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VACUITY COEFFICIENT AND DIET IN *CLARIAS JAENSIS* (BOULENGER, 1909) IN THE MBÔ FLOODPLAIN (CAMEROON)

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ABSTRACT: *The Diet of Clarias jaensis was studied in the floodplain of Mbô in Cameroon. In order to reduce over-exploitation through knowledge of the food habits, 230 fish caught by artisanal fishing methods were collected monthly between November 2016 and September 2017 in three sites (Menoua, Nkam and flooded ponds). The digestive tract dissection was made according to the standard method. The standard length and total weight of specimens ranged from 10.50 to 47.50 cm and between 9.99 and 1165.59 g respectively. Overall, 43 stomachs were empty with a general vacuity coefficient of 18.69%. It varied between 16.85 and 26.08%, respectively between the dry and rainy seasons, and then by 24.00; 11.43 and 26.00% respectively in the Menoua, Nkam and flooded ponds. The diet characterized on the basis of occurrence and numerical percentages, having varied from one season to another. Insect-dominated animal organic matter was significantly ($p < 0.001$) higher (73.54%) compared to plant matter (36.59%) and detritus (24.09%). The food spectrum of C. jaensis, with 9 items, showed that it was an omnivorous species with an insectivorous tendency.*

KEYWORDS: Clarias jaensis, vacuity coefficient, diet, floodplain, Cameroon

INTRODUCTION

The biological diversity of wildlife is currently the subject of several evolutionary studies. Knowledge of a species food ecology is closely linked to population dynamics and contributes to the understanding of topics such as resource sharing (Guedes and Araujo, 2008) [1], habitat preference (Wetherbee and Cortés, 2004) [2], prey selection, predation, competition, energy flux within and between ecosystems (Baxter *et al.*, 2004) [3]. Feeding fish in the wild is the only source of energy acquisition that is used for growth, reproduction and migration (Paugy *et al.*, 2006) [4]. It depends on the anatomy (Paugy and Lévêque, 2006) [5] and physiology (Moreau, 1988) [6] of the species on the one hand, and on environmental factors such as the availability of prey, (Castillo-rivera, 2013) [7] and the physical and chemical parameters of the water on the other hand. The diet of fish makes it possible to understand not only their biology and ecology, but also to characterize the trophic relationships between predators and the various living resources of the environment (Ben Slama *et al.*, 2007)[8].

Africa is home to a biodiversity of 3800 species of freshwater fish, sufficient to support sustainable aquaculture development (Mbéga, 2013) [9]. In Cameroon, this endogenous diversity is represented in many rivers by different species. Thus, in the Mbô floodplain, two species of clariids (*Clarias gariepinus* and *Clarias jaensis*) are found in the watercourses.

However, while data exist on the feeding ecology of *C. gariepinus* (Ikpi *et al.*, 2012) [10], information on the feeding of *C. jaensis* is scarce. However, this species is regularly included in uncontrolled artisanal catches, leading to its disappearance in its biotope. This habitat, characterized by marked seasonal variations (floods and decreases) is strongly threatened by the activities of riparian populations. The development of the production of this species requires the control of its bio-ecology. To this end, a better knowledge of its biology in the natural environment is essential to consider an optimal exploitation of its breeding potential for the promotion of its breeding in small, medium and large production units. It is with this in mind that this study was initiated with the general objective of contributing to the preservation and enhancement of the biodiversity of endogenous fish resources in general and of Clariids in particular through the assessment of the influence of endogenous and exogenous factors on the characteristics of the diet of *C. jaensis*.

MATERIALS AND METHODS

Study period and area

The study took place from November 2016 to September 2017, in the Mbô floodplain (LN: 5° 10' -5° 30' and LE: 9° 50'-10', average altitude: 700 m) in Cameroon. It is located in the upper Nkam valley and extends north to the Mbô cliff (Dschang) and south to the summit of Mount Manengouba.

Data collection and analysis of stomach contents

Fish caught with sparrowhawk gillnets 3 to 4 fingers (3 to 4 cm), traps and baited hooks from the natural environment were collected monthly in the morning from fishermen, then tagged (date of collection and location), placed in an ice box and transported to the Laboratory of Ichtyology and Applied Hydrobiology at the University of Dschang and; then identified according to Stiassny et al (2007) [11].Each individual was measured to the nearest millimeter (standard length) and weighed respectively and dissected. The intestine was unrolled and measured (intestinal length or Li). The stomach was collected, weighed and stored in 5% formaldehyde after noting its state of repletion (full stomach or empty stomach). Stomachs filled to 1/4, 1/2 and 3/4 are all considered full. In the laboratory, stomach contents were poured into petri dishes, filtered through sieves (100, 250 and 500 µm mesh) (Konan *et al.*, 2014) [22] and then observed with a binocular magnifying glass and/or microscope. Fresh weight was recorded to the nearest thousandth of a gram, prey was counted and then determined using the identification keys Elouard (1981) [13], Tachet *et al* (2003) [14] and Moor and Day (2002) [15]. For the enumeration of insect remains and plant debris, the number 1 has been assigned to their presence in a stomach, regardless of quantity and weight (Rosecchi and Nouaze, 1987) [16]. Sediments (mud and sand) were not included in the numerical analyses of stomach contents. To characterize the diet of *C. jaensis*, the vacuity coefficient (Cv), frequency of occurrence (%F) and numerical percentage (%N) of prey items were calculated according to the following formulas:

$Cv = (N_V / N_T) \times 100$ with: N_V= number of empty stomachs and N_T= total number of stomachs examined; $\%F = (N_P/N_T) \times 100$ with N_P = number of stomachs containing prey i and N_T =

number of stomachs studied; %N= (ni/Ni) x100 with ni= number of individuals in food category i and Ni= total number of all foods.

Statistical analysis

The data collected were analyzed and compared using descriptive statistics. The chi 2 test was used to compare the vacuity coefficient and diet according to seasons, sexes, sites and size class (LS≤ [10-18[cm; [18-26[cm;] [26-34[cm; ≥34cm). All these analyses were performed using SPSS 22.0 software with a probability threshold of 1 and 5%.

RESULTS

Vacuity coefficient according to sex and season in *Clarias jaensis*

A total of 230 *Clarias jaensis* specimens ranging in size from 10.50 to 47.50 cm LS were studied. The vacuity Coefficient shows higher numbers in the dry season (n=184) than in the rainy season (n=46). Of the total number of individuals caught, 43 had empty stomachs, for a vacuity coefficient of 18.69%. However, the value of the vacuity coefficient was significantly higher (p<0,001) in females compared to males and undetermined sexes as well as in the dry season compared to the rainy season (Table 1)

Table 1: Vacuity coefficient according to sex and season in *Clarias jaensis*

Seasons and sex	Ts	Fs	Ev	Vc (%)	P<0.05
dry					
♀	87	64	23	26.44[a]	0.0116
♂	75	68	7	9.33[b]	
Ind	22	21	1	4.55[b]	
Total (ds)	**184**	**153**	**31**	**16.85** [B]	
rainy					
♀	20	14	6	30.00[b]	
♂	20	17	3	15.00[c]	0.0001
Ind	6	3	3	50.00[a]	
Total (rs)	**46**	**34**	**12**	**26.08** [A]	
Total Seasons and sex					
♀	107	78	29	27.10[a]	
♂	95	85	10	10.53[c]	0.0007
Ind	28	24	4	14.29[b]	
Total (ds + rs)	**230**	**187**	**43**	**18.69**	

Ts: total stomachs analysed; Fs: full stomachs; Es: empty stomachs; Vc: vacuity coefficient; ♀: females; ♂: females; ♂: males; *ind*: Undetermined sex; ds: dry season; rs: rainy season; a, b, c: the affected figures of the same letter by exposing are not significantly different
(P < 0.05); P: probability

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Vacuity coefficient according to height and weight classes

The vacuity coefficient as a function of height and weight class as shown in Table 2 shows that, with the exception of the height class[18-26[cm] where it is relatively average ≥ 25%, it is low in all other class. With regard to weight class, the vacuity coefficient is low regardless of the weight class considered. The highest value being recorded with the largest weight class ≥500g and the lowest recorded in weight class 300 to 400g. However, no significant differences (p>0, 05) were observed between weight classes.

Table 2: Vacuity coefficient according to height and weight class

Height class	Vc (%)	Weight class	Vc (%)
[10-18[(27)	14.81	[0-100[(55)	20.41
[18-26[(71)	29.58	[100-200[(45)	20.00
[26-34[(100)	14.00	[200-300[(46)	17.39
≥34 (32)	12.50	[300-400[(41)	9.76
/	/	[400-500[(30)	10.00
/	/	≥500 (13)	23.08
Probability:	**(χ^2): 8.05; P: < 0.04**		**(χ^2): 3.64; P: < 0.60**

Vc : vacuity coefficient; ♀ : females ; ♂ : males : *ind* : undetermined sex ; () : observation numbers

Frequency of occurrence and numerical percentage as a function of organic matter

The frequency of occurrence and the numerical percentage as a function of organic matter illustrated in figure 1 show that, animal organic matter is significantly (p < 0.001) higher (73.54%) in the stomachs of *Clarias jaensis* compared to plant matter (36.59%) and detritus (24.09%).

Figure1: Frequency of occurrence and percentage of abundance as a function of organic matter in *Clarias jaensis*

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Frequency of occurrence according to season, site and sex

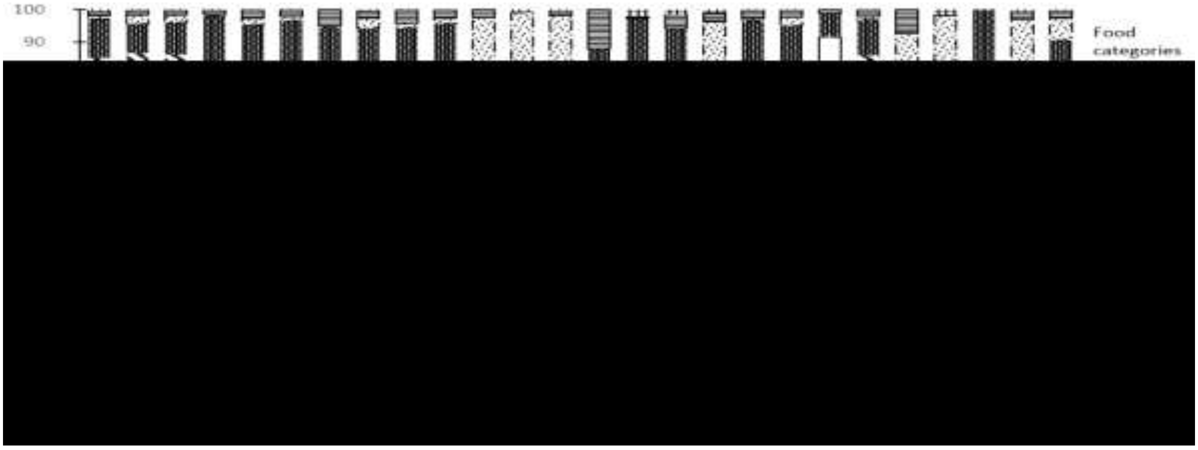
The frequency of occurrences of food categories (figure 2a) generally shows that macrophytes were more frequent (18.42%), followed by detritus (17.62%), algae (17.28%), insects (16.00%) and crustaceans (14.35%). The least frequent are vertebrates (1.70%), protozoa (3.12%), nematodes (2.46%) and other invertebrates (7.04%). When comparing the seasons, in the dry season the frequency of occurrence of insects was higher (21.37%), followed by that of macrophytes (18.98%). While in the rainy season, detritus had a higher frequency (22.00%), followed by macrophytes (19.01%). When considering the sites, the frequency of detritus occurrence was higher (22.66%) in the Menoua River, followed by insects (23.25%) in the Nkam. The lowest frequency was vertebrates (0.88%) in flooded ponds. However, crustaceans and detritus were respectively higher (22.89 and 23.07%) in the undetermined sexes compared to males and females.

R: river; E: ponds; ♀: female; ♂: male; indeterminate sex; DS: dry season; RS: rainy season

Figure 2a: Frequency of occurrence of food categories according to site, season and sex in *Clarias jaensis* in the Mbô plain.

Numerical percentage according to site, season and sex

The numerical percentage of food categories found in *Clarias jaensis* is illustrated in figure 2b. It shows that crustaceans were the highest (34.94%), followed by algae (18.69%) and vertebrates were the lowest (0.31%) regardless of site, season and sex. When comparing the seasons, the numerical percentage of crustaceans was higher (57.74%) in the dry season while in the rainy season, algae (24.31%) and macrophytes (19.54%) dominate. Protozoa and vertebrates were the lowest in all seasons. Taking into account the sexes, the numerical percentage of crustaceans was the highest in the dry season for all sexes. The opposite was observed for vertebrates in females and males and for other invertebrates in indeterminate. In contrast, in the rainy season, macrophytes and algals counts were higher in females and males and indeterminate respectively.



R: river; E: ponds; ♀: female; ♂: male; *ind*: indeterminate sex; DS: dry season; RS: rainy season

Figure 2b: Numerical percentage of food categories by site, season and sex in *Clarias jaensis* in the Mbô plain.

Frequency of occurrence and numerical percentage according to size class

The frequency of occurrence by height class illustrated in figure 3a shows that crustaceans were the highest (23.59%) followed by algae in fish in the height class[10-18[cm. the lowest value (0.51%) being that of vertebrates in the height class[18-26[cm. In addition, macrophytes was higher (22.56%) in the height class [18-26[cm] followed by insects (20.22%) in the height class [10-18[cm.

The numerical percentage by height class (figure 3b) shows that: overall, crustaceans were the highest (54.74%) and vertebrates the lowest (0.16%).

Figure 3: Frequency of occurrence (a) and numerical percentage of food categories according to size classes in *Clarias Jaensis*

DISCUSSION

The vacuity coefficient in *C. jaensis* in the Mbô floodplain was generally low (18.69%). This result is similar to that reported by Koné *et al.*, 2014[12] in *Clarias buettikoferi* from the Tanoé-Ehy marsh forest in Côte d'Ivoire. According to El Bakali *et al*, (2010) [17], the low values of the vacuity coefficient may be an indication of the availability of food and/or the frequency of trophic activities of species in the environment. The recorded vacuity coefficient was significantly higher (26.08%) in the rainy season compared to the dry season. This observation is similar to that made by Sylla *et al.*, 2008[18] in a Carangidae (Trachinotus teraia) in the Ebrié lagoon. This is explained on the one hand by the small number of fish caught during this period and on the other hand by the catch techniques used by fishermen. In fact, gear such as Nass and longlines are fish traps in which a fish can spend hours during which the digestive tract is empty. Our results are contradictory to those of Konan *et al.*, (2014) [22] where the vacuity coefficient is lower in the rainy season and similar to those obtained by Diaha *et al.*, 2010[19] showing that the egg-laying period that occurs between May and June in *Scomberomorus tritor* is the period when the vacuity coefficient is higher (Cv= 46.76%). These results could be explained by the increase in gonad weight that compresses the digestive tract, reduces the food bolus and causes fish to eat less (Layachi *et al.*, 2007)[20]. The vacuity coefficient varied from one height and weight class to another in *Clarias jaensis*. However, the highest size class 18 to 26 cm and weight class ≥500g could be explained by the physiological state explained above (Layachi *et al.*, 2007) [20] because in this class interval, almost all fish have reached sexual maturity.

The global analysis of the stomach content of *Clarias jaensis* in the Mbô floodplain shows a predominance of prey of animal origin both in frequency of occurrence and in numerical percentage. In addition, our results show that *Clarias jaensis* is a species that consumes a wide variety of food consisting of detritus and eight other categories of prey found in all levels of the water column. These results are similar to the observations made by Pham (1979) [21] on the feeding habits of African freshwater fish, particularly of the genus clarias. This dietary diversity could be explained by the fact that Clariidaes have the ability to breathe atmospheric oxygen and can thus adapt to the harshest living conditions, thus facilitating their search for food. In addition, the abundance of algae, macrophytes, crustaceans, other invertebrates, eggs and larvae of fish, fry and the frequency of aquatic insects and terrestrial ants in the diet of *C. jaensis* prove that it is a species with a general food preference. Our results are similar to those found in other Clariidaes such as *C. anguillaris* in the Cross River in Nigeria (Offem *et al.*, 2010)[23] , *C. gariepinus* in Lake Awassa in Ethiopia (Dadebo, 2000)[24] and in Agbokim Falls in Nigeria (Ikpi *et al.*, 2012)[10], *C. liocephalus* in the Rwizi-rufuha River in Uganda (Yatuha *et al.*, 2013)[25] and *C. buettikoferi* in the Tanoé-Ehy marsh forest in Côte d'Ivoire (Koné, *et al.*, 2014) [12]. In addition, the presence of sand and stones found in the stomach of *C. jaensis* may be justified by the fact that they would be ingested when feeding in the lowlands. The latter could therefore contribute to the grinding of food items. The result obtained suggests that *Clarias jaensis* is a benthic species just like *Clarias buthupogon* in the rivers of Yoko, Biaro and their tributaries (Ndjaki,2009)[26]. The same observation was made in Clariids *Chrysichthys nigrodigitatus* (Offem *et al.*, 2009) [27] in the cross river in Nigeria. So just as the latter *C. jaensis* could be a benthopelagic fish and would be bred in captivity in a polyculture system with other species.

The comparative analysis between the catch sites shows that the diet of *C. jaensis* appears to be more diversified in the Nkam River than in Menoua and flooded ponds. The difference can be explained by the number of tributaries in the Nkam River and the micro-habitat used by this species. Indeed, Welcome (1988)[28] argues that benthic organisms are particularly abundant in rocky bottoms. Thus, our results are similar to those observed in *C. buthupogon* in the rivers of Yoko, Biaro and their tributaries (Ndjaki, 2009) [26].

The diet of *C. jaensis* in the Mbô plain varies according to the seasons. Fish feed mainly on food of endogenous (aquatic) origin in the dry season, consisting of insect larvae, shellfish that are benthic organisms, while in the rainy season, food of exogenous (terrestrial) origin, including ant, terrestrial insects, fruits, algae and macrophytes, dominates the diet. According to Castillo-Rivera, (2013) [7]; during the rainy season, water runoff brings to aquatic environments a significant amount of organic matter (plants and/or insects) and nutrients of terrestrial origin that enrich these environments. In addition to this nutrient supply, in the Mbô floodplain, insects and other terrestrial organisms, fruits and plant debris could also fall into the water under the influence of wind and rain. Therefore, the seasonal variation in the diet of *C. jaensis* indicates that in the rainy season (period of food abundance), fish preferentially exploit exogenous food arriving in the water body through rainfall. On the other hand, during the dry season, in the absence of food of exogenous origin, *C. jaensis* gets most of its food by searching the mud, hence the preponderance of benthic organisms and the presence of sediments in the stomachs. These results are similar

to those found in *C. buettikoferi* (Koné, *et al.,* 2014)[12], *C. buthupogon* (Ndjaki, 2009)[26] and *C. gariepinus* (Dadebo, 2000)[24].

In addition, the high frequency of occurrence of insects, nematodes and crustaceans encountered in females and males of *C. jaensis* in the rainy season shows that this species could have an omnivorous diet with a carnivorous tendency as reported by Akete (2014) [29] through studies conducted on *C. gariepinus* in Lake Kivu and work done by Palenfo (2015) [30] in the biosphere Reserve of the Mare to the Hippopotame on the same species. This food eclecticism indicates that this predator is not a danger to the fish populations because its opportunism explains its adaptation to the trophic conditions in the environment (Cherghou *et al.,* 2002)[31].

The frequency of occurrence and the numerical percentage showed differences between the height and weight class considered. According to (Paugy and Lévêque, 2006) [5] fish vary greatly in height and weight during their development, and their nutritional needs and feeding behaviours also vary. These variations can be explained, among other things, by the difference in the ability to capture large prey, which is proportional to the opening of the oral cavity (Bouchereau and Guélorget, 1999[32]; Konan *et al*., 2008) [33]. Thus, the frequency of occurrence and percentage of higher crustaceans, insects and algae in fish height class [10-18[cm and weight ([0-100[g show that they are more zooplantonophagous than fish of higher height and weight class. This result is similar to those of Dadebo, (2000) [24]; and Ikpi *et al,* (2012) [10] found in other species of the genus Clarias (*Clarias pachynema, gabonensis, gariepinus*) and Palenfo, (2015) [30] which shows that young *C. gariepinus* have a preference for insects. However, it differs from the one found in *C. buettikoferi* by Koné *et al.,* (2014) [12], which stipulates that fish of standard length between 9 and 13 cm have plant debris as their main food.

In addition, individuals in class [18-26[cm and weight [100-200[g have a higher frequency of occurrence of macrophytes: therefore they are considered as macrophages. Our results differ from those of N'guessan *et al*, (2010) [34] in the Bia River which states that *C. anguillaris* has a preference for insects and molluscs in the weight class [90-200[g. This difference is justified according to Herder and Freyhof, (2006) [35] by the consumption of available and accessible resources in the habitat, because the diversity of food dependent on the wealth of prey ingested is probably dependent on the prey available in the environment. Overall, individuals of all height and weight class feed on insects but in different proportions. This observation could suggest that *Clarias jaensis* has a broad food spectrum that gives it the status of an insectivorous omnivorous fish, a result similar to that found in *C. buettikoferi* (Koné, *et al.*, 2014) [12] and those of the authors Sanogo, (2010)[36] and Diguingue, (2001) [37] whose work has shown that *C. gariepinus* is insectivore.

CONCLUSION

This study shows that *Clarias jaensis* has a very wide food spectrum, which gives it the status of an omnivorous fish with an insectivorous tendency. The species has opportunistic feeding behaviour and explores different stream habitats (benthic and pelagic). It has the ability to adapt its diet according to the resources available in the environment and according to the hydrological season.

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