AGE AND GROWTH OF *POLYNEMUS HEPTADACTYLUS* CUV. AND VAL. FROM THE BOMBAY-SAURASHTRA REGION[1]

P. V. KAGWADE

*Central Marine Fisheries Research Institute; Sub-station, Bombay-*1

ABSTRACT

The age and growth of *Polynemus heptadactylus* were studied from the length frequency distribution and by the annulus method using scales and otoliths. The lengths attained at the end of first through eighth years of life are 83 mm, 128 mm, 158 mm, 188 mm, 213 mm, 237 mm, 255 mm and 273 mm respectively as deduced from the length frequency method. The studies on annuli revealed identical results for the first four years of life. A 'larval ring' found on the otoliths of fish of above 26 mm was not present on the scales. The causes of formation of annuli are not known at present.

Three stages, each with a distinct growth chracteristic, were observed in the life of the fish-an early juvenile stage up to the second year, a stage of sexual maturity from the third to sixth year and a stage of old age subsequently.

Estimation of parameters of the Bertalanffy growth equation gave values of $L_\infty = 368$ mm, K = —0.1570 and t_0 = — 0.59. Age composition of landings by bull-trawlers showed a preponderance of the third and fourth age groups.

INTRODUCTION

Polynemus heptadactylus supports a fishery of some importance in the Bombay and Saurashtra waters. A comprehensive study was undertaken by the author during 1956-59 on the biology of the species and the present paper deals with age and growth of the species. The results of work done on the food and feeding habits and maturation and spawning have been published earlier (Kagwade, 1972*a*, *b*). The specific growth rates, growth constants and characteristics are presented in this paper so that, when these growth factors are determined for other polynemids, it would be possible to find out the interspecific differentiations from different localities.

MATERIAL AND METHODS

The length frequency study is based on 22,439 specimens collected randomly from the landings of 'dol' or bag nets and trawl nets at the fish landing contres of Sassoon Dock and Versova in Bombay from January 1956 to May 1959. From the bag nets 126 samples, totalling 12,191 fish, were collected in 34 months at an

1. From the thesis of the author for the award of Ph.D degree of the Bombay University.

average of 4 samples, each of about 100 fish, a month. From the trawl nets 84 samples, totalling 10,248 fish, were collected in 33 months.

The scale and otolith material was obtained from 765 fish, ranging 15-255 mm in furcal length, during August 1957 - June 1959. Scales were from the region beneath the distal end of the pectoral fin and were kept in envelopes. No special clearing agent or mounting medium was used for the examination of scales and otoliths. Alternate wide and narrow rings on scales and opaque and translucent rings on otoliths were clearly seen when they were placed in water and viewed through a binocular microscope.

LENGTH FREQUENCY STUDIES

Fish were measured in furcal length, which is the distance from the tip of the snout to the shortest fin ray. Consistent differences were noticed in the size composition of *P. heptadactylus* landed by the two types of gear. The mesh size at the cod end of the 'dol' net was small measuring 12.75 mm. The cod end of the trawls had their meshes ranging from 50.8 mm to 63.5 mm. Hence it was considered necessary to analyse the two materials separately. The bag nets were operated in the inshore waters of Bombay, otter trawls just outside the Bombay harbour and bull-trawls from Bombay to Dwarka in the north.

The size range in the 'dol' catch was from 15 mm to 225 mm whereas that in the trawl catch was from 32 mm to 273 mm. The above size ranges were grouped into 5 mm class intervals. The progression of the frequency polygons could be followed up to a length of 190 mm. The fish larger than this length did not yield any encouraging results, and hence the older fish were grouped into still smaller ranges of 3 mm class intervals.

The spawning which is throughout the year in this species, is marked by two peak periods, one in March-June and the other in August-November (Kagwade, 1972 *b*). Based on the length frequency distribution, it is possible to distinguish two batches recruited in a year; i.e. during the pre-monsoon and post-monsoon periods. For example fish in the first year of life indicated by the mode *A*1 in the month of April 1956 (*vide* Table 1) at a length of 33 mm being 5 months old (with a growth rate of about 6 mm per month), belong to the brood resulting from the post-monsoon spawning in about November 1955. Similarly fish indicated by a_1 appearing in January 1957 at a length of 58 mm (*vide* Table 1) being about 8 months old, must have been recruited in the pre-monsoon month of May 1956.

Tables 1 and 2 show the time of recruitment and growth of different broods of *P. heptadactylus* in different years in 'dol' net and trawl net samples respectively. The numbers accompanying the letters which represent the brood, indicate the year groups to which the fish belongs. In Table 1 the batches A_1 of 1956, B_1 of 1957, C_1 of 1958 and D_1 of 1959 appear to have been recruited in the post-monsoon month

TABLE 1. *Growth of year-classes of* Polynemus heptadactylus (*based on 'Dol' net samples*)

Length (mm)	1956												1957												1958												1959				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
13																																									
18													B_1																												
23																										C_1													D_1		
28																											C_1	C_1					C_1								
33				A_1										B_1																											
38					A_1										B_1																									D_1	D_1
43						A_1																	b_1													C_1					
48																	B_1							b_1							C_1						C_1				
53																		B_1								b_1															
58													a_1						B_1													C_1						C_1			
63	m_1																			B_1																			C_1		
68																											b_1						C_1								
73																					B_1																				
78																												b_1													
83			m_1														a_1					B_1												C_1							
88	M_2			m_2																															C_2						
93					m_2																				B_2													C_2			
98			M_2	M_2											A_2					a_2																				C_2	

TABLE 1. (*Contd.*)

Length (mm)	1956												1957												1958												1959				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
103	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B_2	–	–	–	–	–	b_2	–	–	–	–	–	–	–	–
108	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	A_2	A_2	–	–	a_2	a_2	–	–	–	–	–	B_2	–	–	–	–	–	b_2	–	–	–	–	–	–	–
113	n_2	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	–	–	–	–	–	a_2	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–
118	–	–	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	–	–	–	–	–	a_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
123	–	–	n_2	–	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	A_2	–	–	–	–	a_2	–	–	–	–	–	–	–	–	–	–	–	–	–	b_2	–
128	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	A_2	A_2	–	–	–	a_2	–	–	–	–	–	B_2	B_2	–	–	–	–	–	–
133		–	–	–	–	–	–	–	–	–	–	M_3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
138	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
143	–	–	–	–	–	–	–	–	–	–	–	n_3	n_3	–	–	–	M_3	–	–	–	–	–	m_3	–	–	–	–	A_3	–	–	–	–	–	–	–	–	–	–	–	–	–
148	–	–	–	–	–	–	–	–	–	–	–	–	–	n_3	–	–	–	–	M_3	–	–	–	–	m_3	m_3	–	–	–	–	–	–	–	–	a_3	–	–	–	–	–	–	–
153	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
158	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	n_3	–	–	–	–	M_3	–	–	–	–	–	–	–	–	–	–	–	–	A_3	–	–	–	–	–	–
163	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M_4	M_4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
168	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
173	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
178	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
183	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	M_3	–	–	–	–	–	–

Table 2. *Growth of year-classes of* Polynemus heptadactylus (*based on trawl net samples*)

Length (mm)	1956												1957												1958												1959				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
38	–	–	–	A_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
43	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
48	–	–	–	–	A_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
53	–	–	–	–	–	–	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	–	–	b_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
58	–	–	–	–	–	–	–	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63	–	–	–	–	–	–	–	–	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	b_1	b_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
73	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
78	–	–	–	m_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	b_1	–	–	–	–	–	–	–	–	–	–	–	–	–
83	–	–	–	–	–	–	–	–	–	–	A_1	–	–	–	–	–	a_1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
88	–	–	–	–	–	–	–	–	–	–	–	–	–	A_2	–	–	–	a_2	–	–	–	–	–	B_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
93	–	–	–	–	–	–	–	–	–	–	–	–	–	–	A_2	–	–	–	–	–	–	–	–	–	B_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
103	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	A_2	A_2	–	–	–	–	–	–	–	–	–	–	B_2	–	–	–	–	–	b_2	–	–	–	–	–	–	–
108	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	–	A_2	–	–	–	–	–	a_2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
113	–	–	–	–	–	–	–	–	–	–	–	m_2	–	–	–	–	–	–	A_2	–	–	–	–	–	a_2	–	–	–	–	–	–	–	–	–	–	b_2	–	–	–	–	–
118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a_2	–	–	–	B_2	–	–	–	–	–	–	–	–	–	–	–
123	–	–	–	–	–	–	–	–	–	M_2	–	–	–	–	m_2	m_2	–	–	–	A_2	–	–	–	–	–	–	a_2	–	–	–	–	–	B_2	–	–	–	–	–	–	b_2	–
128	–	–	–	–	n_2	–	–	–	–	–	M_2	–	–	–	–	–	–	–	–	–	–	A_2	–	–	–	–	–	a_2	–	a_2	–	–	–	–	B_2	–	–	–	–	–	b_2

TABLE 2. (*Contd.*)

Length (mm)	1956												1957												1958												1959				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
133	—	—	—	—	—	—	—	—	—	—	—	M_3	M_3	—	—	—	—	—	—	m_3	m_3	—	A_3	—	A_3	—	—	—	—	—	a_3	a_3	—	—	—	—	—	—	—	—	—
138	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	m_3	—	—	—	—	A_3	A_3	—	—	a_3	—	a_3	a_3	—	—	B_3	B_3	—	—	—
143	—	—	—	—	—	—	—	—	—	n_3	—	—	—	—	—	M_3	—	M_3	—	—	—	—	—	m_3	m_3	—	—	—	—	A_3	—	—	—	—	a_3	a_3	—	—	B_3	B_3	—
148	—	—	—	—	—	—	—	—	—	—	—	n_3	—	—	—	—	—	—	M_3	—	—	—	—	—	—	m_3	—	—	—	—	A_3	—	—	—	—	—	—	a_3	—	—	B_3
153	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	M_3	M_3	—	—	—	—	—	m_3	—	—	—	—	A_3	A_3	—	—	—	—	—	a_3	a_3	—
158	—	—	—	—	—	—	—	—	—	N_3	—	—	—	—	—	—	n_3	—	—	—	—	M_3	M_3	—	—	—	—	m_3	—	—	—	—	—	A_3	A_3	—	—	—	—	—	a_3
163	—	—	—	—	O_4	—	—	—	—	—	N_4	N_4	—	—	—	—	—	—	—	—	—	—	—	—	M_4	—	—	—	—	—	—	—	—	—	A_3	A_4	—	—	—	—	—
168	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	n_4	—	—	—	—	—	M_4	M_4	—	—	—	—	m_4	—	—	—	—	A_4	A_4	—	—	—
173	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N_4	—	—	—	—	—	n_4	—	—	—	—	M_4	—	M_4	—	—	—	m_4	m_4	—	—	—	A_4	A_4	—
178	—	—	—	—	—	—	—	—	—	—	O_4	—	—	—	—	—	—	—	N_4	—	—	—	—	—	—	—	—	—	—	—	—	M_4	—	—	—	—	—	m_4	—	—	—
183	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N_4	N_4	—	—	—	—	—	n_4	—	—	—	—	—	—	—	—	—	—	—	—	m_4	—
188	—	—	—	—	—	—	—	—	—	—	O_4	—	—	—	—	—	O_4	O_4	—	—	—	N_4	—	—	—	—	—	n_4	—	—	—	—	—	M_4	—	—	—	—	—	—	m_4
192	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N_5	—	—	—	—	—	—	—	n_5	—	—	—	—	—	—	—	—	—	—
195	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O_5	—	—	—	—	—	N_5	—	—	—	—	n_5	—	—	—	—	M_5	—	—	—	—
198	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O_5	—	—	—	—	—	—	—	—	—	—	n_5	—	—	—	—	M_5	—	—	—
201	—	—	—	—	—	—	—	—	—	—	P_5	—	—	—	—	—	O_5	—	—	—	—	—	O_5	—	—	—	—	—	—	—	—	—	—	n_5	—	—	—	—	M_5	M_5	M_5
204	—	—	—	—	P_5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O_5	—	—	—	—	—	—	—	—	n_5	—	—	—	—	—	—
207	—	—	·	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O_5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
210	—	—	—	—	q_5	—	—	—	—	P_5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O_5	O_5	—	—	—	—	N_5	—	—	—	—	n_5	—	—	—

TABLE 2. (*Contd.*)

Length (mm)	1956												1957												1958												1959				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
213	–	–	–	–	–	–	–	–	–	–	P_5	–	–	–	–	–	P_5	–	–	–	–	O_5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	n_5	–
216	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N_6	–	–	–	–	n_6
219	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P_6	P_6	–	–	–	–	–	–	–	–	–	–	–	O_6	–	–	–	–	N_6	–	–	–	–
222	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N_6	–	–
225	–	–	–	–	–	–	–	–	–	–	q_6	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	O_6	–	–	–	–	–	–	–	O_6	–	–	–	–	–	–
228	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
231	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
234	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	O_6	–	–	–	–	–	–	O_6	–	–
237	–	–	–	–	–	–	–	–	–	–	Q_6	–	–	–	–	–	–	–	–	–	–	–	P_6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	q_7	–	–	–	–	–	P_7	–	–	–	–	–	–	–	–	–	–	O_7	O_7	–	–	–	–
243	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O_7	–	–	–
246	–	–	–	–	–	–	–	–	–	–	r_7	–	–	–	–	–	–	–	–	–	–	–	q_7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O_7	–
249	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
252	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	q_7	–	–	–	–	–	–	–	–	–	–	–	–	–	–
255	–	–	–	–	–	–	–	–	–	–	R_7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	q_7	–	–	–	–	–	–	–	–	–	–	–	–	–
258	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
261	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	q_8	–	–	–	–	–	P_8	–	–	–
264	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
267	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
270	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r_8	–	–	–	–	–	–	–	–	–	–	–	–	–
273	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	R_8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

of November in 1955, 1956, 1957 and 1958 respectively. These can be traced independently till A_1 completes the third year, B_1 the second year and C_1 the first year of life, while D_1 cannot be followed up in a similar manner for want of data. The mode M_2 of 1956 representing the fish which have completed one year and are in the second year seems to have been the result of recruitment in the post-monsoon month of November 1954. This can be traced till 1958 when it is in the fourth year of its life. The batches n_2 and m_1 of 1956, a_1 and b_1 of 1957 and c_1 of 1958 seem to have been recruited in the pre-monsoon month of May in 1954, 1955, 1956, 1957 and 1958 respectively. These can be traced till the end of 1958 or the beginning of 1959.

The pre-monsoon and post-monsoon recruitments are evident in the trawl samples also (Table 2). The post-monsoon batches R_7, Q_6, P_5, O_4, N_3, M_2 and A_1 of 1956 and B_2 of 1957 appear to have been recruited in November of the successive years from 1949 to 1956. The pre-monsoon batches r_7, q_6, p_5, o_4, n_2, m_1 and a_1 of 1956 and lastly b_1 of 1957 seem to have been recruited in May of the successive years from 1950 to 1957. With the exception of a few batches of higher age groups most of these batches can be traced further in the following years till the beginning of 1959.

From the length frequency studies it can be said that *P. heptadactylus* grows with a monthly average rate of 6 to 7 mm in the first year of life, 3.5 to 4 mm in the second year, about 2.5 mm in the third and fourth years, 2 mm in the fifth and sixth and lastly about 1.5 mm in each of the seventh and eighth years of its life, the fish measuring 83 mm, 128 mm, 158 mm, 188 mm, 213 mm, 237 mm, 255 mm and 273 mm at the end of the first year to eighth year in that order. No difference in the rate of growth between the samples from the two gears, 'dol' and trawl nets has been noticed, but in the former the younger year classes, especially the first year class are better represented and in the latter the older year classes. Modes for the first 3 year classes can be followed up clearly in the 'dol' net smaples; the fourth year class is scantily represented and the higher year classes are almost absent. Modes in the trawl net samples can be traced smoothly for the second to fourth year classes; the modes in the first year are poorly represented. There appears to be a gradual fall in the representation in the samples of the last 4 years, i.e. from the fifth to the eighth.

Studies on Scales and Otoliths

Scale lengths and otolith lengths were plotted separately against the fish lengths (Fig. 1) in a scatter diagram. By the method of least squares straight lines were fitted to describe the relationships. Using the regression formula, regression coefficients were estimated for the back-calculation of the fish growth at a known length of the scale of otolith and also of the scale or otolith growth at a known length of fish.

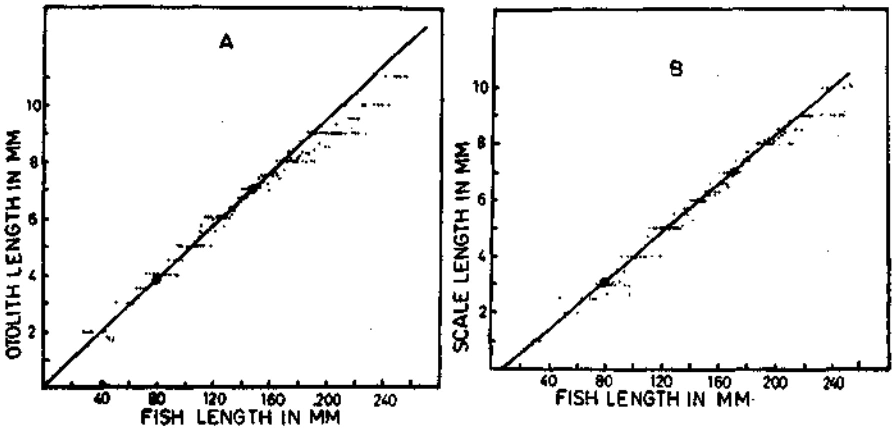


FIG. 1 Relation between otolith length and fish length (A) and scale length and fish length (B) in *Polynemus heptadactylus*.

The values of constants 'a' and 'b' in the linear regression y = a + bx were computed when the fish length is 'L' and scale length 'S' and the relationship between these two lengths was noticed to be

$$S = -0.37 + 0.043\ L$$
$$L = 9.87 + 22.97\ S.$$

similarly in the case of otolith when the fish length is 'L' and otolith length 'O', their relationship was found to be

$$O = 0.63 + 0.042\ L$$
$$L = -0.07 + 21.05\ O.$$

The value of the constant 'a' in the equation for the fish length relationship with the scale length is 9.87 which, in other words, is the fish length in mm when the scale length is zero. The smallest *P. heptadactylus* examined during the course of this study was 15 mm in length when the scales were already seen to have developed on its body. It was not possible to observe if there existed any difference in growth of scales in different specimens of this species below 15 mm, as found in pilchard measuring below 40 mm (Blackburn, 1949).

In the relationship of fish length with the otolith length, the value of 'a' is — 0.07. Fairbridge (1951) found a similar case in the otolith of flathead (*Neoplatycephalus macrodon*), the regression line cutting the fish length axis at a negative otolith value. Considering this as absurd the presumed disproportionately faster growth of otolith in very small flatheads. This disproportionately faster growth of otolith in the early period of life of a fish can be substantiated by the presence of otoliths in the embryonic stages itself as recorded in the embryo of a muraenid eel of about 1 mm in diameter (Bensam, 1966) and in the pro-larvae of *Caranx carangus* of about 1.15 mm in diameter (Subrahmanyam, 1966).

Growth rings on scales and otoliths

Growth is recorded on the scales in the form of sculpture. It appears as rings with widely spaced sclerites or circuli during the period of rapid growth and closely spaced ones during slow growth (Pl. I). Growth pattern in otoliths is recorded in the form of wide white zones and narrow dark zones in reflected light and in reverse form in transmitted light. In *P. heptadactylus* the rings are very distinct and are more easily discernible in the otoliths than in the scales. Such a difference in the scale and otolith readings has been noted by Kohler and Clark (1958) especially in the case of old haddock.

Most of the juvenile fish above 26 mm in length show a ring on their otoliths. The otoliths of 25 fish ranging 22 - 30 mm in furcal length were examined. It was found that a faint ring around the nucleus appeared when the fish was about 23 mm. The ring remained in a faint condition till the fish reached about 26 mm. When the fish grew to the size of 27 mm it was found that 67% of them clearly showed one ring each in their otoliths. The percentage occurrence of rings in otoliths of fish above 27 mm in length was found to be always 100.

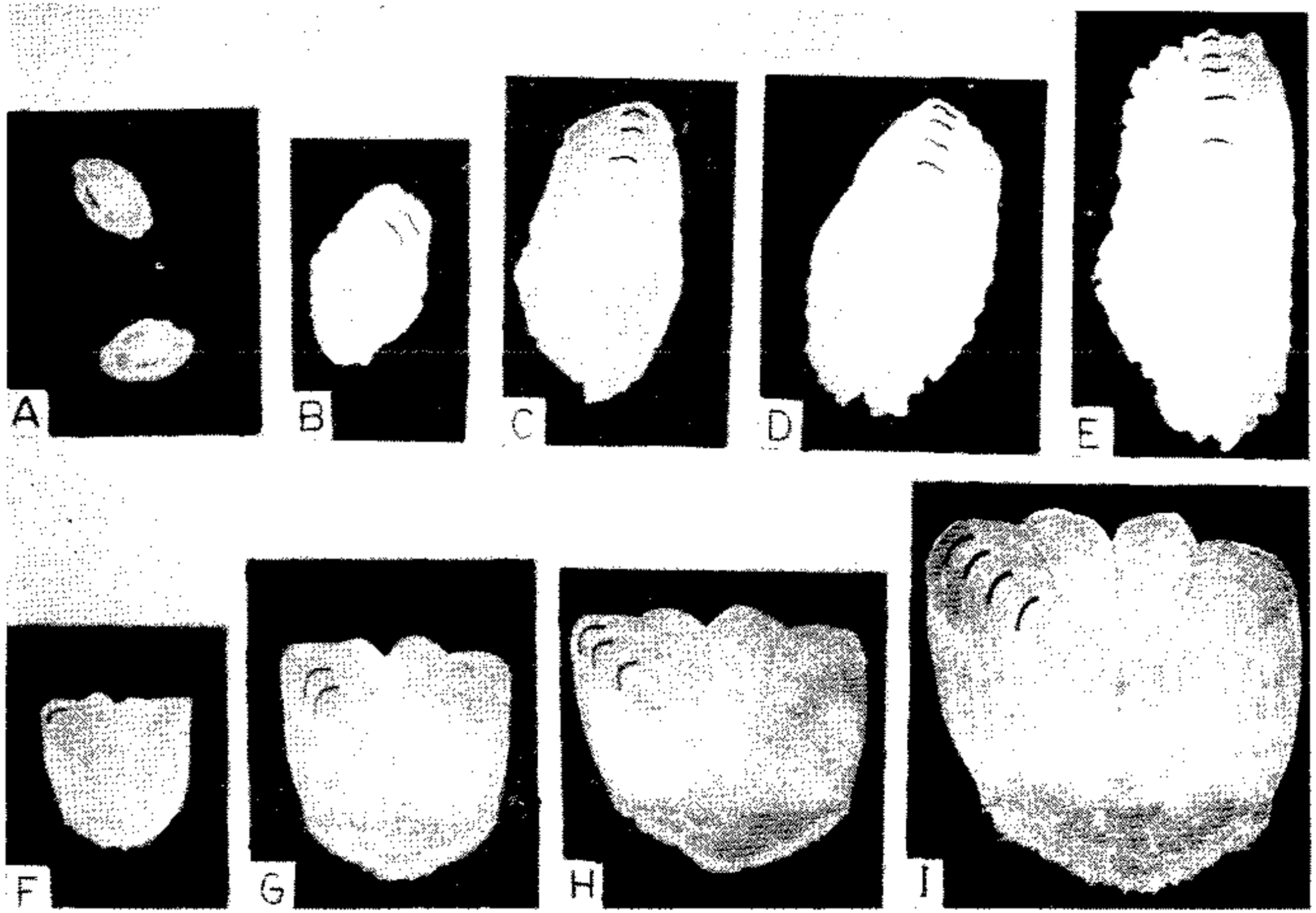
Gottlieb (1956) in his work on age and growth of the red mullet of the Mediterranean waters came across a similar ring which he referred to as 'larval ring'. The cause for the formation of this ring has been attributed to the change in the habitat from pelagic to demersal where the temperature of water is low. To find whether such a change in habitat occurs in *P. heptadactylus* also, the food of very small fish was analysed, but no variation in the food composition was noticed from that of other larger juveniles. Secondly, fish below 23 mm were found to occur along with the larger fishes in the bag net catches from the inshore waters. Hence, the formation of this ring cannot be attiibuted to the change of habitat alone.

No ring corresponding to the 'larval ring' of the otoliths was noticed in the scales of this species.

The number of rings observed in otoliths varies from 1 to 5 (Pl. I). Table 3 shows the ring distribution in percentage at 15 mm class intervals. The 'larval ring' alone is seen till the fish attains a length of 68 mm; the second, third, fourth and fifth rings are seen at 83 mm, 128 mm, 158 mm and 188 mm respectively. The lengths referred to here are the mid-point values of the corresponding size groups.

The number of rings on scales varies from 1 to 4 (Pl. I, Table 4). The first ring on the scale is seen mostly when the fish attains a length of 83 mm and, likewise, the second, third and fourth rings are seen at lengths of 128 mm, 158 mm and 188 mm respectively.

From the above it is clear that the appearance of the rings on the otoliths bears a close correspondency to that on scales except for the larval ring of otoliths. The second to fifth rings on the otoliths correspond to the first to fourth rings on the



Growth rings on otoliths (A—E) and scales (F—I) of *Polynemus heptadactylus.*
Fork length of fishes: A—48 mm, B— 95 mm, C—144 mm, D—168 mm. E—240 mm, F—96 mm, G—138 mm, H—152 mm, and I—230 mm.
(All photographs five times the actual size)

(*Facing P. 42*)

TABLE 3. *Percentage frequencies of number of rings in the otoliths of* P. heptadactylus *at different length groups.*

Size-group Mid-point (mm)	Fish examined	Percentage of fish with no. of rings				
		1	2	3	4	5
23	16	100	—	—	—	—
38	15	100	—	—	—	—
53	3	100	—	—	—	—
68	14	100	—	—	—	—
83	24	83	17	—	—	—
98	7	57	43	—	—	—
113	20	25	75	—	—	—
128	77	14	75	11	—	—
143	109	13	65	22	—	—
158	141	1	43	50	6	—
173	138	1	25	66	8	—
188	105	—	10	71	18	1
203	56	—	2	59	37	2
218	22	—	—	50	45	5
233	10	—	10	40	40	10
248	8	—	—	12	63	25

TABLE 4. *Percentage frequencies of number of rings in the scales of* P. heptadactylus *at different length groups.*

Size-group Mid-point (mm)	Fish Examined	Percentage of fish with no. of rings			
		1	2	3	4
23	—	—	—	—	—
38	—	—	—	—	—
53	—	—	—	—	—
68	—	—	—	—	—
83	1	100	—	—	—
98	2	100	—	—	—
113	9	100	—	—	—
128	26	88	12	—	—
143	59	75	25	—	—
158	109	46	50	4	—
173	103	14	81	5	—
188	98	5	50	44	1
203	55	7	33	55	5
218	20	—	50	45	5
233	10	10	30	50	10
248	8	—	50	25	25

scales and they appear at fish lengths of 83 mm, 128 mm, 158 mm and 188 mm respectively. The sequence in which the rings appear on the otoliths and scales suggests that they are valid as growth checks in the age determination of the species.

The formation of rings of an annual nature in fishes has been attributed primarily to the retardation or cessation of growth brought about by the low temperature in winter or by the metabolic strain after the act of spawning. The study on the food and feeding of *P. heptadactylus* revealed that the feeding intensity did not show marked seasonal variation during any part of the year (Kagwade, 1972*a*). The feeding intensity appeared to vary widely in both juveniles and adults but showed no significant fluctuation with reference to the breeding of this fish. Thus it is unlikely that food may be the possible cause of the formation of these growth checks. Blackburn (1949) has recorded spawning checks in the Australian pilchard. It is not likely that the growth rings found in *P. heptadactylus* have any relation to spawning periodicity as they are found even in those fish which are one year old and sexually immature. The causes of the formation of the gowth checks in *P. heptadactylus* are not known. The annual growth increments are 83 mm during the first year, 45 mm in the second year and 30 mm each in the third and fourth years. Length frequency studies on this species have shown that the growth rates in the first four years are almost the same as those described above and that in the subsequent higher age groups, the growth rates are still less, being 24 mm each in the fifth and sixth years and 18 mm each in the seventh and eighth years.

Rate of growth in males and females

Differences in the growth rates between males and females are generally met with in fishes, as pointed out by Fairbridge (1951) in the tiger flathead, by Orcutt (1950) in the starry flounder and by Hagerman (1952) in the Dover sole. In all these three fishes the rate of growth was found to be higher after a certain age in females which grew to a larger size than the males. An attempt was made here to find out if there exists any difference in the growth rates between the two sexes of *P. heptadactylus*.

It is seen from Table 5 and 6 that the mid-points of size groups for females range from 83 mm to 248 mm, while those for males from 98 mm to 188 mm. In females the second ring in the otoliths and the first in the scales appear at a length of 83 mm. In males the corresponding otolith ring makes its appearance in fish of 98 mm but not the scale ring. However, the first and second rings in scales in the males are noticed at 128 mm. This is because the number of specimens at these lengths was small in the samples and also because the scale rings were less clear than the otolith rings. Again in females, the fifth ring in the otoliths and fourth in the scales appear at 188 mm whereas these are not seen in the males at this length. This may also be due to the number of males of this length being very small in the catches. At this length when 109 females showed rings in otoliths and 90 in scales, only 4 males showed rings in otoliths and 2 in scales. These two discrepancies which might have been caused largely by the absence of sufficient number of males in the samples

TABLE 5. *Percentage frequencies of number of rings in the otoliths of male and female* P. heptadactylus *at different length groups*

Size-group Mid-point (mm)	Males (Number of rings)				Females (Number of rings)			
	2	3	4	5	2	3	4	5
	%	%	%	%	%	%	%	%
83	—	—	—	—	100	—	—	—
98	100	—	—	—	100	—	—	—
113	100	—	—	—	100	—	—	—
128	90	10	—	—	79	21	—	—
143	79	21	—	—	64	36	—	—
158	54	39	7	—	34	60	6	—
173	41	53	6	—	21	70	9	—
188	25	75	—	—	5	77	17	1
203	—	—	—	—	2	56	40	2
218	—	—	—	—	—	50	45	5
233	—	—	—	—	8	42	42	8
248	—	—	—	—	—	11	67	22

TABLE 6. *Percentage frequencies of number of rings in the scales of male and female* P. heptadactylus *at different length groups*

Size-group Mid-point (mm)	Males (Number of rings)				Females (Number of rings)			
	1	2	3	4	1	2	3	4
	%	%	%	%	%	%	%	%
83	—	—	—	—	100	—	—	—
98	—	—	—	—	100	—	—	—
113	—	—	—	—	100	—	—	—
128	93	7	—	—	82	18	—	—
143	78	22	—	—	65	35	—	—
158	68	26	6	—	30	67	3	—
173	21	64	15	—	12	84	4	—
188	—	100	—	—	4	49	46	1
203	—	—	—	—	8	30	56	6
218	—	—	—	—	—	65	30	5
233	—	—	—	—	10	40	40	10
248	—	—	—	—	—	50	25	25

have not been considered to have any effect on the calculation of growth rates of the species as the appearance of other rings at different lengths in both the sexes is similar. The rarity of males of the size group with the mid-point 188 mm and above and the availability of the largest male of 210 mm as against the largest female of 273 mm in the catches, indicate that the chances of survival of the males after completing 4 years are remote. The females appear to grow to a much largei size and live larger than the males.

Growth Characteristics

The increase in length of a small-sized fish is not comparable with that of a larger fish species because the increase is relative and proportional to the maximum size to which the fish grows. Such comparisons should be based on the specific growth rate which is expressed by the formula (Chugunova, 1963).

$$C_1 = \frac{\log l_2 - \log l_1}{0.4343\,(t_2 - t_1)}$$

wheie C_1 = specific growth rate, l_1 = fish length at the beginning of the time interval for which specific growth rate is calculated, l_2 = fish length at the end of the time interval, t_1 = time at the beginning of the time interval, and t_2 = time at the end of the time interval for which the specific growth rate is calculated.

As cited by Chugunova (1963), Shmalhausen (1935) found different growth constants in different periods in the life span of an animal; in each of these periods, the growth constants for the individual years vary very closely from the average growth constant for that entire period. He denoted this growth constant by the product of the specific growth rate and the time factor, i.e.

$$C_{1t} = C_1 \times \frac{t_2 + t_1}{2} .$$

As reported by Chugunova (1963), Vasnetsov (1934) noticed that the turning point in the growth of fish from two different basins was at different ages but at the same length and thus he came to the conclusion that transition from one period of average growth constant and the specific growth rates are related not to the time factot $\frac{t_2 + t_1}{2}$ but to the length of the fish. He called this as the growth characteristic which is given by

$$C_{1p} = C_1 \times l_1 .$$

By the applications of the respective formulae mentioned above to the age-length data of *P. heptadactylus*, the specific growth rates, growth constants and growth characteristics have been calculated (Table 7). It is noticed that the specific growth rate differs from year to year but decreases with the advance in age. There appears to be three distinct periods, each with a growth constant varying from one another. However, there is only a narrow variation in the growth constants of different years

TABLE 7. *Growth constants and characteristics of* P. heptadactylus

Age	Length (mm)	Specific growth rate= C_l	Growth constant $=C_{lt}$	Growth Characteristic $=C_{lp}$	Average constants by periods	Average growth characteristics
I	83	—	—	—	—	—
II	128	0.433	0.6495	35.939	0.6495	35.939
III	158	0.210	0.5250	26.880		
IV	188	0.173	0.6055	27.334	0.5679	25.026
V	213	0.124	0.5580	23.312		
VI	237	0.106	0.5830	22.578		
VII	255	0.073	0.4745	17.301	0.4922	17.320
VIII	275	0.068	0.5100	17.340		

within the same period. The growth constants of *P. heptadactylus* for the first period up to and inclusive of the second year is 0.6495; in the second period covering third year to sixth year, the growth constants range from 0.5250 to 0.6055, varying slightly about the average growth constant of 0.5679 for the period, and lastly, in the third period of seventh and eighth years, the average growth constant is 0.4922.

Just as the growth constants, the growth characteristics too show three distinct periods. The first period till the second year records the value of 35.939 for the growth characteristic. The second period from third year to sixth year, has the growth characteristics ranging between 22.578 and 27.334 in different years with the average growth characteristic of 25.026 for that period. The third period formed by the seventh and eighth years shows an average growth characteristic of 17.320.

The three distinct periods recognisable in the life span of a fish with the help of growth characteristics have different biological characters. The first one at the juvenile stage of the fish is influenced greatly by the external environment and the availability of the food. During this period the growth is the fastest. It is significant to note that the second period wihich is said to be of sexual maturation, is the least affected by the environment as is found in the case of bream which showed almost the same value of growth characteristic for specimens coming from four different basins (Chugunova, 1963) and thus this period is said to be one of hereditory-fixed growth rate. Burd (1962) in his studies on the growth of herrings by von Bertalanffy's and Walford's methods also found a change in the growth rates during the pre-maturity and post-maturity stages of the fish. He also assumed the pre-maturity growth to be related to the feeding intensity. By its merit of being the hereditory-fixed growth rate, it is the growth characterstic of the second period which is used in comparing the growth rates of the same species from different localities and of different species from the same habitat.

The turning point in the growth characteristics from the second period to the third of old age in *P. heptadactylus* is noted after the sixth year. The maturity studied of this fish have revealed (Kagwade, 1972 *b*) that the early maturity stages II and III occur less frequently with the increase in the length of fish and these are almost absent in fishes above five years old. This apparently indicates that the gonads of older females either do not recover or recover very slowly after spawning. The exploitation of *P. heptadactylus* above six or even five years which can all be considered as old fish, may not affect its fishery potential.

Growth Parameters

Length-weight relationship

The length-weight relationship in most fishes has been expressed by the allometric growth formula $W = aL^b$, where W = wieght of the fish, L = length of the fish, a = constant and b = exponent.

To determine whether the value of the exponent 'b' in *P. heptadactylus* differs in males and females, the analysis of data of each sex was carried out separately. In all, 181 males ranging from 80 to 210 mm and 419 females ranging from 78 to 245 mm in furcal length were considered for this study.

The values of 'a' and 'b' in the above formula were determined and the relationship for the males was found to be $W = 0.00001089\ L^{3.0832}$ and for the females $W = 0.00001147\ L^{3.0745}$. The difference between the exponents, when tested, was found to be significant.

Growth equation

The values of different parameters of the Bertalanffy growth equation

$$L_t = L_\alpha\left(1 - e^{-K(t-t_0)}\right)$$

where L_t = length of the fish at the age t, L_α = maximum or asymptotic length that a fish can theoretically reach, K = the coefficient of catabolism and t_0 = time or age when the fish length is theoretically supposed to be zero, obtained are as follows: L_α = 368 mm, K = 0.1570, and t_0 = -0.59.

Making use of these values the theoretical lengths at different ages were calculated and these have been presented in Table 8. It can be seen from this table that the theoretical and observed values agree very closely.

Age Composition of Commercial Catches

The numbers of fish in the age groups II to V, as calculated by the method adopted by Fairbridge (1952), for each month for the landings of the bull-trawlers of New India Fisheries Company have been plotted in Fig. 2. It is clear from the figure that the second age group was poorly represented in the catch throughout and as

TABLE 8. *Fit of the von Bertalanffy equation to the length at age data for* P. heptadactylus

Age (t)	$t-t_o$	$-K(t-t_o)$	$e^{-K(t-t_o)}$	$1-e^{-K(t-t_o)}$	Theoretical length	Observed length
1	1.59	-0.24963	0.7791	0.2209	81.3	83
2	2.59	-0.40663	0.6659	0.3341	122.9	128
3	3.59	-0.56363	0.5691	0.4309	158.6	158
4	4.59	-0.72063	0.4865	0.5135	189.0	188
5	5.59	-0.87763	0.4158	0.5842	215.0	213
6	6.59	-1.03463	0.3554	0.6446	237.2	237
7	7.59	-1.19163	0.3037	0.6963	256.2	255
8	8.59	-1.34863	0.2596	0.7404	272.5	273

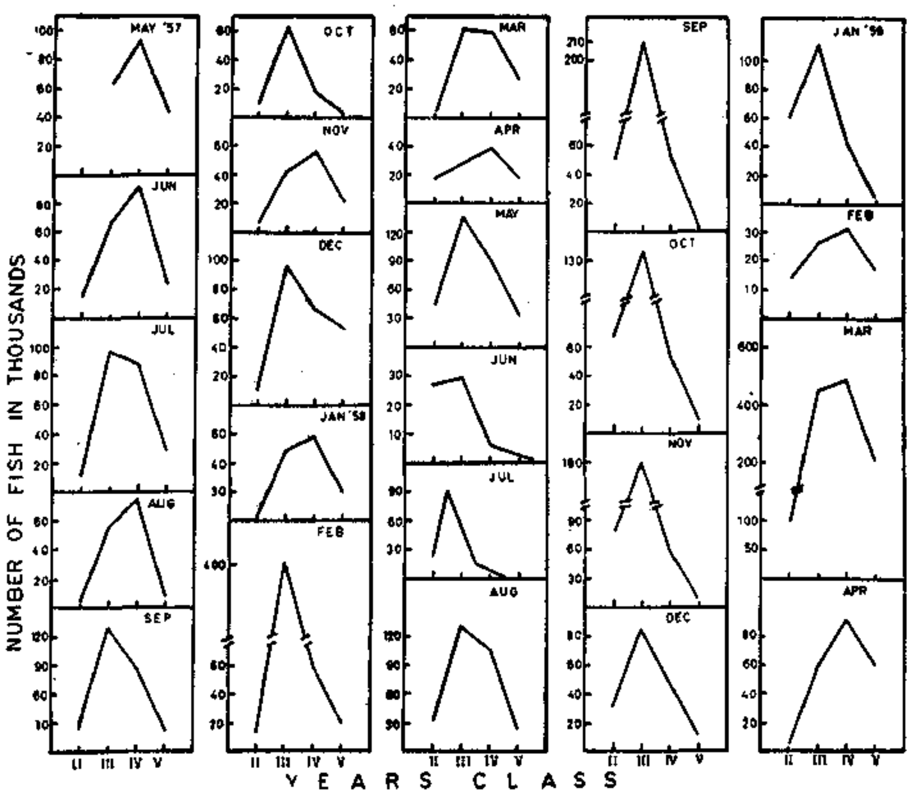


FIG. 2 Monthly age composition by numbers of *P. heptadactylus* in the New India Fisheries trawl catch from May 1957 to April 1959.

mentioned earlier, it may be due to the incomplete sampling of the gear. The maximum number of 78,283 fish belonging to this age with an approximate weight of 2.6 metric tons was fished during November 1958, while the minimum of 3,329 fish with an approximate weight of 0.1 metric ton during August 1957. The fish of fifth and above age groups together formed relatively a small number in the catch and becuase of their lesser contribution to the commercial catch they were pooled. The maximum of 206,928 fish of these age groups with an approximate weight of 3.4 metric tons was caught in March 1959 and the minimum of 628 fish with an approximate weight of 0.09 metric ton in June 1958. The third and fourth age groups contributed to the bulk of the catch. During March 1959, the third and fourth year classes were seen to yield the maximum number of 454,721 and 482,806 fish respectively with the corresponding weights of 26.7 and 46.7 metric tons. The monthly percentage of these two important year groups ranged from 60 - 90. The fourth year group was commercially important during most of the months in the first year of observation and the third year group was dominant in the second year. The number of third and fourth year classes were more or less of equal importance, for neither of these two age groups showed a uniform dominance over the other.

Thus it is seen that the bulk of trawl catch for this species consisted of the third and fourth year classes. The fish is found to attain maturity after the completion of two years. The fish in the third year may have completed the first spawning or even the second. Hence, it appears beneficial to catch the fish belonging to the fourth year and above.

Since the catch data were not available for *P. heptadactylus* either from the 'dol' (bag) net or from the otter trawl, the age composition of the catches from these two gear could not be worked out. However, from the length frequency studies it can be deduced that in 'dol' net samples, the first year group dominated throughout the period of observations forming about 80% of the total catch. The second and third year groups varied from 2% to 12%. The fourth year group occurred only in small numbers. The otter trawl catches also showed a high percentage of the first year group. The second year group was better represented in this case than in the 'dol' catch, forming about 30%. The other age groups occurred in small proportions.

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References

Bensam, P. 1966. The eggs and early development of a muraenid eel. *J. mar,. biol. Ass. India.* **8**: 181-187.

Blackburn, M. 1949. Age, rate of growth and general life history of the Australian pilchard (*Sardinops neopilchardus*) in New South Wales waters, *Bull. Coun. sci. industr. Res. Aust.*, **242**: 9-86.

BURD, A.C. 1962. Growth and recruitment in the herring of the southern North Sea. *Fish. Invest. Lond.*, Ser. 2, **23** (5): 1-42.

CHUGUNOVA, N.I. 1963. *Age and growth studies in fish*. Published for the National Science Foundation, Washington, D.C. by the Israel Program for Scientific Translations, Jerusalem: 1-132.

FAIRBRIDGE, W.S. 1951. The New South Wales tiger flathead *Neoplatycephalus macrodon* (Ogibly). I. Biology and age determination. *Aust. J. mar. Freshw. Res.*, **2**: 117-178.

FAIRBRIDGE, W.S. 1952. The New South Wales tiger flathead *Neoplatycephalus macrodon* (Ogilby). II. Age composition of the commercial catch, overfishing of the stocks and suggested conservation. *Aust. J. mar. Freshw. Res.*, **3**: 1-31.

GOTTLIEB, E. 1956. The age and growth of the red mullet *Mullus barbatus* L. in Israel waters, 1953-55. *Bull. Sea Fish. Res. Sta.*, **12**: 3-20.

HAGERMAN, F.B. 1952. The biology of the Dover sole, *Microstomus pacificus* (Lockington). *Calif. Fish and Game, Fish Bull.*, **85**: 1-48.

KAGWADE, P.V. 1972 *a*. 188-197 Food and feeding habits of *Polynemus heptadactylus* Cuv. and Val. *Indian J. Fish.*, **16**: 188-197.

KAGWADE, P.V. 1972 *b*. Maturation and spawning in *Polynemus heptadactylus* Cuv. and Val. *Indian J. Fish.*, **17**: 76-89.

ORCUTT, H.G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). *Calif. Fish and Game, Fish Bull.*, **78**: 1-64.

SHMALHAUSEN, I.I. 1935. Opredelenie Osnovnykh ponyati imethodika issledovaniya rosta (Basic definitions and methods in the study of growth). Rost zhivotnykh, Biomedgiz.

SUBRAHMANYAM, C.B. 1966. Eggs and early development of two more carangids from Madras. *J. mar. biol. Ass. India*, **8**: 188-192.

VANSNETSOV, V.V. 1934. Opyt sravnitel'nogo analizo lineinogo rosta semeistva karpovykh (An attempt at a comparative analysis on linear growth of carp). *Zoologicheskii zhurnal*, **13** (3).