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Length-Weight Relation and Conversion of "Whole" and "Headless" Weights of Royal-Red Shrimp, *Hymenopenaeus robustus* (Smith)

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ABSTRACT

Differences in the length-weight regression coefficient (b) between sexes are noted for shrimp in one of three areas, and differences among areas are apparent.

Equations for converting whole weight to headless weight and vice versa are given for three areas. The estimating equations differ between the areas. Estimating equations for each area are adequate for describing the relation between whole and headless weights and headless and whole weights.

INTRODUCTION

Exploratory research vessels of the Bureau of Commercial Fisheries have found royal-red shrimp, Hymenopenaeus robustus (Smith), along the upper Continental Slope in the western North Atlantic from Cape Hatteras, N.C., to Brazil (Bullis, 1956; Bullis and Cummins, 1963). Population density varies widely throughout the species range, however, and only three areas with commercial potential have been delineated. One lies off the east coast of Florida, from St. Augustine to Fort Pierce; another lies south-southwest of the Dry Tortugas; and the third is off the Mississippi River Delta from southeast of the Mississippi Passes to off Mobile, Ala.

Commercial harvesting of the royal-red shrimp has increased since the discovery of these areas. During 1967, over 70,000 pounds of headless (or "heads off") royal-red shrimp, valued at more than $55,000, were landed. Roe[1] estimated that the three areas could produce annually 1.6 million pounds of 20-count whole shrimp.

With the development of a royal-red shrimp fishery, there is need for biological studies. Information on the length-weight relation of this species is required for studies of condition, growth, sexual maturity, and equilibrium yield in terms of weight. This paper describes the length-weight relation of royal-red shrimp for each of the three commercial fishing areas off the southern United States.

Statistics on commercial shrimp fisheries of the South Atlantic and Gulf States are collected and published by the Bureau of Commercial Fisheries. Shrimp landings are tabulated in units of "headless" (or "heads off") weight. Because fishery biologists and industry personnel need information on both total and tail weight of shrimp, an appropriate conversion factor is required. Estimates of headless weight when whole weight is given and whole weight when headless weight is given also are presented in this paper.

MATERIAL AND METHODS

Length-weight and total weight-tail weight equations were computed from measurements of 1,978 shrimp caught by exploratory research vessels during October and November 1965. Of these, 1,547 were taken from the St. Augustine area, 227 from the Dry Tortugas area, and 204 from the Mississippi Delta grounds.

Standardized handling procedures were used to decrease variation due to handling and processing of specimens. The specimens were frozen immediately after capture. Prior to measurement, the samples were thawed and excess moisture was removed by blotting with

[1] Unpublished manuscript. The distribution of royal-red shrimp, Hymenopenaeus robustus (Smith), on three potential commercial grounds off southeastern United States by Richard B. Roe, 1967, Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Pascagoula, Miss. 39567, 24 pp.

paper towels. Total length of the shrimp was measured to the nearest millimeter, and the sex was determined for each individual. Weights of individual whole and beheaded shrimp were recorded to the nearest one-tenth gram. The same techniques were used to behead shrimp as are commonly used in the shrimp industry. Length-frequency distributions of these samples are given in table 1.

Table 1.--Total length-frequency distributions of royal-red shrimp collected from three areas, October and November 1965

Total length of shrimp	Area								
	St. Augustine, Fla.			Dry Tortugas			Mississippi River Delta		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
Mm.	Number	Number	Number	Number	Number	Number	Number	Number	Number
80-84	1	1	2	--	--	--	--	--	--
85-89	--	--	--	--	--	--	--	--	--
90-94	1	1	2	--	--	--	--	--	--
95-99	8	4	12	--	1	1	--	--	--
100-104	33	16	49	--	--	--	--	--	--
105-109	43	17	60	--	--	--	--	--	--
110-114	53	34	87	1	--	1	--	--	--
115-119	60	53	113	4	--	4	--	--	--
120-124	74	41	115	2	1	3	--	--	--
125-129	106	44	150	25	3	28	3	--	3
130-134	111	31	142	31	3	34	13	--	13
135-139	75	26	101	31	--	31	28	1	29
140-144	50	31	81	21	3	24	27	3	30
145-149	29	55	84	2	4	6	20	3	23
150-154	20	70	90	1	12	13	12	5	17
155-159	7	80	87	--	12	12	7	9	16
160-164	7	88	95	--	21	21	2	8	10
165-169	--	68	68	--	18	18	1	7	8
170-174	--	47	47	--	14	14	1	15	16
175-179	1	31	32	--	8	8	--	8	8
180-184	1	22	23	--	3	3	--	6	6
185-189	--	21	21	--	1	1	--	5	5
190-194	--	25	25	--	3	3	--	2	2
195-199	--	27	27	--	1	1	--	7	7
200-204	--	18	18	--	--	--	--	4	4
205-209	--	13	13	--	1	1	--	4	4
210-214	--	1	1	--	--	--	--	1	1
215-219	--	1	1	--	--	--	--	1	1
220-224	--	1	1	--	--	--	--	--	--
225-229	--	--	--	--	--	--	--	1	1
Total	680	867	1,547	118	109	227	114	90	204

In describing the length-weight relation, I assumed that weight is an exponential function of length. This assumption was substantiated by plotting samples of each set of data on log-log paper. This relation, expressed empirically as $Y = aX^b$, was used in the logarithmic form, i.e.,

$$\log_{10} Y = \log_{10} a + b \log_{10} X$$

where

Y = total weight in grams
X = total length in millimeters
a and b are constants

I assumed a linear relation of the form $Y = a + bX$ between total weight and tail weight, where

Y = total weight in decigrams
X = tail weight in decigrams
a and b are constants

Landing statistics are given only in units of tails per pound and tail weight; however, biologists frequently require information on the total weight as well as the headless weight of shrimp. Thus it is necessary to be able to convert from headless to total weight and vice versa. Because both regression equations, one relating headless to whole weight and another relating whole to headless weight of shrimp, are equally important, both equations were computed.

A UNIVAC 1107 at the University of Alabama performed the mathematical computations using an unpublished program made available by the Bureau of Commercial Fisheries Biological Laboratory at Galveston, Tex.

RESULTS AND DISCUSSION

The regression equations for estimating log weight ($\hat{Y}$) from log length (X) are listed by sex and by area in table 2. The estimated variances of the regression coefficients (b)

Table 2.--Regression equations for estimating log weight (Y) from log length (X) of royal-red shrimp. Estimated variances of the regression coefficient S_b^2 are listed by sex and area; estimated standard errors of the difference between regression coefficients $S_{b_♀ - b_♂}$ are listed for each area. Values of t compare $b_♀$ and $b_♂$ for each area (weight in grams)

Area	Sex	Sample size	Regression equation	S_b^2	$S_{b_♀ - b_♂}$	t
		Number				
St. Augustine, Fla.....	Female....	867	$\hat{Y} = -5.18220 + 3.00X$	1.002	0.042	1.19
	Male......	680	$\hat{Y} = -5.08408 + 2.95X$	1.003		
	Combined..	1,547	$\hat{Y} = -5.21706 + 3.01X$	1.001		
Dry Tortugas...........	Female....	109	$\hat{Y} = -5.67188 + 3.22X$	1.010	0.168	2.36*
	Male......	118	$\hat{Y} = -4.79226 + 2.82X$	1.057		
	Combined..	227	$\hat{Y} = -5.10459 + 2.96X$	1.005		
Mississippi River Delta	Female....	90	$\hat{Y} = -5.36404 + 3.06X$	1.008	1.77	1.26
	Male......	114	$\hat{Y} = -4.87595 + 2.83X$	1.022		
	Combined..	204	$\hat{Y} = -5.23262 + 3.00X$	1.008		
All areas combined.....	Female....	1,066	$\hat{Y} = -5.10707 + 2.96X$	1.001	0.082	
	Male......	912	$\hat{Y} = -4.88201 + 2.85X$	1.003		
	Combined..	1,978	$\hat{Y} = -5.13327 + 2.97X$	1.001		
			$\hat{Y} = -7.35 \times 10^{-6} X^{2.97}$			

*Significant at the 95 percent level.

are listed as S_b^2, which provides information on the variation about each regression coefficient. Values of $S_{b_♀ - b_♂}$ the estimated standard errors of the differences between regression coefficients for females and males are listed in table 2. I used the method outlined by Ostle (1966) ($t = b_♀ - b_♂ / S_{b_♀ - b_♂}$) to test statistical differences between regression coefficients (b) for males and females of each area. The resulting values of t are listed in table 2. No significant difference was noted between coefficients for males and females in the St. Augustine and Mississippi River Delta areas.

The regression coefficients (b) ranged from 3.00 to 3.22 and from 2.82 to 2.95 for females and males, respectively. It appears from these data and the variances of the regression coefficients (S_b^2) that the slopes of the lines for the females in the three areas were dissimilar; likewise the slopes of the lines for the males were also dissimilar. Using analysis of covariance on the data from the three areas, I determined whether the regression coefficients for females differed between areas and whether the regression coefficients for males differed between areas. Carrying out the "F" test outlined by Dixon and Massey (1957), I obtained F = 21.176 with degrees of freedom V_1 = 2 and V_2 = 1,062 for females and F = 7.80 with degrees of freedom V_1 = 2 and V_2 = 905 for males. These are significant at the 1-percent level. Thus the regression coefficients for females and for males differed statistically among the three areas. For the convenience of the reader, however, I have included the two estimating equations using combined female data and combined male data to provide an overall description of the length-weight relation of this species. In addition, all of the data from each area and for each sex were combined and a single estimating equation was calculated.

Table 3 lists the regression equations for estimating tail weight ($\hat{Y}$) from total weight (X) and vice versa. The regression coefficients for estimating tail weight ranged from 0.551 to 0.560 and those for estimating total weight ranged from 1.794 to 1.905. Because of the difference in the two regression coefficients between areas, it was desirable to determine by statistical tests whether the slopes of the regression lines within each group were the same. Using analysis of covariance, I computed F = 7.694 with V_1 = 2 and V_2 = 1,972 degrees of freedom for predicting total weight from tail weight, and F = 9.50 with the same degrees of freedom for predicting tail weight from total weight. There is a real difference in regression coefficients between areas for both estimating equations. However, I provide a combined estimating equation for tail weight and total weight.

Table 3.--Regression equations for estimating tail weight ($\hat{Y}$) from total weight (X) and estimating total weight ($\hat{X}$) from tail weight (Y) of royal-red shrimp (weight in decigrams)

Area	Sample size	Regression equations $Y = a + b X$
	Number of shrimp	
St. Augustine, Fla..........	1,547	$\hat{Y}$ = 1.006 + 0.553 X
		$\hat{X}$ = 1.342 + 1.833 Y
Dry Tortugas................	227	$\hat{Y}$ = 1.050 + 0.553 X
		$\hat{X}$ = 1.051 + 1.905 Y
Mississippi River Delta.....	204	$\hat{Y}$ = 1.012 + 0.560 X
		$\hat{X}$ = 1.115 + 1.794 Y
All areas combined..........	1,978	$\hat{Y}$ = 1.010 + 0.551 X
		$\hat{X}$ = 1.353 + 1.834 Y

Y = Tail weight.
X = Total weight.

I conclude that these equations, using data from each area, satisfactorily describe the relation between whole and headless weights and can be used to convert values of each.

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