Mac Vet Rev 2013; 36 (2): 73–83

Available online at
www.macvetrev.mk

Original Scientific Article

UDC: 639.3.09:597.552.512(497.7)

FIN DAMAGE OF FARMED RAINBOW TROUT IN THE REPUBLIC OF MACEDONIA

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Received 6 June 2013; Received in revised form 23 July 2013; Accepted 20 August 2013

ABSTRACT

The aims of this study were to determine the prevalence of fin damage in farmed rainbow trout and to see whether the level of damage differed between different fish categories and farms. The study was field based and included the fin damage analysis and clinical description of the damaged fins. Fins were analyzed in two categories of fish [weight below 30g (min. 5g) and over 100g (max. 250g)]. Thirty fish per category were randomly selected, netted and each rayed fin was assessed and photographed (total of 5880 fins were analyzed in 840 fish from seven rainbow trout farms). The prevalence of fin damage was 100% and there was a large range in the level of damage which was mainly characterized by surface abrasions. Worst affected fins in both fish categories were dorsal and pectoral fins. Fin damage was present to a lesser degree in the smaller categories, but there was fin damage in the smallest fish examined. Pattern of damage was Dorsal Pectoral>Abdominal>Anal>Tail fin. Differences in fin damage in all surveyed farms indicate that some factor or group of factors specific to each farm influence the extent of damage. Fin damage is operational welfare indicator and future research should identify and explore the impact of the factors affecting fin damage and propose management practices that can minimize the level of fin damage. Additional knowledge is needed to identify whether fin damage is etiologically connected to different production system, handling procedures or another background.

Key words: rainbow trout, fin damage, fish welfare, welfare indicator

INTRODUCTION

The term “fin damage” includes visible changes and/or loss of fin tissue and it is a well known abnormality in many farmed and wild fish species, especially salmonids (1). It has been recognized and accepted as a common problem in farmed rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) for more than four decades (2). The presence of fin damage is so ubiquitous in some species that it can be used to distinguish the origin of the fish (farm or open water) (3). Damaged fins reduce the aesthetic appearance of the fish for both consumers and anglers, and potentially affect the survival of the fish for stocking open waters (4-6). Fin damage has been associated with the constantly increasing intensification of the farming process and was largely tolerated by the industry until it was highlighted as a welfare issue. Fish welfare is gaining more and more attention and fin damage has been highlighted as a fish welfare issue representing injury to live tissue that has blood vessels, nerves and nociceptors involved in the perception of pain (7-10). Latest studies of salmonid welfare included

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Competing Interests: The authors have declared that no competing interests exist.

fin damage as an "operational welfare indicator" (2, 11-24) because as an external injury is evident and understandable, easily recognizable by fish farmers and welfare evaluators, and potentially easy to quantify (2).

Despite the extensive experimental work, there is little objective information on the prevalence and severity of fin damage on commercial farms. It has been documented that fin damage is widespread in the salmon and trout farms in the USA and Europe (4, 13, 25-30) and the severity can vary from superficial erosions to total loss of one or more fins (13, 29, 31-33).

There is no similar data about rainbow trout farmed in Republic of Macedonia, so the aims of this study were to determine if farmed rainbow trout experience fin damage, to compare the level of damage of all the rayed fins among different rainbow trout categories, and to see whether the level of damage differed between farms. The collected data should help to identify risk factors that favor the process of fin damage.

MATERIALS AND METHODS

The study included seven trout farms with a total annual production of 650.000 kg of rainbow trout [~75% of the annual production of rainbow trout in Republic of Macedonia (V. Stevanovski, pers. comm.)]. The selection of the farms was based according to the scale of production and the willingness to participate in the study. All of the selected farms had their own hatcheries and were producing fish for consumption. The location of the farms is shown with dotted squares on Figure 1.

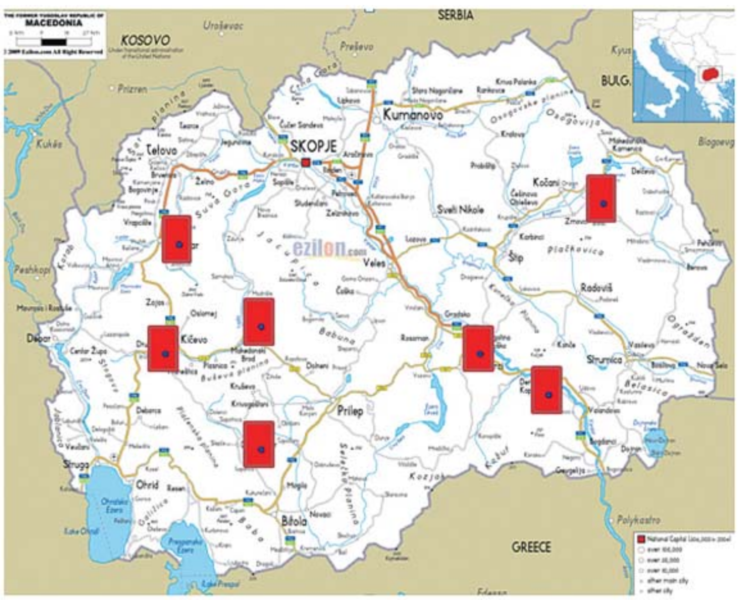


Figure 1. Map of Republic of Macedonia showing the locations of the selected trout farms (dotted squares). Source: http://www.ezilon.com/maps/europe/macedonia-maps.html

The study was field based and included the fin damage analysis and clinical description of the damaged fins. Before the onset of the fin damage analysis, the fish from the selected breeding units were clinically examined for signs of diseases.

Fins were analyzed in two categories of fish [weight below 30g (min. 5g) and over 100g (max. 250g)]. From the rearing units where these categories were present, 30 fish per category were randomly selected, netted and each rayed fin [dorsal (D), caudal (C), anal (A), pectoral (P1) and pelvic (P2)] was assessed and photographed. To determine whether seasonal variations in the farming process affect the level of fin damage, the first assessment was carried out in late winter and early spring, and the second during the summer period in 2012. In total, 5880 fins from 840 fish were analyzed. All fins were scored by the same operator [A.Cvetkovikj].

Fin damage was analyzed using the validated quantitative macroscopic key described by Hoyle et al. (15). In brief, the analysis was based on rapid macroscopic description of all rayed fins in field conditions and included two parts. In the first part, based on a photographic key, the lack of fin tissue was quantified on a scale of 0 to 5 (0 - no damage; 5 - almost complete loss of fin). In the second part, based on the qualitative clinical descriptors, the injuries and lesions of the fins were classified as: damaged edges (surface abrasions); splits ("V" shaped tear between the rays); exposed rays (lack of soft tissue); hemorrhages (dark red spots with clearly defined margins); inflammation (presence of unnatural redness and swelling); healing and/or thickening (presence of white and smooth tissue with greater thickness compared to a normal fin) and side folding (as a consequence of re-growth).

The time needed for the assessment was 10-15 sec and was sufficient for analysis of the fin profile without compromising the welfare of the fish. After the analysis, the fish were returned to the same breeding unit.

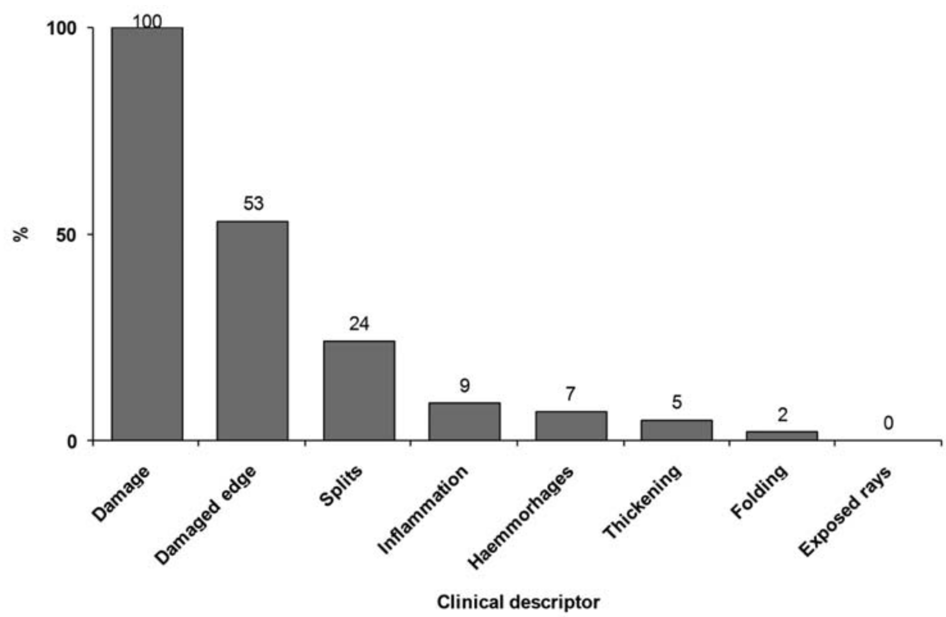
Statistical analyses were performed using Daniel's XL Toolbox ver. 4.01 (http://xltoolbox.sourceforge.net), and all results were expressed as mean ± SE. To determine whether there are intra- or inter-farm statistical differences, all data were subjected to one-way analysis of variance (ANOVA). The results were considered statistically different at 0,01 significance level ($p<0,01$).

RESULTS

Prevalence of fin damage

Fin damage occurred throughout all the tested rainbow trout farms. The prevalence was determined from the presence of the clinical descriptors of fin damage. Fins were classified as "damaged" on all farms, in all rearing units, and the prevalence reached 100% in all fins (Graph. 1). Recording of damaged edge was consistent on every fin, so we excluded it when there was presence of another clinical descriptor.

The clinical descriptors are shown on Figure 2, 3, 4, 5, 6 and 7.



Graph. 1. Prevalence (%) of clinical descriptors of the fin damage observed in all analyzed fins (n=5880)

Figure 2. Damaged edge on caudal fin

Figure 3. Split on dorsal fin

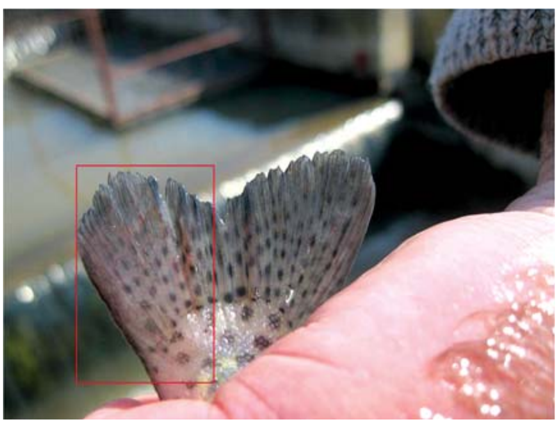


Figure 4. Inflammation of caudal fin

Figure 5. Hemorrhages on left pectoral fin

Figure 6. Thickening of dorsal fin

Figure 7. Folding of left pectoral fin

Level of fin damage

The results from the level of the fin damage are presented in Table 1. The data is presented as mean ± SE values of the level of damage calculated on 60 individual fish per category [ANOVA for seasonal variations showed non-significant differences (p>0.1, data not shown) and we recalculated the results for 60 individual fish per category].

Table 1. Level of the fin damage and significance of the results between the different fish categories and fish farms

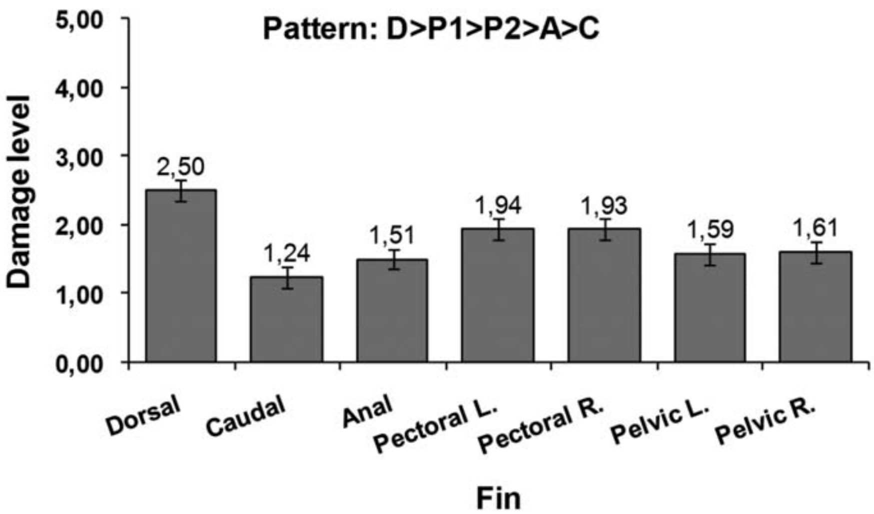
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	p-level
Dorsal < 30g	3.63 ±0.06	2.53 ±0.13	3.02 ±0.15	2.30 ±0.11	1.50 ±0.09	2.35 ±0.12	2.13 ±0.15	**p<0.001**
Dorsal > 100g	4.27 ±0.06	3.23 ±0.12	4.07 ±0.09	2.77 ±0.12	2.10 ±0.09	2.72 ±0.13	3.32 ±0.15	**p<0.001**
p	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.01**	**p<0.001**	
Caudal < 30g	1.43 ±0.06	1.30 ±0.06	1.37 ±0.06	1.33 ±0.06	1.03 ±0.02	1.13 ±0.04	1.07 ±0.03	**p<0.001**
Caudal > 100g	2.95 ±0.3	1.73 ±0.07	2.07 ±0.07	1.85 ±0.10	1.73 ±0.09	1.73 ±0.08	2.28 ±0.11	**p<0.001**
p	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	
Anal < 30g	1.73 ±0.07	1.67 ±0.09	1.52 ±0.09	1.47 ±0.06	1.10 ±0.04	1.73 ±0.08	1.33 ±0.06	**p<0.001**
Anal > 100g	3.60 ±0.10	1.85 ±0.08	2.37 ±0.09	2.07 ±0.11	1.80 ±0.10	2.03 ±0.09	2.40 ±0.11	**p<0.001**
p	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.01**	**p<0.001**	
Pectoral left < 30g	2.10 ±0.13	2.02 ±0.12	1.78 ±0.09	1.82 ±0.09	2.10 ±0.08	2.03 ±0.09	1.73 ±0.17	**p>0.05**
Pectoral left > 100g	4.10 ±0.13	2.70 ±0.11	2.57 ±0.08	2.43 ±0.13	3.07 ±0.14	2.43 ±0.06	3.08 ±0.18	**p<0.001**
p	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	
Pectoral right < 30 g	2.07 ±0.14	2.03 ±0.12	1.80 ±0.10	1.83 ±0.10	2.07 ±0.07	2.02 ±0.09	1.70 ±0.12	**p>0.05**
Pectoral right > 100 g	4.12 ±0.13	2.67 ±0.09	2.53 ±0.08	2.47 ±0.14	3.10 ±0.10	2.40 ±0.08	3.05 ±0.17	**p<0.001**
p	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.01**	**p<0.001**	
Pelvic left < 30 g	1.58 ±0.11	1.75 ±0.09	2.18 ±0.14	1.50 ±0.09	1.33 ±0.06	1.30 ±0.06	1.47 ±0.09	**p<0.001**
Pelvic left > 100 g	3.07 ±0.10	1.93 ±0.11	3.03 ±0.06	2.13 ±0.12	1.87 ±0.07	1.90 ±0.09	2.47 ±0.12	**p<0.001**
p	**p<0.001**	**p<0.01**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	
Pelvic right < 30 g	1.57 ±0.10	1.77 ±0.11	2.20 ±0.14	1.53 ±0.09	1.43 ±0.08	1.33 ±0.07	1.43 ±0.09	**p<0.001**
Pelvic right > 100 g	3.05 ±0.10	1.97 ±0.10	3.07 ±0.13	2.15 ±0.12	1.97 ±0.08	1.93 ±0.09	2.43 ±0.11	**p<0.001**
p	**p<0.001**	**p<0.01**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	

For the smaller fish category (<30g), the most damaged fin was the dorsal fin in the farm 1 (3.63±0.06) and the least damaged was the caudal fin in the farm 5 (1.03±0.02). Fins with the greatest level of damage were: dorsal and pectoral fins in the farms 1, 2, 4, 6 and 7; dorsal and pelvic fins in the farm 3 and pectorals and dorsal fin in the farm 5. The caudal fin was the least damaged in the all tested fish.

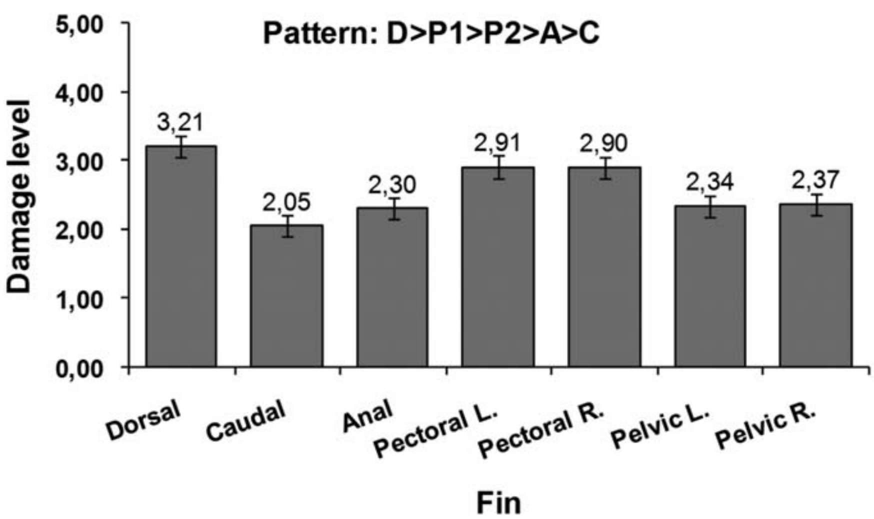
Fin damage was greater for the large fish than the small fish. For this category (>100g), the most damaged fin, as for the smaller ones, was the dorsal fin in the farm 1 (4.27±0.06), and the least damaged was the caudal fin in the farms 2, 5 and 6 (1.73±0.07). Fins with the greatest level of damage were again the dorsal and pectoral fins in the farm 1, 2, 4, 6 and 7; dorsal and pelvic fins in the farm 3 and pectorals and dorsal fin in the farm 5. The caudal fin was also the least damaged in all the tested fish.

Although there was a large range in the fin grade, we observed complete fin loss for every fin, especially for the dorsal and pectoral fins.

The pattern of the fin damage and the summarized data on the level of the fin damage on the all farms are presented on Graph. 2 and Graph. 3.



Graph. 2. Mean damage level on the separate fins for category < 30g in all the fish farms. Bars represent SE.



Graph. 3. Mean damage level on the separate fins for category > 100g in all the fish farms. Bars represent SE.

As it is shown in Table 1, as well as in Graph. 2 and Graph. 3, different fins were differently prone to fin loss, but the pattern of the fin damage, i.e. Dorsal > Pectoral > Pelvic > Anal > Caudal was consistent for both fish categories.

The data for the left and right pectoral and pelvic fins from both fish categories were correlated (Table 2). If one fin was damaged, in almost every case its pair was also damaged in the same way.

Table 2. Pearson's correlation coefficient

Pearson's	Pectoral right < 30g	Pectoral right > 100g	Pelvic right < 30g	Pelvic right > 100g
Pectoral left < 30g	0.987*			
Pectoral left > 100g		0.998*		
Pelvic left < 30g			0.990*	
Pelvic left > 100g				0.997*

* p<0.01

DISCUSSION

The fin damage can be assessed in many different ways with different or similar pros and cons (9). The method used in this study by Hoyle et al. (15) was applied because it considers all types of fin damage and enabled us to quantify the fin damage in a very short period of time, without the need for anesthesia or euthanasia of the fish. The proposed five levels of damage gave an instant picture of the fin profile and can be used in future research of fish quality and welfare. The only difficulty is that it is still unknown what level and type of fin damage are acceptable in terms of welfare (11, 34-37).

The fin damage analysis showed 100% prevalence and all rayed fins were damaged to some extent. This is the first study in Republic of Macedonia that confirms the suggestions that fin damage is ubiquitous, agreeing with previous research that it is widespread in rainbow trout farms worldwide and that all rayed fins are prone to damage (4, 9, 13, 15, 25, 29, 30). During the study, we did not find any diseased fish and there was no mortality in all examined rearing units. From a single point of view, this implies that damaged fins do not pose a serious threat to the production. This is expected, because fin damage is greatly tolerated in the expansive development of the salmonid culture over the past four decades (2).

The most damaged fins in both fish categories were the dorsal and pectoral fins. However, the severity of damage varied for the other fins that suggest that some fins were more prone to damage compared to others. Bosakowski and Wagner (25) made similar observations. The dorsal and pectoral fins were damaged even in the smallest fish examined (5g), which indicates that the damage occurred in the early life stages in the hatchery. These findings do agree with previous research (13, 38), even though the method used to assess fin damage was different. The other fins had higher level of damage in the larger fish category, which implies that the living conditions, factors that differ between farms and the ongrowing technology significantly affect the extent of damage. This is also supported by the ANOVA analysis that showed that the interfarm comparison of the level of damage of the pectoral fins in the small fish category was the only nonstatistically significant result. The overall fin damage was present to a lesser degree in the small fish categories. This finding supports the findings of Barrows and Lellis (39) and St-Hilaire et al. (13) that fin damage continues to increase throughout the entire farming process.

The severity of damage varied between fins and the pattern of the fin damage was consistent for both fish categories, although there were minor differences at a farm level. The pattern, with the exception of dorsal and pectoral fins, is not in accordance with other published research. Abbott and Dill (40) assessed tissue loss by subjective classification of the damage and found D>P1>C>P2>A in juvenile steelhead trout. Turnbull et al. (41) by assessing tissue damage from the length of the fin splits found D>P1>C>P2>A in Atlantic salmon parr. The following three studies assessed tissue loss by comparing the fin lengths of farmed fish with those of control (feral or wild) fish. Bosakowski and Wagner (4) found P1>D>A>P2>C in cutthroat trout and D>P1>A>P2>C in rainbow and brown trout; Pelis and McCormick (42) found P1>D>P2>A>C and D=P1>A>P2>C in two Atlantic salmon hatcheries and St-Hilaire et al. (13) found D>P1>C>A>P2 in rainbow trout. The different findings may be due to the different methodology used for the fin damage assessment, the causes of damage were different and were acting individually or in a combination, and/or different fins were differentially prone to different causes and factors affecting the process of fin damage. Generally, observation of fin damage can be divided in two major groups. First is fin damage as a result of bad handling and management of fish and second due to individual damage as a result of aggression, interactions among fish etc.

We didn't find any seasonal differences in the level of fin damage in both fish categories. This is in accordance with previous research (43) and this finding further emphasizes the importance of farm practices in the process of fin damage.

The almost perfect correlation between the left and right-paired fins implies that a similar process affects the level of damage of these fins. This finding is also in accordance with previous research of St-Hilaire et al. (13).

The lack of the fin damage of wild trout and trout reared in isolation indicates that farm conditions (e.g. rearing unit surface; handling and transport; water quality; sunburn; feed quality) initiate the damage (38). Therefore, fin damage is considered as a phenomenon in the farmed trout. Differences in fin damage in all surveyed farms indicate that some factor or group of factors specific to each farm influence the extent of damage (e.g. temperature; stocking density; water current; feed ration and distribution). Future research should identify and explore the impact of the factors affecting fin damage and propose management practices that can minimize the level of fin damage.

The primary function of the fins is locomotion and posture control. Having in mind the behavioral welfare aspects of fin damage, it can be easily proposed that fin damage could affect its primary function during routine swimming and feeding behavior (44). There are some experimental data that show that reduction of the pectoral fin area had no effect upon the swimming capacity of the fish (45, 46). The authors suggest that fish make behavioral compensations to adjust for the reduced fin size. However, the complete loss (amputation) of pectoral fins reduces the ability of station-holding of Atlantic salmon parr (47). The evidence that damaged fins do not affect the behavioral performance is scarce and additional studies are needed to demonstrate whether fish do compensate for the behavioral changes due to fin damage.

Severe fin damage is indicative of bad fish health and acts as fish quality indicator (13, 15, 18). Therefore, the difference in the fin damage level indicates that it may be possible to improve the fin profile on rainbow trout farms, which would benefit both the welfare of the fish and the aesthetic quality of table fish.

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Please cite this article as: Cvetkovikj Aleksandar, Radeski Miroslav, Blazhekovikj-Dimovska Dijana, Kostov Vasil, Stevanovski Vangjel. Fin damage of farmed rainbow trout in the Republic of Macedonia. Mac Vet Rev 2013; 36 (2): 73-83.