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RESEARCH ARTICLE

NATURAL DIET OF *AMNIRANA ALBOLABRIS* (HALLOWELL, 1856), A FROG SPECIE FROM BANCO NATIONAL PARK (CÔTE D'IVOIRE)

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Abstract

We have established the natural diet of *Amnirana albolabris* from the Banco National Park (Cote d'Ivoire), through this study. Firstly, a general analysis of prey composition in the stomach of 238 specimens (obtained by the force-feeding technique) has been done, and secondly, according to the age, sex of specimens, climatic seasons, and sampling sites. Nine categories of prey (Insects, Arachnids, Annelids, Molluscs, Myriapods, Crustaceans, animal debris, macrophytes, and undetermined prey) have been identified in the diet of this species of frog. Adult's diet is statistically different from juvenile one. However, males and females consume the same foods. In terms of the climatic seasons, the foods consumed during the long rainy season differ from those during the short dry season. Similarly, the foods eaten during the major dry season differ from those consumed by this frog during the minor dry season. At the spatial level, the diet of this species does not differ significantly from one habitat to another. The diet composition of *Amnirana albolabris* revealed that this frog species has an omnivorous diet with an insectivorous tendency in Banco National Park.

Introduction:-

The diet of amphibians is generally influenced by the availability of food in their environments. It also depends on their ability to capture and the selection of prey they operate on. Amphibians are recognized as animals with an eclectic diet (Perret, 1979). In these animals, adult individuals generally attack only alive and mobile prey. Several species of frogs have a diet composed of small prey such as insects. This is the case for Ptychadena longirostris and P. oxyrhynchus (Konan *et al*., 2016a) and the tree frog Scinax squalirostris (Kittel & Solé, 2015). In addition, the presence of plant fragments in the stomach contents of amphibians has been mentioned (Kouamé *et al*., 2008a; Tohé et al., 2015; Konan *et al*., 2016b). Concerning *Amnirana albolabris* little information is available in our country. Theinformation available on this species of frog is that of Assemian, (2009) who reported its presence in Banco National Park (Côte d'Ivoire), and Konaté *et al*. (2021; 2022) whose work relates to its reproduction strategy. Regarding its diet, no data is yet available in our country. Therefore, it seems important to us to conduct a study in order to provide a better knowledge of the natural food habit of Amnirana albolabris from the Banco National Park.

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Materials and Methods:-

Study site

The study was conducted in the Banco National Park (Figure 1) located within the vast urban area of Abidjan between 5°21' and 5°25' north latitude and between 4°1' and 4°5' west longitude with an altitude between 0 and 113 m (De Koning, 1983).

Methodology:-

Two samplings have been performed at night each month for 12 months. A total of 274 specimens *of Amnirana albolabris* were sampled. The method of capture consisted of immobilizing the frog with the light of the torch and then capturing it by hand. After each sampling, the stomach contents were obtained using the force-feeding technique proposed by Solé *et al*. (2005), Hirschfeld & Rödel (2011), and Kittel & Solé (2015). This method consisted of inserting a gavage syringe containing water into the frog's snout. Then collect the stomach contents in a jar. This operation was repeated two (02) times. The stomach content obtained is kept in pillboxes containing 70% alcohol. Stomachs are considered empty when there is no food in the jar. Each prey was identified by using a binocular magnifier and the identification keys of Roth (1979) and Tachet *et al*. (2010).

Data analysis

Numerical percentage

The numerical percentage (N) consisted in counting tach category of prey individuals "i" for a given sample (Hureau, 1970). It expresses the ratio of the number of individuals of an identified prey to all the different categories of prey inventoried. Its formula is as follows:

$\mathbf{N} = \left(\frac{\mathbf{Ni}}{\mathbf{Ne}}\right) * \mathbf{100}$ **;** With : **N**i total number of prey "i"; Ne = total number of prey inventoried.

Volume percentage

This parameter consists in evaluating the volume of each fully preserved prey (Griffiths & Mylotte, 1987). Its formula is as follows:

$\mathbf{V} = \frac{\mathbf{4}}{\mathbf{3}}\boldsymbol{\pi}(\frac{\mathbf{1}}{\mathbf{2}}\mathbf{L}) \times (\frac{\mathbf{1}}{\mathbf{2}}\mathbf{l})^{\mathbf{2}}$ **;** with: L= prey length; l = width of the prey.

Frequency of occurrence

It consists of counting the number of stomachs in which prey is present (Gray et al. 1997; Young et al. 1997). Its formula is as follows:

F= (Nc / Nt)*100 ; with: Nc= number of stomachs containing a category of prey "i" ;
Nt = number of non-empty stomachs.

Relative importance index

The use of the relative importance index (IRI) was chosen in this study because it gives a good interpretation of the diet. The various indices above seem to give an incomplete idea of the diet (Wootton, 1990). According to Pinkas et al. (1971), its formula is as follows :

$$\mathbf{IRI} = (\%\,\mathbf{N} + \%\,\mathbf{V}) \times \%\,\mathbf{F}$$

Statistical analysis

Non-parametric tests have been done by using Mann-Whitney and Kruskal-Wallis ($n < 30$). These tests allowed us to compare the diet of the species studied and were carried out by using the STATISTICA software version 7.1

Results:-

General diet

The stomach contents of 274 specimens of *Amnirana albolabris* were examined (Table I). The snout-anus length of the sampled specimens varies from 35 to 72 mm. Thirty-six stomachs analyzed are empty (either an emptiness index of 13.14%) and 238 contain food. Nine food categories have been identified in the stomachs of this species of frog. These include Insects, Arachnids, Annelids, Molluscs, Myriapods, Crustaceans, Animal Debris, Macrophytes, and undetermined prey. To these nine are added grains of sand. Insects represent the preferential food (IRI = 61.84%) of

this frog. It feeds on Molluscs (IRI = 20.42%) as secondary food. The other foods whose index is less than 5% are accessory foods. With respect to insects, ten orders have been identified in the alimentary bolus of this frog. Among these orders, Hymenoptera and Coleoptera with respective relative importance indices of 24% and 21.67% are the most consumed by this species.

Diet by age group

Table II summarizes the diet composition of adult and juvenile specimens of *Amnirana albolabris*. The food spectrum of adults is composed of nine types of prey (Insects, Arachnids, Annelids, Molluscs, Myriapods, Crustaceans, Animal Debris, Macrophytes, and Indeterminates) against three (Insects, Molluscs, and Macrophytes) for juveniles.

In juveniles, insects (IRI= 80.87%) constitute the main prey. the other prey constitutes the accessory food. On the other hand, adult specimens feed preferentially on Insects (IRI = 57.16%), and molluscs (IRI = 22.9%) represent their secondary foods. All other foods with an index below 6% are accidentally eaten. Adult and juvenile specimens have insects, molluscs, and macrophytes in common in their food bowls.

With respect to insects, six orders (Coleoptera, Hymenoptera, Lepidoptera, Isoptera, Orthoptera, and Odonata) are common to the diets of the two age groups. Adults also consume Trichoptera, Heteroptera, Diptera, and Dermaptera. In adults as in juveniles, the Hymenoptera constitute the most abundant order of insects with respective indices of 22.14% and 38.38%. Beetle tracking (19.98% in adults and 19.09% in juveniles).Statistically, the diet of juveniles differs significantly from the diet of adults (Mann-Whitney test, n1 = 19; n2 = 9; U = 50; z = -1.74; p = 0.001)

Composition of the diet according to sex

The composition of the diet of males and females of *Amnirana albolabris* is shown in Table III.

The food spectrum of male specimens consists of eight categories of prey against nine in females. Males feed on Insects (IRI = 63.79%) as preferential food. Molluscs (IRI= 16.03%) are their secondary prey. Others constitute the accessory food. As for the females, they feed preferentially on insects and molluscs with respective indices of 43.65% and 36.57%. The other preysare eaten accidentally.

Regarding insects, males and females consume seven orders in common, namely, Coleoptera, Hymenoptera, Trichoptera, Lepidoptera, Isoptera, Diptera, and Dermaptera. Insects belonging to the order Heteroptera, Orthoptera, and Odonata are specific to the diets of male individuals. Statistical analysis reveals that the diet of male specimens does not differ from the diet of females (Mann-Whitney test n1= 18; n2= 16; U = 125, Z= 0.65; p-value = 0, 52).

Seasonal variation in diet.

Table IV illustrates the food spectrum in *Amnirana albolabris* from the Banco National Park according to the climatic seasons. The distribution gives nine (09) food types during the long rainy season (LRS), seven (07) during the short rainy season (SRS) against ten (10) and four (0 4) during the long dry season (LDS) and the small dry season (SDS) respectively.

Insects (IRI= 64.81%) constitute the preferential prey and Molluscs (IRI= 20.72%) constitute the secondary food of this frog during the LRS. As for the short rainy season, these individuals consume insects (IRI= 57.57%) as preferential prey as well as arachnids (IRI= 14.6%), and molluscs (IRI= 11.56%) as secondary food. The other foods are eaten accidentally. During the great dry season, these frogs feed on insects (IRI= 59.2%) as preferential food as well as Macrophytes and Molluscs with the respective index of 14.64 and 12.18% as secondary prey. However, during the small dry season, molluscs (50.39%) constitute the preferential food while insects represent the secondary food (IRI = 36.96%). All other prey is incidental food.

Concerning the orders of Insects, during the LRS and the SRS, the Hymenoptera (with respectively 33.29% and 35.68%) and the Coleoptera (respectively 12.67% and 12.39%) are the most abundant. Coleoptera (IRI= 42.49%) constitute the dominant food of this frog during the LDS. Lepidoptera (IRI= 19.22%) and Coleoptera (IRI= 14.91%) are the most abundant orders during SDS. Statistically, there is no significant difference between the foods consumed by these individuals during the long and short rainy season (Mann-Whitney test, n1 = 18; n 2 = 11; U = 65, Z = -1, 52; p = 0.133). However the foods consumed by this frog during the long dry season differ from those consumed during the short dry season (Mann-Whitney test; n1= 17, n2 = 6, U = 20, Z = - 2.17 ; p-value = 0.029).

Similarly, the prey consumed by *Amnirana albolabris* during the LRS are statically different from those consumed during the SRS (Mann-Whitney test; n1= 18, n2 = 6, U = 23, Z = - 2.06; p -value = 0.039). In addition, the foods consumed during the long rainy season are not statistically different from those consumed during the long dry season (Mann-Whitney test; n1= 18, n2 = 17, U = 149, Z = 0.13; p-value = 0.91). Also the foods consumed during SRS do not differ statistically from those consumed in SDS (Mann-Whitney test; n1= 11, n2 = 6, U = 22, Z = 1.10; p-value = 0.3).

Spatial distribution of diet

Table V presents the composition of the food spectrum and the relative importance index (IRI in %) of *Amnirana albolabris* in the three surveyed habitats.

The distribution gives nine (09) food categories at the fish farm, against eight (08) in the intermediate habitat and at the bay.

At the fish farm, these frogs consume insects (IRI = 68.53%) as preferential food and Molluscs (IRI = 21.31%) as secondary food. Relative to the intermediate habitat, insects (IRI = 56.03%) are the preferred prey and molluscs (IRI = 26.67%) are consumed secondarily in this environment. As for the berry, the preferred food is insects (IRI = 61.47%). Myriapods (IRI= 11.64%) and indeterminate prey constitute the secondary food in this environment.

The prey consumed did not show any significant difference from one habitat to another (Kruskal-Walis test, n1= 17; n2 = 15; n3 = 16, p-value = 0.47).

Regarding the insects consumed, six (06) orders (Coleoptera, Hymenoptera, Trichoptera, Lepidoptera, and Isoptera) are identified in the food bolus of this frog in the three habitats. Dermaptera and Odonata are missing in the stomach contents respectively at the fish farm and in the intermediate habitat. As for the Heteroptera, they are non-existent in the foods at bay and in the intermediate habitat.

Discussion:-

The diet was studied in general and then according to sex, age, seasons and sampling sites in *Amnirana albolabris* from Banco National Park.

Regarding the general diet, nine food categories were observed in the dietary spectrum of the specimens. These include insects, arachnids, annelids, molluscs, myriapods, crustaceans, plant debris, undetermined prey, and animal debris. *A. albolabris* is therefore an omnivorous species. Among these food categories, insects are the most abundant prey with a relative importance index of 61.84%. This frog is omnivorous with an insectivorous tendency. Our results corroborate those of Cibiha (2017) who reports that the diet of *A. albolabris* in Masako (Congo) is dominated by insects. Moreover, among these insects, those belonging to the order of Hymenoptera and Coleoptera constitute an important fraction of the food bolus of this frog. The abundance of these prey could be related to their availability in the environment. Grains of sand have no nutritional value. Their ingestion would probably have taken place at the time of food intake. Indeed, frogs catch their prey and it is surely at this moment that the ingestion of the grains of sand and plant debris present in the stomach would take place. The low index percentages of these items would indicate that they would be consumed involuntarily by specimens of *A. albolabris*. Indeed, the frogs by capturing the prey fixed on the plants or on the ground consume the plants as well as the grains of sand in an involuntary way. Such observations have been made by Hill *et al.* (2015), Kouame *et al*. (2008) and Assemian *et al*. (2015). Furthermore, some studies on anurans have reported that frogs can ingest a large number of plants (Kouamé *et al*. 2008; Ogoanah & Uchedike, 2011; Tohé *et al*., 2014).

Relative to the diet according to the size of specimens of *A. albolabris***,** the diet of adults shows significant differences from juveniles (p = 0.001; Mann-Whitney test). Insects represent the preferred food (57.16%) in adults and they constitute the bulk of the food bolus in juveniles (80.87%). Adult specimens consume prey of more diverse sizes ranging from insects (small size) to molluscs (large size). Indeed, frogs grab their food. Thus, the larger oral cavity of adult individuals could explain the presence of large prey in their diet. Also, the abundance of Hymenoptera and Coleoptera which are small-sized foods as essential resources in the food spectrum of juveniles would be linked to the smallness of their oral cavity. This observation was also made by Tohé (2009) who reported in *Hoplobatrachus occipitalis*, *Ptychadena mascareniensis*, and *P. pumilio* from the Banco National Park that adults consume larger prey than juveniles.

Regarding the diet according to sex, the results show that the foods consumed by males and females are not significantly different (P= 0.52; Mann-Whitney test). In addition, the proportion of insects in the food bolus of male specimens is higher than that of females. This result could be explained by the fact that the males have a skill in jumping, this would facilitate them to be more active and to capture more easily the more mobile prey. Hymenoptera and Coleoptera are abundant in the food spectrum of both males and females. This result could be explained by the abundance of these insects in this biotope. Indeed, variations in the use of resources between the different sexes, according to Belovsky (1978), shine *et al*. (2002), and Martins *et al*. (2006), would result from different behavioral or energetic morphologies related to reproduction. In addition, observations reveal that large preys are more abundant in the stomach contents of female specimens than males. This result would be related to the size of the specimens. Indeed, in *A. albolabris*, females that are large ingest large prey more easily.

Regarding the seasonal variation of the diet, the results indicate that except for the short dry season, the food consumed by this species is dominated by insects. Moreover, the proportions of insects consumed during the rainy seasons (short and long rainy seasons) are more important in the food spectrum of *A. albolabris* than those of the dry seasons (small and long dry seasons). This abundance of insects in the food bowl during the rainy season could be explained by the availability of these prey in the environment. Indeed, this climatic period would be favorable to the proliferation and development of insects. Moreover, on this subject, Dietoa (2002) specifies that reproduction in most insects coincides with the rainy season, which would explain their abundance in the environment during the rainy season and therefore their presence in the food bolus at this time of the year. On this subject, Tohé *et al*. (2014; 2015) reported in *Hoplobatrachus occipitalis* and *Phrynobatrachus latifrons* an abundance of insects in the diet during the rainy season.

At the spatial level, the food resources of *Amnirana albolabris* in the three habitats are diversified. Insects are the staple food in these habitats. In addition Hymenoptera, Coleoptera and Molluscs are more consumed at the fish farm. On the other hand, in the intermediate habitat, Lepidoptera and Molluscs constitute the most abundant prey. As for the berry, Coleoptera and Lepidoptera are abundant in the food bowl of this frog. However, the differences between diets from one habitat to another are not significant (Kruskal-Walis test, p-value = 0.47). The differences observed between prey from one habitat to another would be linked to the environmental conditions of each biotope.

Conclusion:-

Amnirana albolabris in Banco National Park has an omnivorous diet with an insectivorous tendency. Among the insect orders, Coleoptera and Hymenoptera are the most represented.The diet of this frog varies with the seasons and the different age groups (adults, juveniles).

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Figures:-

Figure:- 1

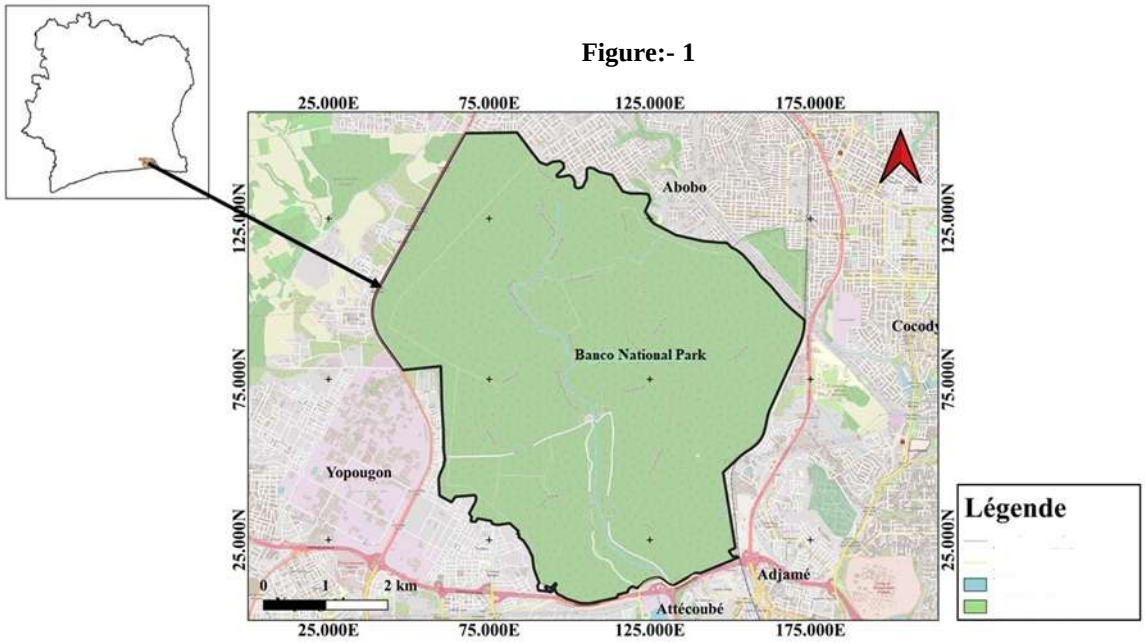

Fig. 1:- Geographical position of Banco National Park (Ivory Coast).

Table I:- Compositions of the general diet and indices of relative importance (IRI %) of the different categories of prey in *Amnirana albolabris* from Banco National Park: F = Frequency of occurrence N = numerical percentage, V = volume percentage.

Ingested prey	**Indices (%)**			
	F	**N**	**V**	**IRI**
Insects				
Coleoptera	14.98	12.46	11.10	21.67
Hymenoptera	12.78	20.58	10.54	24.41
Trichoptera	3,96	3,19	6,86	2.45
Heteroptera	0.44	0.29	0.33	0.02
Lepidoptera	7.05	7.54	7.40	6.47
Isoptera	4.41	4.64	4.56	2.49
Diptera	2.20	2.32	4.17	0.88
Orthoptera	4.85	3.77	4.38	2.42
Dermaptera	2.20	2.03	0.94	0.40
Odonata	2.20	2.32	2.40	0.64
∑Insects	**55.07**	**59.13**	**52.69**	**61.84**
Arachnids	**4.41**	**3.77**	**11.87**	**4.23**
Annelids	**2.64**	**2.32**	**3.41**	**0.93**
Molluscs	**13.22**	**13.62**	**11.53**	**20.42**
Myriapods	**5.29**	**4.06**	**6.63**	**3.47**
Crustaceans	**0.88**	**0.58**	**1.29**	**0.10**
Animal Debris	**3.96**	**3.19**	**4.83**	**1.95**
Macrophytes	**6.61**	**6.09**	**2.87**	**3.64**
Indeterminates	**5.29**	**4.64**	**4.34**	**2.92**
Sand	**2.64**	**2.61**	**0.53**	**0.51**

Table II:- Compositions of the diet and indices of relative importance IRI (in %) of *Amnirana albolabris* specimens according to age classes from Banco National Park: n = number of full stomachs.

Ingested prey	**IRI (%)**	
	Adults (n = 223)	(Juveniles n = 15)
Insects		
Coleoptera	19.98	19.09
Hymenoptera	22.14	38.38
Trichoptera	2.94	0
Heteroptera	0.02	0
Lepidoptera	6.12	8.06
Isoptera	2.2	4.45
Diptera	1.06	0
Orthoptera	1.65	9.69
Dermaptera	0.49	0
Odonata	0.55	1.19
∑Insects	**57.16**	**80.87**
Arachnids	**5.07**	**0**
Annelids	**1.12**	**0**
Molluscs	**22.9**	**2.7**
Myriapods	**4.18**	**0**
Crustaceans	**0.12**	**0**
Animal Debris	**2.35**	**0**
Macrophytes	**2.77**	**14.8**
Indeterminates	**3.53**	**0**
Sand	**0.8**	**1.62**

Table III:- Compositions of the diet and indices of relative importance (IRI %) of the different food categories contained in the food bolus of *Amnirana albolabris* according to sex in Banco National Park; n = number of full stomachs.

	IRI (%)	
Ingested prey	Males n = 199	Females n = 24
Insects		
Coleoptera	20.56	16.61
Hymenoptera	21.63	21
Trichoptera	4.21	0.94
Heteroptera	0.05	0
Lepidoptera	7.43	3.47
Isoptera	2.82	1.08
Diptera	1.41	0.44
Orthoptera	3.69	0
Dermaptera	0.76	0.11
Odonata	1.24	0
∑Insects	**63.79**	**43.65**
Arachnids	**5.25**	**4.28**
Annelids	**1.3**	**0.69**
Molluscs	**16.03**	**36.57**
Myriapods	**3.77**	**4.41**
Crustaceans	**0**	**1.02**
Animal Debris	**4.11**	**0.25**
Macrophytes	**1.96**	**4.29**
Indeterminates	**3.28**	**3.66**
Sand	**0.51**	**1.18**

Table IV:- Compositions of the diet and indices of relative importance IRI (in %) of specimens of *Amnirana albolabris* according to the seasons; n = number of stomachs containing food; LRS= Long Rainy Season; SRS= Short Rainy Season; LDS= Long Dry Season; SDS= small Dry Season.

	IRI(%)			
Ingested prey	LRS (n = 97)	SRS (n = 33)	LDS (n = 74)	SDS (n = 27)
Insectes				
Coleoptera	12.67	12.39	42.49	14.91
Hymenoptera	33.29	35.68	6.01	0
Trichoptera	4.56	0	0.87	0
Heteroptera	0.05	0	0	0
Lepidoptera	5.25	1.76	5.87	19.22
Isoptera	3.97	3.26	0.14	0
Diptera	1.07	4.48	0	0
Orthoptera	2.18	0	3.14	2.83
Dermaptera	0.67	0	0.28	0
Odonata	1.09	0	0.41	0
∑ Insects	**64.81**	**57.57**	**59.2**	**36.96**
Arachnides	**4.64**	**14.6**	**0.22**	**0**
Annelids	**1.34**	**1.04**	**0.16**	**0**
Molluscs	**20.72**	**11.56**	**12.18**	**50.39**
Myriapods	**4.39**	**0**	**3.08**	**3.41**
Crustaceans	**0**	**0**	**1.56**	**0**
Animal Debris	**1.84**	**2.32**	**1.48**	**0**
Macrophytes	**0.65**	**3.43**	**14.64**	**9.24**
Indeterminates	**1.47**	**9.48**	**4.37**	**0**
Sand	**0.15**	**0**	**3.11**	**0**

Table V:- Composition of the diet and indices of relative importance (IRI in %) of the food categories of *Amnirana albolabris* at the fish farm, in the intermediate habitat, and the bay of Banco National Park: n = number of full stomachs.

Ingested prey	**IRI (%)**		
	Fish farm (n = 98)	Intermediate habitat (n = 62)	Bay (n = 78)
Insectes			
Coleoptera	25.82	14.23	14.57
Hymenoptera	34.19	10.1	13.5
Trichoptera	1.85	1.4	4.74
Heteroptera	0.07	0	0
Lepidoptera	0.7	18.06	11.19
Isoptera	4.31	0.64	1.19
Diptera	0	8.59	0
Orthoptera	1.29	3.02	3.48
Dermaptera	0	0	7.71
Odonata	0.3	0	5.1
∑Insects	**68.53**	**56.03**	**61.47**
Arachnids	**2.79**	**5.3**	**3.65**
Annelids	**0.4**	**1.25**	**1.52**
Molluscs	**21.31**	**26.67**	**5.25**
Myriapods	**1.29**	**2.51**	**11.64**
Crustaceans	**0.4**	**0**	**0**
Animal Debris	**0.98**	**2.56**	**2.47**
Macrophytes	**1.97**	**4.37**	**4.72**
Indeterminates	**2.1**	**0.94**	**7.93**
Sand	**0.24**	**0.37**	**1.35**

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