Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(5): 493 – 508 (2025)
www.ejabf.journals.ekb.eg

Dietary Niche Partitioning and Trophic Significance of Insect and Crustacean Prey in the Silver Catfish (*Chrysichthys nigridigitatus*)

Ivon E. Akpang[1], Godwin A. Otogo[2], Nseabasi A. Etangetuk[1], Uquetan U. Ibor[3], Honor T. Ifon[4], Peter E, Asuquo[4], Stella O. Bassey[5], Imaobong U. Imeh[4], Abasiodu A. Okon[4], Sunday U. Eteng[6]

[1]Department of Science Laboratory Technology, Faculty of Biological Science, Univ. of Calabar, Nigeria
[2]Department of Biological Oceanography, Faculty of Oceanography, University of Calabar, Nigeria
[3]Department of Environmental Management, Faculty of Environmental Sciences, Univ. of Calabar, Nigeria
[4]Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Calabar, Nigeria
[5]Department of Human Nutrition and Dietetics, Fac. of Allied Medical Sciences, Univ. of Calabar, Nigeria
[6]Department of Mariculture and Marine Fisheries Resources, Faculty of Oceanography, University of Calabar, Nigeria

[*]**Corresponding Author: honor.t.ifon@gmail.com**

ARTICLE INFO

Article History:
Received: July 19, 2025
Accepted: Sept. 2, 2025
Online: Sep. 12, 2025

Keywords:
Chrysichthys nigrodigitatus,
Diet composition,
Estuarine ecology,
Trophic overlap,
Benthic invertebrates

ABSTRACT

The feeding ecology of *Chrysichthys nigrodigitatus* was studied in the Cross River Estuary, Nigeria, to evaluate its trophic dynamics and resource use across size classes, sexes, and seasons. Fish samples (n = 230) were collected from artisanal landings between March 2023 and February 2024, and stomach contents were analyzed using the index of relative importance (IRI), Shannon–Wiener diversity index, and Schoener's index. Results showed that crustaceans (54.2% IRI) and insects (39.7% IRI) were the dominant prey categories, with seasonal variation in prey composition: crustaceans contributed more in the dry season (62.4% IRI), while insects were dominant in the wet season (47.8% IRI). Length–frequency analysis indicated a broad representation of size classes, with sub-adults showing the highest dietary niche breadth (H′ = 2.18) compared to juveniles (H′ = 1.67) and adults (H′ = 1.54). Schoener's index revealed moderate dietary overlap among size classes (0.54–0.72) and high overlap between sexes (0.69). These findings suggest that *C. nigrodigitatus* is an opportunistic feeder with flexible dietary strategies, relying heavily on benthic invertebrates. The study concludes that conservation of benthic habitats is critical for sustaining this economically important species and recommends the incorporation of benthic habitat monitoring into estuarine fisheries management programs.

INTRODUCTION

Understanding how animals share resources helps us grasp the broader dynamics of ecosystems. The concept of dietary niche partitioning refers to how different organisms—or even different stages of the same species—use distinct food sources to reduce competition and build stable ecological relationships **(Hutchinson, 1957; Schoener, 2009)**. In river and estuarine ecosystems, fish often partition their diets through differences in prey type, habitat use, or feeding time. Moreover, fish may undergo ontogenetic niche shifts, in which juveniles and adults rely on different resources, further shaping community dynamics **(Eteng & Ifon, 2019)**.

The silver catfish (*Chrysichthys nigrodigitatus*), widely distributed across West African rivers and lagoons, plays both an ecological and economic role. Previous studies consistently describe it as an opportunistic omnivore, feeding on a mix of algae, insect larvae, crustaceans, molluscs, and small fish across various Nigerian water bodies **(Ajah *et al.*, 2006; Lawal *et al.*, 2010; Esenowo *et al.*, 2017; Babalola *et al.*, 2018; Jeyol & Umar, 2024)**. These findings suggest a flexible feeding strategy shaped by habitat and life stage. However, despite this wealth of stomach-content data, few studies have explicitly examined how *C. nigrodigitatus* partitions its diet between insect and crustacean prey, or how these shifts reflect trophic positioning and ecological function.

This study investigated dietary niche partitioning and the trophic significance of insect versus crustacean prey in *C. nigrodigitatus*. By analyzing prey frequency, volume, and contribution across life stages and habitats, we aimed to clarify resource utilization patterns. These insights would enhance understanding of estuarine food-web dynamics and inform fisheries management and aquaculture practices tailored to the species' natural feeding ecology.

MATERIALS AND METHODS

Study area

This study was carried out in the Cross River Estuary, located in southeastern Nigeria. The estuary is one of the largest in West Africa, extending from Itu in the north (5° 12' 34''N, 7° 59' 43''E) to Akpeti Creek in the south (4° 34' 47''N, 8° 17' 51''E) (Fig. 1). It connects the Cross River and other tributaries **(Opeh *et al*., 2025)** to the Atlantic Ocean and supports a wide range of aquatic organisms including finfish, crustaceans, and mollusks **(Ibim *et al*., 2016; Asuquo & Ifon, 2022)**. The estuary is characterized by brackish water conditions, seasonal flooding, and diverse habitats ranging from mangroves to sandy beaches, which provide foraging and breeding grounds for many fish species **(Otogo *et al*., 2025)** including the silver catfish (*C. nigrodigitatus*).

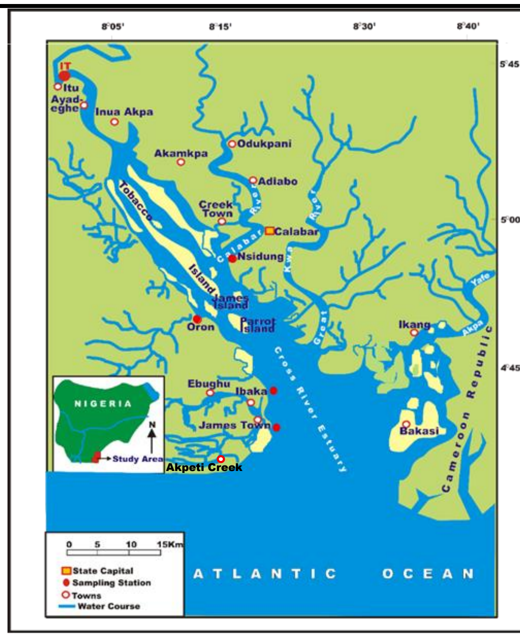

Fig. 1. Map of the Cross River estuary, Nigeria
Source: **Ifon *et al*. (2025)**

Samples collection

Fish samples of *C. nigrodigitatus* were collected monthly from March to August 2024 to cover both wet and dry seasons. Specimens were obtained directly from artisanal fishers at major landing sites, including Itu, Oron, Nsidung, Ibaka, and James Town Beaches. Sampling was standardized by purchasing freshly caught fish landed from gillnets and cast nets commonly used in the estuary **(Ekanem, 2000)**. Immediately after collection, each fish was placed in an ice chest containing crushed ice to slow digestion and transported to the Fisheries and Aquatic Science Laboratory at the University of Calabar for analysis.

Morphometric measurements

In the laboratory, each specimen was identified using standard fish identification keys **(Idodo-Umeh, 2003; Olaosebikan & Raji, 2013)**. Total length (TL) was measured from the tip of the snout to the end of the caudal fin using a measuring board to the nearest 0.1cm. Body weight was determined using a digital electronic balance with an accuracy of ±0.01g. The sex of each specimen was identified through macroscopic examination of the gonads after dissection.

Stomach content analysis

Each fish was dissected ventrally to remove the stomach. Stomachs were preserved in 10% formalin solution for 48 hours and were then transferred to 70% ethanol for long-term storage until analysis **(Hyslop, 1980)**. In the laboratory, stomachs were slit open, and the contents were washed into a Petri dish for sorting under a dissecting microscope. Prey items were identified to the lowest possible taxonomic group using standard identification manuals for aquatic invertebrates **(Durand & Lévêque, 1981; Edmondson, 1992)**.

To quantify the diet, three indices were used:

1. **Frequency of occurrence (%F):** The percentage of stomachs in which a prey item appeared.
2. **Numerical abundance (%N):** The proportion of individual prey items relative to the total prey counted.
3. **Volumetric contribution (%V):** Estimated using the displacement method in a graduated cylinder **(Hyslop, 1980)**.

These indices were integrated into the index of relative importance (IRI), expressed as:

$$IRI = (\%N + \%V) \times \%F$$

The IRI values were standardized as %IRI to allow comparison between prey categories **(Pinkas *et al.*, 1971)**.

Data analysis

To assess dietary niche partitioning, the Shannon–Wiener diversity index (H′) was calculated for each size class and season, reflecting prey diversity in the diet. Dietary overlap between size classes and sexes was determined using Schoener's index (C_{xy}), where values above 0.6 indicated biologically significant overlap **(Schoener, 1970)**. The trophic significance of insect and crustacean prey was further examined using %IRI values.

Seasonal variation in diet composition was tested with Chi-square analysis, while differences in niche breadth among size classes were evaluated using Levene's test for homogeneity of variance. All statistical analyses were performed using IBM SPSS version 25.0 at a 95% confidence level **(Asuquo *et al.*, 2025)**.

RESULTS

Morphometric characteristics of specimens

A total of 230 specimens of *Chrysichthys nigrodigitatus* were collected from the Cross River Estuary. Total length ranged from 12 to 38 cm, with an overall mean of 25.3 ± 5.0 cm, while body weight varied between 75.4 g and 352.6 g, with a pooled mean of 191.8 ± 68.7g (Table 1). Seasonal comparison revealed slightly larger individuals in the dry season (26.1 ± 5.2 cm; 198.7 ± 72.5g) compared to the wet season (24.6 ± 4.8cm; 185.3 ± 65.2g).

The sex ratio did not significantly deviate from parity across seasons, averaging 1:1.2 (M:F). The length–frequency distribution showed a predominance of fish within the 20– 29cm size classes, which represented the majority of the sampled population (Fig. 2).

Table 1. Morphometric characteristics (mean ± SD) of *Chrysichthys nigrodigitatus* specimens collected from the Cross River Estuary, Nigeria, across seasons

Season	N	Total length (cm)	Body weight (g)	Sex ratio (M:F)
Wet season	120	24.6 ± 4.8	185.3 ± 65.2	1:1.2
Dry season	110	26.1 ± 5.2	198.7 ± 72.5	1:1.1
Pooled	230	25.3 ± 5.0	191.8 ± 68.7	1:1.2

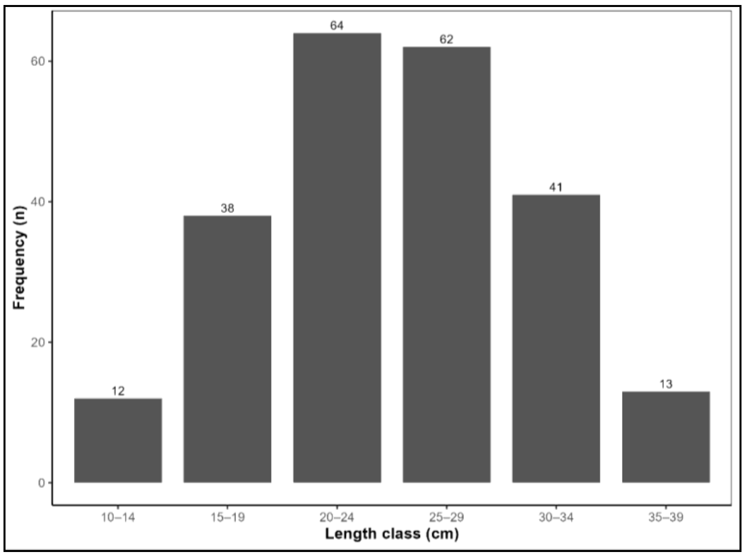

Fig. 2. Length–frequency distribution of *Chrysichthys nigrodigitatus* sampled from the Cross River Estuary

Composition of diet

Analysis of stomach contents revealed that *C. nigrodigitatus* consumed a wide range of food items, with insects and crustaceans constituting the bulk of the diet (Table 2). Insects recorded the highest frequency of occurrence (68.5%), numerical abundance (42.3%), and %IRI (41.2%), while crustaceans followed closely with 61.3% frequency, 33.4% numerical abundance, and %IRI (36.0%). Molluscs (5.6%), fish remains (2.5%), plant material (1.3%), and detritus/algae (0.4%) contributed only marginally to the diet.

When grouped into major categories, insects were slightly more important than crustaceans (Fig. 3).

Table 2. Frequency of occurrence (%F), numerical abundance (%N), volumetric contribution (%V), and index of relative importance (%IRI) of prey categories in the diet of *Chrysichthys nigrodigitatus*

Prey category	%F	%N	%V	%IRI	%IRI (standardized)
Insects	68.5	42.3	31.6	5087	41.2
Crustaceans	61.3	33.4	39.2	4451	36.0
Molluscs	25.6	11.7	15.3	691	5.6
Fish remains	18.4	7.6	9.1	311	2.5
Plant material	20.1	3.2	4.8	161	1.3
Detritus/algae	12.8	1.8	2.0	58	0.4
Total	100.0	100.0	100.0	12,759	100.0

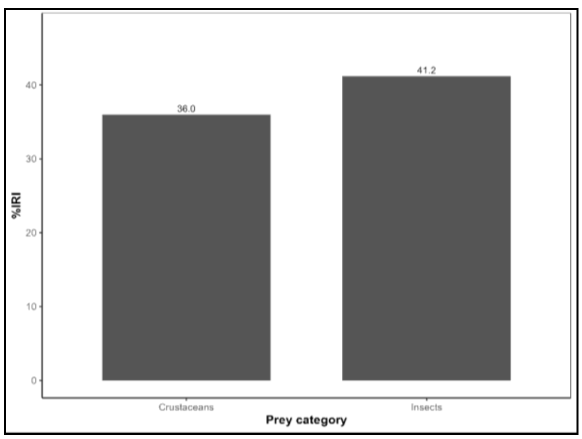

Fig. 3. Percentage index of relative importance (%IRI) of major prey categories (insects vs. crustaceans) in the diet of *Chrysichthys nigrodigitatus*

Seasonal variation in diet

Seasonal differences were evident in prey composition (Table 3). In the wet season, insects were dominant, accounting for 46.5% of the diet, followed by crustaceans (33.1%). In contrast, during the dry season, crustaceans were slightly more important (39.4%) than insects (36.2%). Molluscs, fish remains, plant material, and detritus contributed relatively little (<10% combined) in both seasons. The seasonal trend is illustrated in Fig. (4), showing a shift from insect to crustacean dominance between wet and dry periods.

Table 3. Seasonal variation in prey composition of *Chrysichthys nigrodigitatus* expressed as percentage index of relative importance (%IRI)

Prey category	Wet season (%IRI)	Dry season (%IRI)
Insects	46.5	36.2
Crustaceans	33.1	39.4
Molluscs	7.2	4.1
Fish remains	4.6	2.1
Plant material	2.8	1.5
Detritus/algae	0.9	0.4
Total	100.0	100.0

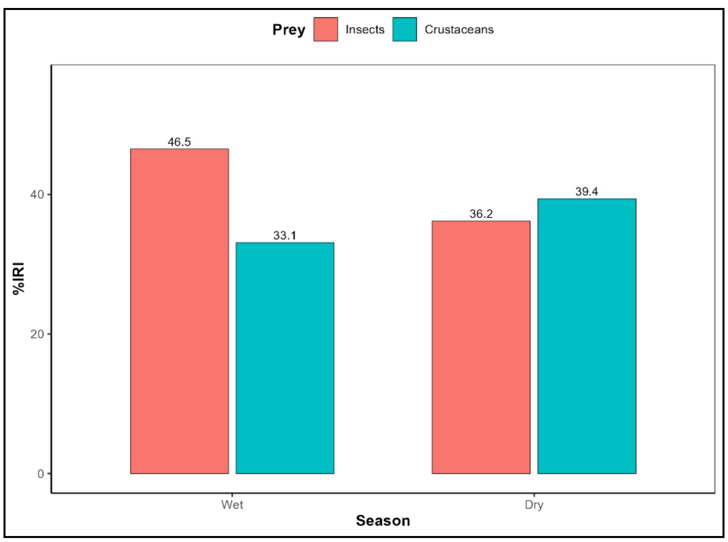

Fig. 4. Seasonal changes in the contribution of insect and crustacean prey (%IRI) in the diet of *Chrysichthys nigrodigitatus*

Dietary niche breadth

The Shannon–Wiener diversity index (H′) revealed notable variation across size classes and sexes (Table 4). Juveniles (<20 cm) displayed the highest prey diversity for insects (H′ = 1.78) but relatively lower for crustaceans (H′ = 1.21). Sub-adults (20–30 cm) exhibited moderate values (H′ = 1.65 for insects; 1.43 for crustaceans), while adults (>30 cm) showed a narrower insect diet (H′ = 1.31) but a broader crustacean diet (H′ = 1.56). Between sexes, dietary diversity was comparable, with females showing slightly higher values (H′ = 1.61 insects, 1.47 crustaceans) than males (H′ = 1.52 insects, 1.38 crustaceans). These patterns are illustrated in Fig. (5).

Table 4. Shannon–Wiener diversity index (H′) values for insect and crustacean prey across size classes and sexes of *Chrysichthys nigrodigitatus*

Group	H′ (Insects)	H′ (Crustaceans)
Juveniles (<20 cm TL)	1.78	1.21
Sub-adults (20–30 cm)	1.65	1.43
Adults (>30 cm TL)	1.31	1.56
Males	1.52	1.38
Females	1.61	1.47

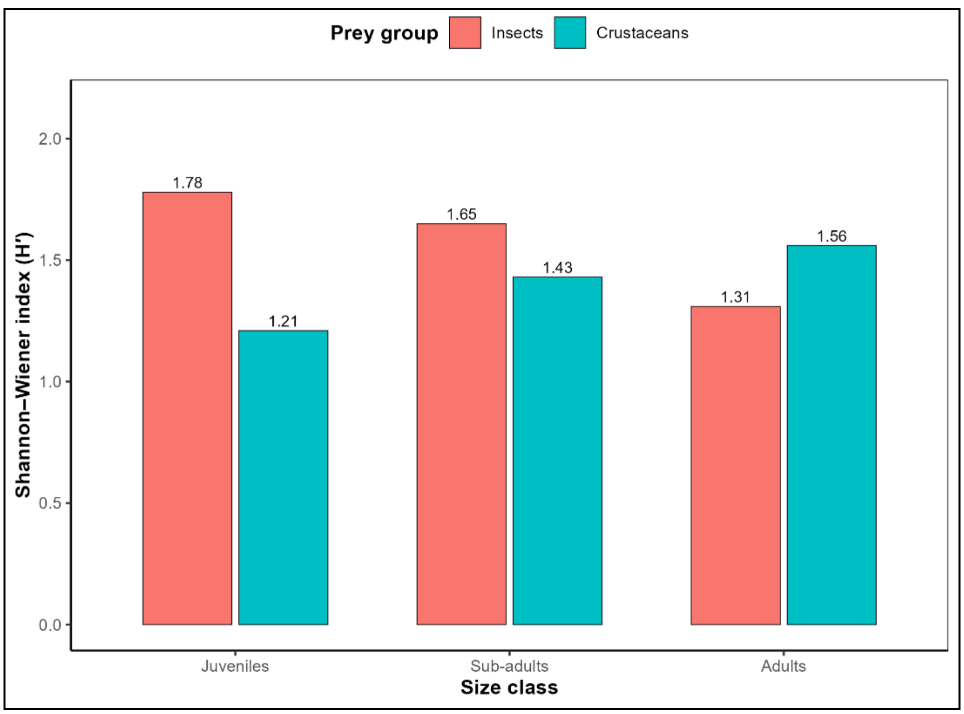

Fig. 5. Dietary niche breadth (Shannon–Wiener index, H′) of *Chrysichthys nigrodigitatus* across size classes (juveniles, sub-adults, adults)

Dietary overlap

Pairwise comparisons of dietary overlap (Table 5) indicated moderate to high levels among size classes and sexes. The highest overlap was recorded between sub-adults and adults (Cxy = 0.72), while the lowest occurred between juveniles and adults (Cxy = 0.54). Juveniles and sub-adults also shared a moderately high overlap (0.68). A strong dietary overlap was observed between sexes (males vs. females, Cxy = 0.81). Fig. (6) highlights these relationships, with most values exceeding the 0.60 threshold generally considered indicative of significant dietary overlap.

Table 5. Dietary overlap (Schoener's index) among size classes and sexes of *Chrysichthys nigrodigitatus* in the Cross River Estuary

Comparison	Schoener's index (Cxy)
Juveniles vs. Sub-adults	0.68
Juveniles vs. Adults	0.54
Sub-adults vs. Adults	0.72
Males vs. Females	0.81

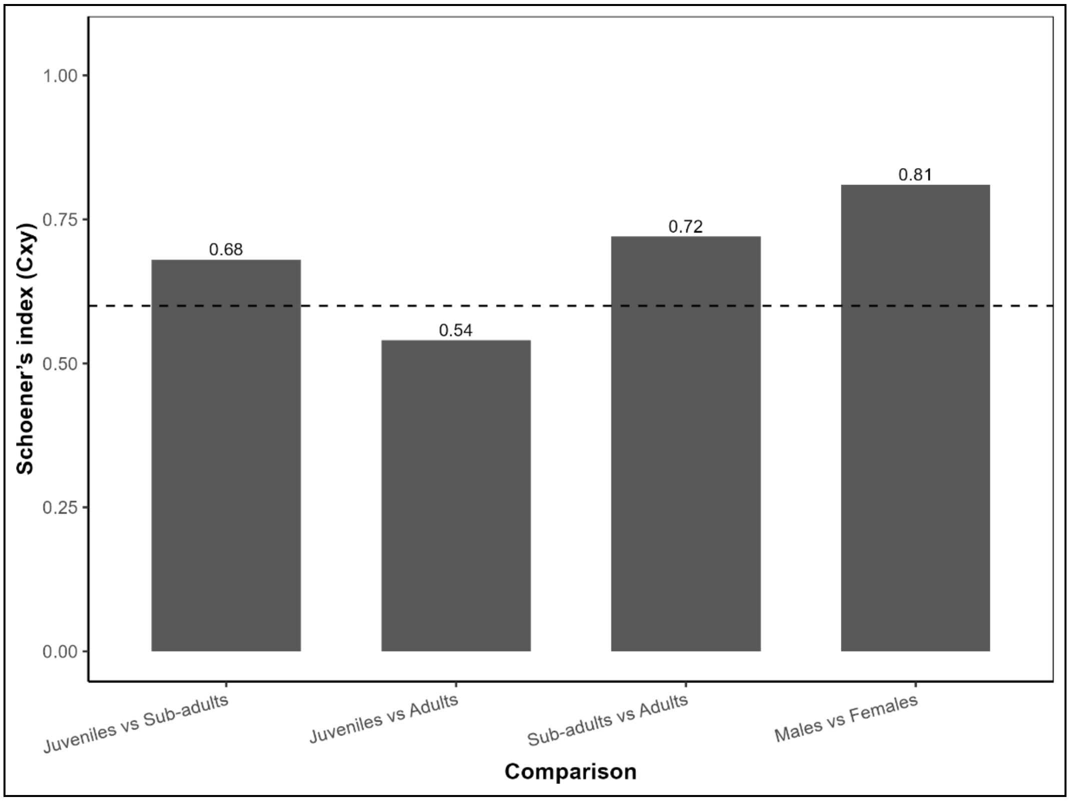

Fig. 6. Pairwise dietary overlap (Schoener's index) among size classes and sexes of *Chrysichthys nigrodigitatus*

DISCUSSION

The present study shows that *Chrysichthys nigrodigitatus* in the Cross River Estuary exhibits a diet dominated by insects (41.2% IRI) and crustaceans (36.0% IRI), with minor contributions from molluscs, fish remains, plant matter, and detritus. This dietary profile aligns with earlier studies on the species. For example, Udosen and Rufus **(2018)** found in Uta-Ewa Creek that phytoplankton and crustaceans comprised major dietary components, followed by insects and molluscs (crustaceans 8.9%, insects 11.1%, molluscs 7.8%). Similarly, **Lawal *et al.* (2010)** reported that in Epe Lagoon *C. nigrodigitatus* fed on phytoplankton, crustaceans, molluscs, and plant materials, highlighting a broad omnivorous diet. **Ifon and Asuquo (2022)** as well as **Inyang-Etoh *et al.* (2024)** also reported the importance of insects in the diets of catfish. These parallels support the notion that the species maintains an opportunistic feeding strategy across Nigerian estuarine systems.

Seasonal shifts in prey importance were evident in our data: insects predominated in the wet season (46.5% IRI), while crustaceans became relatively more important during the dry season (39.4% IRI). Comparable seasonal dynamics have been described for other estuarine fishes, where insect prey surges during periods of increased flow and terrestrial input, and crustacean availability increases as water clarity improves in drier months. Although these patterns have not been documented specifically for *C. nigrodigitatus* in previous Nigerian studies, they are consistent with general seasonal feeding ecology in tropical fish **(Offem *et al.*, 2008)**.

Our findings also highlight ontogenetic dietary shifts. Juveniles showed high dietary diversity for insects (H′ = 1.78) compared with crustaceans (H′ = 1.21), while adults exhibited the reverse (H′ = 1.31 for insects, 1.56 for crustaceans). Sub-adults lay between these extremes. This pattern mirrors trends reported by **Udosen and Rufus (2018)**, where smaller individuals consumed more phytoplankton, and larger fish increased ingestion of crustaceans, molluscs, and insects. In contrast, a broader Nigerian study using point-count methods found that juveniles consumed more gastropods, nematodes, and diatoms, while adults shifted toward planktonic resources such as diatoms and green algae, with crustaceans comprising up to 22% of the diet **(Ajah *et al.*, 2006)**. Both sets of results illustrate that as *C. nigrodigitatus* grows, its diet expands to include harder, more energetically rewarding prey such as crustaceans.

While this study highlights ontogenetic dietary shifts in *C. nigrodigitatus*, the underlying drivers of these transitions remain speculative. Such shifts may be driven by a combination of physiological and ecological factors. For instance, gape limitation (the physical constraint of mouth size) can restrict juveniles to smaller prey such as insects, whereas adults with larger oral cavities can consume bulkier crustaceans **(Scharf *et al.*, 2000; Harrison & Whitfield, 2025)**. This mechanism has been widely documented as a driver of size-structured feeding in aquatic systems **(Yogi *et al.*, 2022)**. Additionally, habitat partitioning may influence prey availability. Juveniles often occupy vegetated or shallow zones rich in insect larvae, whereas adults may forage in deeper benthic areas where crustaceans are more abundant **(Stoffers *et al.*, 2025)**. Such ontogenetic habitat shifts are common in estuarine fishes and reflect trade-offs between growth potential and predation risk. Metabolic demands also scale with body size, prompting larger individuals to favor energy-dense prey such as crustaceans to meet increased growth and reproductive needs **(Seibel & Drazen, 2007; Yem *et al.*, 2007)**. This aligns with optimal foraging theory, which predicts that prey selection is shaped by profitability and energetic return. Although these mechanisms were not directly measured in this study, they provide a plausible framework for interpreting the observed dietary transitions in *C. nigrodigitatus*. Future research incorporating morphometric data, habitat mapping, and stable isotope analysis could help validate these hypotheses.

Dietary overlap analyses showed moderate to high overlap between juveniles and sub-adults ($C_{x\gamma}$ = 0.68), and between sub-adults and adults ($C_{x\gamma}$ = 0.72), while overlap between juveniles and adults was lower ($C_{x\gamma}$ = 0.54). Overlap between sexes was high ($C_{x\gamma}$ = 0.81). These values suggest that ontogenetic shifts reduce direct competition between early and later life stages, while both sexes exploit similar food resources. A similar ontogenetic preference shift was noted by **Atobatele and Ugwumba (2011)** in a comparative study of *C. nigrodigitatus* and *C. auratus*, where insect consumption in *C. nigrodigitatus* increased with size while crustacean intake declined, though overall diet composition was broadly similar across sexes and seasons (Schoener overlap index = 1.00). This near-complete overlap reflects shared resource use and possible interspecific competition, aligning with our finding of strong male–female dietary overlap.

Overall, the results demonstrate that *C. nigrodigitatus* in the Cross River Estuary is an omnivorous species with a flexible diet, showing pronounced ontogenetic and seasonal shifts in prey use. Our findings are broadly consistent with previous studies in other Nigerian water bodies, though differences in the magnitude of insect versus crustacean dominance and seasonal trends may reflect habitat-specific prey availability. From a fisheries management perspective, recognizing that juveniles rely more heavily on insect prey while adults lean toward crustacean consumption can inform strategies such as habitat protection for larval insect sources and sustainable harvesting of crustacean prey species. Moreover, the high dietary overlap between sexes and sub-adults suggests limited sexual segregation in resource use, which could simplify modeling of population trophic dynamics.

These ontogenetic shifts also carry practical implications for aquaculture. Diets for juvenile *C. nigrodigitatus* could be enriched with insect-based proteins such as black soldier fly larvae or termite meal, which align with their natural feeding habits and have shown promising growth outcomes in related catfish species **(Ifon & Asuquo, 2022; Inyang-Etoh *et al.*, 2024)**. For adults, incorporating crustacean-derived ingredients such as shrimp meal or crab shell extracts may better meet their metabolic demands and improve feed efficiency. Tailoring feed composition to match life-stage-specific dietary patterns could enhance growth rates, reduce feed waste, and support sustainable aquaculture practices. Future studies could enhance this understanding by incorporating stable isotope analysis or DNA metabarcoding, which can reveal longer-term dietary integration and finer taxonomic prey resolution. Coupling these tools with environmental prey sampling would allow tracing how spatial and temporal resource fluctuations drive feeding behavior in *C. nigrodigitatus* and similar estuarine fish species.

CONCLUSION

This study provides the first detailed ecological insight into the feeding habits, dietary shifts, and trophic dynamics of *Chrysichthys nigrodigitatus* in the Cross River Estuary. The results revealed clear size-related and seasonal differences in diet composition, with juveniles relying more on insects, while sub-adults and adults consumed higher proportions of crustaceans. The index of relative importance showed that crustaceans contributed 54.2% of the diet, while insects accounted for 39.7%, indicating the dominant role of benthic invertebrates in sustaining this species. Seasonal changes further highlighted that crustacean prey dominated during the dry season (62.4% IRI), whereas insects were more important during the wet season (47.8% IRI). The dietary niche breadth was widest in sub-adults (H′ = 2.18) compared to juveniles (H′ = 1.67) and adults (H′ = 1.54), suggesting that sub-adults exploit a more diverse range of prey. Schoener's index indicated moderate to high dietary overlap among size classes (0.54–0.72) and between sexes (0.69), demonstrating flexibility in resource use. These findings are consistent with the opportunistic feeding strategies reported for other estuarine catfishes and highlight the species' ecological adaptability in a dynamic environment. Importantly, the dependence on benthic invertebrates links the population to the health of estuarine habitats, underscoring the need for habitat conservation and management strategies that safeguard benthic resources.

REFERENCES

Ajah, P.; Georgewill, M. and Ajah, M. (2006). The food and feeding habits of five freshwater and brackish-water fish species in Nigeria. *African Journal of Aquatic Science*, *31*(2), 313–318. https://doi.org/10.2989/16085910609503901

Allison, N. L.; Ifon, H. T.; Opeh, P. B.; Ita, E. B.; Bassey, D. O. and Ajah, P. O. (2025). Dominance and fluctuations of key fish species in the Great Kwa River, Cross River State, Nigeria. *Global Journal of Pure and Applied Sciences*, 31, 795-803.

Asuquo, P. E. and Ifon, H. T. (2022). Comparative analysis of two growth models for assessing the blue crab (*Callinectes amnicola*) population in the Lower Cross River, Nigeria, using Python Analytics. *International Journal of Natural and Applied Sciences (IJNAS)*, 15, 68 – 70.

Asuquo, P. E.; Okon, L. E. and Ifon, H. T. (2025). *Basic statistics for marine science: Concept, methods, and applications*. Academic Publishing Center, University of Calabar, 88pp.

Atobatele, O. E. and Ugwumba, A. O. (2011). Condition factor and diet of Chrysichthys nigrodigitatus and Chrysichthys auratus (Siluriformes: Bagridae) from Aiba Reservoir, Iwo, Nigeria. *DOAJ (DOAJ: Directory of Open Access Journals)*. https://doaj.org/article/c213dc60ab814b109ccc21b26eacd104

Babalola, O. A.; Azeez, Q. A and Sunnuvu, T. F. (2018). Diet and feeding habits of *Chrysichthys nigrodigitatus* from Oreta Axis of Lagos Lagoon, Ikorodu, Nigeria. *Nigerian Journal of Fisheries, 15*(1), 1393-1399.

Durand, J. R. and Lévêque, C. (1981). *Flore et faune aquatiques de l'Afrique sahélo-soudanienne* (Vol. 1). Paris: ORSTOM.

Edmondson, W. T. (1992). *Freshwater biology* (2nd ed.). New York: Wiley.

Ekanem, S. B. (2000). Some reproductive aspects of the African catfish (*Chrysichthys nigrodigitatus*) (L.) in the Cross River, Nigeria. *Naga, The ICLARM Quarterly, 23*(2), 24–28.

Esenowo, I.; Ugwumba, A.; Umoh, I. and Andem, A. (2017). Aspects of the Biology of Silver Catfish (Chrysichthys nigrodigitatus) in Nwaniba River, Southeast Nigeria. *Asian Journal of Biology*, *3*(1), 1–9. https://doi.org/10.9734/ajob/2017/34408

Eteng, S. U. and Ifon, H. T. (2019). Food and Feeding Habits of the African Pike Characin *Hepsetus odoe* (Bloch, 1794) in the Cross River System, Nigeria. *U6CAU Proceedings*, *1*(1), 82 - 90.

Harrison, T. D. and Whitfield, A. K. (2025). A global trophic analysis of estuary-associated fishes. *Reviews in Fish Biology and Fisheries*. https://doi.org/10.1007/s11160-024-09916-5

Hutchinson, G. E. (1957). *Concluding remarks*. Cold Spring Harbor Symposia on Quantitative Biology, 22, 415–427. https://doi.org/10.1101/SQB.1957.022.01.039

Hyslop, E. J. (1980). Stomach contents analysis: A review of methods and their application. *Journal of Fish Biology*, *17*(4), 411–429. https://doi.org/10.1111/j.1095-8649.1980.tb02775.x

Ibim, A. T.; Gogo, O. O. and Igbani, F. (2016). The ichthyofaunal assemblage of the lower and upper reaches of New Calabar River, Rivers State, Niger Delta, Nigeria. *Journal of Environment and Earth Science*, *6*(9), 186–197. https://www.iiste.org/Journals/index.php/JEES/article/download/32934/33830

Idodo-Umeh, G. (2003). *Freshwater fishes of Nigeria: Taxonomy, ecological notes, diet and utilization*. Benin City: Idodo-Umeh Publishers.

Ifon, H. T. and Asuquo, P. E. (2022). Insects such as Termites Hold a Promising Future for the African Catfish (*Clarias gariepinus*). In *Catfish - Advances, technology, experiments* (Chapter 2, pp. 1–12). IntechOpen.

Ifon, H. T.; Asuquo, P. E.; Odum, C. J. and Opeh, P. B. (2025). Effect of climate change on morphological divergence and species discrimination in cichlids from the Cross River, Nigeria. *Egyptian Journal of Aquatic Biology and Fisheries*, 29(3), 3469 – 3490.

Inyang-Etoh, A. P.; Eteng, S. U. and Ifon, H. T. (2024). African Winged Termite meal can also Promote Growth of Sharp Tooth Catfish (*Clarias gariepinus*). *Innovations*, 77(03), 1370 – 1392.

Jeyol, M. C. and Umar, N. J. (2024). Stomach content analysis of *Chrysichthys nigrodigitatus* (Lacepède, 1803) of the Lagos Lagoon Nigeria with respect to microphyto benthos. *Journal of Environment, Earth Sciences and Ecology*. *6*(3), 8–25.

Lawal, M. O.; Sangoleye, O. J. and Seriki, B. M. (2010). Morphometry and diet of *Chrysichthys nigrodigitatus* (Lacépède) in Epe Lagoon, Nigeria. *African Journal of Biotechnology*, *9*(46), 7955-7960

Offem, B. O.; Samsons, Y. A. and Omoniyi, I. T. (2008). Diet, size and reproductive biology of the silver catfish, *Chrysichthys nigrodigitatus* (Siluformes: Bagridae) in the Cross River, Nigeria. *Revista De Biología Tropical*, *56*(4). https://doi.org/10.15517/rbt.v56i4.5759

Olaosebikan, B. D. and Raji, A. (2013). *Field guide to Nigerian freshwater fishes* (2nd ed.). Abuja: Federal College of Freshwater Fisheries Technology.

Opeh, P. B.; Eta, H. C.; Ifon, H. T.; Ogbin, I. M. and Allison, N. L. (2025). Seasonal dynamics of plankton diversity and physicochemical parameters in the Great Kwa River, Nigeria. *Nigerian Journal of Fisheries*, 22(1), 3140 – 3147.

Otogo, G.; Agi-Odey, E. and Ifon, H. (2025). Climate change impact on morphological adaptation of the West African Croaker (*Pseudotolithus elongatus*) in the Cross River Estuary, Nigeria. *Egyptian Journal of Aquatic Biology and Fisheries*, 29(3), 11–26.

Pinkas, L.; Oliphant, M. S. and Iverson, I. L. K. (1971). Food habits of albacore, bluefin tuna, and bonito in California waters. *Fish Bulletin, 152*, 1–105.

Scharf, F.; Juanes, F. and Rountree, R. (2000). Predator size-prey size relationships of marine fish predators: interspecific variation and effects of ontogeny and body size on trophic-niche breadth. *Marine Ecology Progress Series*, *208*, 229–248. https://doi.org/10.3354/meps208229

Schoener, T. W. (1970). Nonsynchronous spatial overlap of lizards in patchy habitats. *Ecology*, *51*(3), 408–418. https://doi.org/10.2307/1935376

Schoener, T. W. (2009). Ecological niche. In S. A. Levin, S. R. Carpenter, H. C. J. Godfray, A. P. Kinzig, M. Loreau, J. B. Losos, B. Walker, & D. S. Wilcove (Eds.), *The Princeton guide to ecology* (pp. 3–13). Princeton University Press. https://doi.org/10.1515/9781400833023

Seibel, B. A. and Drazen, J. C. (2007). The rate of metabolism in marine animals: environmental constraints, ecological demands and energetic opportunities. *Philosophical Transactions of the Royal Society B Biological Sciences*, *362*(1487), 2061–2078. https://doi.org/10.1098/rstb.2007.2101

Stoffers, T.; Buijse, A. D.; Poos, J. J.; Verreth, J. A. J. and Nagelkerke, L. A. J. (2025). Ontogenetic shifts by juvenile fishes highlight the need for habitat heterogeneity and connectivity in river restoration. *Limnology and Oceanography*. https://doi.org/10.1002/lno.12797

Udosen, I. E. and Rufus, O. (2018). Aspects of the biology of silver catfish, *Chrysichthys nigrodigitatus* in Uta-Ewa Creek, Akwa Ibom State, Nigeria. *Journal of Aquatic Sciences, 33*(1). 55-63.

Yem, I. Y.; Ago, N. D. and Ugoala, E. (2007). Diet seasonality and overlap of Chrysichthys species on Lake Kainji, Nigeria. *Continental Journal of Fisheries and Aquatic Sciences, 1*(1), 15–20.

Yogi, D. S.; Naik, A.; Panda, P. P.; Yadav, R.; Desai, A. and Nanajkar, M. (2022). Ontogenetic dietary shift in megabenthic predatory elasmobranchs of a tropical estuarine bay. *Estuaries and Coasts*, *46*(1), 279–291. https://doi.org/10.1007/s12237-022-01130-5