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Study of morphological changes in Brown trout (*Salmo trutta fario)* from Lar Reservoir in IRAN

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ABSTRACT

Brown trout is a vulnerable flock of Caspian Salmonid fishes and usually spreads over most freshwaters upstream of Caspian catchments such as northern rivers of Iran. This fish has good supplies in Lar Reservoir of Mazandaran province, so that a number of 17862 entries of fishery permit were issued in 2006 (July to September). This study was carried out with the aim of taking knowledge of the morphological characteristics and its changes in Salmo trutta fario, to achieve this purpose 190 samples of red spotted trout caught from Elarm, Ab-Sefid, Kamardasht (Lar) and Delichaie of Lar Reservoir lake basin were studied using Electroshocker set in the fall of 2008 and summer and fall of 2009. The averages weight and fork length of studied fish were 136.86 ±103.4 g and 212.81±49.6 mm, respectively. The results show that these fish are descriptively (body color and spots, fins location etc) analogous to other red spotted trout fishes. A number of 17 variables were counted among which the number of scales on lateral line is 108-134, un-branched and branched rays in dorsal fin are 2-5 and 8-11, respectively and in anal fin are 2-5 and 6-9 respectively, the number of gill rakers are 15 to 21 and vertebrae are 57 to 60. From the assessment point view 31 factors were measured among them the averages of some factors are as follow: head length: 22.34±1.4, head depth: 14.80±1.1, maximum body height: 20.87±1.7, dorsal fin base length: 12.52±1.2, pectoral fin length: 15.60± 1.2, ventral fin length: 12.39±1.0, anal fin base length: 9.38±0.9, pre-dorsal distance: 41.24±1.9 and pre-ventral distance: 46.84±2.3 percent of fork length. Meristic counts differences between males and females were not significant, but statistical differences between 18 morphological factors were significant. Differences were significant at a=0.001 in 9 factors, at a=0.01 in 5 factors and at a=0.05 in 4 factors. It is totally suggested that the results from morphometric and meristic data of the present study greatly differ from results from republic of Azarbayjan and seems to be a distinct population.

Key words: Brown trout, Salmo trutta fario, Morphology, Lar Reservoir, Iran.

INTRODUCTION

Salmonids (Salmonidae) possess 11 genera and 66 species and inhabit in cold and clear waters with high oxygen and feed on aquatic insects, fish and other aquatic animals [1]. A group of them are anaderomous fishes and migrate from sea to freshwaters for spawning and other groups of them like red spotted trout fishes are considered as potamodromous which inhabit rivers and lakes and migrate to river upstream to spawn [2,3]. Brown trout is a vulnerable flock of Caspian salmonids and often spreads over freshwaters of Caspian catchment [4, 5, 6].

Brown trout inhabits high lakes and rivers upstream and waters with high Oxygen, steep slope, fast flow, and adequate food [2, 3]. This is one of valuable conservative fishes of rivers such as Lar, Plor, Karaj, Shirud, Tajan , Haraz, Tonekabon, Havigh, Shafarud, Chesli , Sefidrud and many of other rivers of Guilan province [4,7,8,5]. The population of this fish is dominant in tributaries of Lar reservoir which is considered as an important and appealing site of tourism that hosts broad swarms of domestic and foreign tourists, environment friends and sport fishermen each year, brown trout also consists more than 99% of caught fishes in Lar Reservoir and studied rivers reaching the lake. Every year Environmental Conservation Organization acts to sale permits for brown trout catch in Lar Reservoir; for example a number of 17862 entries of fish catch permits were issued in a time period of 75 days from the beginning of July to early September in 2008 [9]. This species possesses delicious meat but its commercial culture is not performed due to low growth rate and the catch of this fish is only considered as a recreation and hooking [10]. Review of the previous researches shows that some studies have been done on this species overseas among which are the researches by Quliyev [6] in the rivers of the republic of Azarbaijan and of [11] in the rivers of Litwania. So far few studies have been done on brown trout in Iran; [12] studied biological properties of this fish in Tonekabon River. The earliest studies on morphology of brown trout in Iran are probably those of [13] in Karaj River who has considered this trout as typical brook species.

According to Quliyev [6] the riverine or brown trout has great variability in measurements and negligible changes in meristic counts in different rivers. Since fishery biologists consider population as the base of supplies exploitation, morphometric-meristic investigation of brown trout in Lar Reservoir which is a conservative region and a shelter for wild life, is of high importance; thereby knowingly and wise measures for rational exploitation and probably restoration of these supplies of fishes will be done. There is not documented information regarding to morphology of brown trout in Lar Reservoir, so researchers have made efforts to measure these properties and determine sexual changes of these attributes in the studied area. Lar Reservoir is a tributary of Haraz River and it enters into Caspian Sea at central area of southern part and Lar river dam has been constructed in 1982 as far as 75 km of Tehran and it is located at 51°59´45´´ longitude and 35°53´45´´ latitude and its absolute height is 2531 m. The reservoir receives its water from 4 main branches including Delichae, Absefid, Elarm, Lar or Kamardasht [9].The temperature of studied area is between -32 to +39 °c and the glacial period lasts for 5 months [9].

MATERIALS AND METHODS

According to short distance among fish sampling sites (4 tributaries) in Lar reservoir basin, they were all considered as a unit studied area (figure 1). The trout fishes were sampled using constant electroshocker (200-250^{V} and 3-5 ^{A}) and also portable Electroshocker (Karl Von Keitz Model) in October and November 2008 and August and October 2009. It was obtained 54 samples of the fish from Absefid river (N 35° 55´ 56.2´´ E 51° 56´ 41.6´´), 34 samples from Delichae river (N 35° 55´ 02.3´´ E 51° 59´ 36.4´´), 66 samples from Elarm river (N 35° 55´ 37.6´´ E 51° 54´ 10.5´´) and 36 samples from Kamardasht river (N 35° 55´ 06.7´´ E 51° 52´ 13.5´´) and they were selected randomly.

Figure 1. the outline of Lar Reservoir basin and its rivers

Sampled trout specimens were carried to laboratory in fresh form and morphologic measurements and meristic counts has been done and data were noted. Measuring and counts have been done on standard methods [14, 15, 16, and 4]. The body component measurements were done by caliper to nearest 0.1 ^{mm} and weights were determined by digital scale to nearest 0.1 ^{g}. Data from anatomical studies and descriptive features such as mouth position, gill raker, body color, spots on body and fins were recorded, too. Relative morphometric measurements (the proportion to fork length) and meristic counts data were set and processed, and their Ranges, averages and standard deviations were prepared using SPSS software (version 13) and presented as tables [17,18]. To determine the statistical differences between males and females the analysis of variance and the means comparison test (t-student) at a=0.05 were used [19].

RESULTS

The measurements of morphometrically and meristically studied trout fish samples (190 samples) were as follow: weight: 893.9 to 22.1 (136.86+103.4) g, total length : 127 to 462 (219.75+50.0) mm, fork length: 122 to 448 (212.81+ 49.6) mm, standard length: 108 to 392.9 (184+42.4) mm; the mean weights of males (110 samples) and females (76 samples) were

measured as 140.55+ 13.4g and 122.29+ 14.0 g respectively; their fork lengths were 214.96+ 20.5 and 205.31+23.6 mm respectively.

Table 1: data from counting meristical variables in brown trout of Lar Reservoir basin

Row	Counting factors	Sample number	Minimum	Maximum	Mean	S.D
1	Scales on lateral line	190	108	134	119.16	2.93
2	Scales above the lateral line	190	24	32	28.08	1.46
3	Scales below the lateral line	190	18	27	22.72	1.63
4	Scales between the lateral line and fin fat	190	14	20	17.22	1.09
5	Number of spines in Dorsal fin	190	3	5	4.25	0.45
6	Number of soft rays in Dorsal fin	190	8	11	9.55	0.69
7	Number of spines in Anal fin	190	2	5	3.30	0.50
8	Number of soft rays in Anal fin	190	6	9	8.10	0.69
9	Number of spines in Ventral fin	190	1	1	1.00	0
10	Number of soft rays in Ventral fin	190	7	9	7.78	0.46
11	Number of spines in Pectoral fin	190	1	1	1.00	0
12	Number of soft rays in Pectoral fin	190	11	12	11.38	0.49
13	Soft rays of Caudal fin	190	16	17	16.96	0.19
14	Gill rakers	190	15	21	17.63	1.21
15	Gill filaments	190	9	12	10.16	0.46
16	Number of trunk vertebrat	20	57	60	58.05	0.95
17	Pyloric coeca	52	31	49	38.10	3.26

The general matrix colors of pectoral, ventral, anal and caudal fins were yellow to graphitic yellow but the terminal to the middle parts of pectoral and ventral fins were usually graphitic and the remained yellow; the anal fin was yellow with graphitic matrix and caudal fin from the middle to the end was yellowish graphitic and the matrix color of the dorsal fin was also yellow and its margin was graphitic with orange spots, dark and graphitic with moderate and coarse sizes. The scales were fine, lateral line was approximately direct, adipose fin was lower than moderate level and pectoral and ventral fins were relatively small. There were many teeth in nearly equal moderate sizes on the upper and lower jaws, hyoid, vomer, supramaxillary and palatines and branchial rakers were also serrate, rough, thin, sharp and relatively long.

The results of the present study showed that the number of scales on the lateral line was 108 to 134; the number of non- branched and branched rays in dorsal fin were 2 to 5 and 8 to 11 respectively; the number of non- branched and branched rays in anal fin equaled 2 to 5 and 6 to 9 respectively; the number of branchial rakers was also 15 to 21; the number of branchio teges were 9 to 12; the number of spine vertebra was 57 to 60 and the number of pyloric caeca equaled 21 to 49 (table 1). The ranges and averages of other meristical variables such as the number of scales above and below the lateral line, pectoral, ventral and caudal fins formula are presented in table 1. The results of morphometery also showed that the head length ranged between 18.3 to 25.9%, the snout length between 3.9 to 7.2%, the upper jaw length between 7.2 to 12.6%, the lower jaw length between 9.5 to 16.4% and the eye ball diameter ranged between 3.9 to 7.0% of the fork length. Also the maximum height of the body was 16.1-25.1%, caudal peduncle length was 10.4-19.2%, the dorsal fin base length was 10.2-15.7%, pectoral fin length was 12.3-19.2%, ventral fin length was 9.4- 14.8% and the anal fin base length was 7.2-12.0% of the fork length (table 2). In addition, the adipose fin length was 2.5-5.2% and its height was 5.8- 10.2%, the distance between the snout tip to the beginning of ventral fin (the pre- ventral length) was 42.7-51.0% and the distance between the snout tip to the beginning of anal fin (the pre- anal length)

was 57.3- 68.8% of the fork length and the range and average of other morphometrical variables (totally 31 morphological factors) are also presented in table 2.

Differences were observed in colors between the two sexes. The color of male body, head and fins was dark olive; fins of males were thicker and the lower jaw was reversed upwards. The investigation of the morphometrical differences between males and females of trout fish showed that there was no significant meristical difference between the two sexes, but there was a statistical significant difference in 18 of 31 morphometrical factors (table3). As it is clear from table 3, the mean values of 16 morphometrical factors and the mean values of 2 meristical factors (the distance of ventral-anal fins and the anal fin base length) in females are significantly higher than those in males. Totally in 41.94% of morphometrical factors (13 factors) there was not any difference between the two sexes and the differences observed at a=0.01 in 13.16% of meristical factors (5 factors) and at =0.001 in 29.03% of meristical factors (9 factors).

Table2. Table 1 data from counting morphometrical variables in brown trout of Lar Reservoir basin

Row	Measurement Factors	Sample number	Minimum	Maximum	Mean	S.D
1	Head length	190	18.3	25.9	22.34	1.41
2	Snout length	190	3.9	7.2	5.53	0.79
3	Length of maxillary	190	7.2	12.6	9.96	1.14
4	Length of mandibular	190	9.5	16.4	12.45	1.33
5	Eyeball diameter	190	3.9	7.0	5.17	0.59
6	Distance of interorbital	190	5.0	8.5	6.53	0.65
7	Postorbital head length	190	9.9	14.7	12.29	0.94
8	Maximum height of body	190	16.1	25.1	20.87	1.68
9	Minimum height of body	190	6.2	11.6	8.77	0.91
10	Caudal peduncle length	190	10.4	19.2	15.23	1.53
11	Dorsal fin base length	190	10.2	15.7	12.52	1.15
12	Dorsal fin height	190	10.2	19.0	14.31	1.99
13	Pectoral fin length	190	12.3	19.2	15.60	1.20
14	Ventral fin length	190	9.4	14.8	12.39	1.04
15	Distance pectoral –Ventral	190	24.4	35.2	29.62	1.98
16	Distance Ventral-Anal	190	14.2	22.3	18.24	1.45
17	Anal Fin height	190	9.0	15.5	12.14	1.23
18	Denominator Anal fin base length	190	7.2	12.0	9.38	0.91
19	Between the Dorsal	190	30.4	40.0	36.6	1.87
20	Length between Dorsal and Adipose fins	190	15.1	23.2	19.53	1.60
21	Length between Caudal and Adipose fins	190	10. 4	5.3	13.0	0.92
22	Adipose fin height	190	5.8	10.2	7.95	1.0
23	pre-Ventral length	39	42.7	51.0	46.84	2.32
24	pre-Anal length	39	57.3	68.8	63.46	2.91

In the other hand, there are significant differences between males and females in head length, head height in the neck, Snout length, the upper jaw length, the lower jaw length, Inter eye distance, posterior eye length, ventral fin length and adipose fin height factors (table 3). Most of the observed differences are related to head components.

DISCUSSION

Numerous fish biologists have studied descriptive and morphological properties of fishes in Caspian catchment among the most important of them are the researches of [20, 5, 21, 22, and 6]. Several researchers such as [23, 25, 26, and 27] have studied morphological properties of fishes

in costlines of Iran. Their results showed that species in different regions possess moderate to high changes in color and morphology and minute changes in meristical attributes and in most regions form ecological populations.

Table3. morphometrical differences between the two sexes of brown trout in Lar Reservoir basin (proportional to body fork length(%))

Row	Measurement Factors	Males number	(Mean±S.D)	female number	(Mean±S.D)	(P-Value)
1	Head length	110	22.80±1.44	76	21.67±1.00	0.001
2	Snout length	110	5.70±0.71	76	5.26±0.83	0.001
3	Length of maxillary	110	10.28±1.19	76	9.44±0.83	0.001
4	Length of mandibular	110	12.77±1.06	76	11.85±0.95	0.001
5	Pectoral fin length	110	15.83±1.26	76	15.27±1.03	0.01
6	Distance of interorbital	110	6.69±0.66	76	6.27±0.52	0.001
7	Ventral fin length	110	12.71±1.03	76	11.94±0.89	0.001
8	Postorbital head length	110	12.48±0.90	76	11.97±0.89	0.001
9	Distance Ventral-Anal	110	17.98±1.30	76	18.65±1.60	0.01
10	Maximum height of body	110	21.10±1.67	76	20.48±1.60	0.05
11	Denominator fin base length	110	9.26±0.97	76	9.55±0.83	0.05
12	Minimum height of body	110	8.94±0.92	76	8.57±0.85	0.01
13	Dorsal fin height	110	14.58±1.95	76	13.90±2.05	0.05
14	Denominator adipose fin base length	110	3.77±0.59	76	3.55±0.65	0.05
15	Adipose fin height	110	8.34±0.96	76	7.37±0.77	0.001

Brook trout has variable coloration and according to habitat, age, gender, season and genital materials changes color intensively. Out of breeding season, the back of fish is dark green and the sides are light, the color of semi- inferior of the body is pale to blond but at breeding season the color of male body is homogeneous olive [28]. According to [29] there are completely big circle dark spots on the operculum, red spots on the dorsal and adipose fins and other fins remain colorless. Although having some minute differences with valid references [6,28,29,4,27], the descriptive results of the present study corresponds totally with the findings of the above references in teeth, mouth shape, body coloration and spots existing on the body and fins and also the shape of caudal fin.

Comparison of the meristical data from the present study with the other water resources such as Gigel lake and Khalkhalchae and Lankaranchae rivers stusies by [6] showed that some meristical data are approximately located inside the range of these water resources; for example the number of scales on the lateral line equaled to 108 – 134 in the present study, 116 - 134 in Gigel lake, 111-131 in Khalkhalchae river and 119 – 132 in Lankaranchae river, but there as not any similarity in the number of vertebra and pectoral fin branched rays. But a few meristical variables in the present study differ from the mentioned water bodies; for example the number of pyloric caeca processes in the present study (31 to 49) is lower than those of most of them (37 to 82) but corresponds nearly with the results of Ekrachae river (26 to 65), the number of branchio raker in the present study (15 to 21) is also lower than those of republic of Azarbayjan water resources (19 to 24).

The number of non – branched rays in dorsal and anal rays was more than the above water bodies (3 to 4), so it is included that not only there are differences between the range of meristical data from the present study and the above water resources but also in many cases there are differences

between the mentioned water bodies themselves which is particularly obvious in the case of differences between Gigel lake and rivers.

The comparison of meristical data means in the present study with the water resources of republic of Azarbayjan [6] also indicates the differences between Lar dam samples and those of them in most variables, but a relative similarity is observed with Ekrachae river (table 4).

Table4. The comparison between the trout morphometrical results of the present study and those of other water resources (Quliyev , 2005)

Row	Counting factors	Lar dam	Gigel lake	Lankaranchae river	Khalkhalchae river	Shamkirchae river	Ekrachae river
	Fork length	212.8	303.0	147.0	122.0	197.8	180.6
1	Number of trunk vertebrat	58.05	56.45	57.1	58.4	56.21	59.15
2	Scales on lateral line	119.16	122.20	127.3	121.0	125.10	118.26
3	Scales above the lateral line	28.08	28.4	29.3	28.9	32.87	29.45
4	Scales below the lateral line	22.72	26.72	25.7	24.7	22.65	25.67
5	Pyloric coeca	38.10	54.97	70.0	55.6	47.26	49.54
6	Number of Gill rakers	17.63	19.05	18.10	20.40	15.86	22.30
7	Soft rays in Dorsal fin	9.55	10.36	10.60	10.10	10.29	9.76
8	Soft rays in Anal fin	8.10	8.53	8.70	8.60	8.50	8.10
9	Soft rays in Pectoral fin	11.38	12.05	11.90	11.80	11.88	11.43
10	Soft rays in Ventral fin	7.78	8.11	8.26	8.20	8.33	8.71
11	Snout length	5.53	4.85	5.40	5.30	5.48	5.38
12	Eyeball diameter	5.17	3.62	6.00	6.10	5.20	4.15
13	Postorbital head length	12.29	9.86	11.70	11.90	11.90	11.91
14	Head length	22.34	20.03	22.50	23.00	22.39	22.08
15	Distance of interorbital	6.53	6.19	5.70	6.80	4.98	6.30
16	Length of maxillary	9.96	10.09	8.70	9.20	10.19	10.61
17	Length of mandibular	12.45	12.11	12.00	12.50	12.10	12.07
18	Maximum height of body	20.87	21.01	19.70	19.80	20.02	20.85
19	Minimum height of body	8.77	8.32	8.40	8.50	9.00	8.91
20	Pre-Ventral length	46.84	49.51	48.50	48.70	48.22	48.05
21	Pre-Anal length	63.46	68.10	65.40	65.50	66.62	66.11
22	Between the Dorsal	36.60	41.75	39.80	33.76	40.22	40.41
23	Peduncle Caudal length	15.23	18.05	18.40	16.90	17.67	17.96
24	Dorsal fin base length	12.52	12.53	11.40	11.20	13.10	12.32
25	Dorsal fin height	14.31	12.51	15.10	14.80	12.95	13.54
26	Denominator fin base length	9.38	8.78	8.90	8.90	8.94	8.78
27	Anal Fin height	12.14	10.33	13.00	15.60	12.20	11.36
28	Pectoral fin length	15.60	15.22	15.70	17.30	16.83	16.78
29	Ventral fin length	12.39	11.14	11.70	13.40	13.08	12.59
30	Distance Pectoral –Ventral	29.62	31.63	28.00	28.50	28.71	28.99
31	Distance Ventral-Anal	18.24	19.63	18.60	18.10	19.60	18.39

The spine vertebra means in Lar dam were more than Gigel Lake and in contract about half of meristical variables such as the number of scales on the lateral line, the number of pyloric caeca processes and brachio rakers of Lar dam samples were lower than Gigel dam. In comparison with Lankaranchae River which is nearer to Lar dam basin, the meristical differences between the number of scales on the lateral line and above it, and also the number of pyloric caeca processes are completely apparent and other variables have minute external differences. The meristical differences exist not only between Lar lake samples and those of the water resources of republic of Azarbayjan, but also there are reports suggesting differences between those water bodies themselves [6] (table 4).

Comparison of the morphometrical data of Lar dam basin with other water resources (table 4) presented by [6] shows differences and similarities. For example the average of head length in Lar and Gigel lakes and Lankaranchae, Khalkhalchae, Shamkirchae and Ekrachae rivers are 22.34, 20.03, 22.50, 23.00, 22.39 and 22.08% of body fork length respectively and pectoral fin length are 15/60, 15.22, 15.70. 17.30. 16.83 and 16.78% of body fork length respectively (table 4). As it is seen Lar lake samples show lower similarities with those of Gigel Lake and higher similarities with those of rivers. Gigel Lake has originated in 12 A.D. and fishes inhabited there have changed their natures which differ from their primal form of lives in morphological beacons and life style [6], while Lar Lake is 25 years old. The means of the fork lengths of studied fishes are different in the two lakes (table 4). Since some of morphometrical variables such as snout length, eye diameter, dorsal fin length and length depend on the body size [6], so this is another factor of differences between the fishes of two lakes. Riverine trout fishes possess longer body, caudal peduncle, ventral and pectoral fins, head length and height to feed properly and overcome the water flow in rivers with fast flows but in lakes, the distance between ventral and pectoral fins and dorsal fin length has little increased [6] so it is suggested that the trout of Lar lake are more riverine than laker due to new formation of the lake and also spending a part of life in the rivers of the basin. The comparison of the red spotted trout morphometrical variables in Lar Lake with those in Lankaranchae [6] indicates that the most of variables in the present study have wider ranges and the ranges of some variables are the same or a little lower. According to table4 the differences in posterior distances, caudal peduncle length, anal and dorsal fins heights, pectoral fin length and head height in the cranium terminal among mentioned water resources are more than other morphological variables stated by [6]. Generally morphological properties are controlled by intractions between environmental conditions and genetlcs [30, 32]. Environmental properties were dominated during fish primal evolution and individuals are more susceptible to environmental conditions, fishes that live in the same conditions during their early periods of life possess the same morphological situations [32]. The direct impact of diverse environmental factors on fishes in addition to a broad spectrum of species reactions are the main reason for their morphological beacons variability [33]. According to [6] morphological beacons of trout from different rivers of Azarbayjan and different ecological conditions specially temperature and food, cause formation of different populations that are differ from each other in morphometrical and meristical beacons. On the base of [6] brook trouts have distinct ecological populations in great Ghafghaz, little Ghafghaz, Talesh and Gigel lake. The results of Akbarzade [26] showed that 64/1% of morphometrical properties and 46.2% of meristical variables of red spotted trout in two rivers heslimasal and Khormaroud, Langroud, differ from each other. This phenomenon not only involves red spotted (brook) trout but also contains other species of salmonids [20, 6]. White perch (*Sander lucioperca*) in the Lake of Aras dam, Anzali lagoon, and eastern and western coastlines of Gilan province has moderate morphological and minute meristical changes [26]. The studies of Quliyev [6] showed that morphometrical beacons of trout fishes in different rivers of Azarbayjan are of high variability and among meristical beacons the number of scales on the lateral line and the number of vertebra have relatively lower constancy. The studies of Quliyev [22] on the economic carps and perches of southern and middle Caspian showed that most of these fishes are generating new species and have formed populations, for example kolme has formed 7, common carp 4, dark coli 3 and white fish 2 ecological flocks. Sand gobiids in the study area in coastlines of Gilan province also have significant differences in morphometrical properties [25]. The studies of Abbasi [23] showed that siacoli (local name of the fish) of

Sefidroud is different from other Caspian siacolis. On the base of literature it is suggested to prioritize the population related investigations (morphometrical and meristical).

CONCLUSION

Based on the study 18 differences in morphometrical parameters has distinguished between two sexes of Brown trout (*Salmo trutta fario*) in Lar Reservoir basin; but in 9 parameters the differences was significant. The differences might be created through the subsist in river and lake ,two different environment, so in order to comparison and realize reasons of the differences, survey of Brown trout in other adjacent regions is necessary. Identification of different population is the necessity of stock recruitment.

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