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Growth, Mortality and Recruitment Pattern of Longsnouted Catfish, Arius argyropleuron (Valenciennes, 1840) in Kuala Muda and Merbok, Kedah

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Abstract
A study was conducted to investigate the growth parameters, mortality and recruitment pattern of longsnouted catfish, *Arius argyropleuron* collected at Kuala Muda and Merbok estuary fish landing site, northern part of Peninsular Malaysia. *A. argyropleuron* were collected from March 2009 to December 2009. The length-frequency data was analyzed using FAO-ICLARM Stock Assessment Tools (FiSAT) software. Bhattacharya's plot produced two groups of *A. argyropleuron* at modal length 11.13 ± 1.28 cm and 25.10 ± 2.32 cm. Population parameters were estimated by using various models including Powell-Wetherall plot, ELEFAN I , growth performance index, mortality estimation and recruitment pattern. Overall, growth parameters; asymptotic length ($L\infty$) = 34.26 cm and growth coefficient (K) = 0.7 year^{-1}. Growth performance index ($Ø'$) = 2.915, total mortality (Z) = 2.56 year^{-1}, natural mortality (M) = 1.39 year^{-1}, fishing mortality (F) = 1.17 year^{-1} and exploitation rate (E) = 0.46 year^{-1}. The length at first capture at 50%, (Lc) was 24.56 cm. The observation of the annual recruitment of *A. argyropleuron* was found to occur in two pulses in January and August.
Keywords: *Arius argyropleuron*, growth, mortality, recruitment pattern

1. Introduction

The longsnouted catfish, *Arius argyropleuron* (Fig. 1) are demersal fish belonging to the family Ariidae. They abundantly distributed in the tropical climate, commonly in South and Southeast Asia, southern New Guinea and northern Australia (Marceniuk and Menezes, 2007). *A. argyropleuron* plays an important role in the ecology and fisheries in the Northern Part of Peninsular Malaysia, particularly in Kedah waters. Furthermore, it supports a major artisanal fishery for coastal communities in this area.

The fundamental models in fish stock assessment for management are based on four important parameters namely growth, natural and fishing mortality and recruitment (Ricker, 1975). Despite of the important of these parameters, a study was conducted to provide an essential prerequisite estimation of growth, mortality and recruitment pattern of *A. argyropleuron* in Kuala Muda and Merbok, Kedah using length-frequency data. The information on the population parameter of this species from the study area is vital for conservation and management of the sustainable artisanal fisheries due to Ariidae family regarded as biological indicator in a particular area (Mansor *et al*. 2012).

2. Materials and methods

The study was carried out at Kuala Muda (5º35´ N and 100º 26´ E) and Merbok (5º42´ N and 100º 34´ E), Kedah (Fig. 2) for ten month, from March 2009 to December 2009. Monthly random samples of *A. argyropleuron* were caught using trammel net and barrier net. This fish samples were placed in cooling box filled with ice, transported to the research laboratory and systematically identified according to Kailola (1999) and Ambak *et al.* (2010). The total length (TL), from snout to the caudal fin tip of individuals recorded to the nearest 0.1 cm. The length frequency data of *A. argyropleuron* analyzed using FiSAT II (FAO-ICLARM Stock Assessment Tools – Version 1.2.2). The FiSAT routines were followed thoroughly base on the user's manual (Gayanilo *et al.* 1996) and reference manual (Gayanilo and Pauly, 1997).

3. Results and discussion

A total of 539 *A. argyropleuron* were used in this study. The length frequency data (Table 1) of *A. argyropleuron* was analyzed in FiSAT software using various methods to estimate the growth, mortality and recruitment. For many fishery resources, growth parameters ($L\infty$ and K) have been estimated because these population parameters are important to describe the species and inputs in several fishery production models (Hilborn and Walters, 1992). $L\infty$ is the largest theoretical mean length that a species could attain in its habitat whereas K is the speed it grows towards their final size.

3.1 Bhattacharya's plot

By using the Bhattacharya's method in FiSAT, *A. argyropleuron* produced two groups or cohorts at modal length 11.13 ± 1.28 cm and 25.10 ± 2.32 cm respectively (Fig. 3).

3.2 Powell-Wetherall plot

The *L*∞ and *Z/K* were estimated using Powell-Wetherall plot resulted the value 34.50 cm and 3.138 yr^{-1} respectively (Fig. 3). The value of *L*∞ obtained was found to be greater than *Lmax* as recommended by Gayanilo and Pauly (1997). According to length-frequency data, the value of *Lmax* was 32.5 cm. Thus, the value of L∞ in this method was at acceptable ranged.

3.3 Growth parameters

The *K-scan* routine in ELEFAN I was used to obtain the best combination of *K* and *L*∞. This routine gave the *L*∞ = 34.13 cm and *K* = 0.68 yr^{-1} (Fig. 3). This value found to be the best combination of *K* and *L*∞ with the *Rn* at 0.244. The *Response surface* routine computed by using wide range of *K* input and *L*∞ input. The given value by this routine were *L*∞ = 34.2 and *K* = 0.68. This value further used in *Automatic search* routine. The purpose of *Automatic search* was also to estimate *K* and *L*∞. The seed value *L*∞ = 34.2 cm (step size 0.10) and seed value *K* = 0.7 (step size 0.01) were used. Step size means the growth line shift at certain value to calculate the best fit of points at the graph. The given value by using this routine were *L*∞ = 34.2 and *K* = 0.7 with the *Rn* at 0.214. This value further used to obtain the graph of von Bertalanffy Growth Function (vBGF). In Table 2, the value of *L*∞, *K*, *Rn*, R^2 and *Ø'* summarized using various methods in FiSAT software namely Powell-Wetherall, *K-scan*, *Response surface* and *Automatic search*. All the value of *L*∞, *K*, *Rn* and *Ø'* in this table was from different method but slightly similar between each other indicated that all the method can be used to determine the growth parameters. Different model used to determine the *L*∞ and *K* value because there were many uncertainties in the sea. Various method and model are necessary in dealing with the fish stocks of *A. argyropleuron*. Overall, in this study, the value of *L*∞ and *K* range from 34.13 to 34.50 cm and 0.680 to 0.758 $year^{-1}$. The vBGF is the most widely used model for describing fish growth. According to Sparre and Venema (1992), the von Bertalanffy always gives a reasonable estimate of *L*∞ and *K*. The vBGF of *A. argyropleuron* illustrated in Fig. 3 indicated that the origin of the growth curve starting in November for the first group of *A. argyropleuron* and the second group of *A. argyropleuron* started in April.

According to Pauly and Munro (1984), they have indicated a method to compare the growth performance of various fish stocks was by computing the Phi index (*Ø'*) = log *K* + 2 log *L*∞. From the above routine, the *Ø'* was ranged from 2.899 to 2.955 (Table 2). Generally, Phi index (*Ø'*) are species specific parameters, means that their values are usually similar within related taxa and have narrow normal distributions. Perhaps this value could be used to compare with similar species or genus from other areas for the population characteristics confirmation of the species or stock (Table 4). According to Velasco and Oddone (2004), they found that the Ariidae family has relatively high value of *L*∞ and low values of *K*. Sparre and Venema (1992) stated that the value of *K*= 1.0 is fast growth, *K*= 0.5 is medium growth and *K*= 0.2 is slow growth. Hence, *K*= 0.70 for *A. argyropleuron* obtained from this study considered as an intermediate growth.

3.4 Mortality coefficients

Mortality means the death of fish from the stock due to fishing mortality or natural mortality includes predation, disease and old age. Fishing mortality assumed to be associated with physical injury or physiological stress from being captured in the gear used during capture. Natural mortality (*M*) and fishing mortality (*F*) were additive instantaneous rates that sum up to total mortality (*Z*). The total mortality coefficient, $Z = M + F$ (Gulland, 1969). When comparing mortality rates to the total births or recruits to the population, we can determine if a population is increasing or decreasing.

The length-converted catch curve was used to determine the value of natural mortality (*M*), fishing mortality (*F*) and exploitation rate (*E*). The *Z*, *M* and *F* of *A. argyropleuron* were estimated as 2.56 yr^{-1}, 1.39 yr^{-1} and 1.17yr^{-1}, respectively (Fig. 4). *A. argyropleuron* in Kedah showed high mortality rates which related to fishing mortality and natural mortality. The exploitation rate estimated to be 0.46 yr^{-1}. This value slightly lower than 0.5 yr^{-1} indicated an optimum level of exploitation rates of *A. argyropleuron* in Kedah.

Estimating natural mortality (*M*) is one of the most difficult and critical elements of a stock assessment (Hewitt *et al.* 1985). The Pauly's Model by using growth parameters is an indirect way of estimating natural mortality. It assumes that there is a relationship between size and natural mortality. Pauly's original method was based on the correlation of M with von Bertalanffy growth parameters (*K* and *L*∞) and temperature. The empirical equation of natural mortality showed in Fig. 4 and the natural mortality of *A. argyropleuron* in FiSAT estimated at *M* = 1.384 yr^{-1}. The example of natural mortality includes predation, cannibalism, competition, disease and old age (Sparre and Venema, 1992).

3.5 Length at first capture (Lc)

The length at first capture, *Lc* of *A. argyropleuron* was estimated at 24.56 cm (Fig. 4). The *Lc* was the length at which 50% of the fish are vulnerable to be captured by fishermen. This is the average size of fish vulnerable to be fishing or enter the fishing ground, both in Kuala Muda and Merbok estuary.

3.6 Recruitment pattern

The recruitment patterns of *A. argyropleuron* suggested that there were two main pulse of annual recruitment, in agreement with the group separation using Bhattacharya's Plot. The major pulse appeared in January and the minor pulse observed in August (Fig. 4), According to Lecomte *et al.* (1998), Ariidae family presenting two annual growth cycles. Each year, the two fast growth seasons alternating with two slow growth seasons which probably linked with the wet and dry seasons. Thus, the two peaks of the recruitment pattern of *A. argyropleuron* in this study were in agreement with the above statement.

Overall, the population parameters summarized in Table 3. This value can be used for future comparison if the fishing efforts or fishing pressure is planning to be decreased or increased. The *K* values from Table 4 were varied between each other. Majority of the *Ariidae* catfish family gave the general knowledge that catfishes are moderately growing fish.

4. Conclusion

Present study discovered that *A. argyropleuron* composed of two cohorts in a year with supported by the recruitment patterns of two main pulses annually. The growth parameters of asymptotic length 34.26 cm, growth coefficient 0.70 year^{-1} and growth performance index 2.915. *A. argyropleuron* from study area had high total mortality 2.56 year^{-1} and fishing mortality 1.17 year^{-1}. The exploitation rates 0.46 year^{-1} indicated an optimum level of exploitation. Thus, all of this information would be the valuable sources for comparison in future, especially when the conservation and management of this fish stock is to be made.

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Table 1. The length-frequency data of *Plicofollis argyropleuron.*

Length Class (cm)	Mid-Length (cm)	No. of fish
8-9	8.5	2
9-10	9.5	3
10-11	10.5	21
11-12	11.5	15
12-13	12.5	17
13-14	13.5	3
14-15	14.5	1
15-16	15.5	0
16-17	16.5	2
17-18	17.5	3
18-19	18.5	5
19-20	19.5	10
20-21	20.5	11
21-22	21.5	31
22-23	22.5	41
23-24	23.5	58
24-25	24.5	59
25-26	25.5	78
26-27	26.5	71
27-28	27.5	43
28-29	28.5	29
29-30	29.5	13
30-31	30.5	11
31-32	31.5	11
32-33	32.5	1
Total		539

Table 2. Summary of the value of L∞, K, Rn, R^2 and Ø' from various method in FiSAT.

Method	**L∞ (cm)**	**K (yr^{-1})**	**Rn**	**R^2**	**Ø'**
Powell-Wetherall	34.50	0.758	-	0.951	2.955
K Scan	34.20	0.680	0.244	-	2.899
Response Surface	34.20	0.700	0.214	-	2.901
Automatic Search*	34.13	0.680	0.244	-	2.913

* The value obtained from this method used in further estimation on mortality coefficient and recruitment pattern.

Table 3. Population parameters of *P. argyropleuron.*

Population Parameters	Values
K	0.70 yr^{-1}
L∞	34.26 cm
Ø'	2.915
Z	2.56 yr^{-1}
M	1.39 yr^{-1}
F	1.17 yr^{-1}
E	24.56 cm
Lc	0.46 yr^{-1}

Table 4. Growth parameters (L∞, K and t0) and growth performance index (Ø') for some Ariidae catfish species quoted from journal of Velasco and Oddone (2004) with additional information of the present study.

Species	Region	L∞ (cm)	K ($year^{-1}$)	t_0	Ø'	Source
1) *A. dussumieri*	India	102.7	0.17	-0.50	3.254	Vasudevappa and James (1989); Froese and Pauly (1996)
2) *A. heudelotii*	Guinea	70.00*	0.14	-0.39	2.842	Conand *et al*., (1995)
3) *A. heudelotii*	Cameroon	68.50	0.15	-	2.847	N'jock (1990); Froese and Pauly (1996)
4) *A. latiscutatus*	Guinea	65.00*	0.15	-0.31	2.813	Conand, Camara and Domain (1995)
5) *A. maculatus*	Indonesia	45.00	0.73	-	3.170	Dwiponggo *et al*., (1986); Froese and Pauly (1996)
6) *A. parkii*	Guinea	61.20*	0.17	-0.28	2.806	Conand, Camara and Domain (1995)
7) *A. spixii*	Venezuela	29.86**	0.34	-	2.487	Etchevers (1978)
8) *A. tenuispinis*	India	82.00	0.21	-0.18	3.150	Dan (1980); Froese and Pauly (1996)
9) *A. thalassinus*	Kuwait	106.40	0.06	-2.10	2.860	Bawazeer (1987)
10) *A. thalassinus*	India	92.23*	0.10	-0.79	2.925	Modified from Dmitrenko (1975)
11) *G. barbus*	Brazil	118.60	0.04	-1.50	2.782	Velasco *et al*., (2007)
12) *H. guatemalensis*	Mexico	124.84*	0.07	-0.38	3.040	Modified from Warburton (1978)
13) *N. troschelii*	Costa Rica	48.00	0.20	-	2.664	Stephenson (1980); Froese and Pauly (1996)
14) *P. argyropleuron*	**Kedah, Malaysia**	**34.26**	**0.70**	**-**	**2.915**	**Present study**

* L∞ (cm) refers to fork length (FL) **to standard length (SL) Other cases refer to total length (TL)


Figure 1. *Arius argyropleuron* or longsnouted catfish.

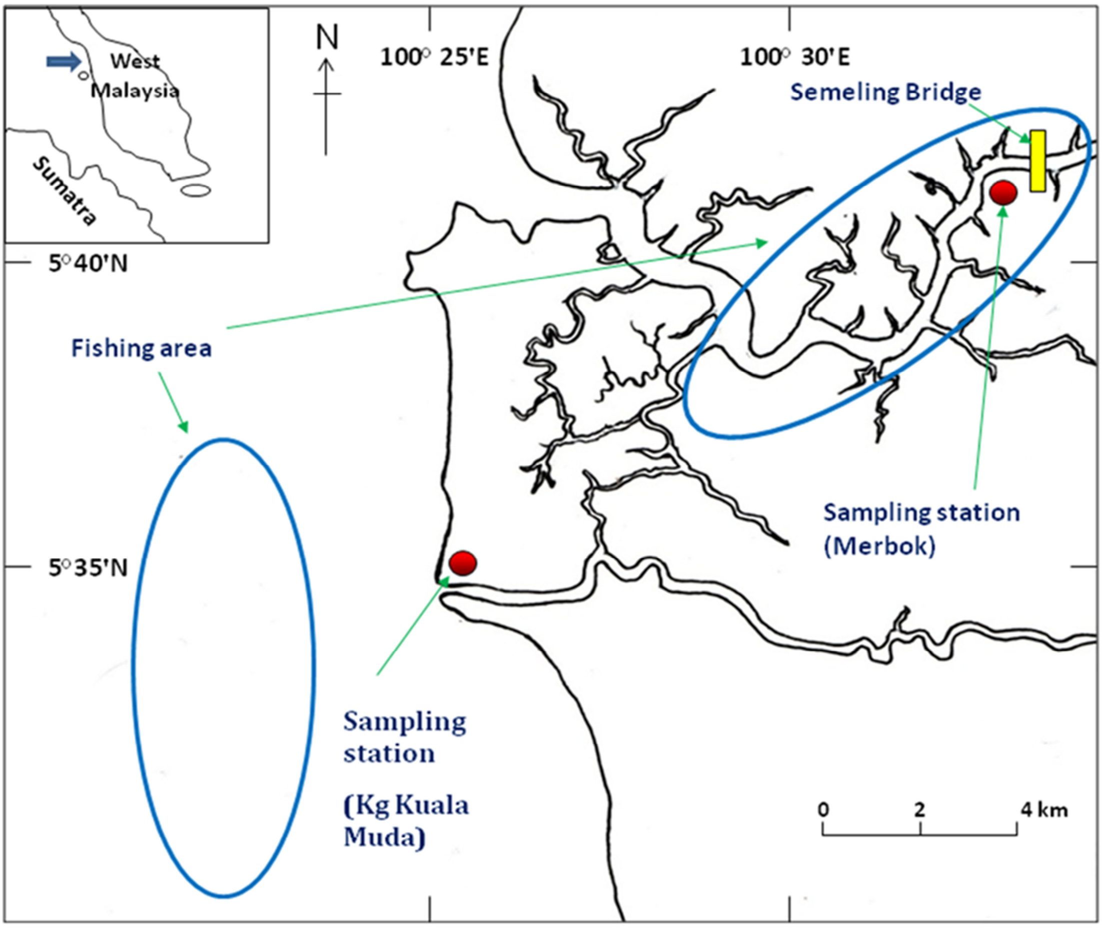

Figure 2. Map showing the fishing area and the sampling station.

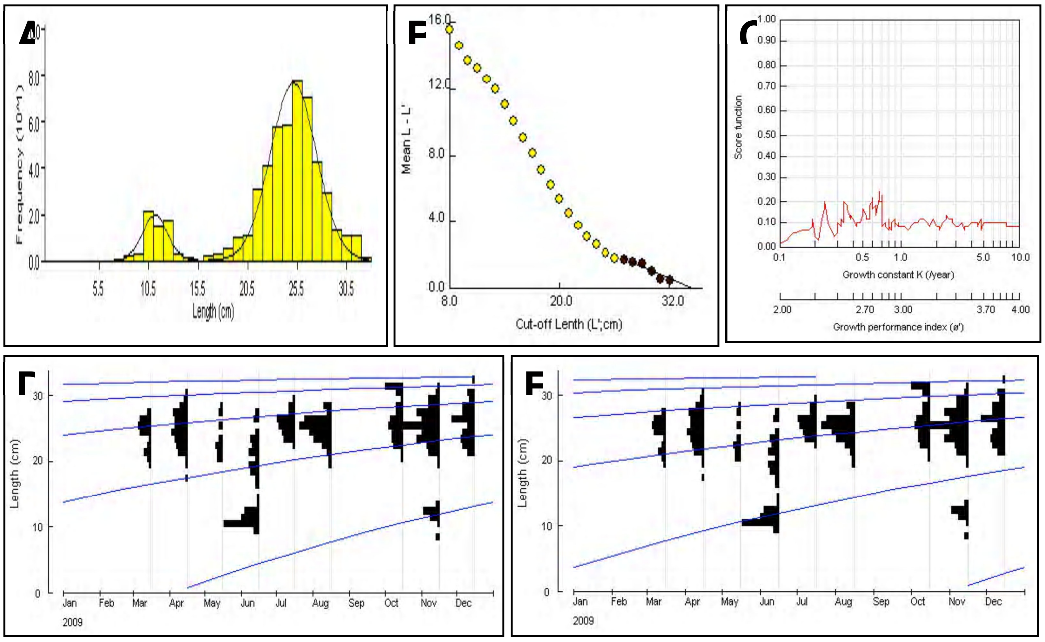

Figure 3. Results of analyses using FiSAT for *Arius argyropleuron* in Kedah waters;

A) Bhattacharya's Plot of *P. argyropleuron* comprised of two distinctive groups.
B) Powell-Wetherall Plot ($L\infty$ = 34.50 cm and Z/K = 3.138, R^2 =0.951). The general equation, Y= 8.34 + (-0.242)*X.
C) K-Scan computed to obtain initial combination of $L\infty$ = 34.13, K = 0.68.
D) vBGF for the first cohort of *A. argyropleuron* starting in November.
E) vBGF for the second cohort of *A. argyropleuron* starting in April.

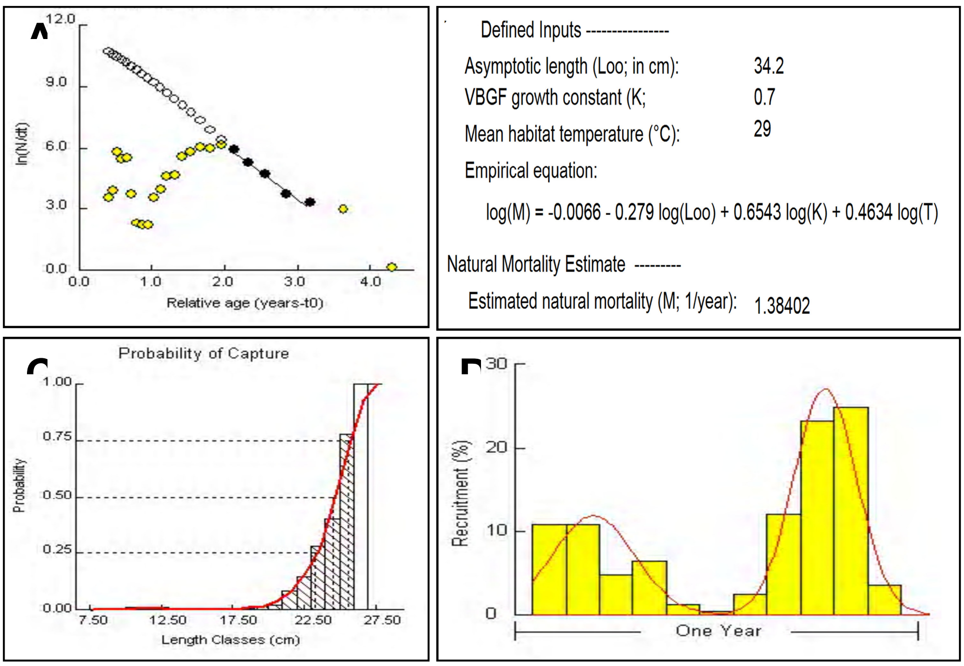

Figure 4. Results of analyses using FiSAT for *Arius argyropleuron* in Kedah waters;
A) Extrapolate catch curve resulted from Z = 2.56yr^{-1} (C.I. = 1.78 to 3.35), r^2 = 0.9729, M at 29ºC = 1.39, F = 1.17 and E = 0.46 yr^{-1}. The linear equation, Y= -a + bX.
B) Natural mortality estimated as M = 1.384.
C) Probability capture at $L_{0.25}$ = 23.25, $L_{0.50}$ = 24.56, $L_{0.75}$ = 25.62 cm.
D) Major recruitment occurs in August and second recruitment in January.

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