Asian Fisheries Science **22**(2009):1117-1129
ISSN: 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2009.22.4.006

Asian Fisheries Society, Selangor, Malaysia

Reproductive Biology, Length-Weight Relationship and Population Parameters of a Marine Ornamental Fish *Abudefduf vaigiensis* (Quoy & Gaimard, 1825) (Osteichthys, Pomacentridae) from the Shallow Waters of Visakhapatnam Coast

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Abstract

An attempt has been made to study the reproductive biology, length-weight relationship, relative condition factor and other population dynamics of *Abudefduf vaigiensis* of Visakhapatnam coast. The regression coefficients of length and weight in males and females showed a significant difference, hence separate equations were developed. The equations obtained were: males: log W = -4.6392 + 2.9681.log L (r=0.96); females: log W = -4.5023 + 2.9048.log L (r=0.95). The mean relative condition factor (Kn) values ranged from 0.992 to 1.027 in males and 0.983 to 1.019 in females. In males and females low Kn values were clearly related with the spawning season. Size at first maturity was estimated at 126 mm. Ripe specimens were observed in length groups 121-150 mm between October and March. The females marginally dominated the catch and the average sex ratio of males to females for the study period was 1:1.36. Fecundity ranged from 11,294 to 40,208 and average fecundity was estimated as 19,548. Fecundity increased with total length, fish weight and ovary weight. Population dynamics parameters estimated were: L_∞ = 180.27 mm, K=0.48 per year, ϕ' (growth performance index) = 2.508, natural mortality coeffi-

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cient (M) =1.07377 per year, total mortality coefficient (Z) =1.29277 per year, fishing mortality (F) = 0.219, exploitation ratio (E) = 0.2039.

Introduction

The coastal waters of Visakhapatnam harbours a wide biodiversity. This rocky intertidal shore consists of different ecologically, pharmaceutically and ornamentally important finfish resources. The Indo-Pacific sergeant *Abudefduf vaigiensis* (Quoy & Gaimard 1825) (Pomacentridae) is a dominant ornamentally important species in the rock pools of Visakhapatnam coast. It inhabits coral reefs and rocky shores at depths 1-12 m in the tropical Indo-West Pacific (Smith and Heemstra 1986).

Knowledge on the biology and fisheries parameters is very helpful in the study of growth of stock and population dynamics (Damayanti et al. 1990). Earlier studies (Anand and Pillai 2002; Jayasankar 1990; Mohan et al. 1986; Morato et al. 2001; Murty 2002; Pillai and Mohan 1990; Pillai et al. 2002) on the biology and population parameters of marine ornamental fishes are meager. Rao et al. (2004) carried out studies on the occurrence of marine ornamental fishes at Visakhapatnam.

In the present study, an attempt has been made to study the reproductive biology length-weight relationship, relative condition factor, growth and mortality of Indo-Pacific sergeant occurring in the shallow coastal waters of Visakhapatnam coast.

Materials and Methods

This study was carried out in the Indo-Pacific sergeant occurring in the intertidal rocky shore habitats of Visakhapatnam (Lat. 17°43'N; Long. 83°22'E) during the period August 2004 to July 2005. Samples were collected twice a week by operating cast nets at the intertidal rock pools along the Visakhapatnam coast with the help of the local fishermen. During the study, 451 individuals were examined of which 181 were males ranging in total length from 75 to 158 mm and 270 were females ranging in total length from 85 to 158 mm. Total length (TL) was taken in mm from the tip of the snout to the tip of the longest ray in the caudal fin while weight was taken to nearest to 0.1 g. Length and weight were taken separately for

females and males. The specimens were dissected and the gonads were examined to determine the sex and stage of maturity. Fecundity was estimated using the gravimetric method. The length-weight relationship was calculated using the formula: $W = aL^b$, and was logarithmically transformed into: log W = log a + b log L where, W is the weight of the fish in grams, L is the total length of the fish measured in millimeters and 'a' and 'b' are constants. Significance of difference at 5% level between the regression coefficients of the sexes was tested by ANCOVA (Snedcor and Cochran 1967). The relative condition factor, Kn (Le Cren 1951) was estimated using the equation, Kn = W/W' where W represents observed weight and W' the calculated weight derived from the length-weight relationship.

An attempt has also been made to estimate the other population parameters using FiSAT II (Version 1.2.2) (Gayanilo et al. 2005) software. The parmeters L_∞ and K (year^{-1}) of the von Bertalanffy growth equation were estimated using length distribution data. This was done using Powell-Wetherall method (Wetherall 1986; Wetherall et al. 1987) and ELEFAN I routines incorporated in FiSAT software. The Powell-Wetherall method was used to provide an initial estimate of L_∞. This was then used as a seed value for ELEFAN I analysis to determine the value of K. Total mortality (Z) was estimated using the mean length method of Beverton and Holt (1956) model while natural mortality was estimated using Pauly's M empirical equation (Pauly 1980) (where mean temperature of the study area was 29^{o}C). Fishing mortality was estimated using the formula F= Z-M and exploitation ratio was calculated using the equation E= F/Z.

Results

Length-weight relationship

The regression equations for male and female were obtained as (Fig. 1):

Males: log W = -4.6392 + 2.9681.log L (r=0.96)

Female: log W = -4.5023 + 2.9048.log L (r=0.95)

ANCOVA revealed significant difference in the regression coefficients of the two sexes (Table 1), hence separate equations were developed for males and females.

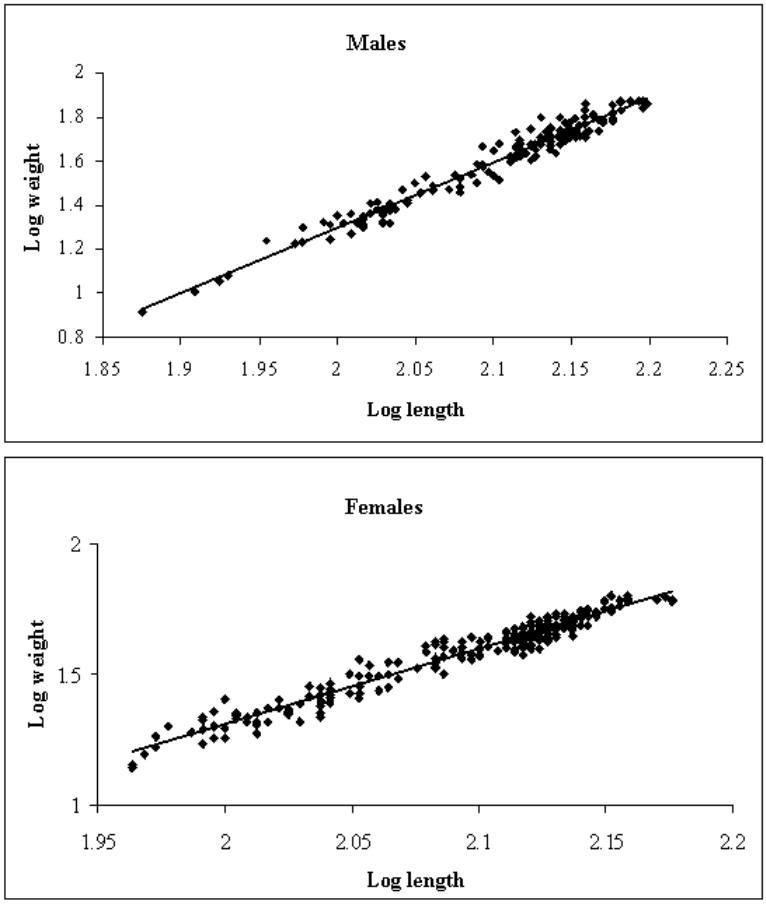

Figure 1: Length - weight relationship of *Abudefduf vaigiensis*

Relative condition factor

The mean relative condition factor (Kn) values ranged between 0.992 to 1.027 in males and 0.983 to 1.019 in females. The plot of Kn values against different body lengths for males and females showed almost similar trends (Fig. 2). In males low Kn values were observed from November 2004 to March 2005, whereas, in females low Kn values were observed from December 2004 to March 2005.

Maturation of gonads

The gonads are of unequal size and six maturity stages have been identified based on the macroscopic examination of the gonads (Table 2).

Table 1. Analysis of covariance for testing differences in regression coefficients between males and females of *A. vaigiensis*

S.No.	With in	DF	Σx^2	Σy^2	$\Sigma x y$	Regression Coefficients		DF	SS	MSS
						Intercept (a)	Slope (b)			
1	Males	180	4.3968	2.5407	3.3271	-4.6392	2.9681	179	0.2681	
2	Females	269	4.3830	2.5118	3.3085	-4.5023	2.9048	268	0.3054	
3	Total							448	0.5735	0.001280
4	Pooled	450	4.3885	2.5234	3.3160	-4.5685	2.9356	449	0.5786	0.001288
5	Difference between slopes (4&3)							1	0.0051	0.005100
6	With in + between							450	0.5837	0.001297
7	Difference between adjusted means (6&4)							1	0.051	0.005100

For comparison of slopes:
F = 0.005100/0.001280 = 3.98 (df = 1,448) – significant i.e. the slopes of males and females are significantly different.

For comparison of elevations:
F = 0.005100/0.001288 = 3.95 (df = 1,449) – significant i.e. elevations are significantly different.

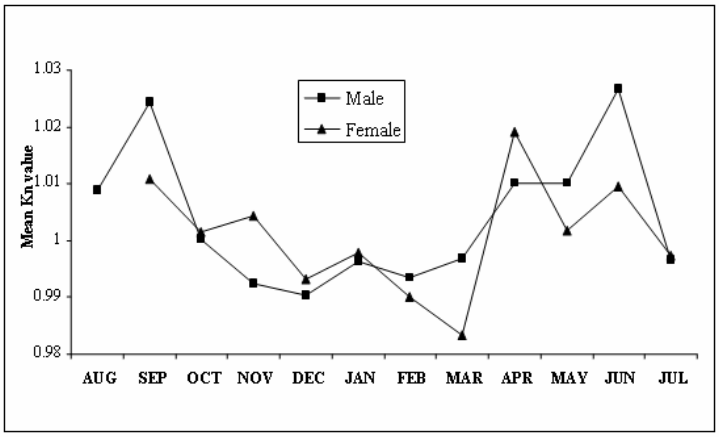

Figure 2. Relative condition factor of *A. vaigiensis* in different months during the period August 2004 to July 2005

Table 2. Characteristics of gonads of *A. vaigiensis*

Maturity stage	Testis	Ovary
Stage I (Immature)	Appear as pale flattened thread like structures	Appear as short and translucent
Stage II (Early maturing)	Increased in size than the previous stage	Oocytes in the ovary are semi opaque and closely arranged
Stage III (Maturing)	Become more vascular and pale white in colour	Acquires a light yellow or creamy colour and ova become opaque and visible to the naked eye
Stage IV (Mature)	Milky white in colour and occupying 3/4th of the body cavity	Become bright yellow in colour
Stage V (Ripe)	Turgid and milt oozes out on pressing the abdomen	Bright pinkish in colour, ova are ripe, translucent and with distinct oil globules
Stage VI (Spent)	Flaccid, slender and translucent	It is shrunken, flaccid, wrinkled and partly filled with few ova of stage V

Size at maturity and spawning

The length at which 50% of the fish were mature was found to be 126 mm (Fig. 3). Specimens of advance stages of maturity were observed between 121-150 mm total length groups. Ripe fishes were found between October and March, hence spawning season appears to be between October

to March with peak in December and January. The spent ovaries were observed during March to May.

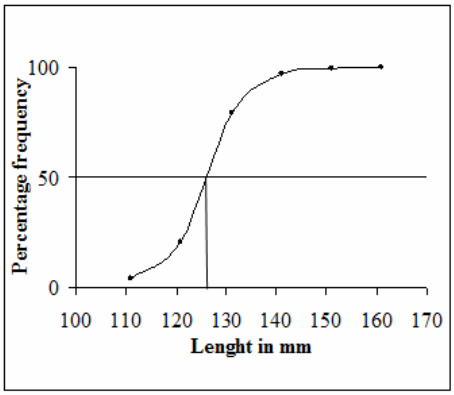

Figure 3. Length at first maturity

Sex Ratio

The percentage of males and females in the natural population for the various months during the period of study is presented in table 3. Average sex ratio of males to females for the study period was 1:1.36. Chi-square value shows that there is no significant variation at 5% level.

Table 3. Sex ratio of *A. vaigiensis* in different months

Month	n	Males	% of males	Females	% of females	Ratio of females (males = 1)
AUG	--	--	--	--	--	--
SEP	27	13	48.15	14	51.85	1.07
OCT	28	15	53.57	13	46.43	0.86
NOV	18	7	38.89	11	61.11	1.57
DEC	54	23	42.59	31	57.41	1.34
JAN	52	20	38.46	32	61.54	1.60
FEB	53	24	45.28	29	54.72	1.20
MAR	53	21	39.62	33	62.26	1.57
APR	14	6	42.86	8	57.14	1.33
MAY	40	17	42.50	23	57.50	1.35
JUN	57	22	38.6	35	61.4	1.59
JUL	24	10	41.67	14	58.33	1.40
Chi-square: 2.947; Not significant at 5% level						

Fecundity

Fecundity studies were made on 52 ripe specimens, with size ranging from 121 to 158mm TL. The fecundity estimated ranged from 11,294 to 40,208 while the average fecundity was estimated as 19,548.

Linear relationship between fecundity and total length (TL), body weight (BW) and ovary weight (OW) was estimated by applying regression equation. The number of ova increased with an increase in total length, body weight and ovary weight (Fig. 4). The regression equations obtained were:

Fecundity (F) Vs Total Length (TL): logF = 0.9594+1.5568.logTL (r = 0.03) (Fig. 4A)

Fecundity (F) Vs Fish Weight (FW): logF = 3.1266+0.6871.log FW (r=0.05) (Fig. 4B)

Fecundity (F) Vs Ovary Weight (OW): logF = 4.141+0.5339.log OW (r=0.39) (Fig. 4C)

The correlation coefficient values (r) of F vs TL (0.03) and F vs FW (0.05) are close to 0 indicating no linear correlation between fecundity and total length, as well as fecundity and body weight. The 'r' value of F vs OW (0.39) is < 5 indicating the weak correlation (Snedcor and Cochran 1967) between fecundity and ovary weight.

Population parameters

A preliminary estimate of asymptotic length (L_∞) was obtained by Powell and Wetherall method (Wetherall 1986; Wetherall et al. 1987), which gave the L_∞ = 180.27 mm, Z/K = 4.051 (Fig. 5). The monthly size distribution of Indo-Pacific sergeant collected during 2004-2005 was utilized for the estimation of growth parameters through ELEFAN-I programme. Estimate of K (von Bertalanffy growth coefficient) was obtained with the input of L_∞ = 180.27 mm which gave the value of K as 0.48•year^{-1}. It also gave an estimated ϕ' (growth performance index = log K + 2 log L_∞) for the species as 2.508.

The natural mortality coefficient (M) was estimated as 1.07377•year^{-1}, total mortality coefficient (Z) was 1.29277•year^{-1}, fishing mortality (F) was 0.219 and exploitation rate (F/Z) estimated was E=0.2039.

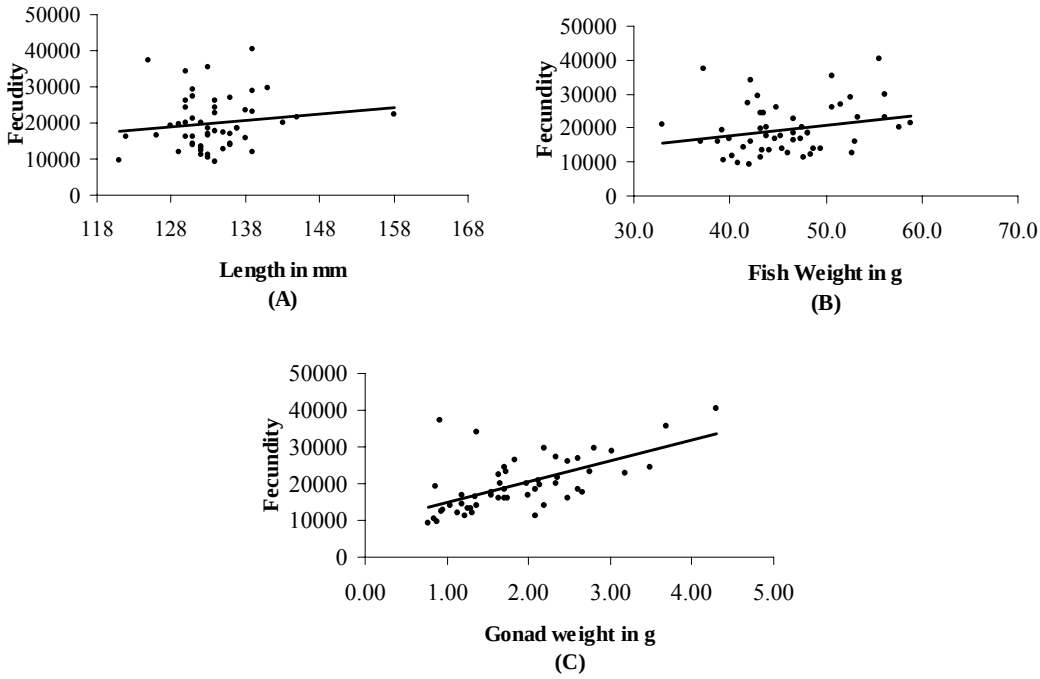

Figure 4. Linear relationship between fecundity and (A) length (B) weight and (C) ovary weight of *A. vaigiensis*

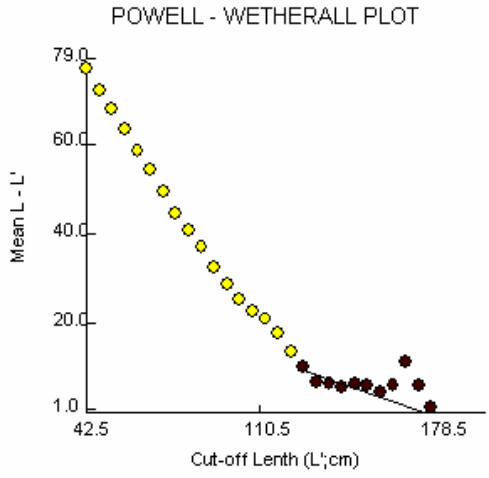

Figure 5. Powell-Wetherall plot of *A. vaigiensis*

Discussion

Fishes generally obey the cube law for their growth but many deviations have been noticed which are largely attributed to the environmental factors and the condition of fishes (Damayanti et al. 1990). However, this cube law may depart significantly from this (Le Cren 1951), as fishes normally do not retain the same shape of body outline throughout their life span and the specific gravity of the tissues may not remain constant (Sekharan 1968). In the present investigation the exponential (b) values are negatively allometric, since they are less than 3. Murty (2002) observed positive allometric value (b=3.2668) for Indo-Pacific sergeant from the Lakshadweep Islands. This indicates that fish from the rock pools of Visakhapatnam coast grew slender with an increase in length when compared to fishes of coral reefs of Lashadweep Islands. Vacchi and Chiantore (2000) also observed a negative allometric value (b=2.8) from the Philippines. This variation in growth may be influenced by feeding habit. Difference in the "b" values may also vary with state of maturity, sex and between different populations of a species (Muhammad et al. 2003)

The condition factor can be influenced by a number of factors such as spawning (De Silva and Silva 1997; Al-Daham and Wahab 1991), maturity (Hoda 1987), environmental condition, breeding season, feeding (Wijayaratne and Costa 1987; Dhanze and Dhanze 1997), sex and maturity (Doddamani et al. 2001). In the present study, among males low Kn values were observed from November 2004 to March 2005, whereas, among females low Kn values were observed from December 2004 to March 2005. The low index values were clearly related to low feeding intensities which were observed during November 2004 to March 2005 (Sudhakar and Shameem 2006). Mature fishes were also observed during October 2004-March 2005. Murty (2002) also identified the peak breeding months for Indo-Pacific sergeant as November, January and April from the Lakshadweep Islands. According to Murty (2002) fish reached first maturity at 120 mm TL. But in the present investigation it was observed that fish reached the first maturity at 126 mm TL.

The sex ratio for the various months slightly deviated from the expected ratio of 1:1 showing domination of females in the present population. A small predominance of female indicated in nature suggests that a male will spawn with more than one female at a time. Mohan et al. (1986) also observed the same kind of phenomenon in damselfish Ternate chromis (*Chromis caeruleus*, Pomacentridae) from Minicoy atoll.

Beverton and Holt (1956) pointed out that the natural mortality co-efficient (M) of a fish is directly related to the growth coefficient (K) and inversely related to the asymptotic length (L_∞) and life span. Murty (2002) estimated the L_∞=200mm, K=0.85 per year and M=1.83. In the present investigation L_∞=180.27mm, K=0.48 per year and M= 1.07377 per year. When these values are compared to other tropical fishes (Silvestre and Garces 2004) it indicates that this species grows moderately faster and reaches its maximum length and dies between one to two years. Still there is no commercial exploitation of these species, and since these fishes are caught as by catch in the cast net operations along the rocky shores of Visakhapatnam, it may result to an average fishing mortality (0.219) and exploitation rates (0.2039).

Acknowledgment

The authors are grateful to Ministry of Earth Sciences, New Delhi for sanctioning the project "Rearing and Breeding of Marine Ornamental Fishes" under the MMD program. Thanks are also due Prof. K.V. Ramana Murty, former Research Co-ordinator, OSTC, Dept. of M.L.R., Andhra University for his support and constant encouragement.

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Received: 17 December 2007; Accepted: 10 October 2008