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Fisheries Research 78 (2006) 380–384
FISHERIES RESEARCH
www.elsevier.com/locate/fishres

Short communication

Scale reading validation for estimating age from tagged fish recapture in a brown trout (*Salmo trutta*) population

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Received 1 June 2005; received in revised form 14 November 2005; accepted 23 November 2005

Abstract

This study presents the validation of a scale-reading method for age estimation of brown trout (*Salmo trutta*). Age estimated from the scale reading was compared with the true age from recaptured fishes pit-tagged at the 0+ stage. Recapture was performed via electrofishing or trapping during migration up to 6 years later. A sample of 375 fish was analysed, including freshwater (363 fish) with two sub-groups (resident and migratory) and anadromous forms (12 fish). Average percentage of error in the scale reading was low (6.4%) in the whole sample. Error rate dramatically increases with age. There was no error in the sea trout sample. When considering freshwater fish alone, average error rate remained low (6.6%) and was higher in resident fish (older individuals) than in migratory fish (younger individuals). No statistical difference was observed between the true age and the age estimated from scales, thus confirming the reliability of scale reading for age estimation.

Keywords: Validation; Scale-reading; Pit-tagging; Age; Ageing error; Brown trout; *Salmo trutta*

1. Introduction

Management of fish populations for restoration or conservation requires an assessment of the present status, and reliable knowledge of the spatial and temporal dynamics of the population. We require a precise analysis of demographic characteristics to establish a reliable estimation of the age of individuals. Scales are commonly used for estimating age of fish (Jearld, 1983; Baglinière and Le Louarn, 1987). In salmon and trout species, scale-reading is considered a reliable and useful method for age estimation (Baglinière, 1985; Richard and Baglinière, 1990). Practical manuals provide standardized criteria to interpret scales and estimate age for some species such as Atlantic salmon (Anonymous, 1984; Baglinière, 1985), sea trout (Richard and Baglinière, 1990) or European shads (Baglinière et al., 2001).

Using scales for age estimation requires a validation of the scale reading method to avoid errors in age estimation. Errors in age estimation may invalidate population models based on age distributions (Beamish and McFarlane, 1983; Francis, 1990; Raitaniemi et al., 1998), and may in turn lead to large errors in the management of stocks and fisheries (Pikitch and Demory, 1988). However, despite its importance, such a validation step is not carried out systematically (Beamish and McFarlane, 1983). In recent years this validation concerns marine fish (mainly through use of otoliths) (Ortiz de Zarate et al., 1996) as well as some freshwater fish (use of scales).

Several methods are available for age validation (Rodriguez-Marin et al., 2002), including some new approaches such as radiometric dating (Campana and Jones, 1998; Andrews et al., 2002). A more classical and straightforward method is to compare the estimated age from scale reading with fish of known age (Ombredane and Baglinière, 1992; Raitaniemi et al., 1998; Machias et al., 2002). These

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0165-7836/$ – see front matter
doi:10.1016/j.fishres.2005.11.018

fish can come from the recapture of hatchery-reared fish stocked in barren water bodies (Hesthagen, 1985). Alternatively, it is possible to use wild fish tagged with vital stains (Sire, 1981; Hall, 1991; Hining et al., 2000; Powell et al., 2000) or fish with internal and external tags (Robitaille et al., 1984; Richard and Baglinière, 1990; Heifetz et al., 1999; Gries and Letcher, 2002). Such methods require that tagging does not modify the growth of the fish (Beamish and McFarlane, 1983).

A study on the population dynamics and life history strategies of brown trout (*Salmo trutta*) has been carried out for 20 years in the River Oir, a tributary of Sélune River flowing into the Mont Saint-Michel Bay (Lower Normandy, France). The R. Oir is 19.5 km long with an average slope of 11‰ and a drainage area of 85 km^2. This study was based on an extensive tagging programme, using individual tagging at sub-yearling stage. Brown trout is present as freshwater and anadromous forms. Recent results have demonstrated a continuum of life history tactics, ranging from resident trout to trout migrating into sea via fish with an intermediate tactic of migration within the tributary-main river subsystem (Cucherousset et al., 2005).

The aim of the present study was to test the reliability of the scale reading method in brown trout (*S. trutta*) using comparisons with ages estimated from recaptured fish tagged with pit-tags at the 0+ stage. When comparing estimations between the true age and the age estimated from scales, particular attention was paid to the sources of errors related to the biological form, the actual age and the type of fish (resident or migrating).

2. Materials and methods

Brown trout were collected in the River Oir. Fish were tagged with pit-tags (TROVAN system) at the end of their first year of life (0+) during an electrofishing survey in the main stream and some tributaries. We assumed that pit-tagging had no significant impact on the survival and growth of young trout (Ombredane et al., 1998). Recaptures of tagged fishes were performed by two methods: electrofishing in the same zones, and upstream and downstream trapping in a counting fence located in the lower reaches of the R. Oir. All recaptured fish were measured (fork length) and scales were sampled from a standard area (Ombredane and Baglinière, 1992). Regenerated scales were discarded. Scales from each fish were read only once using a microfiche reader (50×), and age was designated by a standard notation following Baglinière and Le Louarn (1987) and Richard and Baglinière (1990). Individual tagging provided the true age of fish at the time of recapture. It was assumed that no error in initial ageing (0+ -age) was made at first capture.

We calculated two measures of the error between true age and estimated age. The standard error percentage (or rate) was calculated by group or by age as the simple ratio between the number of errors in ageing and the sample size considered at 95% confidence limits according to Scherrer (1984). Another error percentage depending on true age was calculated with a modified equation from Beamish and Fournier (1981):

$$\frac{1}{N}\sum_{i=1}^{N}\left(\frac{|X_i - Y_i|}{X_i}\right)$$

where N is the total number of fish, X_i and Y_i are the true age (Pit-Tag) and the estimated age (scale-reading) for the fish i, respectively. This second error percentage corrects for the fact that the higher the true ages are, the greater are the absolute errors in estimating the age from scale reading. In the following, this measure is referred to as the age-corrected error percentage. True age and age estimated from scales were compared using χ^2 tests.

3. Results

A total of 375 fish was analysed by scale-reading (Table 1). Several groups were distinguished within the whole sample: sea trout (ST) and freshwater trout (FR). Only 12 fish were sea-trout and eight of them were finnocks (0+ in sea). Freshwater trout (N = 363) were divided into two subgroups: resident fish that stay in the main stem of the Oir river or in its tributary, and migrating fish. Migrating fish are either juveniles leaving the Oir River to grow in the River Sélune, or adult fish migrating upstream from the Sélune River back to the Oir river for spawning. Most of the freshwater trout (89.2%) were 1+ and 2+ years old, while resident fish were on average older than migrating fish.

In the total sample (N = 375), the standard error percentage was 6.4% and the age-corrected error percentage was 3.1%

Table 1
Distribution of age estimated by scale-reading in the brown trout population from the R

Age	Total	Resident fish			Migrating fish
		Total	Oir	Tributaries	
A					
1+	128	80	44	36	48
2+	196	147	108	39	49
3+	29	28	18	10	1
4+	7	7	7	0	0
5+	3	3	3	0	0
Total	363	265	180	85	98

Age		Number of fish	Observations
Freshwater	Sea		
B			
2	0+	8	
2	1+	2	One fish with two spawning marks fish with three spawning marks
2	2+	1	
2	3+	1	

Oir: (A) freshwater trout; (B) sea trout.

Table 2
Error rate (%) in age estimation according to the brown trout form

Form	Number of fish	Error					
		Number	Underestimated	Overestimated	% (1)	CL 95% (1)	% (2)
Freshwater	363	24	12	12	6.6	4.2–9.8	3.2
Sea	12	0	0	0	0	0	0
Total	375	24	12	12	6.4	4.1–9.5	3.1

Standard error percentage; (2) age-corrected error percentage; 95% confidence interval is given for method (1) only.

Table 3
Error rate (%) in age estimation according to age class in freshwater brown trout

Age class	Number of fish	Error					
		Number	Underestimated	Overestimated	% (1)	CL 95%	% (2)
1+	134	4	0	4	3.0	0.8–7.6	3.0
2+	190	8	0	8	4.2	1.8–8.3	2.1
3+	27	7	7	0	25.9	11.1–46.3	8.6
4+	7	2	2	0	28.6	3.7–71.0	10.7
5+	4	2	2	0	50.0	6.8–93.2	10
6+	1	1	1	0	100	–	16.7
Total	363	24	12	12	6.6	4.2–9.8	3.21

(1) standard error percentage; (2) age-corrected error percentage; 95% confidence interval is given for method (1) only.

(Table 2). There was no ageing error in sea trout ($N = 12$). When considering freshwater trout alone, the standard and age-corrected error percentages were 6.6% and 3.2%, respectively (Table 2), and there were no significant differences (χ^2 test, $p < 0.05$) between the true and scale reading age distributions. Both the standard and age-corrected measures of error dramatically increase with age (Table 3). Nevertheless, this increase is buffered when using the age-corrected error percentage. Moreover the average error percentage over all age classes was higher in main-stream-resident trout than in migrating and tributary-resident fish (Table 4). This difference is mainly due to the low proportion of old fish (>3+) in the samples of migrating and tributary resident fish.

4. Discussion

The percentage of error is rather low, except for the oldest fish for which there is a very high risk of an error of one or two 2 years. This demonstrates the reliability of scale reading

Table 4
Error rate (%) in age estimation according to age class and population type in freshwater brown trout

Type of freshwater fish	Age class	Number of fish	Error					
			Number	Underestimated	Overestimated	% (1)	CL 95%	% (2)
Resident								
Oir	1+	48	2	0	2	4.2	0.5–15.0	4.2
	2+	103	5	0	5	4.8	1.6–11.3	2.4
	3+	18	5	5	0	27.8	9.7–53.5	9.3
	4+	6	1	1	0	16.7	0.4–64.1	8.3
	5+	4	2	2	0	50.0	6.8–93.2	10
	6+	1	1	1	0	100	–	16.7
	Total	180	16	9	7	8.9	5–14.5	4.0
Tributaries	1+	37	1	0	1	2.7	0.07–15.1	2.7
	2+	38	2	0	2	5.3	0.6–19.0	2.6
	3+	9	2	2	0	22.2	2.8–60.0	7.4
	4+	1	1	1	0	100	–	25
	Total	85	6	3	3	3.5	5.6–15.4	3.4
Total	Total	265	22	12	10	8.3	5.2–12.6	3.8
Migrating	1+	49	1	0	1	2.0	0.05–11.4	2.04
	2+	49	1	0	1	2.0	0.05–11.4	0.7
	Total	98	2	0	2	2.0	0.24–7.3	1.4

(1) standard error percentage; (2) age-corrected error percentage; 95% confidence interval is given for method (1) only.

for age estimation in brown trout, for the majority of the local stock. Indeed, the oldest fish, for which the error rate is high, are rare in the trout population of the R. Oir. The life span is short and does not exceed 6 years, whatever the form or type (resident or migrating) (Gouraud, 1999). Thus, the sample analyzed in this study is representative of the age structure of the population.

The present study also shows that the age estimation becomes more difficult with increasingly older fish (Hoxmeier et al., 2001). In old fish, scale interpretation is perturbed by the slower growth and the presence of successive sexual maturations (Craig, 1985; Hesthagen, 1985; Tankevich, 1990; Baglinière et al., 2001). For the older fish, age estimation from otoliths may be a valuable alternative to scale reading (Raitaniemi et al., 1998; Baglinière et al., 2001; Hoxmeier et al., 2001).

We assume that no error occurs in the estimation of the initial age of young fish at the time of tagging, so they are all considered as young of year. This hypothesis is supported by the knowledge of the growth of brown trout juveniles, provided by studies that have been carried out over the last 20 years on the brown trout population in the R. Oir (Gouraud, 1999) and in other rivers from the same geographical unit (Baglinière and Maisse, 2002). These studies demonstrated that 0+ trout and 1+ trout can be distinguished based on the fish length. Moreover, to reduce the risk of errors in the identification of 0+ fish, the particular growth conditions associated with habitat type or stream order were accounted for. Therefore, the identification of 0+ fish in autumn can be considered as highly reliable.

No ageing error was observed in sea trout. However, the sample size is small and the sampled fish are rather young. Nevertheless the sample is representative of the dominant component in adult populations (>77% type 0 fish: Marchand F., Baglinière J.L., unpublished data; type 0 has been defined by Richard and Baglinière, 1990 and includes finnocks and multispawners having spawned previously as finnock). In order to improve reliability of the scale reading method for sea trout, it would be necessary to examine more fishes with a long marine period (only four in the analysed sample).

The average error rate calculated for all age classes of freshwater brown trout is low. This is also related to the low proportion of old fish in the sample. Otherwise, the lack of fish older than 2 years in the migrating trout sample could explain their lower average error rate than in resident trout (Oir River and tributaries). The average error rate calculated from the sample of trout resident in the Oir River is higher than the rate calculated from the sample of resident trout in the tributaries. The similar age distributions between the two samples (83.9% and 88.2% of 1+ and 2+ age classes for the sample of Oir-resident fish and tributary-resident fish, respectively) may not be the only reason for the higher error rate for the sample of Oir-resident fish. In fact, the difference can also be explained by the higher growth rate observed in the fish from the Oir River compared to the tributaries (Table 5). Indeed, a higher growth rate leads to the presence of supplementary rings or a lack of visible rings on the scales, which results in a misinterpretation of the age (Baglinière, 1985; Ombredane and Baglinière, 1992). This is in agreement with the observations of Hoxmeier et al. (2001), who showed it was more difficult to estimate age in populations with longer and more indistinct growing seasons.

Table 5
Average size (FL: fork length in mm) by age class in resident trout population sampled in the River Oir and its tributaries (*N*: number of fish; S.D. standard deviation)

Age class		R. Oir	Tributaries
1+	FL	225	200
	N	48	37
	S.D.	15.2	27.4
2+	FL	267	239
	N	103	38
	S.D.	28.2	33.3
3+	FL	286	270
	N	18	9
	S.D.	21.6	16.1
4+	FL	341	265
	N	6	1
	S.D.	31.3	0
5+	FL	342	
	N	4	
	S.D.	35.8	
6+	FL	406	
	N	1	
	S.D.	0	

In conclusion, the comparison with tagged fishes confirms the reliability of scale-reading for estimating the age of brown trout. Furthermore, the examination of scales in brown trout provides information about life history (marine or river form, time spent in sea or river, maturity age, number of spawnings) that is not available from an examination of recaptured tagged fishes. For example, examination of live recaptured tagged trout does not allow us to determine whether the fish is a true sea trout since this criterion is not completely reliable for discriminating between the two forms, notably in stocks with large individuals (Baglinière et al., 2000). However, the risk of error in ageing fish from scale reading is reduced when the biologist is experienced in the principles of scale reading and has a good knowledge of the biology of the local brown trout stocks (Ombredane and Baglinière, 1992; Raitaniemi et al., 1998).

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