INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-8, Issue-2 April-June-2018 Coden:IJPAJX-CAS-USA, Copyrights@2018 ISSN-2231-4490

Received: 4th Mar-2018 ***Revised: 19th Mar-2018*** ***Accepted: 25th Mar-2018***

DOI: 10.21276/Ijpaes ***http://dx.doi.org/10.21276/ijpaes*** ***Research Article***

CHEMICAL COMPOSITION OF "LIFE" *TRICOMYCTERUS PUNCTULATUS* VALENCIENNES (1846) (TELEOSTEI: SILURIFORMES: TRICOMYCTERIDAE)

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ABSTRACT: The "life" *Trichomycterus punctulatus* Valenciennes (1846) is a very delicious species, consumed by the ancient habitants of the coast of Peru and now threatened with extinction. The aim of the present study was to determine the chemical composition of the specimens collected in Lambayeque region (Peru) and surrounding areas (Cajamarca and La Libertad) from the western slopes of the Peruvian Andes. 68 females and 33 males were sampled, grouped in sizes and gonadal stages, determining the moisture content, proteins, fats, total ashes and minerals, using several analysis techniques. It was determined the content of moisture (72.73%), protein (19.04%), fat (5.46%), total ash (2.61%), calcium, potassium, magnesium, iron and copper minerals. It was observed differences according to sex, size (<100, 100-160 and > 160 mm in females and <100, 100-130 and > 130 mm in males) and stages of sexual maturation (gonads in stages I, III and VI). The nutritive value, caloric value and the nutritive ratio in average for both sexes was 0.62; 124.07 Kcal and 1:1, respectively. The "life" is a species with high nutritional value, carrier of plastic elements and large amount of energy elements.

Keywords: Catfish; Chemical analysis; Minerals; Nutritive value; Protein determination.

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INTRODUCTION

Trichomycteridae is a family of small-sized catfish, which are widely distributed throughout Southern Central America and South America [1]. Trichomycteridae family comprises nine sub-families, 37 genera and 156 species. Subfamily Trichomycterinae includes six genera: *Bullockia*, *Eremophilus*, *Hatcheria*, *Rhizosomichthys*, *Scleronema* and *Trichomycterus* where the latter is the most diversified, possibily with more than 75 species, widely distributed throughout South America, from the Atlantic to the Pacific coast [2]. However, other study states that this family has 171 described species, distributed between 39 genera and eigth subfamilies: Trichogeninae, Copionodontinae, Sarcoglanidinae, Glanepteryginae, Tridentinae, Vandellinae, Stegophilinae, and Trichomycterinae [3]. Trichomycteridae is a monophyletic group because it exhibits seven synapomorphies, most of which are concentrated in the opercular suspensory arch, a highly modified structure that enables fish to anchor on either the substrate or the tissue of their hosts [4].

Studies on freshwater fish in Peru are scarce. A pioneering study conducted in Lambayeque classified the "life" as *Pygidium dispar* Tschudii [5] and in an evaluation of the ichthyofauna of the La Leche river and the Refugio de Vida Silvestre Laquipampa (Lambayeque) "life" was reported as *Trichomyterus punctulatus* [6]. However, a recent annotated list of freshwater fish reported that Siluriformes (393 species) together with Characiformes (395 species) constitute the most important groups with around 74% of registered species [7]. This study also stated that exist two species of *Tricomycterus* in the rivers of the Pacific basin: *T. piurae* Eigenmann (1922) and *T. punctulatus* Valenciennes (1846), popularly known as "bagre". For Titicaca Lake it was reported *T. dispar* Tschudii (1846), also with the name "bagre" [8]; the same species was reported by a research about the ichthyofauna of Titicaca Lake as *T. dispar* ("mauri") Tschudii (1845). In addition, *T. rivulatus* was reported for the same lake [9].

This is why this study has adopted the modern identification of "life" as *Trichomycterus punctulatus* Valenciennes (1846). This is a native species of restricted distribution to the Lambayeque and surrounding areas of Cajamarca and La Libertad regions much consumed by the ancient settlers of the north of Peru, represented in several pre-Columbian ceramics and currently facing serious danger of extinction.

Confusion in the identification of the species of the family Trichomecteridae has happened not only in Peru, but also in many parts of the world, especially in South America. This problem has motived the realization of several studies in molecular biology. Cytogenetic analysis of *Trichomycterus davisi*, collected from Iguaçu River basin, showed a diploid number of 2n = 54 chromosomes; however, also it was observed intra-individual numerical polymorphism in three cell populations with diploid number 2n = 54, 55, and 56 chromosomes [10]. The descriptions of the karyotypes of five *Trichomycterus* species: *T. florensis*, *Trichomycterus* sp. aff. *Trichomycterus itatiyae*, *T. reinhardti*, *T. davisi* and *T. auroguttatus*, collected from different Brazilian hydrographic basins, had 2n = 54 chromosomes (42 metacentric, 10 submetacentric and 2 subtelocentric), with *T. reinhardti*, *T. auroguttatus* and *T.* sp. aff. *T. itatiyae* exhibiting only one chromosomes pair with silver-stained nucleolus organizar regions (NORs) [11]. In addition, the cytogenetic analysis, karyotype and nuclear DNA content of *Trichomycterus aereolatus*, collected from the Tijeral and Huilma Rivers in southern Chile, has shown a diploid chromosome number (2n = 54), and this DNA content is higher than the mean value described for other species in this genus [12].

Among the relevant studies on the "life" reported in Peru a research carried out by Delgado (1977) [5] in Lambayeque, established seven gonadal stages of sexual maturation, both for females and for males. Likewise, this study stated that growth of *T. punctulatus*, in three population densities in intensive culture system with recirculation was affected by population density in direct with a higher density of 3.68 “lifes”/liter: 90.90 mm and 5.95 g [13]. *T. pun*ctulatus, from Pisco river middle basin (Peru), is a predator and as such is a good integrator of ecological information, establishing that the species mainly consumes individuals from the Chironomidae, Hydropsychidae and Leptohyphidae families during the dry season; whereas in the wet season, it consumes individuals from the Chironomydae and Elmidae families [14].

The works on the chemical composition and nutritional aspects carried out in the "catfish" are scarce and restricted to very specific geographical areas. In Peru we have the study carried out on the chemical composition of *Trichomycteru*s sp. "bagre" and *T. rivulatus* "suche", collected in a river of Cuzco [15]. In other parts of the world, the fatty acid of farmed Tra catfish (*Pangasius hypophthalmus*), from the Mekong Delta of Vietnam, was determined and compared to farmed Atlantic salmon (*Salmo solar*) and to wild-caught Asian seabass (*Lates calcarifer*). The saturated fatty acids were most abundant in catfish (42.6%) while salmon and seabass were rich in polyunsaturated fatty acids [16]. In another study, gender differences in the chemical composition and selected properties of African catfish (*Clarias gariepinus*) meat, from a freshwater fish farm in northern Poland, was determined [17]. Likewise, proximate amino acids, fatty acids, vitamins and mineral analysis of catfish, *Arius maculatus* and *Plotosus lineatus*, from Parangipettai south east coast of India, was studied [18]. The lipid profiles of three species of Troglobitic fish (*Ituglanis passensis*, *Trichomycterus itacarambiensis* and *Stygichthys typhlops*) from Brazil, was studied to determine the influence of the subterranean environment on the metabolism of these animals, especially those that were altered due to the medium they inhabited [19].

The aim of this study was to determine the chemical composition of “life” *Trichomycterus punctulatus* Valenciennes (1846), captured in the Lambayeque region and sourrounding areas.

MATERIAL AND METHODS

Sample collection and preparation

The biological material consisted of specimens of "life" *Trichomycterus punctulatus* Valenciennes (1846), captured in the irrigation channels of the Lambayeque region (Peru), using fishing nets and fishing hooks, as well as acquired in the market of Chiclayo, knowing that they came from creeks and streams of the western slopes of the Andes of the Lambayeque, Cajamarca and La Libertad regions. Specimens were transported on ice, and were washed thoroughly. The species was initially determined using the key of the genus *Pygidium* elaborated by Eigenmann and Eigenmann (1890) [20] and of the Peruvian species elaborated by Everman and Radcliffe (1917) [21]; however, subsequent studies have transferred *Pygidium* species to *Trichomycterus* Valenciennes (1833) [22, 23].

In the determination of the groups of sizes and stages of sexual maturation, 562 specimens, 273 females and 289 males were sampled. Total lenght and body weight of specimens were obtaind using graduate ictiometer and weighing balance, respectively. In the determination of the stages of sexual maturation, it was used the empirical scale proposed by Delgado (1977) [5]: grade I, gonades with initial development; grade III, intermediate development and grade VI, maximum gonadal development and spawning.

One hundred one specimens, 68 females and 33 males, were eviscerated and "filleted", eliminate the head, fins, spine and viscera, to obtain the yield of the "edible part" [24]. After grouping specimens by sex, size and gonadal stages, the filleted samples were obtained at a rate of 50 g per sample. Biological samples was minced placed in plastic bags and stored at 0^oC until taken for analysis. Prior to anlaysis the sample was thawed overnight at 10^oC.

Chemical analysis

Humidity of "filleted" samples was measured by drying them into an oven at 60 °C for 24 h using gravimetric method. These samples were kept at room temperature for subsequent chemical analysis. The determination of total humidity was also performed in an oven at 105 °C for 24 h, with the aim to eliminate all water. In the determination of crude protein (N x 6.25) the method of micro Kjeldhal was used weighing 100 g of sample, performing the digestion with sulfuric acid and calculating the crude protein with the factor 6.25, and in the case of crude fat, the continuous extraction method in Extractor Goldfish was used. To determine the total ash, the direct incineration method was used at 600 °C [25], while Atomic Absorption Spectrophotometry was used in the determination of calcium, phosphorus, magnesium, iron and copper.

In the bromatological analysis, the evaluation of "life" as a food based on its yield was considered [24], Nutritional Value, Caloric Value and Nutritive Relationship [26] and based on the quantity of analyzed minerals [25].

The evaluations were carried out in the Laboratorio de Biología Pesquera of the Facultad de Ciencias Biológicas and the Laboratorio de Nutrición Mineral de la Facultad de Zootecnia, of the Universidad Nacional Pedro Ruiz Gallo de Lambayeque.

Statistical analysis

The statistical analysis was performed with the ANOVA procedure of the statistical package SAS [27], with the average values per treatment. For the comparison of means, the Tukey test ($P \leq 0.05$) was used.

RESULTS AND DISCUSSION

The sampling of 562 life specimens, 273 females and 289 males, served to establish three size groups, for females and males. In the females, the groups <100, 100-160 and > 160 mm were established, with a range of 55 to 263 mm and a mean of 119 mm and for the males the groups <100, 100-130 and > 130 mm, with a range of 48 to 185 mm and an average of 93 mm, resulting in larger females than males; likewise, in the determination of sexual maturity, gonadal stages I, III and VI were taken as reference for both sexes. Performance analysis (Table 1) showed 74.31% for females and 76.60% for males, with the size group <100 mm and the gonadal stages I and III slightly greater for both sexes. These differences can be attributed to the weight of the gonads, which when extracted in the "filleted" determine a lower weight of "edible part" especially in the females since the males have less developed gonads; however, according to the Stansby classification [28], who considers that the performance in fish varies between 60-75%, the yield in the "life" can be considered high because it has a head and fins small, which to be removed does not determine significant losses due to waste.

Moisture, protein, lipids, ash and minerals are the most important micro and macro nutrient components that act as sources of nutritive value of fish meat [29]. However, chemical composition of fish varies greatly depending on their age, sex, environment and season. Protein levels, rang from 16-21%, lipids 0.1-25%, ash 0.4-1.5% and moisture 60-81% [30], for samples analyzed according to standard procedures of Association of Official Analytical Chemist (AOAC) [31], where protein and fat are considered the major nutrients in fish and their levels define the nutritional status of the particular organism. In the analysis of the chemical composition, 101 samples (68 females and 33 males) were evaluated. In the determination of crude protein (N x 6.25) the highest values were reached (19.84% in females and 21.08% in males), both in the gonadal stage I, as well as a mean for the total of specimens of 19.04% (Table 2).

Fish protein is an excellent source of macro nutrients and presents a good degree of digestibility [32]. As the literature does not report studies on the chemical composition of "life", *T. punctulatus*, the discussion will focus on comparisons with other species of *Trichomycterus* and even other species of "catfish". In an early study conducted on two species of *Trichomycterus* collected in rivers of Cusco, *Trichomycterus* sp. "bagre" and *T. rivulatus* "suche", was determined on dry basis, 35.10 and 46.91% of protein [15], data much lower than that reported in the present work. In another study carried out on "African catfish" *Clarias gariepinus*, the content of protein was 17.42% for females and 17.32% for males [17], values very similar to those of shown in the present study (18.47% for females and 19.62% for males), whereas in the "catfish" of India, *Arius maculatus* and *Plotosus lineatus*, the body protein levels (without head) were 42.17 and 32.56 g (g/100 g), respectively, assuming that they were analyzed on a dry basis [18]; these values were also inferior to those shown in the present work for the "life", *T. punctulatus*. Likewise, study of protein content of nine marine fishes in Tuticorin, South East coast of India, showed that species *Velamugil seheli* and *Carangoides chrysophrys* the lowest and highest protein content with 18.6 and 21.8 g/100 g, respectively. These levels are higher than the protein content of beef, lamb and pork [30]. On the other hand, the average moisture content (72.73%) of "life", 73.85% for females and 71.57% for males, determines that their meat can be classified as "firm" since the water: protein ratio it is 3.9:1 [24].

With respect to samples crude fat, the values obtained were highly variable, both in females and males, from the lowest (2.95%) in females in gonadal stage VI and the highest (8.01%) in males in gonadal stage I and a mean for the total specimens of 5.46%. According to the classification of Sánchez and Lam (1970) [24], the species would be classified as semi-fat (4.78%), while females (4.53%) and males (5,29%) would be classified as semi-fat and fatty, respectively.

However, another modern classification, stated that fish can be grouped into four categories according to their fat content: lean fat (<2%), low fat (2-4%), medium fat (4-8%), and high fat (>8%) [33]. In the study conducted in *Trichomycterus* sp. "bagre" and *T. rivulatus* "suche", collected in Cusco, the content of fat in dry basis was 27.51 and 39.40%, respectively [15], values that were slightly higher, in the case of *Trichomycterus* sp. and much higher, in the case of *T. rivulatus*. In "Tra Catfish" *Pangasius hypophthalmus*, collected in Vietnam, the amount of crude fat was 2.55 g (g/100 g) with a low content of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), an extremely low value when compared to Atlantic salmon (*Salmo solar*), shown in the same work [16] and to "life", which doubled the content of crude fat on a dry basis.

In the "catfish" of India, *Arius maculatus* and *Plotosus lineatus*, the body fat levels (without head) on dry basis were 65.04 and 66.03 g (g/100 g), respectively [18], values much higher than those are in this work, so we can deduce that "cat fish" from India were extremely fatty. Likewise, in "African catfish" *Clarias gariepinus*, collected in Nigeria, the lipid content was 1.15% [34], an extremely low value compared to the shown in the work presented; however, similar study conducted on the same species, *C. gariepinus* grown in Poland, the crude fat content was 3.5% [17], a value considered low with respect to *T. punctulatus* but higher than the reported for "cat fish" of Nigeria. On the other hand, the study on the fatty acids of a "troglobitic fish" or "catfish of darkness" (*Trichomycterus itacarambiensis*) of Brazil, determined the occurrence of 28 fatty acids, highlighting the palmitic, stearic, oleic and linoleic acids, influenced by the type of feeding in their cavern habitat [19].

Table 1. Average yield (%) of three size groups and three gonadal stages of females and males of *T. dispar* "life".

Females (%)					
Size groups (mm)			**Gonadal stages**		
< 100	**100-160**	**> 160**	**I**	**III**	**VI**
76.24	71.91	73.12	77.29	77.36	67.22
Males (%)					
< 100	**100-130**	**> 130**	**I**	**III**	**VI**
77.0	76.93	76.32	76.07	78.53	75.08
Total females = 74.31%					
Total males = 76.60%					

Table 2. Average chemical composition of three size groups and three gonadal stages of females and males of *T. dispar* "life".

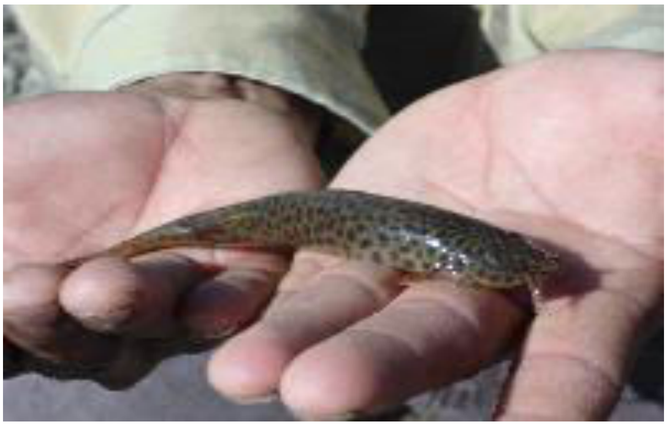
Females (%)				
Chemical composition				
Size groups (mm)	**Crude protein**	**Crude fat**	**Total ash**	**Moisture**
< 100	18.14	6.17	2.44	72.05
100-160	18.02	4.12	2.26	75.76
> 160	17.81	5.24	1.85	74.63
Gonadal stages				
I	19.84	6.84	2.75	69.73
III	18.55	5.16	2.09	74.19
VI	18.48	2.95	2.34	76.73
Total females:	**18.47**	**5.08**	**2.29**	**73.85**
Males (%)				
Size groups (mm)	**Crude protein**	**Crude fat**	**Total ash**	**Moisture**
< 100	19.94	6.22	2.71	70.41
100-130	18.66	4.37	2.68	74.06
> 130	19.87	5.02	2.68	73.16
Gonadal stages				
I	21.08	8.01	4.35	66.78
III	19.77	7.24	2.47	71.46
VI	18.38	4.15	2.69	73.56
Total males:	**19.62**	**5.84**	**2.93**	**71.57**
Total females and males:	**19.04**	**5.46**	**2.61**	**72.71**

Table 3. Average values of some minerals of three size groups and three gonadal stages of females and males of *T. dispar* "life".

Females (%)					
Chemical composition					
Size Groups (mm)	**Ca (%)**	**P (%)**	**Mg (%)**	**Fe (ppm)**	**Cu (ppm)**
< 100	0.59	0.47	0.04	19.12	2.10
100-160	0.52	0.39	0.04	16.23	1.18
> 160	0.33	0.33	0.03	13.90	1.30
Gonadal stages					
I	0.78	0.49	0.05	21.20	1,48
III	0.49	0.36	0.04	21.26	1.66
VI	0.50	0.41	0.03	14.64	1.25
Total females	0.48	0.38	0.04	16.35	1.35
Males (%)					
Size Groups (mm)	**Ca (%)**	**P (%)**	**Mg (%)**	**Fe (ppm)**	**Cu (ppm)**
< 100	0.72	0.48	0.04	23.44	1.77
100-160	0.60	0.40	0.04	17.92	1.27
> 160	0.67	0.47	0.04	19.43	1.60
Gonadal stages					
I	**1.28**	0.94	0.06	33.83	2.75
III	**0.66**	0.45	0.04	19.46	1.72
VI	**0.80**	0.61	0.05	16.88	1.72
Total males	0.71	0.49	0.04	20.39	1.63
Total: (Females and males)	0.55	0.42	0.04	17.67	1.44

Which respect to total ash females showed lower values when compared to the males. Females> 160 mm showed the lowest value (1.85%) while in the gonadal stage I they showed the highest value (2.75%), and males in the gonadal stages III and I showed the minor (2.47%) and higher value (4.35%), respectively; the same trend was observed, with values of 2.93% for males and 2.29%for females. In *Trichomycterus* sp. "bagre" and *T. rivulatus* "suche", collected in Cusco, the ash content in dry basis was 10.64 and 5.0%, respectively [15], values similars to those were shown for *T. punctulatus*. In "African catfish" *Clarias gariepinus*, collected in Nigeria, the ash content (1.23%) was significantly lower [34], while in the same species cultivated in Poland, the crude ash content was similar with 1.06 and 1.13%, for males and females, respectively [17]. According to Salam *et al*. (1995)[35], biochemical composition of body muscles of freshwater catfish *Heteropneustes fossilis* varies on the season, age and feeding habit.

Micronutrients food may have different effects on human beings: they may be essential, non-essential or toxic to them. Minerals such as iron, cooper, zinc and manganese are essential and play important roles in biological systems [30]; however, essential minerals may also produce toxic effects at high concentrations [36]. The analysis of five minerals: calcium, phosphorus, magnesium, iron and copper, on dry basis, showed that iron and copper are presented in greater quantities, being slightly higher in the males with respect to the females, although in general, for each sex, in each group of sizes and gonadal stages, small variations were observed (Table 3). In the "catfish" of India, *Arius maculatus* and *Plotosus lineatus*, the body minerals (without head) in predominant dry base were Zn, Na and Ca, in *A. maculatus* and K, Mg and Ca in *P. lineatus* [18], which does not correlate with what was determined in *T. punctulatus* where Ca and Mg were found in low concentrations. In general, the present work confirms that "life" contain most important micro minerals; therefore consumption of "life" is benefitial for people's health.



a

b

Figure 1. Specimens of "life" *Trichomycterus punctulatus* Valenciennes (1846), captured in freshwater bodies of Lambayeque (Peru). a. Male specimen of size < 130 mm; b. Female specimen > 160 mm.

Table 4. Nutritional Value (VN), Caloric Value (VC) and Nutritive Ratio (RN) for three size groups and three gonadal stages of females and males of *T. dispar* "life".

Females			
Size Groups (mm)	**Nutritive Value**	**Caloric Value (Kcal)**	**Nutritive Ratio**
< 100	0.82	128.01	1:1
100-160	0.55	109.16	1:1
> 160	0.71	118.45	1:1
Gonadal stages			
I	0.82	140.90	1:1
III	0.67	120.62	1:1
VI	0.40	100.44	1:0.4
Total females	0.60	102.07	1:1
Males			
Size Groups (mm)	**Nutritive Value**	**Caloric Value (Kcal)**	**Nutritive Ratio**
< 100	0.74	135.68	1:1
100-130	0.57	133.96	1:1
> 130	0.65	120.19	1:1
Gonadal stages			
I	0.91	156.41	1:1
III	0.88	144.22	1:1
VI	0.55	110.84	-
Total males	0.66	116.96	1:1
Total: (Females and males)	0.62	124.07	1:1

The results of Nutritive Value (VN), Caloric Value (VC) and Nutritive Ratio (RN) are shown in Table 4. The VN was higher in males (0.662) compared to females (0.603) and in both sexes, as increased the gonadal stage decreased the VN, while in the groups of extreme sizes the values were higher than in the intermediate group, especially in individuals less than 100 mm. The VC, expressed in Kcal/100 g of pure meat, was slightly higher in the males (450.95 Kcal) compared to the females (449.19 Kcal), resulting in gonadal status III for both sexes the highest value, while that the groups of extreme sizes reached higher values with respect to the intermediate group. Likewise, the RN was mostly equitable of 1:1, with the only exception in the females with the gonadal stage VI. In general, "life" is considered a species of high VN, carrier of plastic elements and large amount of energy elements, highlighting the males on the females, although the VC levels were similar for both sexes. RN 1/1, due to its narrow condition, indicated the occurrence of a high percentage of protein and a medium concentration of fat, which could be complemented with other carbohydrate-rich foods that lead to obtaining an optimal nutritional balance.

CONCLUSIONS

From the results obtained, it is concluded that "life" is a species of high protein and energy values, which makes it a good nutritional alternative for large sectors of the rural population, although it must be exploited rationally to preserve it as fish resources, currently in danger of extinction.

COMPETING INTERESTS

The authors have declared that no competing interests existed.

ACKNOWLEDGMENT

The authors are grateful to Prof. Alain Monsalve Mera for English improvements

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INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

International Journal of Plant, Animal and Environmental Sciences