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Biology and Environmental Preferences of Wahoo, *Acanthocybium solandri* (Cuvier, 1832), in the Western and Central Pacific Ocean (WCPO)

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Abstract: Wahoo *Acanthocybium solandri* is a common bycatch pelagic species in oceanic fisheries targeting tuna and tuna-like species. Biology and environmental preferences are important parameters in understanding life history of fish species including wahoo. Despite the socio-economic importance of wahoo in many coastal countries, little is known about their biological and fisheries information in the Western and Central Pacific Ocean (WCPO). These parameters were analyzed on the basis of samples collected via the Chinese tuna long-line Fishery Observer Programme in 2012. Results obtained from this study show that the fork length (FL) of wahoo ranged from 59 to 169 cm with an average of 111.3 cm, and two dominant size groups were identified at 100 to 130 cm for males and 90 to 130 cm for females. Body size did not significantly differ between female and male wahoo specimens. Wahoo specimens expressed a positive allometric growth (b = 3.183), and the sex ratio was 1.9:1 (female/male), which differed significantly between both sexes. Only female wahoo were observed in catches of FL > 150 cm. The estimated lengths at 50% maturity (FL_{50}) of female and male wahoo were 84 cm and 83 cm, respectively. Gonadosomatic index (GSI) of wahoo was at its peak in November, and on the basis of the stomach content analysis, wahoo mainly preyed on fish (84.64%), cephalopods (14.26%), and crustaceans (1.1%), found on the basis of prey number. The optimal swimming depth and water temperature of wahoo in the WCPO were found to range between 70 and 110 m and 23.1 and 24 °C, respectively. The updated life history information presented in this work helps to address current data limitations and provides critical information for future assessments of wahoo stocks in the WCPO.

Keywords: bycatch species; stomach content; GSI; length-at-maturity; WCPO

1. Introduction

Wahoo, *Acanthocybium solandri* (Cuvier, 1832), is a pelagic species distributed throughout tropical and sub-tropical oceanic waters worldwide [1–3]. It is retained as bycatch in most commercial fisheries that target large pelagic species such as tunas and swordfish, and it is a socioecological and an economically important fishery for many coastal nations [4,5]. Despite the increasing importance of wahoo to global fisheries, there is a paucity of biological data, particularly in the Western and Central Pacific Ocean (WCPO). Thus far, only a single yield per recruit assessment has been carried on in the

South Pacific Ocean [3], and more information of this species' biology would be important in order to conduct sophisticated assessments in the future in areas with data paucity and lack of literature such as the WCPO. This gap in knowledge currently hinders the implementation of conventional stock assessments and may limit the efficacy of regional fisheries management organizations to ensure catch sustainability.

Past studies (mostly in the Atlantic and South Pacific) reported wahoo to be a fast-growing, large and short-lived pelagic species [1,2,4,6,7]. Estimated maximum age as reported by most researchers was about 10 years; the heaviest captured wahoo was 96.4 kg and the longest wahoo had a fork length of more than 210 cm recorded in 2006 from the South Pacific Ocean [4,8]. They prefer surface temperatures ranging between 18 to 30 °C and can attend depths of about 253 m [9]. Many reports show that wahoo consumes mostly fishes and squids [2,6]. Previous studies report that wahoo species show extended spawning season, largely related with increases in water temperature [5,10–12], but there is no literature as of now that addresses the spawning season of wahoo in the WCPO.

The reproductive biology [5,11–13], age and growth [2,4,7], and feeding behavior [1,14,15] of wahoo have previously been reported in the Atlantic and Pacific oceans and off Taiwanese waters. Reports of wahoo in the Pacific Ocean has mainly been conducted in the South Pacific by Zischke et al. [3–5,10]. Therefore, there is a need for reports in other regions of the Pacific in order to corroborate the findings and help manage and prevent the collapse of this important byproduct species in this ocean.

Furthermore, understanding the basic biological study of wahoo can improve the knowledge of abundance shift. Thus, the biological information of wahoo and environmental data were collected from the Western and Center Pacific Ocean during exploratory fishing by a Chinese observer onboard a longline fishing vessel in 2012. These data were applied in this study to analyze the biological characteristics, feeding habits, and environmental preferences of wahoo. The biological and environmental information provided by this study would be useful in assessment models aiming to providing conservational and managerial measures of wahoo in the WCPO.

2. Material and Methods

Data were collected by a single scientific observer onboard a Chinese commercial longline fishing vessel in the Western and Central Pacific Ocean from July to November 2012. This trip was conducted by the longline vessel "*Zhongshui 811*". The vessel's characteristics are an overall length of 39.6 m, registered beam of 6.8 m, registered depth of 3.6 m, gross tonnage of 424.7 t, and main engine power of 447 kW. For each basket of longline gear, the length of the float line was 25–26 m, and the length of branch line was 19–20 m. The distance between the two consecutive branch lines was 30–38 m. The number of hooks between two consecutive floats was either 26 or 28. The type of bait used were Pacific sardines (*Sardinops sagax*). Generally, deployment of each set started early in the morning (around 06:00) and hauling started in the afternoon (around 17:00).

This fishing vessel was targeting albacore (*Thunnus alalunga*). Fishing activity was principally conducted between 6° S to 17° S and 160° W to 173° W (Figure 1). The hauling process for each set lasted for a period of 12–20 h, making it difficult for the observer to make observations on the entire set. However, the proportion of observed catches in each set was performed at 100%. For each observed basket, individuals of all captured species were identified and, when possible, biological information, including size, weight, and sex, were recorded. The fork length (FL), which is the measurement from the anterior end of the head of a species to the fork of the caudal fin, offers greater operational advantages on board commercial longline vessels where limited space is available. Fork lengths (FL) of captured wahoo specimens were measured to the nearest millimeter and later converted to centimeters. All fish were weighed (body weight, BW) to the nearest gram (g), and sex for captured specimens were also recorded; gonads were removed and weighed to the nearest gram (g).

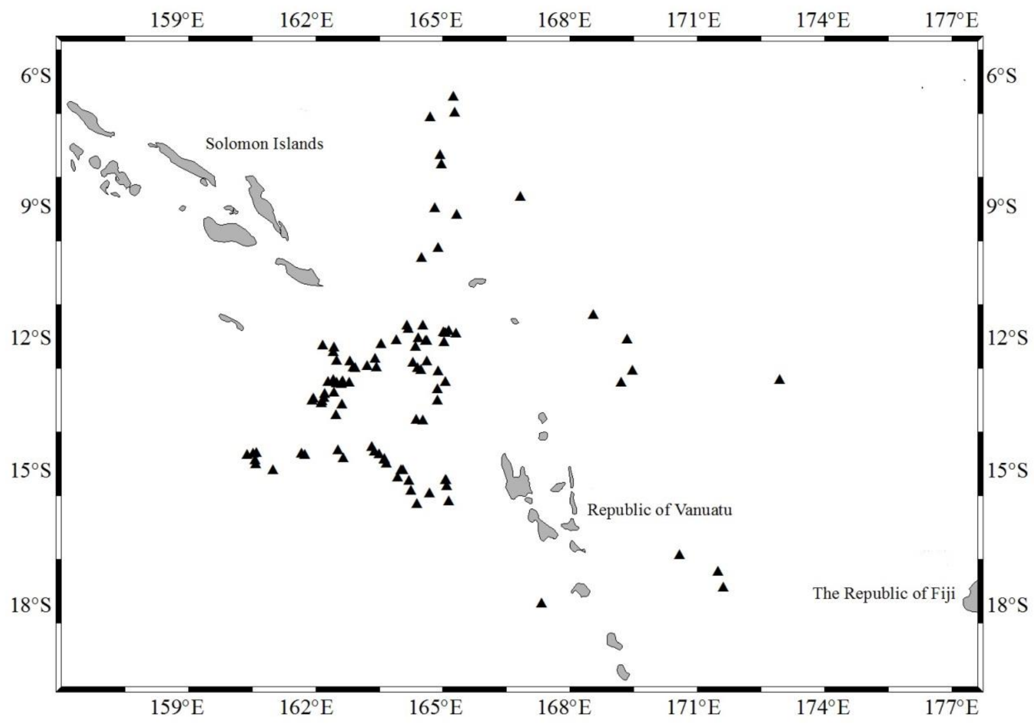


Figure 1. Set locations where wahoo specimens were sampled in the Western and Central Pacific Ocean (WCPO).

2.1. Environmental Observation

The environmental sampling instruments included time domain reflectometers (TDR, RBR Co., Ottawa, ON, Canada). The boat was equipped with three TDRs, and these were used to measure setting depths and record temperature at each sets.

2.2. Data Analysis

2.2.1. Size Class

Size class interval was set to 10 cm, divided into 10 groups. A nonparametric Kruskal–Wallis test (K-W test; H) was applied to test for significant differences in the FL sizes between both sexes. The relationship between fork length and body weight was described by a power function regression:

$$BW = a \cdot FL^{b} \quad (1)$$

where W is the body weight (g), FL the fork length (cm), a is a scaling coefficient, and b is an exponent describing the change in FL relative to weight.

2.2.2. Sex Ratio

Sex ratio, which is the proportion of female to male by each size class (10 cm), was used to predict and estimate the spawning capability of fish [16]. A generalized linear model (GLM) assuming a binomial distribution test was used to test for any significant difference between sex ratio (1:1).

2.2.3. Length at Sexual Maturity

As developed in Beardsley [17], maturity stages for female wahoo were determined macroscopically onboard the vessel by the observer and were grouped in five stages: I (immature), II (early maturing), III (late maturing), IV (mature-active), and V (mature-inactive); and two stages (I—immature, II—mature) for male wahoo specimens.

Maturity occurs at the smallest FL at which the individual is classified as sexually mature according to the criteria adopted for our definition of maturity (stages II–V for females and stage II for males). The corresponding population parameter FL_{50} (FL at which 50% of the individuals are mature) is the FL at which a model fitted to the proportions of maturity of the FL classes predicts the maturity proportion of 0.50 [18]. The proportion of mature individuals by 10 cm FL size class was used to fit the length-based maturity ogives and to estimate the size at maturity FL_{50}. A two-parameter logistic model was to estimate the mean length at 50% maturity for male and female wahoo specimens:

$$PL = \frac{1}{1 + e^{-r(FL - FL_{50})}} \tag{2}$$

where PL is the proportion of mature individuals in size class FL, r is the instantaneous rate of change (cm^{-1}), and FL_{50} is the FL at 50% maturity (cm). For most fish populations in nature, all individuals tend to attain maturity after a specific length [18], and the same is the case for wahoo.

2.2.4. Spawning Season

A sex-specific gonadosomatic index (GSI) for mature specimens were used to estimate the probable spawning season timing of wahoo in the WCPO. Monthly mean GSI values were determined for female and male wahoo specimens in this study. Gonads were assigned a macroscopic phase and sex based on physical appearance and size following Brown-Peterson et al. [19]. GSI is one measure of temporal gonadal development and is calculated as

$$GSI = \frac{GW}{BW - GW} * 100$$

where GW is gonad weight (g), and BW is body weight (g).

2.2.5. Diet Analysis

Every specimen caught was classified and measured on board the vessel. The stomachs were dissected and their content observed. The prey items, identified to the lowest possible taxonomic level on the basis of their digestion state, were counted. Feeding level was divided into five levels, 0 (empty) to 4 (full). Chi-square was used to test for any significant difference in the feeding level of size classes.

Quantitative description—the following criteria were used to determine the importance of the different prey items consumed by wahoo: taxonomic composition of the diet was quantified by percent numerical abundance (%N), and percent frequency of occurrence (%F) of prey items, cumulating all data for each prey item [20].

Ontogenetic shift in diet—cluster analysis based on the Euclidean distance with the group-average linkage procedure of prey items was used to compare feeding level of all food items of individual specimens (unidentified fishes were excluded). The cluster analysis attempts to create groupings of samples (size classes) on the basis of the variables (prey items, n = 600) through a generated similarity matrix.

2.2.6. The CPUEs (Number of Catch per 1000 Hooks) in Different Ranges of Various Environmental Variables

To understand the habitat preference of wahoo, the hooked wahoo specimens were grouped into various environmental variable ranges in the defined intervals from the respective starting point to the final point (Table 1), on the basis of various environmental variables measured at the depths at which wahoo was hooked [21].

Statistics of the number of fish (N_{ij}, N_{ij}) and hooks (H_{ij}, H_{ij}) at different layer ranges and temperature variables.

$$CPUE_{ij} = \frac{1000 * N_{ij}}{H_{ij}} \tag{3}$$

Table 1. Ranges (means) of depth and temperature of wahoo with "intervals" of observation.

Environmental Variables	Starting Point	Final Point	Interval	Total Ranges
Depth	75.6 m	306.9 m	40 m	6
Temperature	23.9 °C	19.8 °C	1 °C	6

3. Results

3.1. Fork Length Composition and the Relationship with Body Weight

A total of 597 individuals of wahoo were measured during the fishing activities in the Western and Central Pacific Ocean. Fork lengths of wahoo ranged from 59 to 169 cm, and the average fork length was 111.3 ± 1.3 cm. Fork lengths recorded for male and female specimens ranged from 70 to 140 cm and 67 to 169 cm, respectively (Figure 2). Only one wahoo's sex could not be identified in this study (FL = 59 cm). Mean FL sizes were not significantly different between sexes (Kruskal–Wallis test; H = 2.994, df = 1, $p = 0.086 > 0.001$).

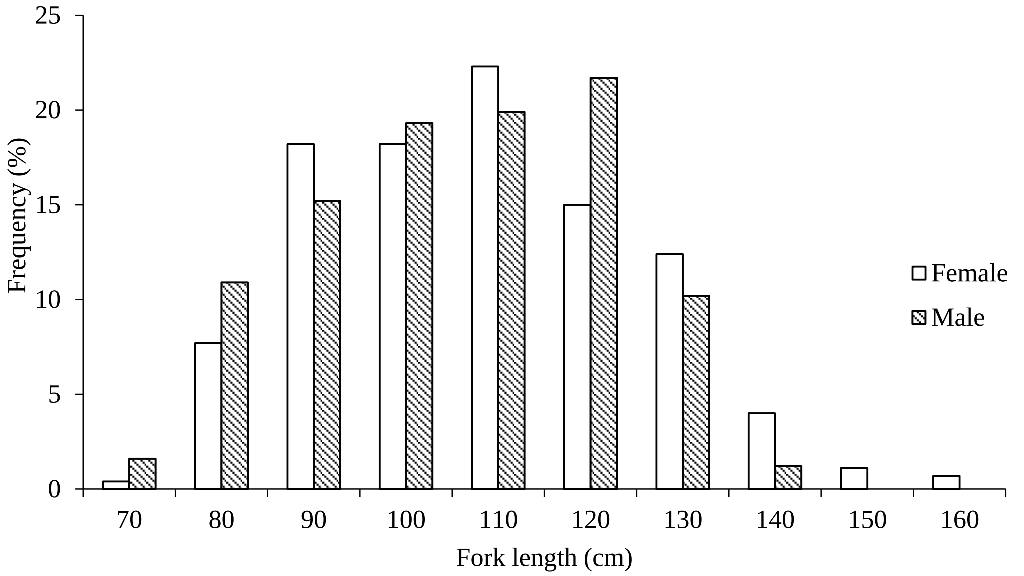


Figure 2. Length–frequency distribution of *Acanthocybium solandri* in the Western and Central Pacific Ocean.

The weight–length relationship plots for combined sex of wahoo showed that the scaling coefficient a and the exponential coefficient b estimated for all specimens were $a = 0.003$, $b = 3.183$, $R^2 = 0.93$, $n = 442$ (Figure 3). The estimated value of $b = 3.183$, which was significantly larger than 3, therefore indicated a tendency towards positive allometric growth (increase in relative body thickness or plumpness) in captured wahoo specimens.

3.2. Sex Ratio and Fork Length at 50% Sexual Maturity

The captured wahoo specimens comprised 391 females and 205 males. The sex ratio of females and males was 1.9:1 indicating a female-biased situation. The sex ratio obtained in this study differed significantly from 1:1 ($\chi^2 = 2.632$, $p = 0.031$). All seven immature wahoo specimens (four females and three males) were collected between July and August from the WCPO, but no immature specimens were sampled from September to November (Figure 4). Mature-active females occurred all throughout the 5 months with a peak in November; the same phenomenon was observed for mature males (Figure 4).

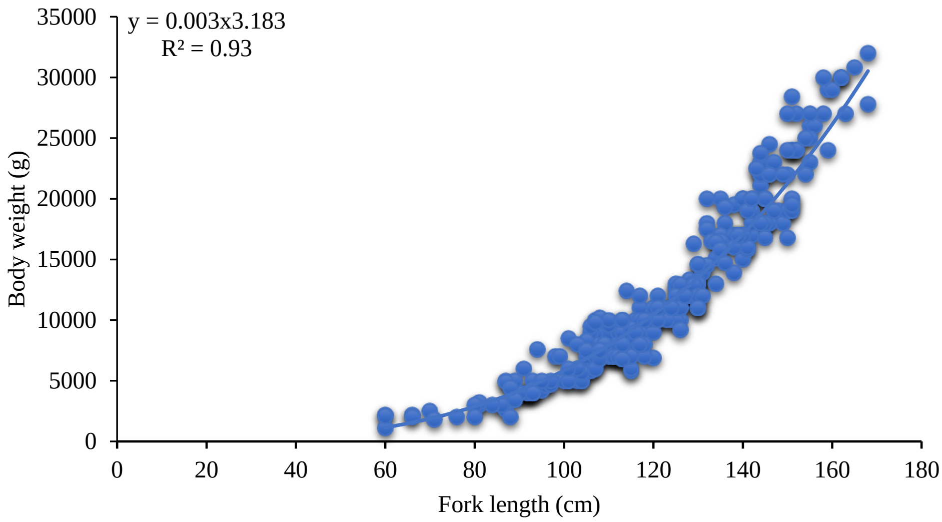
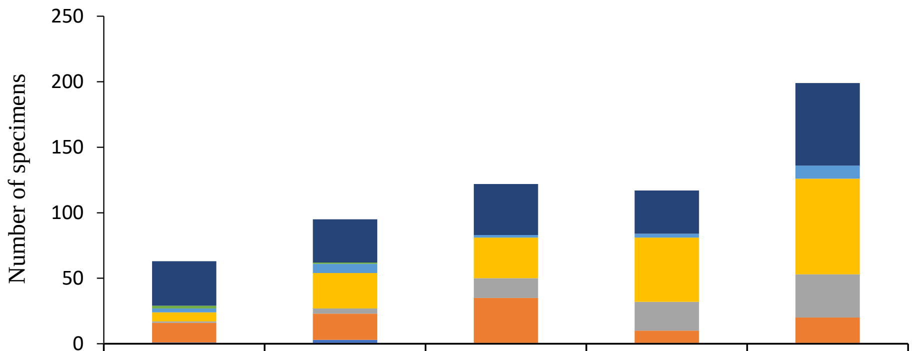


Figure 3. Relationship between body weight and fork length of *Acanthocybium solandri* in the Western and Central Pacific Ocean.



	July	August	September	October	November
Male-mature	34	33	39	33	63
Male-immature	2	1	0	0	0
Mature-inactive	3	7	2	3	10
Mature-active	7	27	31	49	73
Late-maturing	1	4	15	22	33
Early-maturing	15	20	35	10	20
Immature	1	3	0	0	0

Figure 4. Monthly number of wahoo specimens grouped per maturity stages (two for male specimens: first two rows; five for females: last five rows) in the Western and Central Pacific Ocean. Numbers in the table represent monthly catches per maturity stage.

A logistic regression estimated the fork lengths at 50% sexual maturity ($FL_{50\%}$) for female and male wahoo as 84 cm and 83 cm, respectively (Figure 5). Among all individuals that reached sexual maturity for female wahoo, more than 47.6% of them were those from the maturity class IV (mature-active specimens); more than 89% of male wahoo specimens were mature (stage II).

$$\text{Female}: \ P = \frac{1}{1 + \exp^{-0.128*(FL_i - 84)}}$$

(R^2 = 0.98, n = 387).

$$\text{Male}: \ P = \frac{1}{1 + \exp^{-0.129*(FL_i - 83)}}$$

(R^2 = 0.97, n = 202).

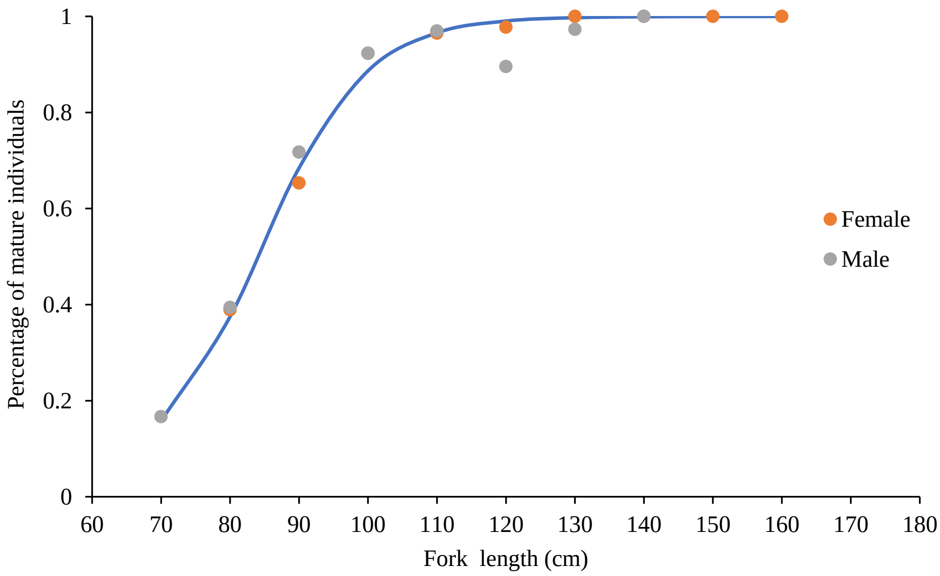


Figure 5. Relationship between percentage of mature individuals and fork length of *Acanthocybium solandri* in the Western and Central Pacific Ocean.

3.3. Gonadosomatic Index (GSI)

Average monthly GSI values for mature females (i.e., maturity stages II–V) ranged between 0.79 (±0.113) in July and 2.42 (±0.682) in November. Average monthly GSI values for mature males ranged from July (0.22 ± 0.033) to November (0.36 ± 0.114). The observed GSI for males was less than that of females; contrary to male wahoo gonads variations, female wahoo gonads increased exponentially (Figure 6).

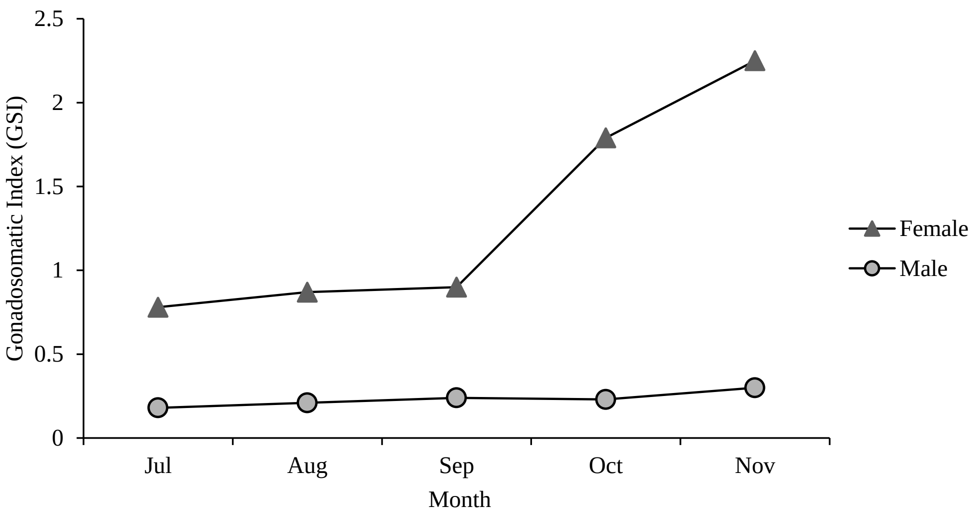


Figure 6. Mean monthly gonadosomatic index (GSI) for *Acanthocybium solandri* collected from the Western and Central Pacific Ocean.

3.4. Feeding Habits

Wahoo preyed on fish, cephalopods, and crustaceans (Table 2). A total of 42 species could be identified, as well as some unidentified species. Stomach content analysis showed that fish species accounted for 84.64%, cephalopods for 14.26%, and crustaceans for 1.1%. Excluding the pacific sardines (used as bait) found in the diet of wahoo, squid in the Sepiidae family (14.26%) was the most abundant in the stomachs of most wahoo specimens; beltfish *Trichiurus lepturus* (14%) was the most abundant finfish preyed on by wahoo.

Table 2. The diet composition of *Acanthocybium solandri* in the Western and Central Pacific Ocean. %*N* = percentage by number; %*F* = percentage by frequency of occurrence.

Ecological Group	Prey Items	%*N*	%*F*	Ecological Group	Prey Items	%*N*	%*F*
Fishes	*Trichiurus lepturus*	14	24.49		*Konosirus punctatus*	1.25	0.68
	Monacanthus chinensis	6.14	11.22		*Alepisaurus brevirostris*	1.25	1.02
	Scomber	5.09	6.46		Lethrinidae	1.25	1.02
	Tylosurus crocodiles	3.56	6.12		*Psenopsis anomala*	1.16	0.85
	Assrtger anzac	2.60	4.08		Neoceratiidae	1.11	0.51
	Drepane punctata	2.56	3.57		*Taractichthys steindachneri*	1.07	0.34
	Mene maculata	2.42	2.72		*Acanthocybium solandri*	1.07	0.34
	Kentrocapros aculeatus	2.25	3.91		*Harpadon nehereus*	1.07	0.34
	Drosera capensis	2.03	2.55		*Fistularia petimba lacépède*	1.07	0.51
	Cypselurus agoo	1.90	3.06		*Lepidocybium flavobrunneum*	1.03	0.34
	Ostracion	1.73	1.87		Syngnathidae	1.03	0.34
	Brama brama	1.68	2.38		*Megalaspis cordyla*	1.03	0.34
	Stromateidae	1.64	2.72		*Xiphias gladius*	1.03	0.34
	Lagocephalus lagocephalus	1.60	1.7		*Mola mola*	1.03	0.34
	Gempylus serpens	1.60	1.53		*Oxymonacanthus longirostris*	0.98	0.17
	Engraulidae	1.42	0.85		*Priacanthus tayenus*	0.98	0.17
	Alepisaurus ferox	1.42	1.7		*Lampris guttatus*	0.98	0.17
	Thunnus alalunga	1.42	1.19		*Amphilophus citrinellus*	0.98	0.17
	Kaiwarinus equula	1.33	1.02		*Sphyraena barracuda*	0.98	0.17
	Katsuwonus pelamis	1.29	1.36	**Crustacea**	Shrimp	0.17	0.34
	Aracana aurita aracanasp	1.25	1.02	**Cephalopoda**	Sepiidae	13.32	32.99

Cluster analysis showed that the trophic level classification can be divided into three fork length groups; small individuals (FL range from 70 to 110 cm), medium individuals (FL range from 110.1 to 140 cm), and large individuals (FL range from 140.1 to 169 cm). Empty stomach rate gradually decreased with increase in individual fork lengths, and the feeding habit of level 1 and level 2 increased gradually, whereas those of levels 3 and 4 decreased (Figure 7). The contingency chi-squared test showed significant differences between the FL groups and the feeding levels (χ^2 = 1666.16, $p < 0.001$).

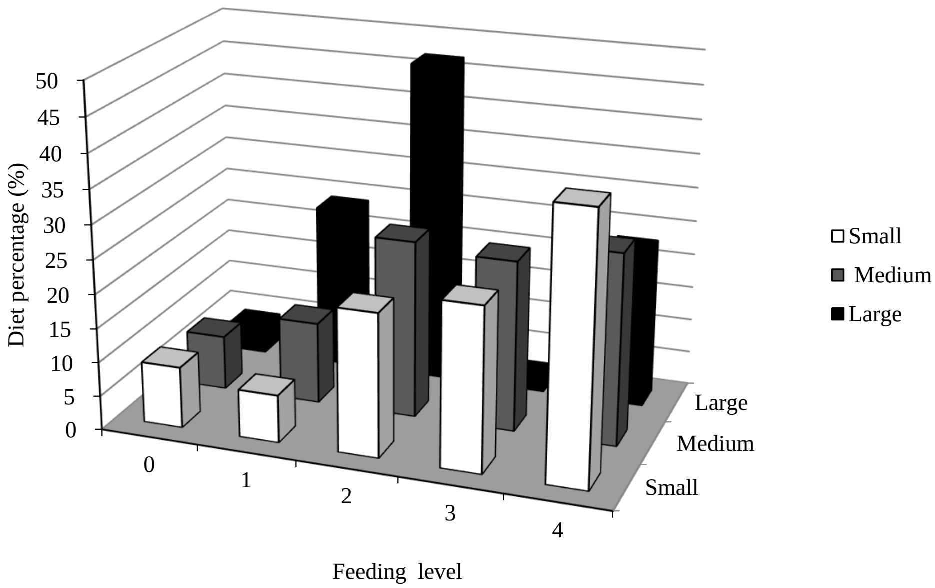


Figure 7. Ontogenetic shift in the feeding level of *Acanthocybium solandri* in the Western and Central Pacific Ocean.

3.5. The Optimum Water Layer and Optimum Temperature of Wahoo

From this study, the CPUE (individuals/thousand hooks) of wahoo in each water layer from 70 to 110 m, 111 to 150 m, 151 to 190 m, 191 to 230 m, 231 to 270 m, and 271 to 310 m were respectively as follows: 5.8 individuals/thousand hooks, 4.7 individuals/thousand hooks, 3.2 individuals/thousand hooks, 1.1 individuals/thousand hooks, 0.2 individuals/thousand hooks, and no individuals/thousand hooks (Figure 8). In the same light, the CPUE (individuals/thousand hooks) of wahoo in each section who had water temperatures ranging from 19 to 20 °C, 20.1 to 21 °C, 21.1 to 22 °C, 22.1 to 23 °C, and 23.1 to 24 °C were respectively as follows: 0.2 individuals/thousand hooks, 0.2 individuals/thousand hooks, 1.3 individuals/thousand hooks, 3.2 individuals/thousand hooks, and 5.4 individuals/thousand hooks (Figure 9). The highest CPUE of wahoo was recorded when the water layer and temperatures were in the range of 70 to 110 m and 23.1 to 24 °C, respectively.

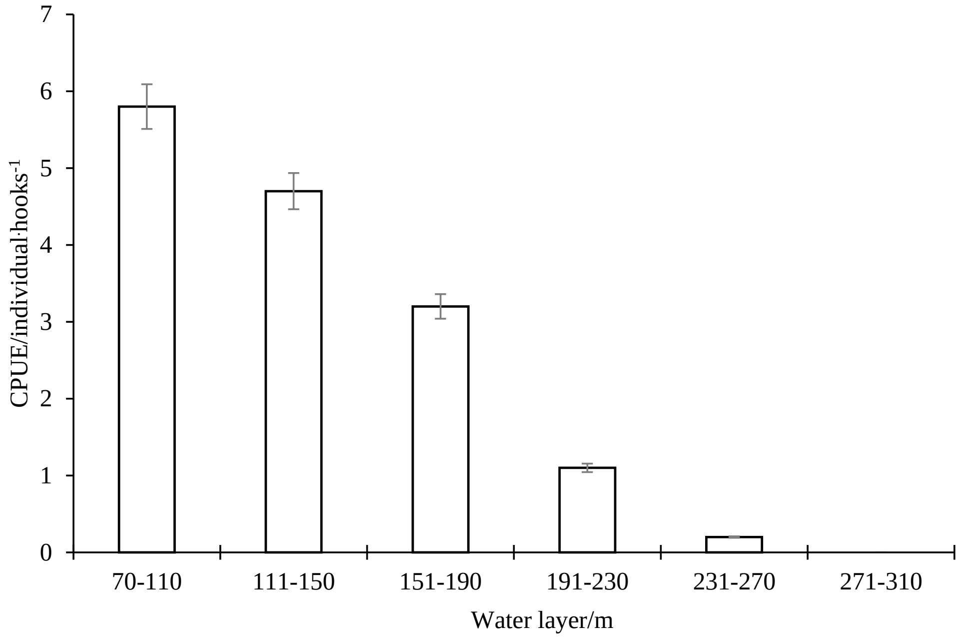


Figure 8. Number of catch per 1000 hooks $(CPUE)_{1j}$ of *Acanthocybium solandri* in different water layer ranges.

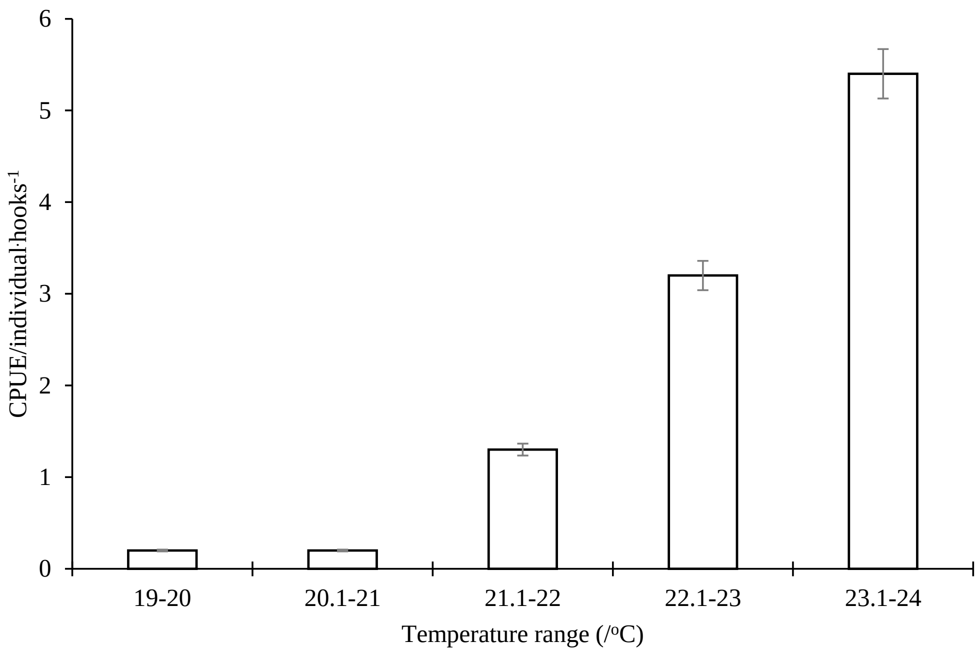


Figure 9. $CPUE_{2j}$ of *Acanthocybium solandri* in different temperature ranges.

4. Discussion

Although wahoo is still considered a low-income species among most commercial fisheries, the increase in their catches worldwide, and given their social and ecological importance to inhabitants along coastal countries, we argue that this species would need to be considered a priority for future management and assessment. Our study provides much-needed biological, feeding, and environmental information for wahoo in the WCPO.

Previous studies of the sex ratio of wahoo in the Pacific and Atlantic are comparable with our results. Hogarth [1] identified a sex ratio of 3.5:1 in favor of wahoo collected off North Carolina, corroborating with the sex ratio obtained from this study. Jenkins and McBride [12] in the North Western Atlantic reported a low proportion of females in their samples as compared to our study, but also reported a sex ratio favorable to females (1.3:1, females: males). The recent study of wahoo in the South Pacific also showed that females dominated males in catches 3.2:1 [5]. Figuerola-Fernandez et al. [22] found the sex ratio of wahoo near Puerto Rico was (0.9:1) in favor of females. This female-biased sex ratios reported for wahoo in the Pacific and Atlantic Oceans may be as a result of a sex-specific difference in migration patterns, generating a greater catchability of females resulting from differences between the sexes in preferred habitat, as is the case for most pelagic marine species [1,6,23].

Life history aspects of wahoo reported off North Carolina by Hogarth [1], showed that the length at 50% maturity ($L_{50\%}$) of females and males were 86 cm and 101 cm, respectively. Brown-Perterson et al. [11] reported an $L_{50\%}$ of females and males to be 93.5 cm and 102 cm from western and central Atlantic Ocean. Jenkins and McBride [12] and Viana et al. [13] reported $L_{50\%}$ for female wahoo of 92.5 and 110 cm, FL, respectively for the Northern and Southern Atlantic Ocean. During the study of wahoo in Puerto Rico, Figuerola-Fernandez et al. [22] estimated $L_{50\%}$ to be 89.6 cm, whereas Zischke et al. [5] estimated it at 104.6 cm for females off eastern Australia, which is much higher than the result presented by Figuerola-Fernandez et al. [22]. The length at 50% maturity presented in our study (females 84 cm, males 83) is the smallest $L_{50\%}$ ever reported for this species. This $L_{50\%}$ observed in our study also suggested that maturity was attained faster at high temperatures and slower in areas with lower temperatures [9,24]. All captured species larger than 110 cm were found to be mature, i.e., at stage II for males or stage II and above for females (Figure 5).

The peak GSI observed in our study was in November, showing that spawning period of wahoo may have started before this period and probably extending throughout winter to spring, as reported by Luan et al. [24] for the same species in the south eastern Pacific Ocean. The presence of the increasing number of mature-active female specimens (stage IV) and increasing number of males with enlarged testes (stage II), during this period may confirm that the spawning season may have started earlier and extending further given the GSI data presented in this study. However, this study corroborates with reports from Iversen and Yoshida [25], who reported that wahoo in the Central Pacific Ocean spawned in both spring and winter. Many previous studies have reported a protracted spawning season ranging from austral spring to summer [5,12,13], and Brown-Peterson et al. [11] reported a spring spawning season for wahoo near the Bahamas. Given the limited survey period in this study, we suggest that a year-round study should be conducted and then compared to this study before effectively reporting a spawning season for this species in the WCPO. Therefore, the result of GSI presented in this section should be taken as a preliminary report of wahoo's spawning season in the WCPO.

Wahoo is a highly esteemed food fish throughout its range as it supports valuable commercial and recreational fisheries in many coastal countries [26]. On the basis of the diet analysis presented in this study, the main stomach content observed was fish (79.25%), cephalopods (14.26%), and crustaceans (1.11%). Excluding the pacific sardines (used as baits) found in the diet of wahoo, squid in the Sepiidae family (14.26%) was the most abundant in the stomachs of most wahoo specimens, and beltfish *Trichiurus lepturus* (14%) was the most abundant finfish preyed on by wahoo. Squid accounted for 14.26% of all the stomach contents observed, which was lower than the proportion of squid (22%) reported by Allain [27] for mahi-mahi in the WCPO, and slightly higher than that reported for wahoo in the Gulf of Mexico (13.4%) by James et al. [14]. In the north–central Gulf of Mexico, James et al. [14] found that small sizes wahoo mainly fed on flying fish, whereas the Scombridae and Carangidae became the main prey for middle- and large-sized individual wahoo. *Scomber*, a member of the Scombridae family, was also reported in this study as a main prey (Table 2). Differences of prey species observed in the stomach content analyses between studies may involve diverse potential factors including number of specimens analyzed, time of sampling day or season, sizes of samples, abilities of observers, environmental conditions, at sampling time.

Samples collected in this study consisted of wahoo caught exclusively with hook-and-line gear all day long. This study showed that the empty stomach rate of this species gradually decreased with the increase of fork length, and the feeding level 1 and level 2 gradually increased, because large individuals could easily prey on other species as food. Although depths of up to 269 m were recorded in this study from the Western and Central Pacific Ocean, nearly all depths recorded during the day and night periods were within the warm waters of the upper mixed layer. This report corroborates with previous reports, which showed that wahoo catches were predominantly higher from shallow-set hooks in longline operations [28,29].

This study analyzed the fishery data depth range from 70 m to 310 m, and wahoo were mostly caught around depths ranging from 70 m to 110 m. However, no catch of wahoo was recorded beyond the depths of 270 m, which is in accordance with previous reports from Theisen et al. [30] and Sepulveda et al. [9]. Within the different water columns, the CPUE decreased with increase in depth. When depth increased, the water temperature decreased, and the CPUE also decreased within the analyzed water columns. This study showed that wahoo preferred to inhabit water layers with temperature ranging between 23.1 and 24 °C. The archival tags from the Western North Atlantic showed that wahoo spent most of their time in temperatures ranging between 17.5 to 27.5 °C, whereas wahoo in the North Pacific Ocean preferred to live in temperatures between 11.1 to 27.9 °C [9]. As shown for other pelagic species, factors such as changes in oceanographic conditions, prey availability, and distribution all contribute to the vertical movements displayed by species at different times and locations [31,32].

This study provides a much-needed information on the reproductive biology, feeding ecology, and the environmental preferences of wahoo in the WCPO, and adds knowledge to the research of wahoo globally. Biological parameters such as length-at-maturity in many cases may contribute to the construction of data-limited assessment methods and help towards the regional management of the species. This study also showed that wahoo plays an important role as a biological control of many species that serve as prey, including fishes as well as cephalopods, and, as a result, it has vital direct and indirect influence on the viability of many fisheries. Furthermore, this work also indicated that wahoo in the WCPO prefer to inhabit water layers with warmer temperatures. We suggest a year-round collection of reproductive biology data in order to give consistent results on the spawning season and frequency of wahoo in this region. The parameters estimated in this study are important for the adoption of conservation and management measures for wahoo stock in the WCPO.

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