*Original Research Article*

Feeding ecology and feeding habits of blue Crab *Callinectes amnicola* (De Rochebrune, 1883) (Decapoda, Brachyura, Portunidae) - Ehotile National Park - Côte d’Ivoire, West Africa

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ABSTRACT

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| **Aims:** In order to control the captive breeding of a species, it is important to understand its diet. The aim of this study is to highlight the feeding ecology and feeding habits of Callinectes amnicola.  **Study design:** Diet of *Callinectes amnicola* from Ehotile National Park Cote d’Ivoire, was investited from Janvuay to December 2018.  **Place and Duration of Study:** Department of Climate Change and Biodiversity, Hydrobiology and Water Ecotechnology Research Unit, between January 2018 and December 2018.**Methodology:** Crab sampling was carried out monthly between January and December 2018 using gillnets and fixed nets. The fixed nets were set without bait at low tide from 6:30 p.m. and removed at 6 a.m. the following day. Drift net fishing began at 6 a.m. and ended at 8 a.m. The total width and length of the carapace were measured for each specimen, and the crabs were dissected. The stomachs were removed, weighed, and stored in pill boxes containing 5% diluted formaldehyde.  **Results:** Six major categories of prey Macrophytes constitued by Insects, Crustaceans, Molluscs, Fishes and Annelids were found in cardiac stomach. Based on the relative importance of food (RIF) and the mean intestinal coefficient (0.52 ± 0.04), *Callinectes amnicola* was an omnivorous species and fed primarily on invertebrates. This species also has a cannibalistic behavior. Relationship between the length of carapace (Lc) and the intestine (Li) was defined by the equation log Li = - 0.3642 + 1.0480 × log Lc. To study ontogenetic changes in diet, *Callinectes amnicola* individuals were divided into 3 sizes classes following the Sturge rule and Hierarchical clustering (44 – 82 ; 83 - 108, and 109 - 147 mm carapace width) representing respectively juveniles or immatures, prematures or subadults, and sexually mature or adults stages. At all stages, crabs feed mainly on macrophytes and their other prey includes crustaceans, molluscs, fish, insects and annelids. varices grades.  **Conclusion:** The data provided by this study will serve as a reference for the manufacture of feed for captive breeding of this species, which is highly prized by the public and sold on the markets. |

*Keywords: Crustaceans, Feeding ecology, Blue crab, Callinectes amnicola*

1. INTRODUCTION

Macroinvertebrates in aquatic environments are natural resources of paramount importance. They play vital roles in aquatic ecosystems, including nutrient cycling, food web interactions, and as indicators of water quality and environmental changes, making them essential for maintaining healthy aquatic environments (Stumpf et al., 2009).  They include species of high economic value (Bougard, 1988) and are a source of protein for most populations. Among these species, *Callinectes amnicola* (De Rochebrune, 1883), a cosmopolitan species, were found in most brackish waters, wetlands and lagoons in West Africa (Abbey-Kalio, 1982 ; Solarin, 1988 ; Coulibaly, 2020). This species has also a great economic value and were found in all markets, either fresh, dried or smoked (Sankare et al., 2014). *Callinectes amnicola* or blue crab belongs to Poruntidae family and Decapoda order. It is also highly prized in human and animal nutrition for the quality of its meat, its high protein and mineral content (Chindah et al., 2000). It is the main food organism caught in coastal fisheries and lagoons in West Africa (Lawal-Are and Barakat, 2009).

In Côte d'Ivoire, from 2006 to 2009, average catches of *Callinectes* *amnicola* were estimated at 5,846 tons/year in lagoons by Sankare et al. (2014). Despite its economic value and widespread distribution in Africa, studies on this species remain very limited. In Ivorian waters, studies on crabs of genus *Callinectes* include those by Emmanuel and Saurin (1981) on the biology and fishing of crabs in the Ebrié lagoon ; Lhomme (1994) on exploitable crustaceans ; Sankare (2007) on exploitation and bioecology in the Aby-Tendo-Ehy lagoon complex ; and D'Almeida (1999) on the reproductive cycle. No data exists on the diet and food preferences of the species. However, according to Ramirez-Luna et al. (2008), information on the feeding ecology of species is fundamental to understanding their roles within their ecosystems. This knowledge highlights the link between food resources and energy flows within communities. In addition, the study of food ecology makes it possible, in the short and medium term, to predict resource sharing within a community and to define food tolerances and/or overlaps and competition between species.

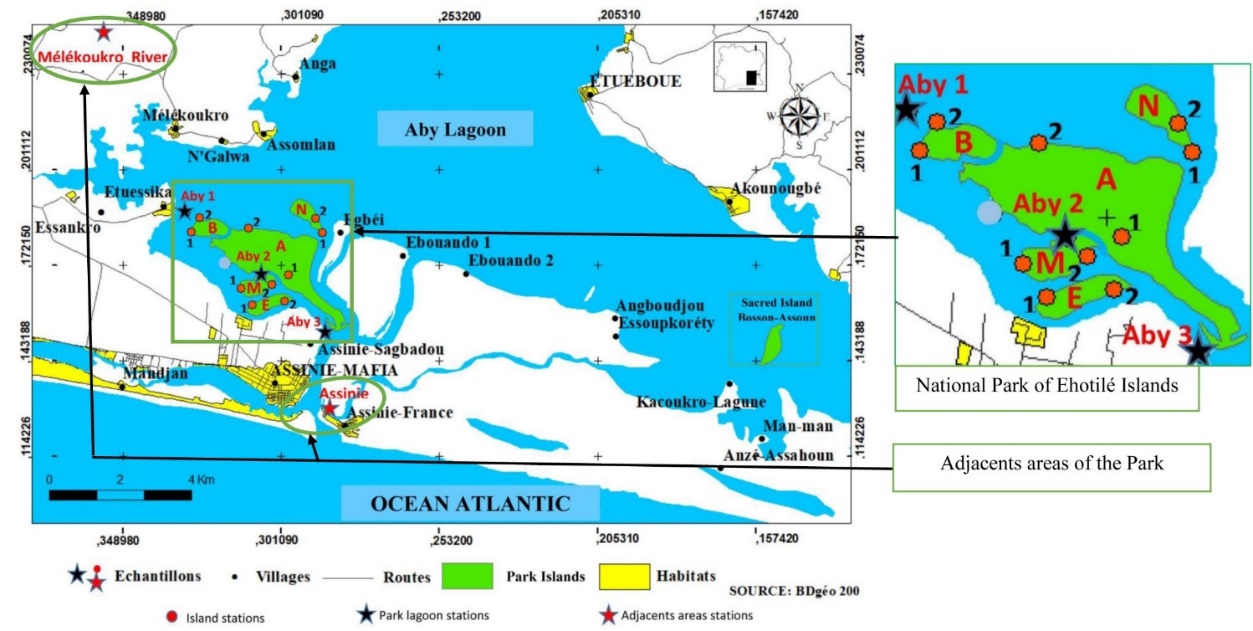
This study, aims to determine the trophic profile of the blue crab *C. amnicola*, its food diversity according to size and sex, and the hydrological seasons. The results of this study will ultimately provide a better understanding of the trophic ecology of this crab in order to define conservation and sustainable management strategies for the species stocks. This knowledge will also be used to develop feed formulations for captive breeding of the species.

2. material and methods

**2.1 Study area**

Ehotilé Islands National Park (PNIE) (Figure 1) is located in the southeast of Côte d'Ivoire in Adiaké department, between 3°16'43“ and 3°18'52” west longitude and 5°9'45“ and 5°11'12” north latitude. It consists of six islands beloning to Assokomonobaha or Assoko (327.5 ha), Baloubaté (75 ha), Méha (45 ha), Nyamouin (47.5 ha), Elouamin (22.5 ha) and the sacred island of Bosson-Assoun (32.5 ha) (**Lauginie, 2007**). All these islands were surrounded by Aby lagoon and separated from each other by lagoon arms, giving the park a total area of 722 ha. Aby lagoon receives water from the Bia River in its northern part and opens onto the sea via the Assinie Canal (Chantraine, 1980).

In this study, three sampling stations (Aby 1, Aby 2, Aby 3) in the lagoon part of the park were selected based on the longitudinal gradient.



**Fig. 1. Sampling sites of blue crabs *Callinectes amnicola* in Ehotile Island National Park (Aby 1, Aby 2, Aby 3) from january to December 2018**

**2.2 Sampling and size class of crabs**

Crab sampling was carried out monthly between January and December 2018 using gillnets and fixed nets. The fixed nets were set without bait at low tide from 6:30 p.m. and removed at 6 a.m. the following day. Drift net fishing began at 6 a.m. and ended at 8 a.m. The total width and length of the carapace were measured for each specimen, and the crabs were dissected. The stomachs were removed, weighed, and stored in pill boxes containing 5% diluted formaldehyde. A total of 150 crab specimens with carapace widths ranging from 44.17 mm to 144.03 mm were examined. Sturge's rule (Scherrer, 1984)was used to determine size classes. Three size classes were defined. Class I, comprising 36 individuals with carapace widths between 44 and 82 mm, represents juveniles ; class II, comprising 65 individuals with sizes between 83 and 108 mm, represents sub-adults. Class III consists of 49 individuals with a size between 109 and 147 mm, which are adult individuals.

**2.3 Analyses of stomach contents and data**

Stomach was sectioned and the contents were observed using a Vision SX25 binocular magnifying glass. Stomachs, prey organisms and macrophytes obtained were weighed to the nearest hundredth of a milligram using a Sartorius TE153S precision scale with a range of 0.001g and a capacity of 150g. When possible, prey were identified at the lowest taxonomic level using the keys provided by Elouard (1981), Dejoux et al. (1981) and Tachet et al. (2003) for insects and crustaceans ; Moor and Day (2002) for mollusks ; Paugy et al. (2003 a and b) for fish. Sand crystals were not taken into account in this study because they have no nutritional value.

Several dietary indices were used to define diet of *C. amnicola*. These included :

(1) Relationship between intestine length and crab length : The relationship between intestine length and crab length has been described by the following equation : 𝐿𝑖 = 𝑎𝐿C𝑏. Li : intestine length, a : ordinate at the origin, LC : carapace length, and b is the allometric coefficient.

(2) Mean intestinal coefficient (CIM) : où  ; where CI = intestinal coefficient ; LI = intestinal length; LC = carapace length; n = total number of crabs examined. The dietary classification of different crab species was defined according to **Paugy (1994)** and is as follows : CIM < 0.85 = fish-eating diet ; 0.32 < CIM < 2.18 = invertebrate-eating diet ; 0.8 < CIM < 3.01 = omnivorous diet ; 4.71 < CIM < 6.78 = plant-eating diet and 10 < CIM < 17 = limivorous diet.

(3) Vacuity coefficient :  ; where CV = Vacancy coefficient ; nev = number of empty stomachs and nte = total number of stomachs examined.

(4) Corrected occurrence percentage (%Oc ) was calculated according to Rosecchi and Nouaze (1987) : %Oc = x100 with %O = x100 ; where %Oi = percentage of occurrence of an item *i* , s = total number of food items ; nei = number of stomachs containing item i and nep = number of full stomachs.

(5) Relative food importance (RIF) of Georges and Hadley (1979) combines the numerical percentage, weight percentage, and corrected percentage of occurrence: where %Oc = corrected occurrence percentage, %N = numerical percentage, %P = weight percentage, and s = total number of food items. Different items were ranked in order of importance using the classification scale established by Georges and Hadley (1979). This classification is as follows : RIF ≥ 50% : main prey, 10% ≤ RIF ˂ 50% secondary prey, and RIF ˂ 10%: incidental or accidental prey.

Spearman's rank correlation coefficient test was used to compare the diet of the species studied according to sex, season, and individual size. All statistical analyses were performed using Statistica software 7.1.

3. results

**3.1 Intestinal coefficient**

The intestinal coefficient of *Callinectes amnicola* ranges from 0.37 to 0.63 with a mean value of 0.52 ± 0.04. Relationship between intestine (Li) and carapace length (Cl) was log Il = -0.3642 + 1.0480 x log CL (Figure 2). Strongly correlation between intestine and carapace (r = 0.96 ; b = 1,11) was recorded. Student *t* test revealed no significant difference between the calculated b-value (b = 1.11) and the theoretical 1-value (*P* ˃ 0.05). These results indicate isometric growth between the two carapace and instestine of *C. amnicola*.



**Fig. 2. Relationship between intestine length (Il) and carapace length (Cl) of *Callinectes amnicola* caught in Ehotile Island National Park (Côte d'Ivoire) from January to December 2018**

**3.2 Vacuity Coefficient**

A total of 150 crab cardiac stomachs with a carapace lengths between 44.17 and 144.03 mm were examined. Fifteen (15) stomachs were empty. The vacuity coefficient recorded was 10 %. According season, 11 crabs out of 77 had empty stomachs with a vacuity coefficient of 14.28% in the rainy season. During the dry season, 4 crabs out of 73 had empty stomachs with a vacuity coefficient of 5.48%.

**3.3 General profile of diet**

Analysis of all cardiac stomachs contents with numerical and relative importance was summary in Table 1. Six categories of prey belong to Macrophytes, Insects, Crustaceans, Molluscs, Fishes and Annelids have been recorded. Insects were represented by Diptera and Hymenoptera ; Crustaceans by Sesarmidae crabs and Palaemonidae shrimps; Molluscs by Gastropods; Annelids by Oligochaete worms and Macrophytes by plant detritus, fruits and seeds. Sand and mud were also found in crabs cardiac stomachs. Molluscs with 36.76% have the highest numerical importance in the stomachs of *Callinectes amnicola*. They were followed by Crustaceans (29.41%), Fishes (20.59%), Insects (7.84%) and Macrophytes (4.9%). The most recurrent prey in the diet of *C. amnicola* were Molluscs (%OCc=29.39), Crustaceans (%OCc=26.31), Macrophytes (%OCc=21.05) and Fishes (%OCc=18.42). Classification of preys base on Relative Importance of Food (RIF) indicated that Molluscs (37.27%) were the most consumed prey. They were followed by Crustaceans (27.62%), Fishes (18.82%) and Macrophytes (11%) as secondary prey. Insects (4.09%) and Annelids (0.31%) have been classified as incidental prey in the diet of *Callinectes amnicola*.

**Table 1**. **General composition of *Callinectes amnicola* diet sampled in Ehotile Island National Park (Côte d'Ivoire) from January to December 2018.** % P = Weight percentage; % N = number percentage ; % CO = Corrected occurrence percentage ; RIF = Relative Importance of Food

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | |  | **% P** | **% N** | **% CO** | **% RIF** |
| **Macrophytes** |  | | |  |  |  |
| Plant debris | |  | 7.07 | 0.49 | 17.98 | 8.51 |
| Fruits | |  | 0.01 | 3.92 | 2.63 | 2.18 |
| Seeds | |  | 0 | 0.49 | 0.44 | 0.31 |
| **Insects** | |  |  |  |  |  |
| **Diptera** | |  |  |  |  |  |
| Tabanidae | | *Tabanus bovinus* | 0.01 | 5.88 | 2.19 | 2.7 |
| **Hymenoptera** |  | | |  |  |  |
| Formicidae | | *Pheidole* sp. | 0 | 1.47 | 1.32 | 0.93 |
| **Insect remains** | |  | 0 | 0.49 | 0.88 | 0.46 |
| **Crustaceans** | |  |  |  |  |  |
| **Crabs** | |  |  |  |  |  |
| Sesarmidae | | *Sesarma* sp. | 6.35 | 9.31 | 8.33 | 7.1 |
| Shrimps | |  |  |  |  |  |
| Palaemonidae | | *Macrobrachiun* sp. | 23.47 | 20.1 | 17.98 | 20.52 |
| **Molluscs** | |  |  |  |  |  |
| **Gastropods** | |  |  |  |  |  |
| Ancylidae | | *Ferrissia* sp. | 35.74 | 27.94 | 25 | 29.56 |
| Bulinidae | | *Bulinus* sp. | 5.02 | 5.39 | 2.63 | 4.35 |
| Planorbidae | | *Planorbis gibbonsi* | 0.95 | 0.98 | 0.88 | 0.94 |
| Turritellidae | | *Turritella* sp. | 3.94 | 2.45 | 0.88 | 2.42 |
| **Fishes** | |  |  |  |  |  |
| Scales | |  | 17.44 | 20.59 | 18.42 | 18.82 |
| **Annelids** | |  | 0 | 0.49 | 0.44 | 0.31 |
| **Total** | |  |  |  |  |  |
| **Macrophytes** | |  | 7.08 | 4.9 | 21.05 | 11 |
| **Insects** | |  | 0.01 | 7.84 | 4.39 | 4.09 |
| **Crustaceans** | |  | 29.82 | 29.41 | 26.31 | 27.62 |
| **Molluscs** | |  | 45.65 | 36.76 | 29.39 | 37.27 |
| **Fishes** | |  | 17.44 | 20.59 | 18.42 | 18.82 |
| **Annelids** | |  | 0 | 0.49 | 0.44 | 0.31 |

**3.4 Variation in diet according to sex**

The diet of *Callinectes amnicola* according sex were reported into Table 2. Males and females feed on Macrophytes, Insects, Crustaceans, Molluscs, Fishes and Annelids.

In males, Crustaceans were the most important numerically preys in stomach (38.38%). They were followed by Molluscs (26.26%), Fishes (18.18%), Insects (13.13%) and Annelids (1.01%). In female, Molluscs were the highest abundance preys (42.32%) consumed. Followed by Fishes (25%), Crustaceans (21.15%), Macrophytes (7.69%) and Insects (3.84%).

Base on Relative Importance of Food (RIF), in males, Crustaceans (RIF = 44.14%) mainly represented by Palaemonidae (RIF = 33.48%), Molluscs (RIF = 18.92%) constitued by the Ancylidae (RIF 16.86%), Fishes (RIF = 18.72%) and Macrophytes (RIF = 11.39%) represented mostly by Plant detritus (RIF = 10.42%) were the main prey. Insects (RIF = 6.2%) mantly constitued by *Tabanus bovinus* (RIF 4.28) and Annelids (RIF = 0.64%) were classified as secondary prey. In females, Molluscs (RIF = 45.33%), Fishes (RIF = 21.62%), Crustaceans (RIF = 18.29%) and Macrophytes (RIF = 12.27%) were the main prey eaten. The incidental prey was represented by Insects (RIF = 2.48%). Spearman's correlation test revealed a significant difference (*p* = 0.04 ˂ 0.05) between prey consumed by males and females of *Callinectes amnicola*.

**Table 2. Composition of the diet according to sex of *Callinectes amnicola* sampled in the Ehotile Island National Park (Côte d'Ivoire) from January to December 2018.** % P = Weight percentage ; % N = number percentage ; % CO = Corrected occurrence percentage ; RIF = Relative Importance of Food

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | |  | **Males** | |  |  | **Females** | |  |
|  | |  | | **% P** | **% N** | **% CO** | **RIF** | **% P** | **% N** | **% CO** | **RIF** |
| **Macrophytes** |  | | | |  |  |  |  |  |  |  |
| Plant debris | |  | | 11.32 | 1.01 | 18.92 | 10.42 | 5.68 | 0.96 | 18.02 | 8.22 |
| Fruits | |  | | 0 | 2.02 | 0.9 | 0.97 | 0.01 | 5.77 | 4.5 | 3.43 |
| Seeds | |  | | 0 | 0 | 0 | 0 | 0 | 0.96 | 0.9 | 0.62 |
| **Insects** | |  | |  |  |  |  |  |  |  |  |
| **Diptera** | |  | |  |  |  |  |  |  |  |  |
| Tabanidae | | | *Tabanus bovinus* | 0.03 | 10.1 | 2.7 | 4.28 | 0.01 | 1.92 | 1.8 | 1.24 |
| **Hymenoptera** | |  | |  |  |  |  |  |  |  |  |
| Formicidae | | *Pheidole* sp. | | 0.01 | 2.02 | 1.8 | 1.28 | 0 | 0.96 | 0.9 | 0.62 |
| Insect remains | |  | | 0 | 1.01 | 0.9 | 0.64 | 0 | 0.96 | 0.9 | 0.62 |
| **Crustaceans** | |  | |  |  |  |  |  |  |  |  |
| **Crabs** | |  | |  |  |  |  |  |  |  |  |
| Sesarmidae | | *Sesarma* sp. | | 10.97 | 11.11 | 9.91 | 10.66 | 4.43 | 7.69 | 7.21 | 6.44 |
| **Shrimps** | |  | |  |  |  |  |  |  |  |  |
| Palaemonidae | | *Macrobrachiun* sp. | | 48.83 | 27.27 | 24.32 | 33.48 | 9.47 | 13.46 | 12.61 | 11.85 |
| **Molluscs** | |  | |  |  |  |  |  |  |  |  |
| **Gastropods** | |  | |  |  |  |  |  |  |  |  |
| Ancylidae | | *Ferrissia* sp. | | 2.79 | 25.25 | 22.52 | 16.86 | 44.7 | 26.92 | 25.23 | 32.28 |
| Bulinidae | | *Bulinus* sp. | | 4.27 | 1.01 | 0.9 | 2.06 | 7.2 | 9.62 | 4.5 | 7.11 |
| Planorbidae | | *Planorbis gibbonsi* | | 0 | 0 | 0 | 0 | 0.93 | 0.97 | 0.9 | 0.93 |
| Turritellidae | | *Turritella* sp. | | 0 | 0 | 0 | 0 | 8.43 | 4.81 | 1.8 | 5.01 |
| **Fishes** | |  | |  |  |  |  |  |  |  |  |
| Scales | |  | | 21.77 | 18.18 | 16.22 | 18.72 | 19.14 | 25 | 20.72 | 21.62 |
| **Annelids** | |  | | 0 | 1.01 | 0.9 | 0.64 | 0 | 0 | 0 | 0 |
| **Total** | |  | |  |  |  |  |  |  |  |  |
| **Macrophytes** | |  | | 11.32 | 3.03 | 19.87 | 11.39 | 5.69 | 7.69 | 23.42 | 12.27 |
| **Insects** | |  | | 0.04 | 13.13 | 5.4 | 6.2 | 0.01 | 3.84 | 3.6 | 2.48 |
| **Crustaceans** | |  | | 59.8 | 38.38 | 34.23 | 44.14 | 13.9 | 21.15 | 19.82 | 18.29 |
| **Molluscs** | |  | | 7.06 | 26.26 | 23.42 | 18.92 | 61.26 | 42.32 | 32.43 | 45.33 |
| **Fishes** | |  | | 21.77 | 18.18 | 16.22 | 18.72 | 19.14 | 25 | 20.72 | 21.62 |
| **Annelids** | |  | | 0 | 1.01 | 0.9 | 0.64 | 0 | 0 | 0 | 0 |

**3.5 Variation in diet according to crab size**

Sturge's rule coupled with hierarchical clustering analysis to define the diet similarities of different age classes in *C. amnicola*, highlighted three size classes : Class I = [44 - 82 mm]; class II = [83 - 108 mm] and class III = [109 - 147 mm] (Table 3). Diet by size class showed that specimens from all three size classes, feed on Macrophytes. In addition to this prey, in size class I, specimens consumed Crustaceans, Molluscs and Fishes ; in size class II, *C. amnicola* consumed Crustaceans, Molluscs, Fishes and Insects. In size class III, crabs consumed, in addition to Macrophytes, Crustaceans, Molluscs, Fishes, Insects and Annelids.

In size class I, Molluscs (47.10%) were numerically abundant in cardiac stomachs. Followed by Crustaceans (23.50%) and Fishes (23.50%). In class II, Crustaceans (32.5%) were the most abundantly consumed. They were followed by Molluscs (27.5%), Fishes (17.5%) and Insects (15%) and Annelids (7.5%). In size class III, the most eaten prey is Molluscs (36.11 %), Crustaceans (29.17 %) and Fishes (20.83%). Followed by Macrophytes (5.55%), Insects (7.63%) and Annelids (0.69%).

Based on Relative Importance of Food (RIF), Molluscs, mostly represented by Ancylidae, were primary prey in class I (RIF = 53.83%) and secondary prey in classes II (RIF =28.35%) and III (RIF = 28.02%). Crustaceans (RIF = 16.7%) most constitued by Palaenomidae shrimps (RIF = 13.2%), Fishes (RIF = 16.4%) and Macrophytes (RIF = 12.1%) constitued by plant detritus, were secondary prey for *C. amnicola*. In class size II, Crustaceans (RIF = 35.7%), Molluscs (28.4%), Fishes (15.8%), Macrophytes (RIF = 11.2%) were secondary prey. Insects (RIF = 8.98) were incidental prey. In size class III, Molluscs (RIF = 35.8%), Crustaceans (RIF = 28.9%), Fishes (RIF = 20%) and Macrophytes (RIF = 11.3%) were secondary prey. Insects (RIF = 3.61%) and Annelids (RIF = 0.44%) were incidental prey. Spearman's correlation test revealed a different diet between size classes I and II (*p* = 0.007 ˂ 0.05); II and III (*p* = 0.00 ˂ 0.05) and I and III (*p* = 0.004 ˂ 0.05).

**Table 3**. **Diet variation according to the size class of *Callinectes amnicola* sampled in Ehotile Island National Park (Côte d'Ivoire) from Janvuay to December 2018.** % P = Weight percentage ; % N = number percentage ; % CO = Corrected occurrence percentage ; RIF = Relative Importance of Food

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | **Size class** | | | | | | | | | | | | | | | | | | | | |
|  | | | **44 - 82 mm** | | | | | | | **83 -108 mm** | | | | | | | | **109 -147 mm** | | | | | |
|  | | | **% P** | | **% N** | | **% CO** | | **RIF** | **% P** | | **% N** | | | **% CO** | | **RIF** | **% P** | | | **% N** | **% CO** | **RIF** |
|  |  |  | |  | |  | |  | | |  | |  |  | |  | | |  |
| Plant detritus | | | 5.84 | | 5.88 | | 27.27 | | 12.1 | 11.9 | | 2.5 | | | 9.52 | | 7.96 | 6.12 | | | 0.69 | 19.11 | 8.64 |
| Fruits | | | 0 | | 0 | | 0 | | 0 | 0.02 | | 5 | | | 4.76 | | 3.26 | 0.01 | | | 4.17 | 2.55 | 2.24 |
| Seeds | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 0 | | | 0.69 | 0.64 | 0.44 |
| **Insects** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| **Diptera** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| Tabanidae *Tabanus bovinus* | | | 0 | | 0 | | 0 | | 0 | 0.02 | | 7.5 | | | 4.76 | | 4.09 | 0.02 | | | 6.25 | 1.91 | 2.73 |
|  |  |  | |  | |  | |  | | |  | |  |  | |  | | |  |
| Formicidae *Pheidole* sp | | | 0 | | 0 | | 0 | | 0 | 0.02 | | 5 | | | 4.76 | | 3.26 | 0 | | | 0.69 | 0.64 | 0.44 |
| **Insect remains** | | | 0 | | 0 | | 0 | | 0 | 0.01 | | 2.5 | | | 2.38 | | 1.63 | 0 | | | 0.69 | 0.64 | 0.44 |
| **Crustaceans** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| **Crabs** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| Sesarmidae *Sesarma* sp. | | | 0.07 | | 5.88 | | 4.55 | | 3.5 | 6.12 | | 10 | | | 9.52 | | 8.55 | 7.23 | | | 9.73 | 8.92 | 8.62 |
| **Shrimps** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| Palaemonidae *Macrobrachiun* sp. | | | 8.43 | | 17.7 | | 13.64 | | 13.2 | 37.4 | | 22.5 | | | 21.43 | | 27.1 | 23.4 | | | 19.4 | 17.83 | 20.2 |
| **Molluscs** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| **Gastropods** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| Ancylidae *Ferrissia* sp. | | | 78.06 | | 47.1 | | 36.36 | | 53.8 | 31.4 | | 27.5 | | | 26.19 | | 28.4 | 30.3 | | | 23.6 | 21.66 | 25.2 |
| Bulinidae *Bulinus* sp. | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 6.56 | | | 7.64 | 3.82 | 6.01 |
| Planorbidae *Planorbis gibbonsi* | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 1.25 | | | 1.39 | 1.27 | 1.3 |
| Turritellidae  *Turritella* sp. | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 5.14 | | | 3.47 | 1.27 | 3.29 |
| **Fishes** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| Scales | | | 7.6 | | 23.5 | | 18.18 | | 16.4 | 13.2 | | 17.5 | | | 16.67 | | 15.8 | 20 | | | 20.8 | 19.11 | 20 |
| **Annelids** | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 0 | | | 0.69 | 0.63 | 0.44 |
| **Total** | | |  | |  | |  | |  |  | |  | | |  | |  |  | | |  |  |  |
| **Macrophytes** | | | 5.84 | | 5.88 | | 27.27 | | 12.1 | 11.9 | | 7.5 | | | 14.28 | | 11.2 | 6.13 | | | 5.55 | 22.3 | 11.3 |
| **Insects** | | | 0 | | 0 | | 0 | | 0 | 0.05 | | 15 | | | 11.9 | | 8.98 | 0.02 | | | 7.63 | 3.19 | 3.61 |
| **Crustaceans** | | | 8.5 | | 23.5 | | 18.19 | | 16.7 | 43.5 | | 32.5 | | | 30.95 | | 35.7 | 30.6 | | | 29.2 | 26.75 | 28.9 |
| **Molluscs** | | | 78.06 | | 47.1 | | 36.36 | | 53.8 | 31.4 | | 27.5 | | | 26.19 | | 28.4 | 43.2 | | | 36.1 | 28.02 | 35.8 |
| **Fishes** | | | 7.6 | | 23.5 | | 18.18 | | 16.4 | 13.2 | | 17.5 | | | 16.67 | | 15.8 | 20 | | | 20.8 | 19.11 | 20 |
| **Annelids** | | | 0 | | 0 | | 0 | | 0 | 0 | | 0 | | | 0 | | 0 | 0 | | | 0.69 | 0.63 | 0.44 |

**3.6 Seasonal variation in diet**

Figure 3showed the diet variation of *Callinectes amnicola* during the rainy and dry seasons. The species consumed Macrophytes, Insects, Crustaceans, Fishes and Molluscs in the both seasons. However, during the rainy season, in additional to those prey, *C. amnicola* ate Annelids. Molluscs were numerically abundant in the rainy season (N = 41.11%) and less abundant in the dry season (N = 28.92%) in the cardiac stomachs. Crustaceans (N = 33.74%), Fishes (22.89%), Insects (N = 7.22%), Macrophytes (N = 6.02%) and Annelids (N = 1.2%) were numerically more important in dry season.

During the two hydrological seasons, preys classification based on Relative Importance of Food (RIF) showed that Molluscs (RIF RS = 44.99%; RIF DS= 27.22%) and Crustaceans (RIF RS = 24.07%; RIF DS= 34.57%) were the main eaten prey by *Callinectes amnicola*. They followed by Fishes (RIF RS = 17.66% ; RIF DS = 21.2%) and Macrophytes (RIF RS = 10.69% ; RIF DS = 11.83%) as secondarily. Insects (RIF RS = 2.59% ; RIF DS = 4.44%) and Annelids (RIF RS = 0% ; RIF DS = 0.74%) were incidental prey.

Spearman's correlation test revealed a significant difference between prey consumed during rainy season and those consumed in dry season (*p* = 0.004 ˂ 0.05).



**Fig. 3. Seasonal variation in the diet of *Callinectes amnicola* sampled in Ehotile Island National Park (Côte d'Ivoire) (Côte d'Ivoire) from Janvuay to December 2018.** RIF = Relative Importance of Food

**3.7 Seasonal variation in diet according to sex**

The seasonal variation in diet according to sex (Figure 4) indicated that males and females feed on Macrophytes, Insects, Crustaceans, Molluscs and Fishes in rainy and dry seasons. In addition to these different prey, males ate Annelids during dry season. During rainy season, Crustaceans (N = 33.93%) and Macrophytes (N = 21.43%) were more abundant in the cardiacs stomachs of males. Molluscs (N = 49.25%) were the most numerical prey in the stomachs of females. During dry season, Insects and Annelids were numerical abundant in males stomach (N = 14.51% and N = 1.61% respectively). Fishes were abundant (N = 22.86%) in females stomach. Relative Importance of Food (RIF) showed that Macrophytes were secondary prey in both rainy and dry seasons by males and females. During rainy season, females consumed mainly Molluscs (RIF RS = 52.23%) and secondarily Fishes (RIF RS = 20.05%) and Crustaceans (RIF RS = 15.8%). Insects (RIF RS = 0,98%) and Annelids (RIF RS =0%) were incidentally prey. In males, crabs consumed mainly Crustaceans (RIF RS = 36.86%) and molluscs (RIF RS = 27.18%). During dry season, females consumed mainly Molluscs (RIF DS = 33.24%), Crustaceans (RIF DS = 23.39%) and Fishes (RIF DS = 22.34%). Males consumed Crustaceans in dry season (RIF DS = 39.71%) as main prey, Fishes (RIF DS = 18.85%) and Molluscs (RIF DS = 19.9%) as secondary prey. Spearman's correlation test using Relative Importance of Food (RIF) revealed a significant difference between prey consumed by males (*p* = 0.004 ˂ 0.05) and females (*p* = 0.004 ˂ 0.05) during both seasons.



**Fig. 4.** **Diet variation according to season and sex of *Callinectes amnicola* sampled in Ehotile Island National Park (Côte d'Ivoire) from Janvuay to December 2018.** M = Males; F = Females ; RIF = Relative Importance of Food

**3.8 Seasonal variation in diet according to size**

Food spectrum of *Callinectes amnicola* according specimens size groups during rainy and dry seasonwereshown byFigure 5.

In the rainy season, crabs in size class I consumed Crustaceans, Molluscs and Fishes but feed on Molluscs and Fishes in the dry season. In size class II, crabs consumed Crustaceans, Molluscs, Fishes and Insects in both seasons. In size class III, crabs feed on Annelids in the dry season in addition to others prey mentioned above.

During rainy season Molluscs were numerical abundant in size class I (N = 42.86%) and III (N = 43.75%). Crustaceans with 35% were abundant in size class II.

In the dry season Crustaceans were numerical abundant in size class II (N = 26.67%) and III (N = 33.33%). Molluscs with 50 % were abundant in size class I.

Relative Importance of Food (RIF) showed that in size class I, Molluscs (RIF RS = 51.8% ; RIF DS = 58.47) were primary prey. Macrophytes (RIF RS = 12.02%; RIF DS = 25.02%) and Fishes (RIF RS = 15.67%; RIF DS = 16.51 %) were secondary prey in both rainy and dry seasons. Crustaceans (RIF RS = 20.51% ; RIF DS = 0%) were secondarily consumed in rainy season.

In size class II, Molluscs (RIF RS = 30.86%; DS =34.04%) and Crustaceans (RIF RS = 32.29%; DS =35.28%) were secondarily consumed in both seasons. Macrophytes (RIF 17.69%) and Insects (RIF 11.45%) were secondarily consumed in rainy season.

In size class III, during both seasons, Molluscs (RIF RS = 42.95%; RIF DS = 24.26%), Crustaceans (RIF RS = 24.67%; RIF DS = 34.35%), Fishes (RIF RS = 21.51%; RIF DS = 19.82%) and Macrophytes (RIF RS = 10.05%; RIF DS = 13.69%) were secondarily consumed by *Callinectes amnicola*. Insects (RIF RS = 0.82% ; RIF DS = 6.91%) and Annelids (RIF RS = 0% ; RIF DS = 0.97%) were incidental prey.

Spearman's correlation test using Relative Importance of Food (RIF) revealed no significant difference between rainy and dry seasons in size class I (*p = 0.22 ˃ 0.05*). A significant difference was recorded between size classes II (*p* = 0.04 ˂ 0.05) and III (*p* = 0.004 ˂ 0.05) between the two hydrological seasons.



**Fig. 5**. **Diet variation according to season and sizes classes of *Callinectes amnicola* sampled in Ehotile Island National Park (Côte d'Ivoire) from Janvuay to December 2018.** I = Size class 1 : juvéniles ; II = Size class II : sub-adultes ; III = Size class III : adultes ; RIF = Relative Importance of Food

4. DISCUSSION

The analysis of the general profile of the stomach contents of *C. amnicola* showed a vacuity coefficient equal to 10 %. The analysis of the stomach filling rate according to the crab catching seasons showed that the vacuity coefficient was high in the rainy season (14.28 %) and low in the dry season (6.31 %). The low vacuity percentages would reflect food availability and/or intense trophic activity of the species as pointed out by El Bakali et al (2010). This obtained vacuity coefficient is higher in any season than that observed in other species such as *Cardisoma armatum* (1.97%) by N’zi and coulibaly (2021), at the same sample site.

The food spectrum of *C. amnicola* contains a diversity of prey consisting of Macrophytes, Insects, Crustaceans, Molluscs, Fishes and Annelids. Sand and mud were also observed in the cardiac stomachs. These results are comparable to those of Arimoro and Idoro (2007) in Nigeria where *C. amnicola* fed on seven major categories of prey. This variety of prey obtained in the present study translates that *C. amnicola* is an omnivorous species. Our results differ from studies conducted on the diets of other *Callinectes species*. Laughlin (1982) recorded that *C. sapidus* fed on 17 prey items and that bivalves were the primary food. Haefner and Paul (1990) found that *C. ornatus* fed primarily on gastropods but ingested other food types when available.

The low value of the mean intestinal coefficient (0.52 ± 0.04) recorded in *C. amnicola* indicates that the species feed mosly on invertebrate. The presence of crabs of the *Sesarma* genus in cardiac stomachs of *C. amnicola* reflects the cannibalistic behaviour noted by Ryan (2003) and Lawal-Are and Barakat (2009) in this species. For some authors such as Wilson (1989) and Guillory (2001), crabs are benthic omnivorous predators that fed on other crustaceans, bivalves, fish, annelids, plants, detritus, and almost any other food they could find, including dead fish, decaying plants, and other crabs of the same or different species.

Concerning the seasonal variation of diet, the stomach contents reveals a consumption of Molluscs, Crustaceans, Fishes and Macrophytes in both rainy and dry seasons. This similarity in diet between the two seasons could be explained by a relative stability and availability of prey in all seasons. Indeed, the park is a reserve composed of several microhabitats with a diversity of animals and plants. These animals and plants are available in all seasons and could therefore constitute potential prey for *Callinectes amnicola*. However, these prey species had a higher numerical abundance in the dry season than in the rainy season. This abundance of prey in the dry season could be explained by an abundant migration of prey species to the Ehotile National Park, which is composed of 40% of mangrove (Unesco, 2006), to shelter or feed because of the lower water levels in the surrounding rivers.

Significant differences in diet between age classes of *C. amnicola* have been noted. This difference could be explained by the availability of food resources and the diversity of habitats explored by the crabs as a function of age. This difference in the diversity of clothing according to age would result in a decrease in competition between individuals of different age classes of the same species. Also, ontogenetic changes in diet have been recorded in crabs of Portunidae family. For example, in the species *C. bocourti* (Stoner and Buchanan, 1990), *C. sapidus* (Laughlin, 1982 ; Stoner and Buchanan, 1990), *C. ornatus* (Stoner and Buchanan, 1990), *Carcinus maenas* (Hines, 2007**)**, *Liocarcinus puber* (Choy, 1986) and *Ovalipes punctatus* (Du Preez, 1984), authors have shown that larger individuals preferentially consume fishes more than smaller individuals. Thus, the feeding habits of crabs are influenced by morphological changes in structures such as mouthparts related to feeding during the growth of individuals. Similar observations have been recorded by others authors such as Perez and Bellwood (1988).

4. Conclusion

*Callinectes amnicola* feed omnivorously on plant and animals such as Insects, Crustaceans, Molluscs, Fishes and Annelids and also on benthic material as mud and sand. The feeding habits of blue crabs from the Ehotile National Park changed with sex and size of individuals, and with saesons. The capture success, the prey type and size, the prey distribution and behavior, the differents of microhabitats, could be factors influencing the diet of *callinectes amnicola*. This information is particularly necessary because the species is confronted to an excessive exploitation with the development of the artisanal fishery. Further research providing more detail on the feeding behavior of the species taking into account the differences between juvenile and adult microhabitats and how these habitats influence their feeding habits, the nutritional value of ingested prey, will help define conservation and preservation policy for the species.

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