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Review article

STUDY OF *Salmo* GENUS (PISCES, SALMONIDAE) ON THE BALKAN PENINSULA

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Summary

Author disputes the position of the authors K o t t e l a t (1997) and K o t t e l a t & F r e y h o f (2007) about the existence of several species belonging to the *Salmo* genus in some parts of Balkan Peninsula: *Salmo aphelios* Kottelat, 1997; *Salmo balcanicus* (Karaman, 1927); *Salmo farioides* (Karaman, 1938); *Salmo labrax* Pallas, 1814; *Salmo letnica* (Karaman, 1924); *Salmo lumi* Poljakov, Filipi & Basho, 1958; *Salmo macedonicus* (Karaman, 1924); *Salmo montenigrinus* (Karaman, 1933); *Salmo pelagonicus* Karaman, 1938; *Salmo peristericus* Karaman, 1938; *Salmo taleri* (Karaman, 1932). Majority of those species were described by dr. Stanko Karaman, the author who is, regarding the number of described species of European freshwater fishes, on the second place, just behind Carl Linnaeus. It is hardly believable that four trout species were formed in a small and oligotrophic microhabitat like Ohrid Lake, or three species in the Vardar River, knowing that the factor of geographic isolation doesn't exist in either of the habitats. The author's position is that all of these species are actually just types of one, highly plastic regarding the micro ecological conditions and phenotypic manifestations, species: *Salmo trutta* (Linnaeus, 1785). The author supports his opinion by his own results, as well the results of other scientists, obtained through studies of ecology and taxonomy of the brown trout in fluent and still water microhabitats. Also the author suggests that it is unacceptable to apply the terminology immanent to the anthropogenic factor in a sphere of another scientific area where such factor doesn't exist (agronomy-race and biology-natural selection).

Key words: *Salmo trutta*, fish taxonomy, evolution theory, Darwinism

INTRODUCTION

By the time of publication of the epochal work of the Swedish scientist Carl L i n n a e u s "**Systema naturae**" (1748)-the system/nomenclature of the Artedi's Ichthyology (K o t t e l a t, 1997), in the newest list of European freshwater fish settlement K o t t e l a t & F r e y h o f (2007) count to 503 (20 still nameless) species. Comparing the species

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listed there, one conclusion arises: the scientist to describe the largest number of fish species, after Carl Linnaeus (56 species), is dr. Stanko Karaman (34 species). Comparing the *terra typica* of the species he has described (K a r a m a n, 1961), one can see that the most of his work is related to Macedonia. This research will mainly focus on several species of *Salmo* genus described by him: *S. balcanicus*, *S. farioides*, *S. macedonicus*, *S. montenigrinus*, *S. pelagonicus*, *S. peristericus*, *S. taleri*) or imputed to be "described" by him ("*Salmo letnica*"="*Salmo aphelios*") in Š o r i ć (1990), K o t t e l a t (1997), S e l l & S p i r k o v s k i (2005) and K o t t e l a t & F r e y h o f (2007). Himself, K a r a m a n (1957), clearly rejected the "existence" of a species "*S. letnica*". In his capital work (K a r a m a n, 1928) he mentions "*S. letnica*" within the description of the "*S. dentex*", though not as an objective ("undisputable") "new species", but only as possible (eventual). As the this work has only summary in English, it is possible that a linguistic barrier may have been the cause of this confusion in the works of K o t t e l a t (1997) and K o t t e l a t & F r e y h o f (2007).

Among the listed fish species in the work of K o t t e l a t & F r e y h o f (2007), *Salmo lumi* can be found, which was inaugurated as "subspecies" "*Salmo letnica lumi*" for the Western part of the Ohrid Lake near the boundary to another state. Because the fishes don't recognise "frontiers" it's very hard to accept the objectivity of the existence of the species that respects anthropologic criteria.

According to K o t t e l a t & F r e y h o f (2007), 181 author participated in the forming of the actual taxonomy of the European freshwater fishes.

DISCUSSION

The most extensive work on species of the *Salmo* genus has been performed by Karaman (1928, 1937, 1957). According to the authors K o t t e l a t & F r e y h o f (2007), out of 18 species in Salmoniformes order listed for Balkan Peninsula, 7 of them are described by dr. Stanko Karaman as "undisputable" for him (Table 1).

Table 1. List of species in the order Salmoniformes listed in K o t t e l a t (1997) and K o t t e l a t & F r e y h o f (2007) for Balkan Peninsula. Species described by dr. Stanko Karaman are marked by an asterisk

Tablica 1. Popis vrsta Salmonida u K o t t e l a t (1997) i K o t t e l a t & F r e y h o f (2007) na Balkanskom poluotoku; vrste opisane po dr S. Karamanu označene su zvjezdicom

1. *Hucho hucho* (Linnaeus, 1758)
2. *Salmo aphelios* (Kottelat, 1997)
3. *Salmo balcanicus* (Karaman, 1927)*
4. *Salmo dentex* (Heckel, 1852)
5. *Salmo farioides* (Karaman, 1938)*
6. *Salmo labrax* (Pallas, 1814)
7. *Salmo letnica* (Karaman, 1924)*
8. *Salmo lumi* (Poljakov, Filipi & Basho, 1958)

9. *Salmo macedonicus* (Karaman, 1924)*
10. *Salmo marmoratus* (Cuvier, 1829)
11. *Salmo montenigrinus* (Karaman, 1933)*
12. *Salmo obtusirostris* (Heckel, 1852)
13. *Salmo ohridanus* (Steindachner, 1892)
14. *Salmo pelagonicus* (Karaman, 1938)*
15. *Salmo peristericus* (Karaman, 1938)*
16. *Salmo taleri* (Karaman, 1932)*
17. *Salmo trutta* (Linnaeus, 1758)
18. *Salmo sp.* (Louros)
19. *Thymallus thymallus* (Linnaeus, 1758)

The position of the author of the debate on the species introduced by dr. Stanko Karaman for the Balkan Peninsula Salmo genus representatives

The Salmoniformes are known to dominate as a top predator of the trophy pyramid in cold waters of the Northern hemisphere (Notogea), both running and still water. The most important ecological factor "limiting" the life of *Salmo* genus is water temperature (4-18 °C), which also means the rhythm of life cycle of the members of the *Salmo* genus is slower than in other freshwater fishes in Europe. For example, P e t r o v s k i (1960) has stated that *Perca fluviatilis* Linnaeus, 1758 populations in the eutrophic Doyran Lake mature at the age of 1+ (males, 33 %) or 2+ (females, 98 %), while females of the *Salmo* genus in the Ohrid Lake microhabitat mature at the age of 7+ (S t e f a n o v i ć, 1948). That also means that evolution of trouts should be much slower than evolution of other fish species. Considering large number of microhabitats all over Europe that *P. fluviatilis* inhabits, a question arises: why doesn't the genotype of *P. fluviatilis* develop into more species (the geographic isolation exists!), when in only one microhabitat, there exist even four trout species. In principal, this is valid also for all the next salmonid species listed by K o t t e l a t & F r e y h o f (2007) for the Balkan Peninsula: "*S. dentex*", "*S. farioides*", "*S. labrax*", "*S. macedonicus*", "*S. montenigrinus*", "*S. pelagonicus*", "*S. peristericus*", "*S. taleri*" and "*Salmo* sp. Louros" (excluding the *S. marmorata* and *S. obtusirostris* whose status is not disputed).

The "molecular clock" of the *Salmo* genus (excluding *S. ohridanus*, *S. obtusirostris*, *S. marmorata* and most probably *S. carpio,* which are excluded from the debate as the author is not sufficiently familiar with them) "ticks" far slower than in other fishes, so objectively, they had not enough (geological) time to evolve into a new species. If we agree to this, how can we explain differences among populations in a single microhabitat of Ohrid Lake? The answer, regarding all cited above, is by their unusually large genetic plasticity stemming from polyploidy.

When commenting the warnings of other ichthyologists on the plasticity of the trouts, B e r n a t c h e z et al. (1992) and K o t t e l a t (1997) write: "This might be true, but the published data do not support this conclusion because there have been so few detailed morphological descriptions"... "the utility of morphological criteria... is hampered by their phenotypic plasticity", "phenotypic plasticity... limits the usefulness of morphological characters" (p. 161).

It is strange that some of the populations (or groups of populations) originating from the same colonizers (let's call it "prae-marmorata" shool) and soft-muzzled descendants of *S. obtusirostris* and *S. ohridanus* continue their evolution, while in the same habitats (same ecological conditions) even 3 species (*S. farioides*, *S. dentex*, *S. montenigrinus*, originating form the same species, let's call it provisional "prae-brown trout" shool) have "stopped" their further evolution in some independent riverine flows (Zrmanja, Krka, Cetina, Neretva, Drim/Bojana system, Devoli, Vjose) where the isolation mechanism as condition is satisfied, but has "advanced" the evolution of *S. trutta* (V u k o v i ć & I v a n o v i ć, 1971) in the Ohrid Lake, where there is no isolation mechanism. Many tertiary forms that disappeared from European freshwater habitats during Diluvium managed to survive in the Ohrid Lake due to stable ecological conditions. If the stable ecological conditions served as conservators for other groups, why is it not the case with the *Salmo* genus representatives? Furthermore, for the neighboring river Vardar, the authors K o t t e l a t & F r e y h o f (2007), list three species inside the genus *Salmo*: *S. macedonicus* - majority of the Vardar river flow, *S. pelagonicus* (found in Tsrna Reka tributary) and *S. labrax* (Lipkovska Reka, a small ecologically isolated salmonid microhabitat, tributary of the river Ptchinya, which is also a Vardar tributary). Similarly, the fact that *S. trutta* is supposed to be present in the upper reaches of the Danube, while *S. labrax* is supposed to be present in middle and lower reaches. Raises the question: where is the "border"? What "stops" the miscegenation by "both" the "species" when not any impassable barrier exists to (waterfall, dry stream)? How can we explain the fact that other species (Acipenserid, Silurid, Cyprinid, Percid, Esocid, Gadid) move up and down the streams, but the trouts "do not"?! How can the "stopped" evolution be explained in separated flows where the isolation mechanism is present (Danube River population consisting of numerous ecologically isolated micropopulations), while the evolution "normally continued" in the Vardar river flow (absence of the isolation mechanism)? Furthermore, in the flow of the Tsrna Reka, where the microhabitats of some reaches are practically isolated by the ecological factors of the surrounding Baba and Nidzhe mountains (K a r a m a n, 1937; E c o n o m i d i s, 1991; G e o r g i e v, 1998), the principle of the absence of isolation mechanism is seemingly respected, even though it has obviously existed for at least several thousands of years. If a specimen of Brown Trout (*Salmo trutta* Linnaeus, 1758) originating from Lipkovska Reka (from the Macedonian Museum of Natural History in Skopje) is compared to the "*S. macedonicus*" sample shown on the page 422 in K o t t e l a t & F r e y h o f (2007), both specimens have similar size, colour and number of spots. Because the shape of the so called "*S. pelagonicus*" from Tsrna Reka is identical to samples inhabiting the Prespa Lake confluents listed as "*S. peristericus*", couldn't it be the same species?

It has been shown that the upper parts of the Devoli river (Adriatic Sea drainage) are in contact with the upper parts of the Bistritsa river (G e o r g i e v, 2003), according to K o t t e l a t & F r e y h o f (2007) also inhabited by "*S. pelagonicus*" (the same one from Tsrna Reka and confluents) and has served as "bridge" where from the endemic genus *Pachychilon* (as well as *Chalcalburnus belvica* (Karaman, 1924) and *Alburnus belvica* (Karaman, 1924)); has extended in both the neighboring flows: Boyana/Drim (Adriatic Sea watershed) and Vardar/Bistritsa flows (Aegean Sea watershed). If the areal extension of the endemic species *Chondrostoma vardarense* Karaman, 1928 both in K o t t e l a t

(1997) and K o t t e l a t & F r e y h o f (2007) is going to be added, far larger than of those both mentioned first, it's obvious that in the fluvial periods Prespa Lake used to be in a close contact to the neighboring flows/watershed, thus exchanging the ichthyofauna (K a r a m a n, 1971). It's believed that connections existed on several occasions and that the lake was inhabited by Cyprinids before *S. trutta* appeared as colonizer. Other question is if the original colonizing specimens of *S. trutta* have had on disposition enough time to evolve to a status of a different species.

Another illogical spot in dr. Stanko Karaman's position on the taxonomy of the Balkan Peninsula salmonids regarding the evolution mechanisms exposed in D a r w i n (1859) should be stressed. K a r a m a n (1937) lists a species "*S. taleri*" in both the neighboring watersheds: Adriatic Sea (Zeta River-surface stream, "Jasenica"-Lika, underground disappearing stream) and Black Sea ("Bosnien bei Drvar" – probably referring to Una river or some of the tributaries, Biogradsko lake "Tara - Zufluss"). What about the "*S. labrax*" in K o t e l l a t & F r e y h o f (2007) from middle and lower reaches of Danube and "*S. trutta*" upper reaches (Northern Alps streams)? Which "factor" did "stop" the mixture of the specimens in the Danube river flow? In the past (500 000 – 900 000 of years in O s i n o v & B e r n a c h e z (1996); 450 000-700 000 years in B e r n a t c h e z et al.(1992); 40 000-60 000 in K a r a k o u s i s & T r i a n t a p h y l l i d i s (1988); 300 000 in A p o s t o l i d i s et al. (1996)), except for the summer, during other period of the year, the *Salmo* genus representatives could freely move up or down and mix the genotypes.

To defend the proposed *Salmo* taxonomy, K o t t e l a t (1997) says: "I haven't got enough proofs that the trouts do show large morphological plasticity", but the published researches on the trouts living in the Balkan Peninsula waters speak differently.

The L-W relationship of specimens from the upper part of Lipkovska River microhabitat, differ from the specimens inhabiting the lower reaches (G e o r g i e v, 1978). While the values from the lower reaches (logW=2,88237*logL-1,7017) are similar to those in Dosnica (logW=2,96282*log L-1,81184) and Kadina Reka (logW=2,95342*log L-1,80967), values in the upper reaches differ significantly (logW=2,69097*logL-1,55311). In other words, different values for this relationship suggest the existence of a morphometric differences: the specimens from the upper reaches are relatively small dimensions (Lc below 22 cm, weight 140 g, large head and smaller body). In the upper reaches, the water is shallow and narrow, and quantity is only 3-5 l/sec, lower reaches are richer in water (more than 50 L/sec) and water is deeper.

The results of S i d o r o v s k i (1955, 1960, 1971) are further proof for the plasticity of Brown Trout: morphometric studies of two artificial separated micropopulations in two ecologically different habitats: fluent (Radika river) and stagnant (Mavrovo reservoir), showed that two of 17 compared characters exhibited statistically significant differences: *diameter oculi* and *maxillare*. The energy spent on resisting the water stream in fluent habitat, in the stagnant habitat is transformed in matter (S i d o r o v s k i, 1971). The L-W equation is logW=3,23008*logL-2,32147 for Mavrovo Reservoir.

These values differ greatly from the values of the micropopulations in the fluent habitats cited above. Furthermore, the differences among the two separated micropopulations found in two different ecological conditions are expressed also in the physiology of females, where the fecundity of specimens form the lotic habitat can be seven times higher (S i d o r o v s k i, 1960). Leading to a conclusion that, the differences in food being ig-

nored (P o p o v s k a – S t a n k o v i ć & G e o r g i e v, 1973; G e o r g i e v, 1976), the energy saved in the still water habitat is re-directed to produce far more eggs.

According to the results of R e s h e t n i k o v (1976) and S a v v a i t o v a (1976), the Salmonidae family plasticity is not only morphological, but also physiological, as some populations are capable of spawning outside of standard winter spawning season. As an example, the Ohrid Lake ecophenotype "letnica" spawns during the summer months, as opposed to populations elsewhere, as well as other populations from the same microhabitat (*S. balcanicus*, *S. aestivalis*, *S. lumi*). C v i j i c (1909/1911) used sublacustrine springs to prolong the spawning season of *S. trutta* in the Ohrid lake.

Papers by other scientists that use the name "Salmo letnica"

Though he was the first to describe "*Salmo letnica*", in his the last work, dr. Karaman, categorically rejected the existence of such a "species" (K a r a m a n, 1957).

The areals (as well their places in the ichthyocenoses) of two European largest salmonids: *S. marmorata* (K o t t e l a t & F r e y h o f, 2007) and *H. hucho*, are almost completely separated throughout the Balkan Peninsula. If we ignore the eel (*Anguilla anguilla*), which can mostly be found in lower, muddy parts of the river flows, no other predatory fish exists in the Adriatic sea watershed, while in the neighboring Black sea watershed (Danube river) even six apex predators (*Silurus glanis (*Linnaeus, 1758), *Esox lucius* (Linnaeus, 1758), *Aspisus aspisus* (Linnaeus, 1758), *Sander lucioperca (*Linnaeus, 1758), *P. fluviatilis*, *Lota lota* (Linnaeus, 1758)) cohabitate. How can we explain the existence of so many predatory fish, without "eliminating" each other? By their different biology - adaptation to the other microhabitats/feeding niches, not being in direct competition for food. But both salmonid predators (*S. marmorata* and *H. hucho*) are competing for the same food source: *Chondrostoma* sp..

Lacking other predator, *S. trutta* has "pressed" the other salmonid fish *S. ohridanus* (K o t t e l a t & F r e y h o f, 2007) in the narrow zone where the shelf is, to feed mainly on medium sized invertebrates (Amphipoda, "hidden" among the *Chara* fields). *S. trutta* in still water habitat Ohrid Lake occupies all the water surface during winter, but is absent from the littoral area in the summer time, when it feeds mainly on zooplankton (*Daphnia*) or pelagic fish (*Alburnus* sp.). Question arises, why is *S. marmorata* absent form the lake when no barriers exists for it to come in, but it remains confined to Tsrni Drim in the vicinity of strong alpine-like confluent Radika (K a r a m a n, 1937; G e o r g i e v, 1999)? In the opinion of the author, the answer is the biology of this fish, adapted to live in the fluent water of alpine character. Even though it is rich in water just after exiting the lake, the first 10 km of Tsrni Drim, in spite of elevation of 700 m above the sea level, is slow-flowing river inhabited mostly by cyprinids. Several alpine-like tributaries (containing *S. trutta* micropopulations) don't change the character of the river for almost 50 km. The character of the river does change only after receiving Radika river, populated by *S. marmorata*. The sample is an exponate in the Macedonian Museum of Natural History-Skopje; length: 110 cm; weight: 12.5 kg; caught in 1961 near "Boshkov Most".

The first author who used the name "*S. letnica*" as "undisputable" species is

S t e f a n o v i c (1948). She has stated that the one only difference among the phenotypes between two groups of fishes caught on 2 different localities and 2 different seasons was the number of vertebrae. The microhabitat Ohrid Lake (30,3 x 14,5 km), G a š e v s k i & Z i k o v, 1992, has ellipsoidal regular form. This form makes the ecological conditions unified everywhere except in summer on the shallower NW part. So, the mechanism of geographic isolation doesn't exist, any fish can freely move around the lake. In such a case, we have to find another factor what would cause (eventual) absence of merging of the genotypes of the individuals belonging to different groups when the reproduction takes place. Originally, S t e f a n o v i ć (1948) recognizes two subspecies in the eastern part: *S. letnica typicus* and *S. letnica aestivalis*. So it is unclear why K o t t e l a t & F r e y h o f (2007) ignore to the first one ("*S. letnica typicus*"), when following the logic they use elsewhere, this one should to be *S. typicus*, analogue to *S. aestivalis*. Terms "populations" and "races", the latter mostly being used in the agronomy (the applied biology branch creating forms under the prospective activity of the anthropogenic factor). As Dr. Stanković was an ecologist, and not a taxonomist but ecologist, it is probable that the confusion is mostly terminological. A detailed studies of *S. letnica* chromosomes (D i m o v s k a, 1959) showed that no significant differences in chromosomal number and structure existed among the three groups of samples. D o r o f e y e v a et al. (1983) concluded that morphology of head bones of *S. letnica* significantly varies from the heads of remaining Eurasian salmonids. No data exist about the putative differences among the three groups of phenotypically different individuals. J a n k o v i ć & R a s p o p o v i ć (1960) report the results of successful introduction of "*S. letnica*" from Ohrid Lake in the Vlasina Reservoir (1300 m altitude). The successful new micropopulation was formed that manifested the same phenotypic characters as the native micropopulation in the Mavrovo Reservoir (S i d o r o v s k i, 1955, 1960, 1971).

CONCLUSION

While Slovakian Academy of Sciences and Arts was behind the previous edition related to the European freshwater fishes (K o t t e l a t, 1997), the last one (K o t t e l a t & F r e y h o f, 2007) is a private edition and the ichthyologists in Europe employed in the state's institutions (universities as well) are not obligated to accept the private opinion of the authors, and are free to use the name *Salmo trutta* (Linnaeus, 1758) everywhere, even in Near East (Euphrates river flow).

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Sažetak

PREGLED ISTRAŽIVANJA RODA *Salmo* NA BALKANSKOM POLUOTOKU

S. Georgiev[1]

U radu autor osporava stajalište K o t t e l a t a (1997) te K o t t e l a t a i F r e y h o f a (2007) da na dijelovima Balkanskoga poluotoka, posebice u Ohridskome jezeru, postoje neke vrste roda *Salmo*: *Salmo aphelios* Kottelat, 1997; *Salmo balcanicus* (Karaman, 1927); *Salmo farioides* (Karaman, 1938); *Salmo labrax* Pallas, 1814; *Salmo letnica* (Karaman, 1924); *Salmo lumi* Poljakov, Filipi i Basho, 1958; *Salmo macedonicus* (Karaman, 1924); *Salmo montenigrinus* (Karaman, 1933); *Salmo pelagonicus* Karaman, 1938; *Salmo peristericus* Karaman, 1938; *Salmo taleri* (Karaman, 1932). Većinu je tih vrsta uveo od dr. Stanko Karaman, autor koji je po broju opisanih vrsta europskih slatkovodnih riba na drugome mjestu, odmah iza Carla Linnaeusa. Prema autoru, proturječno je formalnoj logici da u jednoj malenoj te oligotrofnoj mikronastambi kakva je Ohridsko jezero i u kojoj ne postoji faktor geografske izolacije budu formirane čak četiri vrste pastrva, kao i to da slijev Vardara nastanjuju tri vrste pastrva, dok je kod nekih drugih vrsta u geografski odvojenim sljevovima, u kojima postoji faktor geografske izolacije, razvoj ”zaustavljen”. Njegove tvrdnje da je u biti riječ o populacijama jedne te iste vrste *Salmo trutta* (Linnaeus, 1785) vrlo su plastične glede mikroekoloških uvjeta te fenotipskih manifestacija. Autor svoje tvrdnje potkrepljuje svojim te rezultatima drugih znanstvenika dobivenima proučavanjem ekologije i sistematike potočne pastrve u tekućim i stajaćim mikronastambama, nakon razdvajanja jedne prijašnje cjelovite u dvije nove: rijeka Radika te akumulacija Mavrovo (Republika Makedonija). Osim toga, autor navodi da je neprihvatljiva upotreba terminologije imanentne antropogenom faktoru u području druge znanstvene discipline u kojoj takav faktor ne postoji (agronomija - rasa te biologija - prirodna selekcija).

Ključne riječi: *Salmo trutta*, sistematika riba, teorija razvoja, darvinizam

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