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Population Structure, Reproduction, Age, Virtual Population Analysis (VPA) of *Parailia pellucida* Boulenger, 1901 (Osteichthyes: Schilbeidae) in a Tropical River System

B.I. Uneke
Fisheries Biology Unit, Department of Applied Biology, Faculty of Biological Sciences,
Ebonyi State University, Abakaliki, Nigeria

Abstract: Population structure, reproduction, age, Virtual Population Analysis (VPA) of *Parailia pellucida* was studied with samples collected from commercial artisinal fishers for 13 consecutive months. The length-frequency distribution of the 1722 *P. pellucida* showed that the smallest and largest specimens were 3.8 and 10.2 cm TL, respectively (mean = 6.11cm±0.81) with 1 mode at 5-6 cm TL. The weight ranged between 0.3-7.5 g (mean = 1.4 g±1.04). In the whole 13 months, there was significant heterogeneity (X^2 = 21.09, df = 12, $p<0.05$) with females dominating. Estimated values of length and age at sexual maturity L_m and t_m were 6.3 cm TL and 1.39 year^{-1}, respectively. The sizes attained by the *P. pellucida* are 3.73, 5.47, 7.62, 8.75 and 9.34 cm at the end of 3, 6, 12, 18 and 24 months of age, respectively. Estimated values for age at length zero (t_0), length at age zero (L_0) and potential species longetivity (t_{max})were -0.29 year, 1.81 cm TL and 4.76 years.

Key words: Population structure, reproduction, age, virtual population analysis, *Parailia pellucida*

INTRODUCTION

Although, *P. pellucida* is not the only schilbeid present in this tropical flood river system, its abundance by number and weight in the liftnet fishery is notable and significant. The target schilbeids constituted 55% by number and weight, respectively of the overall catch (Ezenwaji, 2004). According to Ezenwaji and Offiah (2003), this abundance may not be unconnected to a number of factors such as early sexual maturity, all year round breeding, food availability, high growth rate, short life span, high natural mortality and environment. The river system is characterized by many tributaries and floodplain lentic water bodies mainly small sized (<500 m^2) and medium sized (<5,000 m^2) ponds and lakes (Welcomme, 1985) which are fringed by riparian shrubs and forests (Fig. 1). The vegetation in the river system is the rainforest Guinea mosaic and it is typical of this area and areas North of it (Ezenwaji 1998). The rainy season and the dry season are the 2 main seasons of the area. The latter occurs between October to March while the former is from April to October. The present study, was undertaken to estimate key parameters of length-weight relationship, condition factor, reproduction, age, Virtual Population Analysis (VPA) of *Parailia pellucida* Boulenger, 1917 (Osteichthyes: Clupeidae) in a tropical river system. This information is necessary in formulating management and conservation policies, as well as in further development of fishery for this species in Nigeria. Furthermore, with regards to the information gap about small fish, the parameters estimated for *P. pellucida* forms

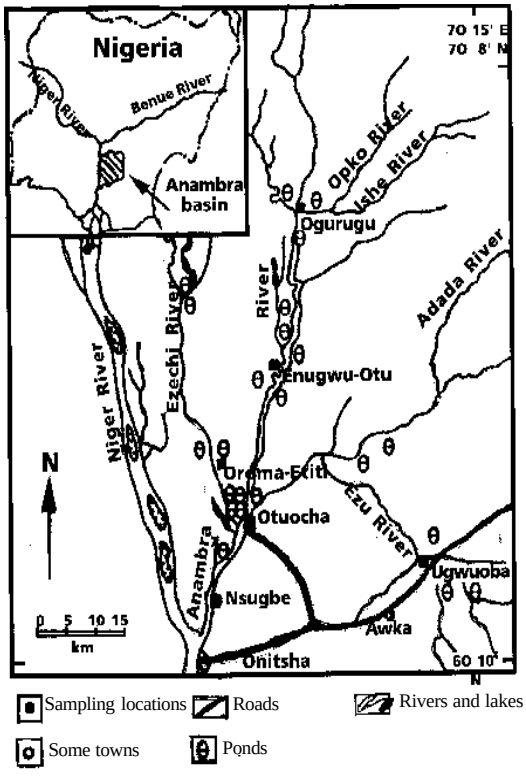

Fig. 1: Map of Anambra river flood system showing the sampling location (Otuocha)

a comparison base for other population studies of small-sized fish species of tropical environments. The results also provide baseline information (as well as reference points) that can be incorporated into wider reference systems relevant to current fisheries assessment and management in the tropical region.

MATERIALS AND METHODS

Monthly samplings of *P. pellucida* were made at Otuocha river port in the Anambra flood river system, Nigeria (Fig. 1). Samples were collected from artisanal fishers for 13 consecutive months (September, 2004-2005). A total of 1722 specimens of *P. pellucida* (981 females and 741 males) with total length ranging from 3.8-10.2 cm and weight of 0.3-7.5 g were analysed. Total Length (TL), Standard Length (SL) and Fork Length (FL) was measured to the nearest 0.1 cm with a meter rule measuring board. Weight measurement would be made for both species with a Mettler PC 2000 electronic weighing balance to the nearest 0.1 g. Sexing of the measured fishes was done by internal examination, through cross sectional dissection of the abdomen. Gonad maturation was evaluated macroscopically following; Ezenwaji and Offiah (2003) who stated 4 maturation stages:

- Immature
- Mature
- Ripe
- Spent

Size at maturity was estimated as the length at which 50% of individuals are in gonad stage 2. The length (l_m) and age (t_m) at sexual maturity was estimated, respectively as (Roff, 1986):

$$l_m = L_\infty\left[3k/(3k+m)\right]$$
$$t_m = \left(1/k\right)\ln(3k+m)/m \quad (1)$$

Age was investigated by fitting the von bertalanffy growth function to length frequency data. The von Bertalanffy growth equation is defined as follows (Sparre and Venema, 1998):

$$L_t = L_\infty\left[\left(1-\exp^{(-K(t-t)}0\right)\right] \quad (2)$$

Where:

L_t = The length at time t
L_∞ = The asymptotic length
K = The growth coefficient
t_0 = The hypothetical time at which length is equal to zero

The response surface analysis routine from the FISAT program provided estimates of L_∞ and K. The age at length zero (t_0) was estimated by employing the equation of Pauly (1980):

$$\text{Log}(-t_0) = -0.3922 - 0.2752\,\text{Log}\,L_\infty - 1.038\text{Log}\,K \quad (3)$$

Length at age zero (L_0) was estimated according to Sparre and Venema (1998) as:

$$L_0 = L_\infty\left[1-\exp^{(kto)}\right] \quad (4)$$

Individual species maximum longetivity (t_{max}) (Pauly, 1983) encountered was evaluated as:

$$t_{max} = 3/K \quad (5)$$

Virtual population analysis (length based cohort analysis) was done using the FAO-ICLARM stock assessment tools (FiSAT) 11 software.

RESULTS AND DISCUSSION

Population structure: In the length-frequency distribution of the 1722 *P. pellucida*, the smallest and largest specimens were 3.8 and 10.2 cm TL, respectively (mean = 6.11 cm±0.81) (Fig. 2). The 5-7 cm TL size ranges were numerically dominant, however there was only 1 mode at 5-6 cm TL (Fig. 2). The weight ranged between 0.3-7.5 g (mean = 1.4±1.04 g). With respect to variation in sex ratio with length class, females dominated between 4-9 cm TL while males dominated in the 3-4 and 9-10 cm TL length classes. The females predominated in the 10-11 cm TL class size (Fig. 3). The overall monthly sex ratio (M:F) was significantly different 1:1.3 (X^2 = 33.44, df = 1, $p<0.05$)

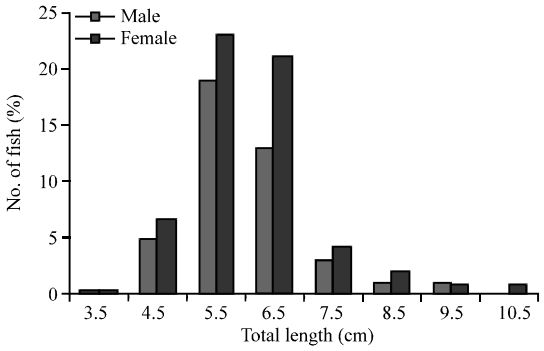

Fig. 2: Length-frequency distribution of male and female *P. pellucida* in the Anambra flood river system

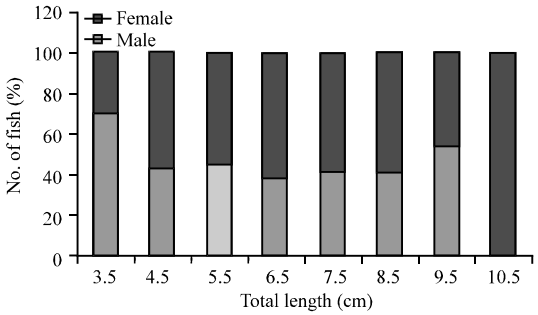

Fig. 3: Variation in sex ratio with size of *P. pellucida* in Anambra flood river system

Table 1: The overall monthly sex ratio of *P. pellucida* in the Anambra flood river system

	Number samples			Sex ratio	
Months	Male	Female	Total	M:F	Calculated X^2
Sep.	51	58	109	1:1.1	0.450
Oct.	66	85	151	1:1.3	2.390
Nov.	71	79	150	1:1.1	0.430
Dec.	60	90	150	1:1.5	6.000
Jan.	63	87	150	1:1.4	3.840
Feb.	66	95	161	1:1.4	5.220
March	43	58	101	1:1.3	2.230
April	66	85	151	1:1.3	2.390
May	64	65	129	1:1.0	0.008
June	62	77	139	1:1.2	1.620
July	61	117	178	1:1.9	17.610
Aug.	9	13	22	1:1.4	0.730
Sep.	59	72	131	1:1.2	1.290
Total	741	981	1722	1:1.3	33.440

(Table 1). Statistical analysis of monthly sex ratio revealed that there was no marked departure from unity in other months except in December, January, February and July when females dominated, however considering the whole 13 months, there was significant heterogeneity ($X^2 = 21.09$, df = 12, $p<0.05$). There were more females than males in the dry seasons (male = 303, 42.6%; female = 409, 57.4%; sex ratio 1:1.3; $X^2 = 15.78$, df = 1, $p<0.05$) and the rainy season (male = 438, 43.4%; female = 572, 56.6%; sex ratio 1:1.3; $X^2 = 17.78$, df = 1, $p<0.05$).

Reproduction: The monthly dynamics in the number and percentage male and female at each maturation stage for *P. pellucida* (Table 2) indicated that immature stage was present between April and June, ripe stage from November to May and spent stage between November and June. The mature stage however was present throughout the year. There were significant differences in the M:F sex ratio in the mature ($X^2 = 5.42$, df = 1, $p<0.05$) and ripe ($X^2 = 23.93$, df = 1, $p<0.05$) stage while the spent and immature stage showed no significant difference (Table 3). Smallest mature male and female *P. pellucida* sampled were 4.8 and 5.2 cm TL, respectively. The largest ripe male and female measured 9.6 and 11.0 cm TL. The median size at maturity for *P. pellucida* for both sexes was 5.6 cm TL while the median size at spawning was 6.5 cm TL for both sexes. Estimated values of L_m and t_m were 6.3 cm TL and 1.39 year^{-1}, respectively.

Age: The length range obtained in the fishery was 3.8-10.2 cm. The estimated von Bertalanffy growth parameters were found to be L_∞ = 11.03 cm and K = 0.61 year^{-1}. It is assumed in the ELEFAN 1 analysis that the value of the third parameter of the von Bertalanffy growth function, t_0 is zero. Therefore, the sizes attained by the *P. pellucida* are 3.73, 5.47, 7.62, 8.75 and 9.34 cm at the end of 3, 6, 12, 18 and 24 months of age, respectively. The absolute increase is available for reading as in Fig. 4. Estimated values for age at length zero (t_0), length at age zero (L_0) and potential species longetivity (t_{max}) were -0.29 year, 1.81 cm TL and 4.76 year.

Virtual population analysis (length based cohort analysis): The results of the length structured VPA analysis of *P. pellucida* are shown in Fig. 5. About 2 peaks of F are evident in the 6-7 cm TL and 9-10 cm TL length groups. For the first peak, F-array was 1.66 with catch in number = 45129.05, survivors = 133262.91 while the second peak had F-array as 2.06, catch in number = 3614.91 and population of survivors as 6780.25. Number of recruits to fishery for *P. pellucida* was 548218.88.

The population of *P. pellucida* (3.8-11.0 cm TL), also exhibited a similar trend with the preponderance of 5-7 cm TL which is a good reflection of its population structure in that the fish grows fast, becomes recruited into the fishery with high fishing and natural mortality. Such range of fish must have been adequately sampled. This is in agreement with the report of Ezenwaji and Offiah (2003).

A sex ratio favouring females obtained in the population of *P. pellucida* may not be unrelated to the genetic factor set up to ensure constant continuous procreation for the regeneration of the stock. Ezenwaji and Offiah (2003) made a similar observation in the same species. For *P. pellucida*, computed L_m of 6.3 cm TL is in contrasts but however, close with L_m values of 5.3 and 5.2 cm TL for the female and male in Kainji Lake (Olatunde, 1977). This may b due to differences in population and environment. The estimated median size for *P. pellucida* at maturity and spawning were 5.6 and 6.5 cm TL, respectively which indicated that the largest number of the most fit fish (5-11.0 cm TL bracket) is in reproductive state.

Table 2: Monthly variation in the number and percentage male (n = 741) and female (n = 981) *P. pellucida* at each maturation stage

		Maturation stage								
	No. of males	Male				Female				No. of females
Months	sampled	1	2	3	4	1	2	3	4	sampled
Sep.	51	24 (47.1)	21 (41.2)	2 (3.9)	4 (7.8)	24 (41.4)	13 (22.4)	13 (22.4)	8 (7.8)	58
Oct.	66	26 (39.4)	38 (57.6)	1 (1.5)	1 (1.5)	39 (45.8)	43 (50.6)	1 (1.2)	2 (2.4)	85
Nov.	71	38 (53.5)	33 (46.5)	0 (0.0)	0 (0.0)	45 (57.0)	34 (43.0)	0 (0.0)	0 (0.0)	79
Dec.	60	19 (31.7)	41 (68.3)	0 (0.0)	0 (0.0)	32 (35.6)	58 (64.4)	0 (0.0)	0 (0.0)	90
Jan.	63	7 (11.1)	56 (88.9)	0 (0.0)	0 (0.0)	9 (10.3)	78 (89.7)	0 (0.0)	0 (0.0)	87
Feb.	66	7 (10.6)	59 (89.4)	0 (0.0)	0 (0.0)	12 (12.6)	83 (87.4)	0 (0.0)	0 (0.0)	95
March	43	2 (4.7)	41 (95.3)	0 (0.0)	0 (0.0)	3 (5.2)	55 (94.8)	0 (0.0)	0 (0.0)	58
April	66	0 (0.0)	66 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	85 (100.0)	0 (0.0)	0 (0.0)	85
May	64	0 (0.0)	64 (100.0)	0 (0.0)	0 (0.0)	1 (1.5)	64 (98.5)	0 (0.0)	0 (0.0)	65
June	62	0 (0.0)	51 (82.3)	11 (17.7)	0 (0.0)	0 (0.0)	56 (72.7)	21 (27.3)	0 (0.0)	77
July	61	0 (0.0)	28 (45.9)	30 (49.2)	3 (4.9)	0 (0.0)	38 (34.5)	67 (57.3)	12 (10.2)	117
Aug.	9	2 (22.3)	3 (33.3)	33 (33.3)	1 (11.1)	3 (23.1)	0 (0.0)	9 (69.2)	1 (7.7)	13
Sep.	59	15 (25.4)	42 (71.2)	2 (3.4)	0 (0.0)	16 (22.2)	50 (69.4)	6 (8.4)	0 (0.0)	72
Total	741									981

Table 3: The dynamics of male and female *P. pellucida* in maturation stage

Maturation stage	Male	Female	Sex ratio M:F
Immature	140	184	1:1.3
Mature	543	657	1:1.2
Ripe	49	117	1:2.4
Spent	9	23	1:2.6
Total	741	981	1:1.3

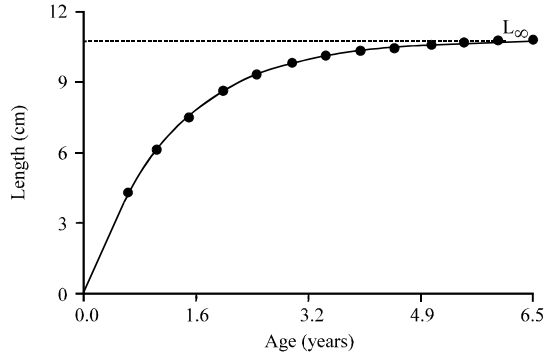

Fig. 4: Calculated growth curve of *P. pellucida* (with L_∞ = 11.03 cm and K = 0.61 year^{-1})

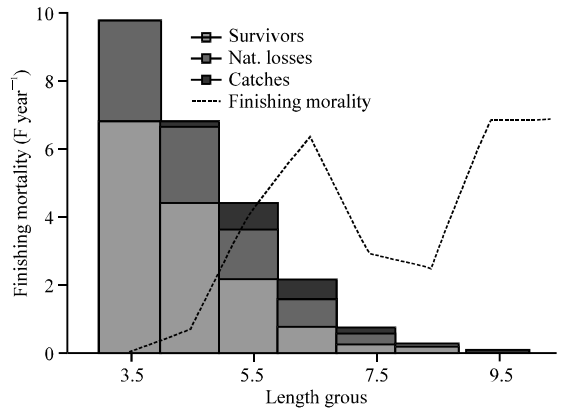

Fig. 5: VPA analysis of *P. pellucida*

B value of the total length-standard length relationship of *P. pellucida* was computed as 1.024 which agrees with b value 1.022 of the same species by Teugels *et al.* (1988) but the a values differed. According to King (1995), marked variability in estimates of length-weight relationships is usually observed among different populations of the same species. It may, also reflect changes in condition of individuals related to feeding, reproductive activities and/or estimation methods. Parameters of length-weight relationships for *P. pellucida* of Volta river in Ghana (a = 0.0043, b = 3.3710) (Teugels *et al.*, 1988) corresponded with those of this study (a = 0.0048, b = 3.442) indicating similarities in the condition of these 2 populations in terms of feeding, reproduction and estimation methods.

Size range of 5-7 cm TL of *P. pellucida* corresponded with the VPA analysis showing lengths between 5-7 and 9-11 cm TL in which fishing pressure is concentrated. It is important to note that dominance in number contributes to fishing pressure but not directly related to it (Sparre and Venema, 1998). This is revealed in *P. pellucida* in which the 9-11 cm TL sampled number was low compared to other length, yet with a high fishing pressure.

CONCLUSION

The results of the length structured VPA analysis of *P. pellucida* revealed two peaks of F with the F-arrays of 1.66 and 2.06. Number of recruits to fishery for *P. pellucida* was 548218.88.

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