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# POPULATION DYNAMIC AND LENGTH–WEIGHT RELATIONSHIPS (LWRS) IN *FENNEROPENAEUS MERGUIENSIS* (DE MAN, 1888) COLLECTED FROM BALOCHISTAN COAST, PAKISTAN

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**ABSTRACT:** Total of (632) *Fenneropenaeus merguiensis* specimens were collected from Damb Fish Landing Centre at Sonmiani, Balochistan during 15th August 2008 to 15th April 2010. The present investigation shows the length-weight relationship, growth coefficient (K), asympotic length (Lα), total mortality (Z), natural mortality (M), fishing mortality (F), length at first capture (LC), recruitment pattern, exploitation rate (E), relative yield-per recruit and biomass-per-recruit. The response surface (Rn) was 0.157 for the main curve (solid line) and 0.129 for the secondary line (dotted-line). The corresponding estimates of Lα and Z∫K in *F. merguiensis* as 24.11cm and 1.838 were measured in 2008-2009 and 24.010 and 1.738 were measured in 2009-2010. The mortality rates M, F and Z computed are 2.46, 3.27 and 5.73 respectively and during the year 2009-2010, the mortality rates M = 2.36, F = 3.17 and Z = 5.63 were measured respectively. Exploitation Rate (E) were determine in between 0.57- 0.58 during 2008-2010. The calculated value of log a -3.0551 and regression coefficient, b 3.3931 were measured in 2008-2009 and the value of log a -3.2751 and regression coefficient b 3.5689 were recorded in 2009- 2010 respectively. The mean condition factor was recorded as 1.0179 and 1.0062 in 2008-2010.

**KEYWORDS:** Population dynamics, *Fenneropenaeus merguiensis*, Balochistan coast, Pakistan.

## INTRODUCTION

*Fenneropenaeus merguiensis* found on mud or sandy-mud substrates and prefers turbid waters and caught mainly by trawl, gill net, fish corral, push net and filter net. Inhabits shallow open sea or in the mouth of a river and bay areas where water is more or less turbid (Motoh, 1980). They are widely distributed in the Indo-West Pacific region in both tropical and subtropical waters (Grey et al., 1983). *F. merguiensis* is an important species for shrimp fisheries and extensive shrimp farming in South-East Asia and Australia (Tseng, 1987; Weidner and Rosenberry, 1992). In the familyPenaeidae *F.merguiensis* is one of the most commonly appearing shrimp in the coastal waters of Pakistan. This species also distributed from coast of Iran, India, Bangladesh, Sri Lanka, the Gulf of Aden to east of Africa, east to Malaysia and Indonesia. Apparently scattered distribution in the Philippine, Singapore, New Guinea to northern Australia.

The aim of the present study is to determine the population dynamics through morphological description, Growth parameters, Exploitation Rate, Mortality**,** Recruitment

Pattern and Spawning, Length–weight relationships (LWRs) and condition factor in *F. merguiensis* from Sonmiani Bay of Balochistan.

## MATERIALS AND METHOD

**Population dynamics:**

**Sample collection:** Total (632) *Fenneropenaeus merguiensis* specimens were collected from Damb Fish Landing Centre Sonmiani, Balochistan (Fig. 1) by Thukri net

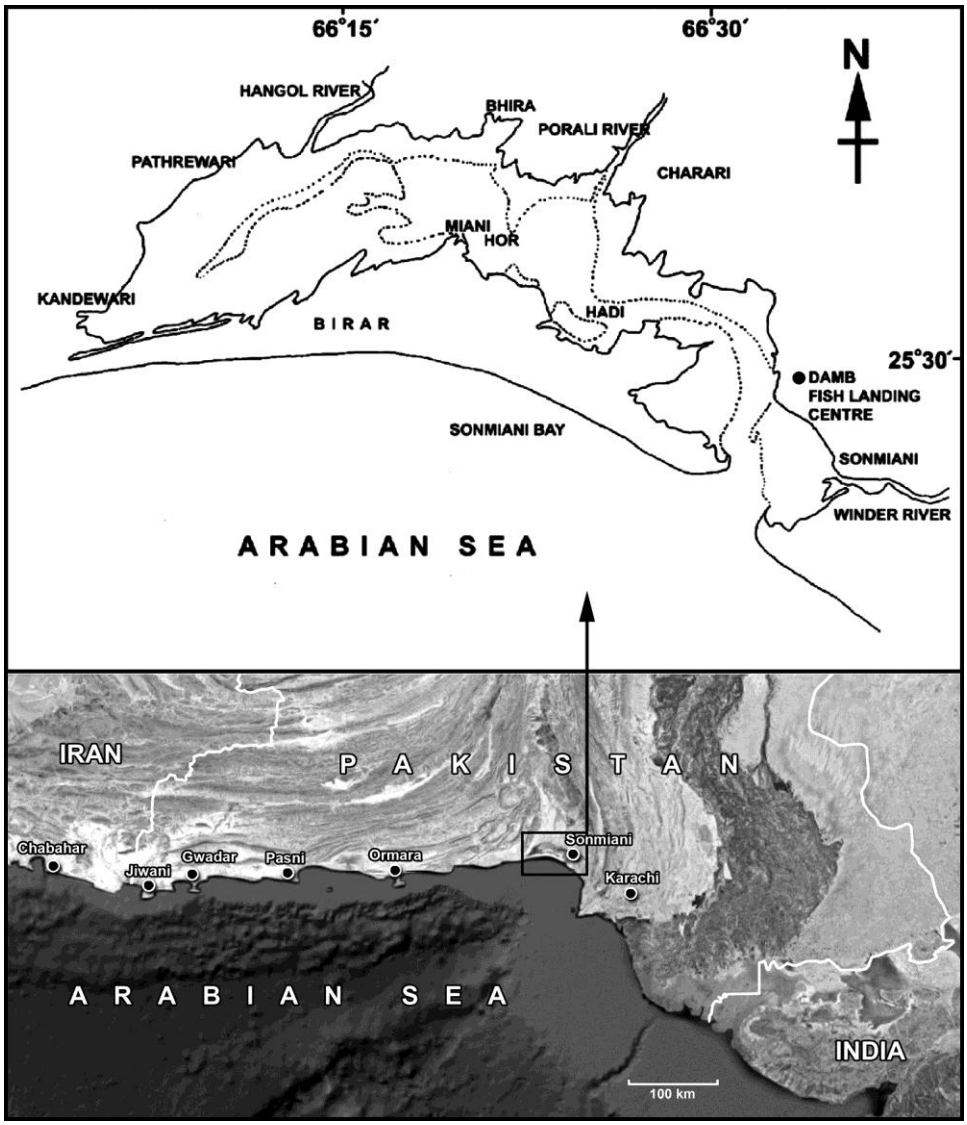


Fig. 1. Area study map.

(length 180-190 m, width 1.5-2.0 m) twice) from 15th August 2008 to 15th April 2009, and from 15th August 2009 to 15th April 2010. There was no fishing on the scheduled sampling days in May, June and July due to rough weather condition and close season of ban period, imposed by the Directorate of Fisheries, Govt. of Balochistan. Standard length and total length of each individual were measured in cm and weight in gms.

**Analysis of data:** Length-frequency data were pooled month wise and pooled data were analyzed through ELEFAN ø program. ELEFAN I & II were used to estimate the population parameters [asymptotic length ($L\infty$), growth co-efficient (K), natural mortality (M), fishing mortality (F), total mortality (Z), recruitment pattern, length at first capture ($L_c$), relative yield-per-recruit and biomass-per-recruit.

**Length-weight relationship:** For the study of length-weight relationship the total lengths of the individuals, from the tip of telson were measured to the nearest 0.1 cm and weight 0.01 g, respectively.

The relationship between length and weight were determined by using the logarithmic transformation (LeCren, 1951; Rounscfell and Everhart, 1953):

$W = a. L^b$

Where a is a constant, b is an exponent, 'W' the weight and 'L' is the corresponding length of body weight.

The calculated body weight for the corresponding observed mid values of total length (TL) were obtained by using the equation.

The exponential form of the above mentioned formula can be expressed in the logarithmic form as follows:

Log W = log a + bLog L

The co-efficient of correlation (r) was calculated by (Pauly, 1983).

where,

r = correlation co-efficient

n = number of observations (groups).

Relative condition factor (Kn), was done using the following formula:

$$Kn = \frac{W}{W'}$$

where,

Kn = relative condition factor

W = observed mean body weight

W' = calculated body weight.

The following standard formulae were used for analysis (Pauly, 1983).

Linear regression equation:

y = a + bx

**Analysis of data:** Length-frequency data were pooled month wise and pooled data were analyzed through ELEFAN ø program. ELEFAN I & II were used to estimate the population parameters [asymptotic length ($L\infty$), growth co-efficient (K), natural mortality (M), fishing mortality (F), total mortality (Z), recruitment pattern, length at first capture ($L_c$), relative yield-per-recruit and biomass-per-recruit.

**The growth model:** The Von Bertallanffy growth function (VBGF) proposed by Pauly and Gaschütz (1979), in used to calculate growth curve.

**Fishing and natural mortality:** The parameter M has been estimated using the empirical relationship derived by Pauly (1980), i.e.:

$Log_{to}M = -0.0066-0.279Log_{to}L\infty+0.543Log_{to}K + 0.4634LogT$

where $L\infty$ is the growth parameters, T $^{o}$C is the mean annual environmental temperature (here it was taken as 28$^{o}$C) and the rest as previously defined.

The estimate of F was taken by subtraction of M from Z. The exploitation ratio E was then computed from expression:

$E = F/Z = F/(F+M)$

**Recruitment Pattern:** Recruitment Pattern is obtained by backward projection, on to the length axis, of a set of length frequency data (seasonally growth curve) according to the routine ELEFAN II (Ingles and Pauly, 1984).

## RESULTS AND DISCUSSION

The present investigation shows the length-weight relationship, growth coefficient (K), a symbiotic length ($L\alpha$), total mortality (Z), material mortality (M), fishing mortality (F), length at first capture (LC), recruitment pattern, relative yield-per recruit and biomass-per-recruit and exploitation rate (E) of *F. merguiensis*, at the Sonmiani bay of Balochistan.

**Colour:** The body of fresh specimen is pale pink with very light grey species. Carina of carapace and upper rostral teeth are much darker pink. Post-rostral carina a dorsal carina on the lost abdominal segment are blackish except at their posterior-ends where they appear to be slightly pink or red in colour. Endopod of uropod is with anteriored and posterior greenish part, leg and pleopods are dark pink (Fig. 2).

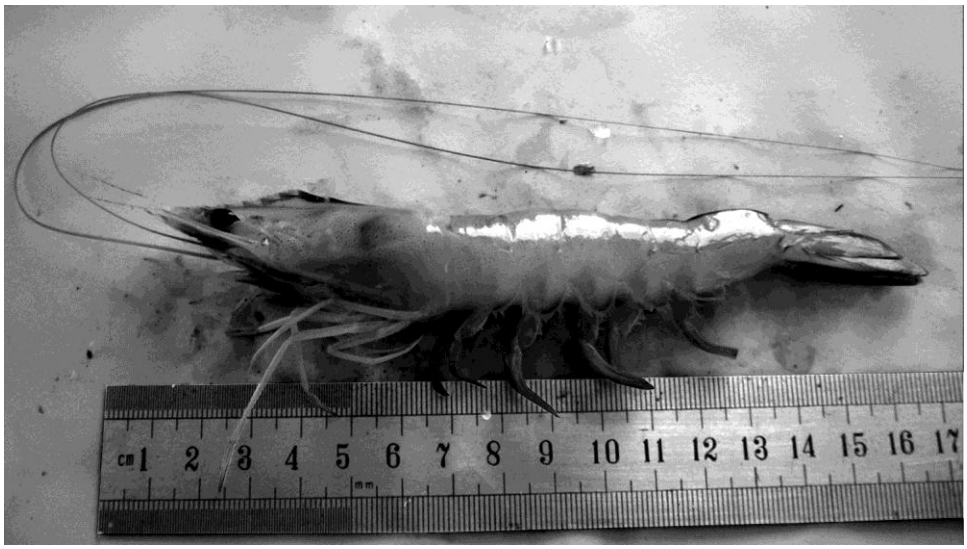


Fig. 2. *Fenneropenaeus merguiensis*

**Size:** TL (Total length); 1.8cm to 19cm.

**Length Weight Relationship:** Table (1 and 2) shows monthly Length-Frequency data and Relative Condition Factor (Kn) in different Size Groups of *F. merguiensis* were collected during August 2008 to April 2010.

**Table 1. Monthly Length-Frequency Data of *F. merguiensis* (n=2112) during August 2008 to April 2010.**

| Mid Length (cm) | August 2008 - April 2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Aug 2008 | Sept 2008 | Oct 2008 | Nov 2008 | Dec 2008 | Jan 2009 | Feb 2009 | Mar 2009 | Apr 2009 |
| 7 | 3 | 1 | 1 | 2 | 1 | 2 | - | - | - |
| 8 | 8 | 4 | 2 | 2 | 2 | 1 | - | 1 | - |
| 9 | 19 | 8 | 4 | 5 | 3 | 2 | 4 | 2 | - |
| 10 | 21 | 16 | 9 | 11 | 11 | 8 | 11 | 10 | 3 |
| 11 | 25 | 39 | 24 | 27 | 21 | 15 | 15 | 16 | 11 |
| 12 | 29 | 46 | 31 | 28 | 29 | 32 | 29 | 29 | 11 |
| 13 | 33 | 35 | 36 | 34 | 33 | 33 | 29 | 31 | 24 |
| 14 | 39 | 52 | 39 | 29 | 32 | 35 | 36 | 32 | 29 |
| 15 | 41 | 51 | 37 | 32 | 32 | 32 | 35 | 32 | 28 |
| 16 | 31 | 35 | 31 | 32 | 29 | 30 | 26 | 25 | 20 |
| 17 | 13 | 12 | 15 | 13 | 12 | 17 | 16 | 14 | 20 |
| 18 | 6 | 3 | 2 | 2 | 6 | 6 | 8 | 2 | 5 |
| 19 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 2 |
| Sum | 269 | 303 | 333 | 219 | 212 | 215 | 211 | 196 | 154 |
| **Mid Length (cm)** | **August 2009 - April 2010** | | | | | | | | |
| | **Aug 2009** | **Sept 2009** | **Oct 2009** | **Nov 2009** | **Dec 2009** | **Jan 2010** | **Feb 2010** | **Mar 2010** | **Apr 2010** |
| 7 | 5 | 3 | 3 | 1 | - | 1 | - | 2 | 1 |
| 8 | 7 | 7 | 9 | 2 | 1 | 1 | 1 | 3 | 1 |
| 9 | 9 | 10 | 10 | 4 | 7 | 6 | 2 | 5 | 2 |
| 10 | 21 | 19 | 21 | 9 | 11 | 12 | 9 | 10 | 9 |
| 11 | 26 | 21 | 25 | 24 | 25 | 15 | 17 | 7 | 11 |
| 12 | 28 | 26 | 29 | 31 | 30 | 27 | 29 | 9 | 14 |
| 13 | 31 | 30 | 33 | 35 | 33 | 28 | 31 | 15 | 20 |
| 14 | 35 | 36 | 39 | 37 | 34 | 31 | 32 | 22 | 23 |
| 15 | 39 | 38 | 41 | 35 | 37 | 34 | 33 | 29 | 24 |
| 16 | 33 | 35 | 31 | 30 | 31 | 25 | 22 | 38 | 25 |
| 17 | 15 | 16 | 12 | 15 | 17 | 15 | 16 | 38 | 21 |
| 18 | 4 | 7 | 6 | 2 | 8 | 8 | 5 | 41 | 19 |
| 19 | 1 | - | 2 | 1 | 2 | 2 | 1 | 9 | 2 |
| Sum | 254 | 248 | 261 | 226 | 236 | 205 | 198 | 228 | 172 |

**Table 2. Length-Weight Relationship and Relative Condition Factor (Kn) in Different Size Groups of *F. merguiensis* (n=322) during August 2008 to April 2010.**

| S. No. | Class Limit (cm) | Frequency (N) | Mid Length (cm) | Log TL (X) | Observed Mean Weight W (g) | Log W (y) | Calculated log w = a+b Log TL (w) | Calculated Weight $W = (al^b)$ | Kn | Mean Kn |
|---|---|---|---|---|---|---|---|---|---|---|
| **August 2008 - April 2009** | | | | | | | | | | |
| 1 | 6.5-7.5 | 2 | 7 | 0.845 | 0.832 | -0.079 | -0.2593 | 0.5499 | 1.5130 | |
| 2 | 7.5-8.5 | 26 | 8 | 0.903 | 0.885 | -0.053 | -0.053 | 0.8859 | 0.9992 | |
| 3 | 8.5-9.5 | 38 | 9 | 0.954 | 0.992 | 0.003 | 0.1296 | 1.3485 | 0.7356 | |
| 4 | 9.5-10.5 | 32 | 10 | 1.000 | 1.375 | 0.138 | 0.2938 | 1.9641 | 0.73336 | |
| 5 | 10.5-11.5 | 48 | 11 | 1.041 | 2.776 | 0.443 | 0.4401 | 2.7599 | 1.0058 | |
| 6 | 11.5-12.5 | 51 | 12 | 1.079 | 3.595 | 0.555 | 0.5757 | 3.7650 | 0.9548 | **1.0179** |
| 7 | 12.5-13.5 | 55 | 13 | 1.113 | 4.958 | 0.695 | 0.6970 | 5.0098 | 0.9896 | |
| 8 | 13.5-14.5 | 30 | 14 | 1.145 | 6.898 | 0.838 | 0.8148 | 6.5266 | 1.0569 | |
| 9 | 14.5-15.5 | 18 | 15 | 1.176 | 9.250 | 0.966 | 0.9219 | 8.3488 | 1.1079 | |
| 10 | 15.5-16.5 | 14 | 16 | 1.204 | 11.899 | 1.075 | 1.0218 | 10.5113 | 1.1320 | |
| 11 | 16.5-17.5 | 5 | 17 | 1.230 | 13.715 | 1.137 | 1.1146 | 13.0504 | 1.0509 | |
| 12 | 17.5-18.5 | 3 | 18 | 1.255 | 15.512 | 1.190 | 1.2038 | 16.0036 | 0.9692 | |
| **August 2009 - April 2010** | | | | | | | | | | |
| 1 | 6.5-7.5 | 2 | 7 | 0.845 | 0.850 | -0.070 | -0.1879 | 0.6486 | 1.3105 | |
| 2 | 7.5-8.5 | 26 | 8 | 0.903 | 0.887 | -0.052 | 0.0088 | 1.0203 | 0.8693 | |
| 3 | 8.5-9.5 | 35 | 9 | 0.954 | 1.350 | 0.130 | 0.1819 | 1.5216 | 0.8872 | |
| 4 | 9.5-10.5 | 31 | 10 | 1.000 | 1.981 | 0.296 | 0.338 | 2.1756 | 0.9105 | |
| 5 | 10.5-11.5 | 48 | 11 | 1.041 | 3.116 | 0.493 | 0.4771 | 3.0062 | 1.0365 | |
| 6 | 11.5-12.5 | 50 | 12 | 1.079 | 3.687 | 0.566 | 0.6060 | 4.0388 | 0.9128 | **1.0062** |
| 7 | 12.5-13.5 | 55 | 13 | 1.113 | 4.979 | 0.697 | 0.7214 | 5.2991 | 0.9395 | |
| 8 | 13.5-14.5 | 28 | 14 | 1.146 | 6.988 | 0.844 | 0.8333 | 6.8141 | 1.0255 | |
| 9 | 14.5-15.5 | 16 | 15 | 1.176 | 9.250 | 0.966 | 0.9351 | 8.6114 | 1.0741 | |
| 10 | 15.5-16.5 | 13 | 16 | 1.204 | 11.995 | 1.079 | 1.0301 | 10.7196 | 1.1189 | |
| 11 | 16.5-17.5 | 4 | 17 | 1.230 | 13.718 | 1.137 | 1.1184 | 13.1679 | 1.04177 | |
| 12 | 17.0-18.5 | 3 | 18 | 1.255 | 15.155 | 1.180 | 1.2032 | 15.9862 | 0.9480 | |
| | **Total:** | **311** | | | | | | | | |

**Table 3. Length-weight relationship and related statistics of *F. merguiensis* during the year 15th August 2008 to 15th April 2010.**

| | Total No. (N) | Minimum Length (cm) | Maximum Length (cm) | Log a | b | $r_{xy}$ |
|---|---|---|---|---|---|---|
| **2008-2009** | 320 | 7.00 | 18.00 | -3.0551 | 3.3931 | 0.9935 |
| **2009-2010** | 311 | 7.00 | 18.00 | -3.2751 | 3.5689 | 0.9839 |

The total length of *F. merguiensis* varied from 07.00 cm to 18.00 cm and the body weight varied from 0.85gm to 15.155gm in (2008-2009).

The calculated value of log a and regression coefficient, b were measured -3.0551 and 3.3931 respectively (Table 3).

The total length varied from 07.00cm to 18.00cm and the body weight varied from 0.832gm to 15.512gm in (2009-2010) Table (1 and 2). The value of log a and regression coefficient b, were measured -3.2751 and 3.5689 respectively (Table 3).

In the present case, the exponent lies between the values mentioned by Hile (1936) and Martin (1949), but it is slightly above the ideal isometric value as mentioned by Allen, (1938) and Ricker, (1963). This aggresses with the results of Sada *et al.*, (1995) and Mustafa *et al*., (1994).

When the total length of the shrimp in (year 2008-2009, data) were plotted against the body weight on an arithmetic scale, a smooth growth curve or curvilinear relationship was obtained (Fig. 3a) and a yielded straight line or linear when plotted on a logarithmic scale (Fig. 4a).

When the total length of the shrimp in (year 2009-2010 data) were also plotted against body weight on an arithmetic scale, similarly a smooth growth curve or curvilinear relationship was obtained (Fig. 3b) and a yielded straight line or linear plotted on a logarithmic scale shows in (Fig. 4b). The coefficient of correlation (r) between log of total length and that of body weight was positive and highly significant at 0.1% (t cal = 40.73) level for the fishing season (2008-2009) and t cal = 40.75 level in (2009-2010).

In population dynamics of any species, the knowledge of length-weight relationship is very important for the determination of fitness, general well beings of body weight and gonadal development (LeCren, 1951). These are the important factors in fisheries management as discussed by Medawar (1955) and Rao (1984). Many researchers have studied the length-weight relationship and reproductive biology on shrimps from Pakistani waters which includes those of Hussain (1994) on *P. merguiensis*; Tirmizi and Tahira (1989) on *Penaeus indicus*, *Metapenaeus affinis* and *Parapenaeopsis stylifera*; Ayub (2000) and Fatima (2001) on *Penaeus merguiensis*, *P. penicellatus*, *Metapenaeus affinis* and *P. stylifera*; Qureshi and Amanat (2014) on *P. merguiensis*.

**Growth parameter:** In the year 2008-2009, the Growth parameter of the Von Bertalanffy growth formula were estimated as K = 1.5 per year $L\alpha$ = 24.48cm. The

response surface (Rn) was 0.157 for the main curve (solid line) and 0.129 for the secondary line (dotted-line). And for year 2009-10, Lα = 24.38cm and K = 1.40/year. The computed growth curve produced with these parameters are shown in (Table 4, Fig. 5 a and b). The $L_o$ value taken as 'O'.

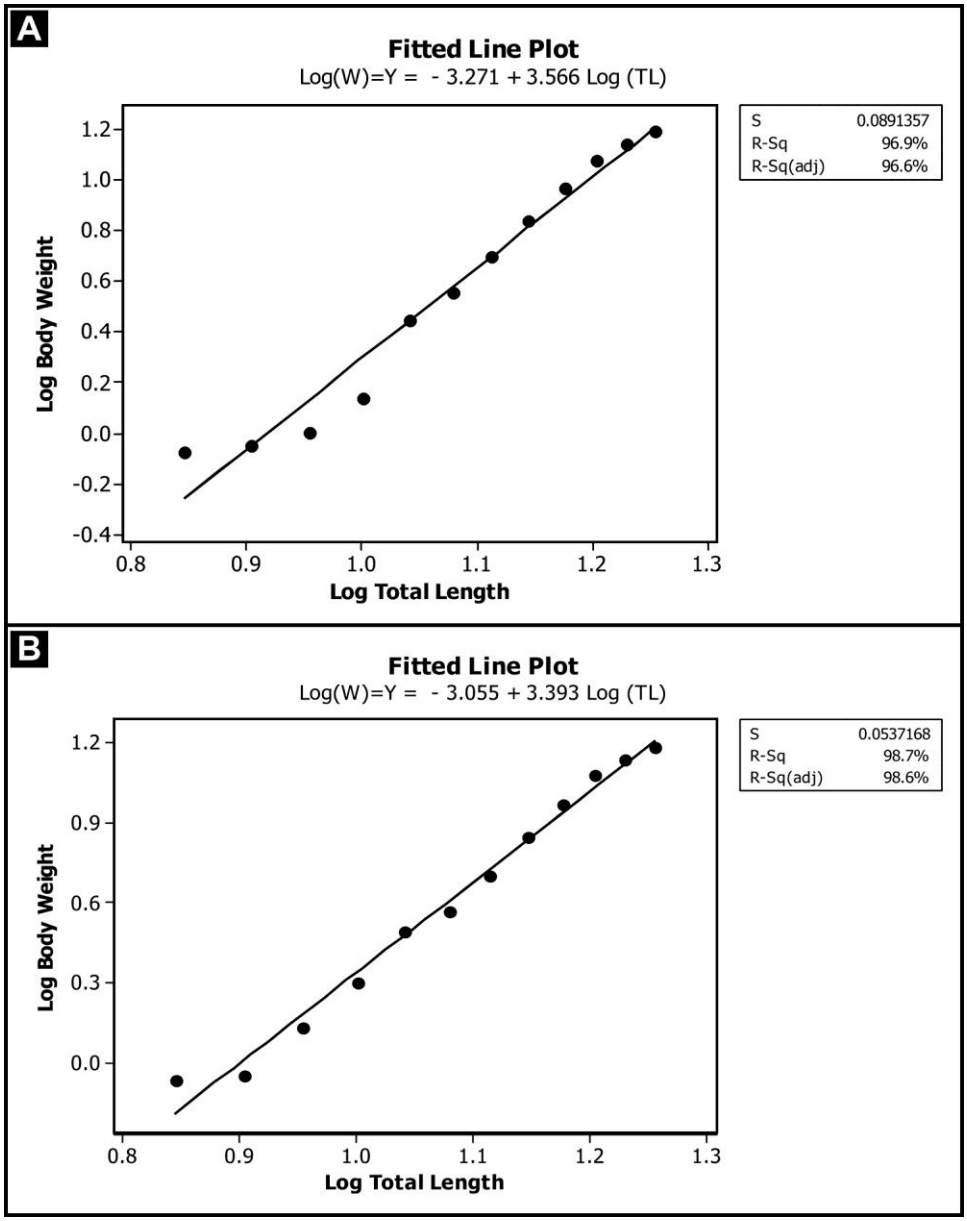


Fig. 3. Relationship between log total length and that of log body weight *F. merguiensis*: A, during August 2008 to April 2009; B, August 2009 to April 2010.

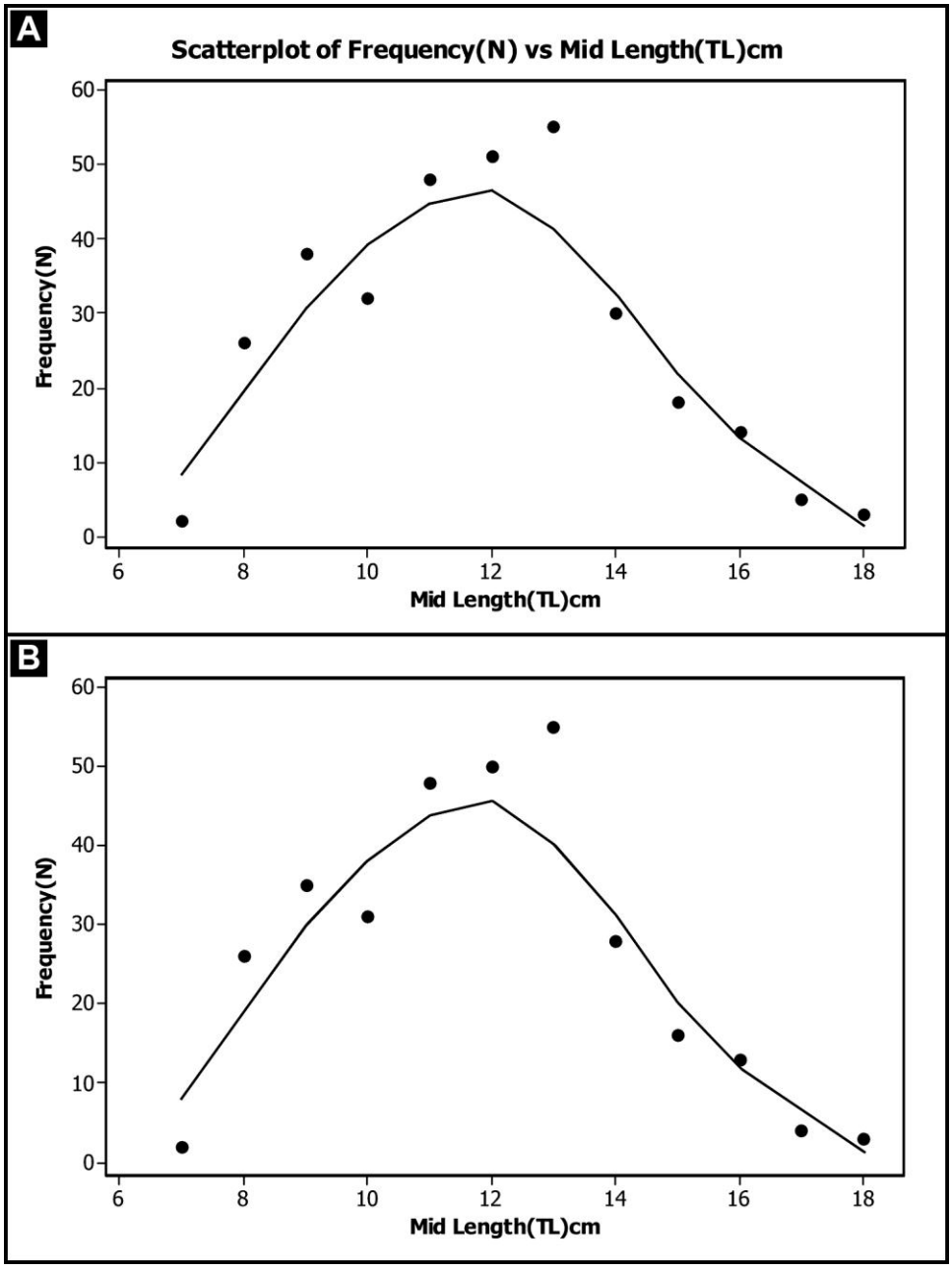


Fig. 4. Scatter graph of mid length and corresponding frequencies for *F. merguiensis*: A, during August 2008 to April 2009; B, August 2009 to April 2010.

The corresponding estimates of Lα and Z∫K for *F.merguiensis* are 24.11cm and 1.838 respectively and for the year 2009-10 are 24.010 and 1.738 respectively. This additional

estimate of Lα is slightly lower than the Lα estimate through ELEFAN-1. The correlation coefficient for the regression was 0.943 (a = b = .352) calculated growth performance index (∅) was found to be 2.953, Mustafa *et al*. (1994) reported Lα = 29.0cm and K value = 0.9 per year for *F. merguiensis* from Kumira Estuary of Bangladesh. Khan *et al*. (1999) have analyzed length frequency of five most commonly occurring penaeid shrimp species with complete ELEFAN Program. The growth parameter i.e. $L_o$ of penaeid shrimp species was 0.720 to 1.665. Islam (1995) also reported that Lα = 30.00cm of another species *Penaeus indicus*.

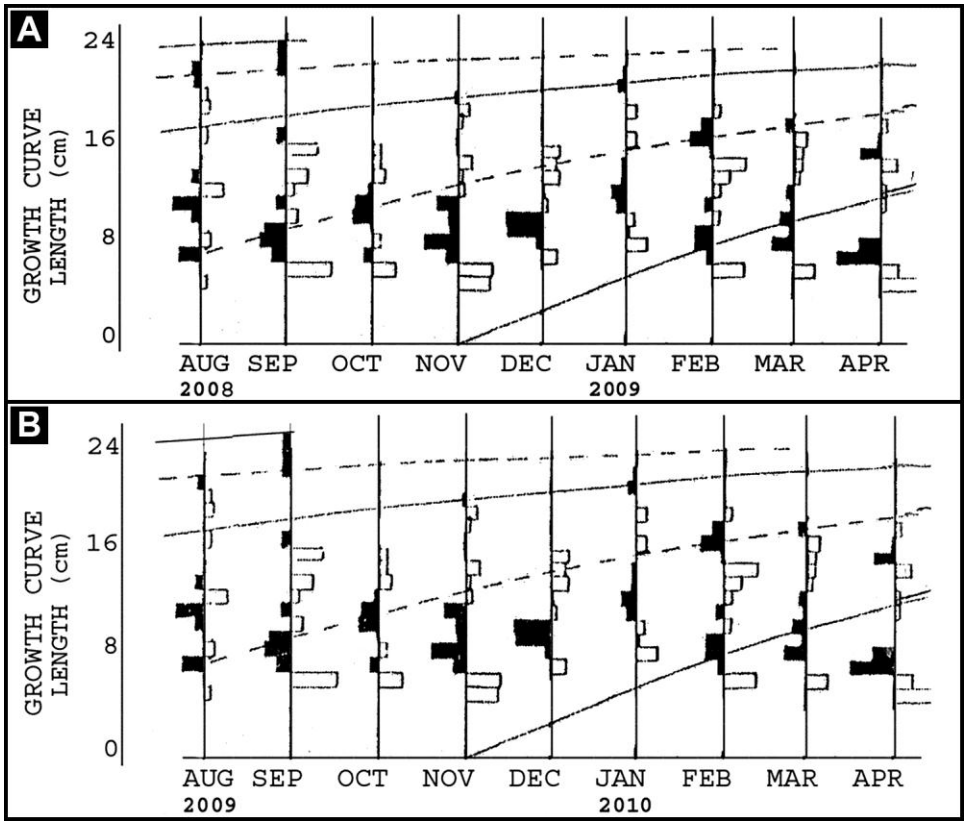


Fig. 5. Growth parameters of *F. merguiensis* estimated by ELEFAN ∝ = 24.38cm and K = 1.40 year$^{-1}$: A, during August 2008 to April 2009; B, August 2009 to April 2010.

**Recruitment Pattern, Spawning and Mortality Rate:** The recruitment pattern (Fig. 6 a,b and Fig. 7a,b) determined through the analysis (Pauly *et al*., 1981 and 1984) with the separation of the normal distribution of the peaks by mean of the NORMSEP Program shows that *F. merguiensis* was recruited during September and October. It was observed that the *F. merguiensis* spawn throughout the year two peak seasons. Shrimp undergoes major spawning in June-July, the peak recruitment followed by spawning, occur in the Thukri net fishing in September (2008-2009) and October (2009-2010), which indicates

that they take about four months to grow to a size of 8.00 cm to 10.00 cm, to be recruited to the fishery on their way to the Arabian Sea.

**Table 4. Population parameters of *F. merguiensis* during August 2008 to April 2010.**

| Year | ELEFAN I | | ELEFAN II | | | | | | POWELL-WETHERALL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $L\alpha$ | K | M | F | Z | $L_e$ | E | $F_{max}$ | $L\alpha$ | $Z\int K$ |
| **2008-2009** | 24.48 cm | 1.50 | 2.46 | 3.27 | 5.73 | 6.747 cm | 0.57 | 0.501 | 24.110 cm | 1.838 |
| **2009-2010** | 24.38 | 1.40 | 2.36 | 3.17 | 5.63 | 6.647 | 0.58 | 0.401 | 24.010 | 1.738 |

The mortality rates M, F and Z computed are 2.46, 3.27 and 5.53 respectively and for the year 2009-2010, the mortality rates M = 2.36, F = 3.17 and Z = 5.63 respectively. The recruitment pattern or nearing to $L\alpha$ and hence discarded from the calculation good fit to the descending right hand limits of the catch curve was considered. The correlation coefficient for the regression was 0.955 (a = 10.65 and b = 5.73). The natural mortality rate estimated from the empirical equation. Pauly (1990), suggest that this method gives a reasonable value of M. This method of estimating M, is widely used throughout the tropical where time series of reliable catch and effort data and several years of Z values are not available so, as to put the most usual methods of estimating M and F. The fishing mortality rate (F) was taken by subs traction of M from Z and was found to be 3.27.

**Selection Pattern:** It appears from (Fig. 8 a and b) that the length at first capture ($L_c$) from "selection pattern" for the year 2008-2009 was found to be 6.747cm and ($L_c$) for the year 2009-2010 is 6.647 on the basis of the present Thukri net used. But this is likely to differ in case of other commercial fishing vessels having nets with different sizes.

For these over-fished marine species, it can be seen from the selection curves that the length at first capture ($L_o$) is too low in comparison to the corresponding values of Lo. For example the $L_o$ of *F.merguiensis* was only 6.747cm and 6.647cm, for on $L_o$ of 24.110 cm and 24.010 respectively.

**Exploitation Rate:** The exploitation rate (E) has been estimated from the Gullands (1971) equation.

E = F/F+M. Thus, from these range of value of F and Z it can be shown that the rate of exploitation (E) is 0.57 and for the year 2009-10, (E) is 0.58. It appears that the stock of *F. merguiensis* of Sonmiani bay is under fishing pressure. This assumption is based on Gulland (1971). He stated that suitable yield is optimized when F = M and when E is more than 0.5, the stock is generally supposed to be over fishing.

**The Yield Per-Recruit and Biomass-Per-Recruit:** The relative yield-per-recruit and biomass-per-recruit were determined as a function of $Lc/L\alpha$ and M/K are 0.28 and 1.64 respectively. The present exploitation rate (E = 0.57) which obtained by analysis of the data (2008-2009) and (E = 0.58) in (2009-2010). Exceed the optimum exploitation rat i.e., $F_{max}$ = 0.50.

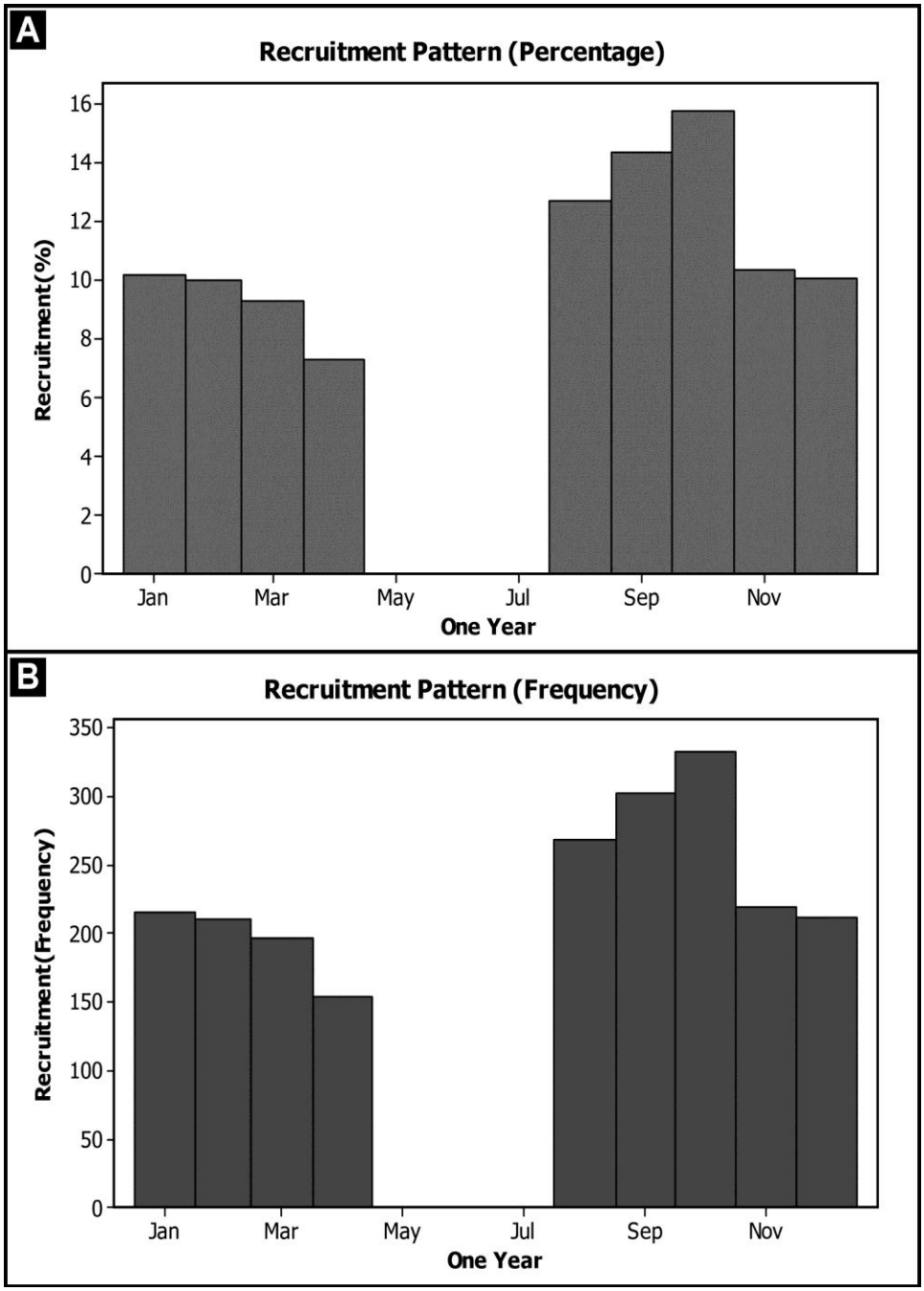


Fig. 6. Recruitment pattern of (%) in *F. merguiensis*: A, during August 2008 to April 2009; B, August 2009 to April 2010.

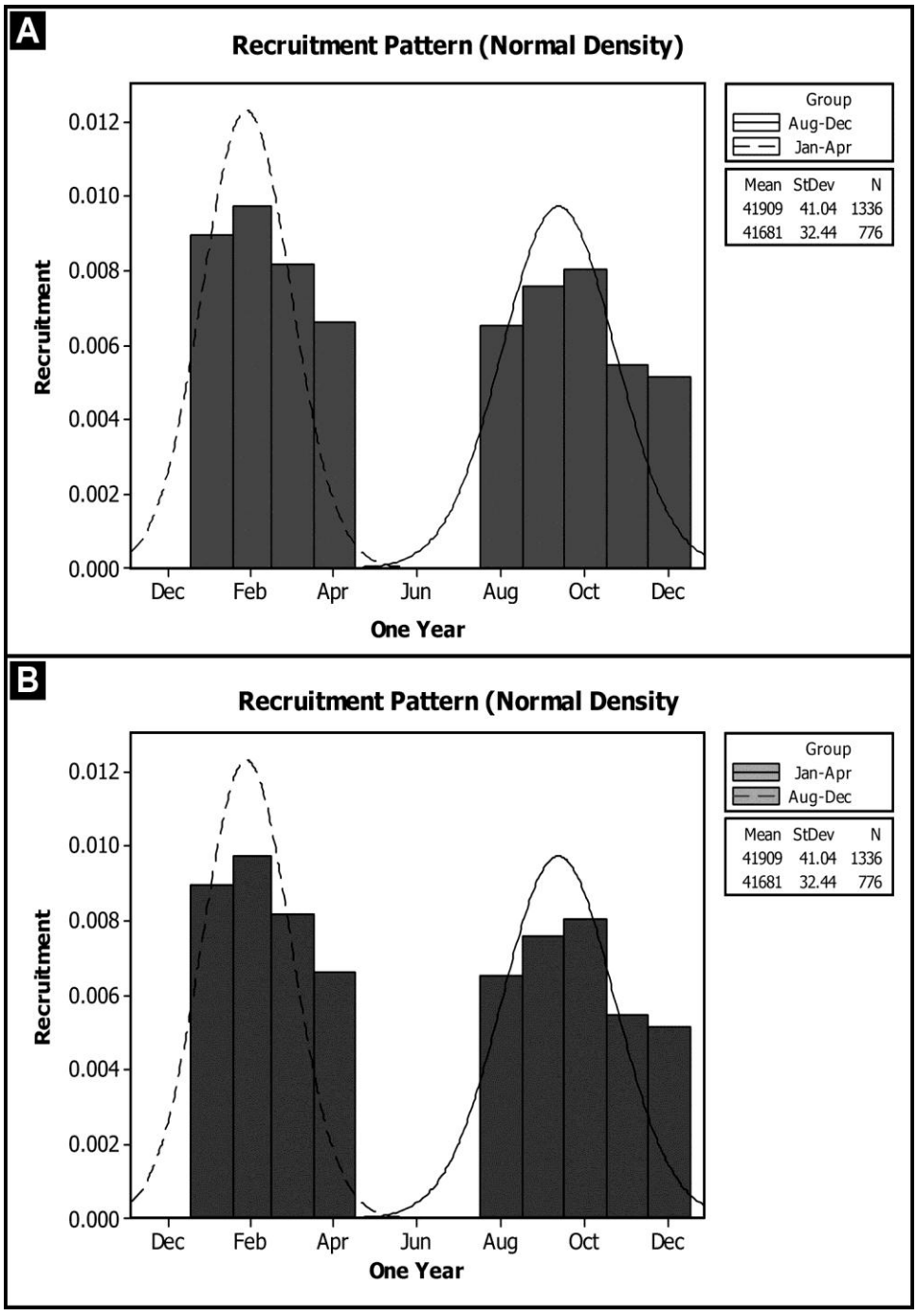


Fig. 7. Recruitment pattern (Normal density) of *F. merguiensis* during the year 15th August, 2009 to 15th April 2010.

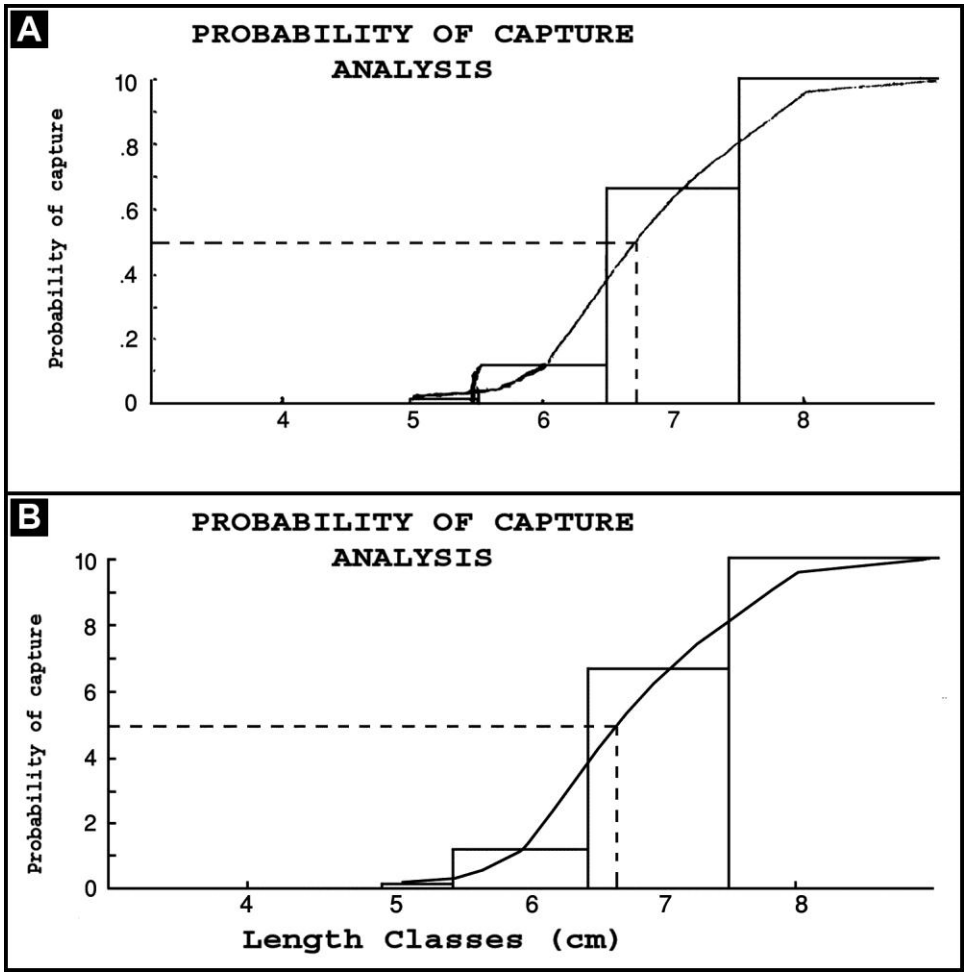


Fig. 8. Selection pattern of *F. merguiensis*: A, during August 2008 to April 2009; B, August 2009 to April 2010.

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