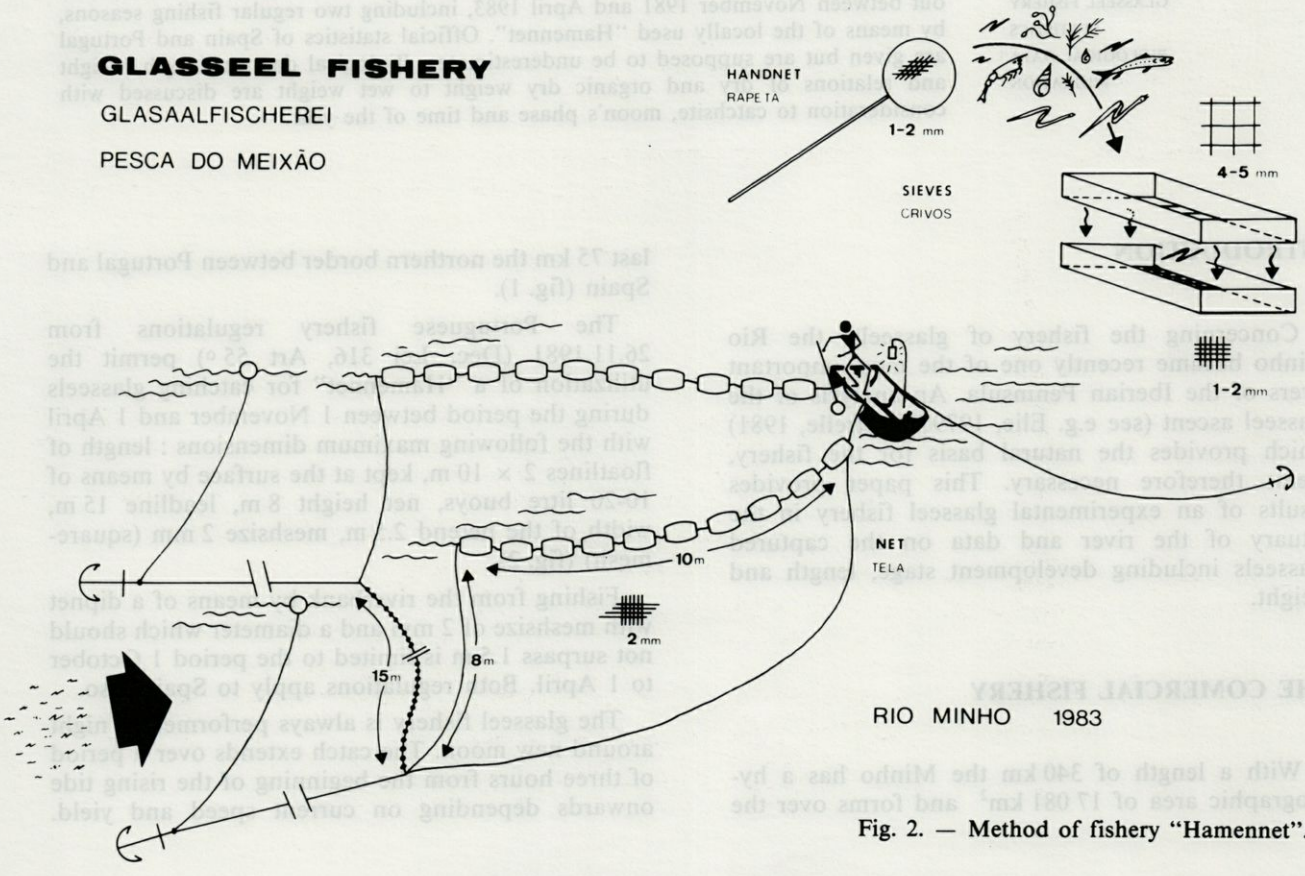

Fig. 2. — Method of fishery "Hamennet".

The by-catch consists mainly of *Atherina presbyter, Palaemon serratus, Bithynia tentaculata* and *Saduriella losadai.* Sometimes juvenile fish like *Alosa fallax, Alosa alosa, Pomatochistus microps, Salmo salar* and *Petromyzon marinus* show up in large quantities. The majority of these organisms die because of exposure to air.

At the end of fishing the boat is set free from the net, one buoy and its anchor are raised, the connecting line is unfastened from the net which then drifts in the current still being held by the second anchor. The floatline, the leadline and the net are hauled in and finally the remaining second anchor.

Since the official beginning of the glasseel fishery in the Minho in 1973, the number of licensed fishermen has increased sharply. Even though this trade can only be pursued during 5 months, the high income is very attractive. Four hundred and fifty licensed fishermen in Spain and seven hundred and fifty in Portugal were registered in 1983, taking into account that the Portuguese number is deduced from the total of license holders distributed over 537 boats. An efficient control is hardly possible due to an uncertain number of amateur fishermen.

According to the statistics given in fig. 3-A, the official catch maximum amounted to a total of 54 tons in 1980/1981. On average 27 tons were caught annually by both countries in the last ten years. The total yield increased by 27.1 % during the periods 1974-1979 and 1979-1984.

In Spain 10 tons, worth 15 Mill. Pesetas, were considered as an official annual mean for the period 1973-1977. The estimation of the actual mean runs up to 50 tons equivalent to 75 Mill. Pesetas (Calviño 1980; in Adega 1981).

MATERIAL & METHODS

From November 1981 to April 1983 glasseels were caught monthly by the method described above at two stations set up in the lower course of the Rio Minho (fig. 1). The fishing was carried out with a small net : floatline length 9.3 m, netheight 5 m, leadline 10 m, netend 0.8 m.

At the upstream site (St. 7), between the Island of Morraçeira and the Portuguese shore, at a distance of 18.7 km from the rivermouth, investigations were carried out over a whole year (November 1981-November 1982). The mean depth was around 3 m. In order to obtain comparable data, as a reference, the same gear was used at St. 3 in the channel of Seixas, 5.2 km away from the rivermouth, in January and February 1982 as well as in the whole season 1982/1983 from November to April. The water depth varied around 6 m.

Fishing took place over the period around new moon and in the summertime at full moon also. Fishing lasted between 30 and 150 minutes depending on the yield. Prior to weighing, the glasseels were cleaned repeatedly in the sieve. After taking subsamples to ascertain data on length and weight the catch was sold. Elvers were taken directly from the first sieve and, like the glasseels preserved in 4 and 10 % buffered formalin. The yield was expressed in terms of catch per hour. The material was classified into 3 size classes or age groups, respectively :

Group I : transparent, unpigmented glasseels
Group II : transparent, pigmented glasseels
Group III: opaque and fully pigmented elvers with palebrown integument.

The individuals were measured in length to the nearest mm and weighed to 1 mg (WW). From each group 20 individuals each month were dried at 80 °C for 24 hours and then incinerated at 550 °C for 3 hours. The organic dry weight (ODW) was obtained by subtracting the ash from the dry weight (DW).

RESULTS

1. Yield

For the whole period of investigation the yield (WW g/h), abundance (N/h) and biomass (ODW g/h) per station and hour of fishing are shown in Table I.

Upriver maximum abundance was recorded in March 1982 and 1983. A slightly lower maximum occured in May 1982. From July onwards the yield decreased conspicuously towards minimal values from August to November. In the estuarine area peak values were recorded in February 1982 and in March 1983. In January and April 1983 abundance was low. In February 1982 extreme variations between the upstream and the downstream station were observed. In the estuary approximately 90 % more glasseels were captured than at a distance of 18.7 km upstream (fig. 3-B). One year later in March 1983 the yields differed only to a small extent.

The percentage of pigmented individuals increased remarkable during the period from March to July. They were almost absent during winter 1981/1982 and then most frequent in April at approximately 40 %. Pigmented glasseels and elvers only were encountered upstream whereas unpigmented individuals exclusively were present in the estuary. Elvers were scarce at less than 1 % and only in spring and summer did they appear more frequently. Towards the end of 1982 they were absent from autumn onwards.

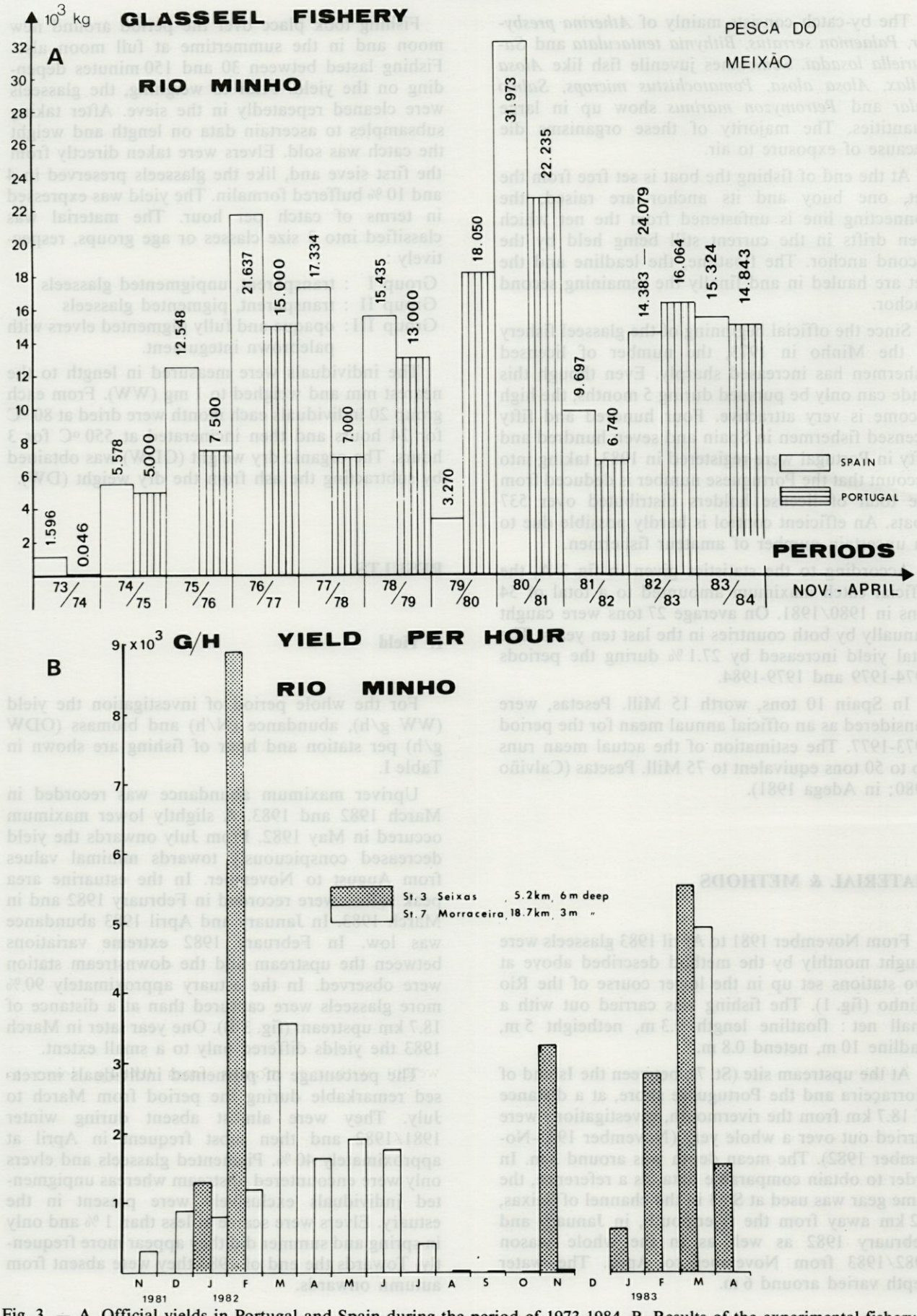

Fig. 3. — A, Official yields in Portugal and Spain during the period of 1973-1984. B, Results of the experimental fishery at two stations.

Table. I. — Yield, abundance and biomass of glasseels and elvers in the Rio Minho. I, unpigmented glasseels; II, pigmented glasseels; III, elvers. WW, wet weight: ODW, organic dry weight; g/h, gram per hour ; N/h, individuals per hour.

date	time (min)	total yield	yield /hour	N/h	ODW (g/h)	N/h	N/h	N/h	WW (g)	ODW (g/h)
		WW/(g)	WW(g/h)	I.+II.	I.+II.	I.	II.	III.		III
Station 7 (18.7 km upstream)										
11.81	145	766	317	1 060	53.6	1 060	—	25	40	8.3
12.81	130	1 908	881	2 360	174.5	2 280	80	37	38	8.6
01.82	60	796	796	2 193	140.3	2 193	—	1	1	0.2
02.82	90	1 528	1 019	3 329	179.7	3 329	—	—	—	—
03.82	90	5 335	3 557	11 075	502.7	10 399	676	45	79	15.7
04.82	90	2 455	1 637	5 469	252.1	3 163	2 306	50	79	15.0
05.82	40	1 271	1 907	5 915	297.9	5 345	571	17	24	4.4
06.82	60	1 744	1 744	5 296	318.5	4 805	491	13	23	4.8
07.82	30	202	404	1 528	64.6	992	536	7	18	3.2
08.82	18	2	7	17	1.0	4	13	—	—	—
9.82	60	1	1	3	0.2	2	1	—	—	—
10.82	75	3	2	6	0.3	4	2	—	—	—
11.82	45	22	29	81	5.0	80	1	—	—	—
13.03.83	120	9 805	4 903	15 838	667.7	13 879	1 959	4	7	1.2
Station 3 (5.2 km estuary)				I.	I.					
01.82	45	955	1 273	4 057	216.3					
02.82	90	13 337	8 891	22 567	1 512.0					
13.11.82	90	769	513	1 147	95.2					
14.11.82	150	5 605	2 242	—	—					
15.11.82	150	8 082	3 233	6 679	594.4					
16.11.82	150	4 752	1 901	4 168	329.3					
17.11.82	120	5 415	2 708	—	—					
18.11.82	90	285	190	—	—					
11.01.83	90	859	573	1 314	107.7					
13.01.83	120	955	478	1 131	88.2					
15.01.83	90	959	639	1 673	117.1					
10.02.83	150	2 386	954	2 334	163.4					
11.02.83	150	1 049	420	938	78.8					
12.02.83	120	1 024	512	1 262	89.6					
13.02.83	115	5 400	2 817	7 205	511.6					
11.03.83	165	5 042	1 831	5 521	247.5					
12.03.83	180	16 490	5 497	14 314	1 016.3					
13.03.83	180	3 527	1 176	3 284	200.3					
13.04.83	120	3 055	1 528	4 163	253.9					
14.04.83	60	381	381	1 125	72.0					

In November 1982 glasseel fishery took place upstream at new moon, two days before and three days after, which resulted in a distinct maximum at new moon with 3233 g/h. The catch two days before and three days after was characterized by an obvious lower yield. The maximum catch per total duration of fishing as well as the yield per hour are given in Table I.

2. Length

The mean length of unpigmented glasseels ranged between 6.5 and 7.3 cm in the course of the year with a maximum in January 1982 and 1983 (Table II). The length of the pigmented individuals were generally smaller than those from group I but showed a slight increase from 6.4 to 6.9 cm within the year, finally surpassing the unpigmented glasseels in October by 0.3 cm. The elvers varied between 9.0 and 11.2 cm (Graphics shown *in* Weber 1985 b).

3. Wet Weight

The mean wet weight deviated between 0.269 and 0.484 g. Upstream within the year 1982 three maxima appeared in January, June and November. Minimum values were predominant in March and July (Table II). The glasseels captured in the estuarine area in the season 1982/1983 were generally heavier than those from upstream but showed a decrease in weight within 5 months from 0.484 g down to 0.339 g.

Towards the beginning of the year the average weight of group II remained distinctly below the values of the size category I, showing a tendency to increase in March and thus surpassing the weight of unpigmented glasseels at around 60 mg in October. The minimum value was recorded in December and the maximum of 0.406 g in October 1982. The mean wet weight of the elvers ranged from 1.0 to 2.6 g, the minimum in December, the maximum in July 1982.

Tabl. II. — Mean length and weight values of glasseels and elvers. L, lenght; WW, wet weight (formalin); ODW, organic dry weight.

date	L (cm)	WW (g)	ODW (g)	L (cm)	WW (g)	ODW (g)	L (cm)	WW (g)	ODW (g)
Station 7		I			II.			III	
11.81	6.8	0.299	0.051	—	—	—	10.2	1.585	0.333
12.81	7.0	0.355	0.075	6.4	0.214	0.044	9.0	1.032	0.232
01.82	7.2	0.363	0.064	—	—	—	—	—	—
02.82	6.6	0.306	0.054	—	—	—	—	—	—
03.82	6.6	0.270	0.046	6.6	0.221	0.036	10.7	1.757	0.349
04.82	6.8	0.325	0.052	6.7	0.258	0.038	10.5	1.587	0.299
05.82	6.8	0.330	0.052	6.7	0.253	0.035	9.7	1.389	0.258
06.82	7.0	0.335	0.062	6.8	0.274	0.042	10.5	1.764	0.371
07.82	6.5	0.269	0.044	6.6	0.255	0.039	11.2	2.596	0.463
08.82	—	—	—	6.9	0.383	0.066			
09.82	6.6	0.314	0.052	—	—	—	—	—	—
10.82	6.7	0.346	0.059	7.0	0.406	0.063	—	—	—
11.82	6.8	0.348	0.061	—	—	—	—	—	—
03.83	7.0	0.325	0.045	6.6	0.200	0.022	10.5	1.664	0.293
Station 3		I							
01.82	6.7	0.338	0.053						
02.82	7.0	0.394	0.067						
13.11.82	7.2	0.447	0.083						
15.11.82	7.3	0.484	0.089						
16.11.82	7.2	0.456	0.079						
11.1.83	7.3	0.436	0.082						
13.01.83	7.2	0.422	0.078						
15.01.83	6.9	0.380	0.070						
10.02.83	7.2	0.409	0.070						
11.02.83	7.2	0.447	0.084						
12.02.83	7.1	0.406	0.071						
13.02.83	7.1	0.391	0.071						
11.03.83	7.0	0.334	0.046						
12.03.83	7.1	0.384	0.071						
13.03.83	7.0	0.358	0.061						
13.04.83	7.0	0.367	0.061						
14.04.83	7.0	0.339	0.064						

4. Organic Dry Weight

The mean organic dry weight of unpigmented glasseels ranged between 0.032 and 0.095 g in the course of the year with a maximum upstream in December 1981 and June 1982. Minimal values were fairly distinct in March and more clearly marked in July (Table II). In the estuary the maximum of group I was registered in November 1982 with 0.095 g.

The weights of group II remained below those of group I, except for a peak of 0.066 g in August. They varied to a slight extent during the period of December 1981 to July 1982 with a mean value of 0.04 g.

In group III, minima were recorded in December 1981 and in May 1982, maxima in November 1981, March and July 1982.

Glasseels from sizegroups I and II were significantly different ($P \leqslant 0.05$) from the elvers of group III by the ratio of dry weight to wet weight ($F = 14.35$; $F_{(0.05,\ 2,24)} = 3.4$) and organic dry weight to wet weight ($F = 14.65$; $F_{(0.05,\ 2,24)} = 3.4$).

Unpigmented and pigmented glasseels were not significantly different ($t = -1.06$, $t_{(0.05,\ 18)} = 2.1$ for DW % and $t = -0.39$, $t_{(0.05,\ 18)} = 2.1$ for ODW %), indicating that the ash and water content of the tissues was relatively constant. Subsequently their dry weight was 18.19 % of the wet weight and organic dry weight 16.19 % of the wet weight ($n = 385$). Ratios for elvers were 21.86 % (DW to WW) and 19.97 % (ODW to WW).

The unpigmented glasseels ($n = 239$) of the estuarine area differed significantly with 19.25 % (DW to WW) and 17.69 % (ODW to WW) from those individuals of group I caught upstream $t = -4.29$, $t_{(0.05,\ 25)} = 2.06$ for DW % and $t = -4.26$, $t_{(0.05,\ 25)} = 2.06$ for ODW %.

5. Length - Weight Relation

The length-weight relation was calculated separately for each month and for each of the 3 groups according to $W = C \times L^b$. The length-weight data were log-transformed and the factor b determined by regression analysis (Weber 1985 b). It became evi-

Table III. — b and c, values of glasseels and elvers (b, regression coefficient; c, condition factor).

		b	c
Station 7 (18,7 km upstream)			
11.81	I.	4.14	0.011
12.81	I.	3.39	0.049
	III.	3.18	0.094
01.82	I.	3.42	0.042
02.82	I.	3.3	0.061
03.82	I.	2.71	0.163
	II.	3.53	0.028
	III.	2.89	0.187
04.82	I.	3.82	0.021
	II.	4.15	0.01
	III.	2.68	0.294
05.82	I.	3.42	0.047
	II.	2.5	0.218
	III.	3.06	0.133
06.82	I.	2.68	0.183
	II.	3.12	0.07
	III.	3.5	0.047
07.82	I.	3.23	0.064
	II.	3.55	0.031
	III.	3.38	0.073
11.82	I.	2.91	0.132
03.83	I.	3.46	0.039
Station 3 (estuary 5.2 km)			
01.82	I.	3.99	0.017
02.82	I.	3.22	0.075
13.11.82	I.	3.41	0.053
15.11.82	I.	3.83	0.024
11.01.83	I.	2.78	0.174
13.01.83	I.	3.2	0.076
15.01.83	I.	3.17	0.083
10.02.83	I.	2.56	0.261
12.02.83	I.	3.04	0.105
13.02.83	I.	3.33	0.057
11.03.83	I.	3.51	0.036
12.03.83	I.	3.16	0.078
13.03.83	I.	3.0	0.104
13.04.83	I.	3.37	0.052

dent that not only the regression coefficient b but also the condition factor C varied to great extent during the year (Table III).

b ranged from 2.5 to 4.15. Since the main percentage of values was concentrated within the range of > 3 one may draw the conclusion that generally an allometric growth was involved.

The factor C was calculated from the equation above. The unpigmented glasseels from the station upstream showed a range from 0.011 to 0.183 with two distinct maxima in March and June 1982. The minima were recorded 1-2 months before and after, namely in January, April and July. In November 1981 the lowest C-value was recorded with 0.011 (Table III).

In the estuary the factor C increased from 0.024 to 0.261 during the period November 1982 to April 1983. Among the pigmented glasseels a maximum could be recorded in May between two minima in April and July, in contrast to the elvers which showed a peak in April at 0.294 and minimum in June at 0.047.

DISCUSSION

Because of burocratic problems it was not possible to take samples continuously in the estuary, so the investigation was limited to only two samples in spring 1982 (February and March) and the catching season 1982/1983 (5 months). Due to the fact that the lower course of the river was inundated by extreme rainfalls in December 1982 the entire fishery had to be cancelled. Hence to those lacking data it could not to be ascertained whether the peak in frequency of individuals in February 1982 might have caused the maximum upstream in the subsequent month. It has been assumed that glasseels delay their travels upstream, resting for an undeterminable time along the shores, avoiding places with strong currents and resuming their journey only after a while. This assumption is probably confirmed by the feature that a high percentage of already pigmented glasseels was captured in the summermonths upstream.

French experimental fishery stated that the migration is influenced by weather conditions, mainly wind direction and force (Gault, 1979). In the Rio Minho yield maxima were recorded in February and March of both years and at both stations. While the tide became stronger frequently the wind speed rose sharply to a force of BFT 7 mainly from ssw-direction (river mouth). In March during two nights the fishery had to be called off : the net had to be separated from the boat in order to prevent it from capsizing.

Tesch 1973 pointed out a possible dependence of migrating glasseels and the phases of the moon but sufficient quantitative data do not seem to be accumulated yet. Comparing the high yield at new moon in November 1982 with the low number caught during the days before and after gives rise to the presumption that glasseels exhibit a lunar activity.

During 1981/1982, comparing pigmented glasseels with unpigmented, the values for length and weight turned out to be distinctly lower. This is ascribed to the theory that glasseels abstain from feeding while migrating into the estuary. Extensive pigmentation and a higher demand of metabolic energy result in a depletion of body resources for up to two weeks before they start feeding again (Forrest, 1976). Length and weight reduction of glasseels during the initial stage of their anadromous migration and during pigmentation is a well known phenomenon (Elie, 1979, Cantrelle, 1981, Lecomte-Finiger, (1983). According to Lecomte-Finiger (1983) rising water temperatures were hold responsible for the acceleration of the process of pigmentation and an extend dwelling in seawater delayes it but increased the loss of weight (32-54 %) and the reduction of length (4-6 %).

Tarr & Hill (1978) studied biomass relations of South-African elvers and glasseels (*Anguilla mossambica, Anguilla marmorata, Anguilla nebulosa labiata*). Since there was no significant difference between the developmental stages I, II and III, the mean ratios were 17.33 % (DW to WW) and 15.91 % (ODW to WW) which is comparable with the values from the river Minho upstream regarding size groups I and II. The difference, however, to the glasseels from the estuary is more apparent. The same applies to the elvers of sizegroup III.

According to the results of this investigation one may assume that not only seasonal differences with respect to the length-weight relation but also the catch site (distance to the mouth) and the time of fishing (phases of the moon) might exert a qualitative influence on aquaculture experiments.

This assumption was partly checked in a closed circulation system (Weber, 1984), by which it could be shown that glasseels with high C-values, captured upstream in March could adapt themselves to food within a shorter time and that they grew relatively faster (0.64 % towards 0.47 % per feedingday) than individuals caught in the estuary in the previous month. However, they seemed to be more receptive to ectoparasitic infections (*Ichthyophthirius multifiliis*). Further experiments will be necessary to prove that glasseels from certain months and catchsites may be considered more suitable for stocking purposes in aquaculture than individuals from other times and places. However, during the summer one has to reckon with lower numbers and more heterogenous material, containing a higher percentage of already pigmented glasseels and elvers.

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