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## ORIGINAL ARTICLE

# Interrelationship between Morphometric Variables and Total weight of Crayfish (*Astacus leptodactylus* Eschscholtz 1823 ) Evaluated by Path Analysis in Shian Dam lake of Kermansha, Iran

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**ABSTRACT**

*The objective of this study was to verify which morphometric variables are more directly associated with the Total weight yields of crayfish ( Astacus leptodactylus ). A total of 182 samples of crayfish ( Astacus Leptodactylus ) from Shian Dam lake with average total weight of 86.82 g ± 31.87 g were sampled, weighed, measured, and studied for morphometric analysis. The morphometric variables taken were: total weight (W g), total body length (TL mm), cephalothorax length (CTL mm), rostrum length (RL mm), post orbital cephalothorax length (POCL mm), propodus length (PL mm), dactylus length (DL mm), chela width (ChW mm) maximum thoracic width (mTW mm), second abdomen segment width (2AW) and telson width (TW mm).The phenotypic correlations analysis between total weight and morphometric measurements showed that total weight was significant positively correlated with other morphometric variables. The total body length (0.925\*\*), cephalothorax length (0.880\*\*), rostrum length (0.808\*\*), post orbital cephalothorax length (0.854\*\*), propodus length (0.832\*\*), dactylus length (0.836\*\*), chela width (0.845\*\*), maximum thoracic width (0.905\*\*), second abdomen segment width (0.424\*\*) and width of telson (0.757\*\*) was highly positively significantly correlated with total weight. These correlations were later deployed in direct and indirect effects through path analysis, and the direct and indirect contributions of each variable were measured in percentage terms. The cephalothorax length, total body length, chelae width and maximum thoracic width measures by the direct effect and post orbital cephalothorax length, propodus length, dactylus length and rostrum length variables by the indirect effect were important for determining the total weight of crayfish ( Astacus leptodactylus ) in this species.*
**Key Words**: *Path analysis, Crayfish, Astacus leptodactylus, Direct effect, Indirect effect*

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## INTRODUCTION

*Astacus leptodactylus* is a widespread species distributed throughout Europe, eastern Russia and Middle east [1]. *Astacus leptodactylus* lives in cold and clear water of anzali lagoon and Aras Dam Lake in northern Iran. Although this species has been introduced to some other reservoirs throughout Iran in recent years [2]. Several studies were conducted in related to survey of reproductive properties, morphometric and meristic characteristics, growth and production of crayfish species in the world [3, 4, 2]. In 2007, 3000 crayfish released to the Shian Dam Lake and no morphometric, meristic , reproduction and growth studies has conducted on it ever before.

## MATERIAL AND METHODS

Samples (126 specimens) were captured in different sites of Shian Dam Lake (longitude 34° 04' 36" N; latitude 46° 41' 95" E; altitude 1415 m). Crayfish were caught by fykenets of 23 mm mesh size from September 2010 to August 2011. Total body length (TL) ,Total weight (W), Cephalothorax length (CTL),

Rostrum length (RL), Post orbital cepalothorax length (POCL), Propodus length (PL), Dactylus length (DL), Chela width (ChW), Second abdomen segment (2AW), Telson width (TW) of each specimen were measured with a digital caliper to the nearest 0.1 mm, while weighted to the nearest 0.1 gr , and each specimen was sexed [5]. The phenotic correlation coefficients were computed and the path confident analysis was performed using phenotypic correlations to assess direct and indirect effect of morphological traits on body weight by used of SAS 9.2, path 2 and SPSS 20 software's.

## RESULTS AND DISCUSSION
### Interrelationship between morphometric variables with total weight
Tomris Deniz et al. [7] reported found correlation between total weight and total body length in order for Male, Female and total (Male & Female) 0.90, 0.88 and 0.83, between cephalothorax length and total weight in order for male, female and total (Male & Female) 0.91, 0.87 and 0.90 Also found correlation between chela length and total weight in order for Male, Female and total (Male & Female) 0.90, 0.81and 0.80 in *Astacus leptodactylus*, Noveri [8] reported found correlation between total body length and total weight in order for male and female 0.93, 0.93, between cephalothorax length and total weight in order for male and female 0.91, 0.93 and found correlation between post orbital cephalothorax length and total weight in order for male and female 0.93, 0.94 in *Astacus leptodactylus* and Mohsenpurazari et al. [9] reported found correlation between total body length and total weight in order for male and female 0.97 , 0.94 in *Astacus leptodactylus.*

The Spearman's rank correlation coefficient between Total weight and Morphometric measurements were calculated (Table 1). The results indicated that TL, CTL, RL, POCL, PL, DL, ChW, mTW, 2AW and TW had a significant ($P<0.01$) positive correlation with Total weight.

Table 1. Spearman's rank correlation between Morphometric measurements and Total weight

| Variable | W | TL | CTL | RL | POCL | PL | DL | ChW | mTW | 2AW | TW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W | 1 | | | | | | | | | | |
| TL | 0.925** | 1 | | | | | | | | | |
| CTL | 0.880** | 0.898** | 1 | | | | | | | | |
| RL | 0.809** | 0.810** | 0.859** | 1 | | | | | | | |
| POCL | 0.854** | 0.877** | 0.988** | 0.771** | 1 | | | | | | |
| PL | 0.832** | 0.765** | 0.813** | 0.719** | 0.797** | 1 | | | | | |
| DL | 0.836** | 0.763** | 0.814** | 0.729** | 0.796** | 0.981** | 1 | | | | |
| ChW | 0.845** | 0.748** | 0.779** | 0.674** | 0.769** | 0.953** | 0.933** | 1 | | | |
| mTW | 0.905** | 0.892** | 0.888** | 0.807** | 0.865** | 0.807** | 0.808** | 0.781** | 1 | | |
| 2AW | 0.424** | 0.512** | 0.387** | 0.361** | 0.374** | 0.002 | 0.022 | 0.028 | 0.472** | 1 | |
| TW | 0.757** | 0.784** | 0.706** | 0.586** | 0.704** | 0.517** | 0.525** | 0.538** | 0.737** | 0.625** | 1 |

Morphometric measurements: total weight (W), total body length (TL), cephalothorax length (CTL), rostrum length (RL), post orbital cephalothorax length (POCL), porpodus length(PL), dactylus length(DL), chela width (ChW ) maximum thoracic width (mTW), second abdomen segment width (2AW) and telson width (TW ). ** significant at the 1% probability levels, respectively, ns; no significant.

The "stepwise" procedure resulted in the inclusion of the following morphometric measures in the path analysis for each response variable studied: Total weight = TL, ChW, 2AW, RL and mTW. The equation of total weight achieved in this study:

$$\text{Total weight} = -180.895 + 0.864\,\text{TL} + 2.952\,\text{ChW} + 0.880\,\text{2AW} + 1.375\,\text{RL} + 0.784\,\text{mTW}$$

Table 2 - Multiple Linear Regression and Analysis of morphometric measurements with total weight

| Source of variation | Degree of Freedom | Means squires | Variable | Coefficients | Adjusted R Square |
|---|---|---|---|---|---|
| Regression | 5 | 33886.599** | (Constant) | -180.895** | |
| Residual | 175 | 76.131 | TL | 0.864** | 0.855 |
| | | | ChW | 2.952** | 0.908 |
| | | | 2AW | 0.880** | 0.920 |
| | | | RL | 1.375* | 0.924 |
| | | | mTW | 0.784* | 0.925 |

Morphometric measurements: total weight (W), total body length (TL), cephalothorax length (CTL), rostrum length (RL), post orbital cephalothorax  length (POCL), porpodus length(PL), dactylus length(DL), chela width (ChW ) maximum thoracic width (mTW), second abdomen segment width (2AW) and telson width (TW ). *; ** significant at the 5% and 1% probability levels, respectively.

T. Deniz et al.  [10]  reported found equation for male log W = - 5/1545 + 2/356 × log TL, For female   log W = -4/6898 + 3/0222 ×  log TL and For both sex log W = -5/0432 + 3/224   × log TL, for male log W = - 3/7338 + 3/0796 × log CL for female log W = -3/4604 + 2/9062 ×  log CL and for both sex  log W = - 3/6949 + 3/0524 × log CL, *in Astacus leptodactylus*, I. Balik et al. [3] reported found equation for male log W = - 10.007 + 2/922 × log L for female log W = -9.206 + 2.724 ×  log L and for both sex log W = -9/714 + 2/850 × log L in *Astacus leptodactylus* and Naviri [8] reported found equation  W= 0.00001163 + 3.255 TL for male and W= 0.0000147+ 2.2662 TL for female, for male W= 0/0003063+2.94 CL for female and W= 0.0008939 + 2.651CL and found equation for male  W= 0.00101+ 2.847 OCL and for female W= 0.003369+ 2.5122 in *Astacus leptodactylus .*

The highest correlation coefficient between the morphometric variables and weight of *Astacus leptodactylus* was observed to be the total body length with a value of 0.960 and cephalothorax length with a value of 0.948 (Table1).The positive highest direct effect value for body weight were total body length (0.449), maximum thoracic width (0.213), chela width (0.212) and dactylus length (0.138) and The highest negative direct effect value for body weight were post orbital cephalothorax  length (-0.072) and porpodus length (-0.006).The positive highest indirect sums of effect value for body weight were post orbital cephalothorax  length (0.941), porpodus length (0.828), rostrum length (0.769)  and telson width (0.752).The highest direct percentage value for body weight were total body length (47.48%), chela width (25.84%), maximum thoracic width (22.96) and second abdomen segment width (22.92%).The highest indirect percentage value for total weight were porpodus length (99.28%), telson width (97.28%), rostrum length (96.73%) and post orbital cephalothorax  length (92.89%), indicating that total body length, maximum thoracic width, chela width and dactylus length is important in determining total weight of crayfish.

Table 3 -Correlation coefficients, direct and sums of the indirect effects, and percentages of direct and indirect effects of morphometric measurements with total weight of crayfish ( *Astacus  Leptodactylus*) in Shian lake dam

| Variables | Correlation coefficient | P value | Direct effects | Sums of indirect effects | % direct effects | % indirect effects |
|---|---|---|---|---|---|---|
| TL | 0.946 | 0.000 | 0.449 | 0.497 | 47.48 | 52.52 |
| CTL | 0.484 | 0.000 | 0.049 | 0.435 | 10.12 | 89.88 |
| RL | 0.795 | 0.000 | 0.026 | 0.769 | 3.27 | 96.73 |
| POCL | 0.870 | 0.000 | -0.072 | 0.941 | 7.11 | 92.89 |
| PL | 0.821 | 0.000 | -0.006 | 0.828 | 0.72 | 99.28 |
| DL | 0.821 | 0.000 | 0.138 | 0.683 | 16.80 | 83.20 |
| ChW | 0.820 | 0.000 | 0.212 | 0.608 | 25.84 | 74.16 |
| mTW | 0.928 | 0.000 | 0.213 | 0.715 | 22.96 | 77.04 |
| 2AW | 0.463 | 0.000 | 0.106 | 0.357 | 22.92 | 77.08 |
| TW | 0.773 | 0.000 | 0.021 | 0.752 | 2.72 | 97.28 |

Morphometric measurements: total weight (W), total body length (TL), cephalothorax length (CTL), rostrum length (RL), post orbital cephalothorax  length (POCL), porpodus length(PL), dactylus length(DL), chela width (ChW ) maximum thoracic width (mTW), second abdomen segment width (2AW) and telson width (TW ).

Table 2 -Estimates of direct and indirect effects, obtained by path analysis, between the morphometric measurements and total weight of crayfish ( *Astacus  Leptodactylus*) in Shian lake dam

| Effects | TL | CTL | RL | POCL | PL | DL | ChW | mTW | 2AW | TW |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0.449 | 0.049 | 0.026 | -0.072 | -0.006 | 0.138 | 0.212 | 0.213 | 0.106 | 0.021 |
| In direct by TL | | 0.022 | 0.021 | -0.063 | -0.005 | 0.102 | 0.155 | 0.190 | 0.056 | 0.017 |
| In direct by CTL | 0.205 | | 0.011 | -0.037 | -0.002 | 0.053 | 0.076 | 0.088 | 0.031 | 0.011 |
| In direct by RL | 0.356 | 0.019 | | -0.054 | -0.004 | 0.094 | 0.137 | 0.169 | 0.039 | 0.012 |
| In direct by POCL | 0.393 | 0.025 | 0.020 | | -0.005 | 0.109 | 0.163 | 0.183 | 0.039 | 0.015 |
| In direct by PL | 0.335 | 0.018 | 0.018 | -0.057 | | 0.135 | 0.202 | 0.168 | -0.001 | 0.010 |
| In direct by DL | 0.333 | 0.019 | 0.018 | -0.057 | -0.006 | | 0.198 | 0.167 | 0.000 | 0.010 |
| In direct by ChW | 0.329 | 0.017 | 0.017 | -0.055 | -0.006 | 0.129 | | 0.164 | 0.002 | 0.011 |
| In direct by mTW | 0.401 | 0.020 | 0.021 | -0.061 | -0.005 | 0.108 | 0.163 | | 0.052 | 0.016 |
| In direct by 2AW | 0.236 | 0.014 | 0.010 | -0.026 | 0.000 | 0.000 | 0.004 | 0.104 | | 0.014 |
| In direct by TW | 0.359 | 0.025 | 0.015 | -0.050 | -0.003 | 0.068 | 0.108 | 0.160 | 0.070 | |

Morphometric measurements: total weight (W), total body length (TL), cephalothorax length (CTL), rostrum length (RL), post orbital cephalothorax  length (POCL), porpodus length(PL), dactylus length(DL),  chela width (ChW ) maximum thoracic width (mTW), second abdomen segment width (2AW) and telson width  (TW ).
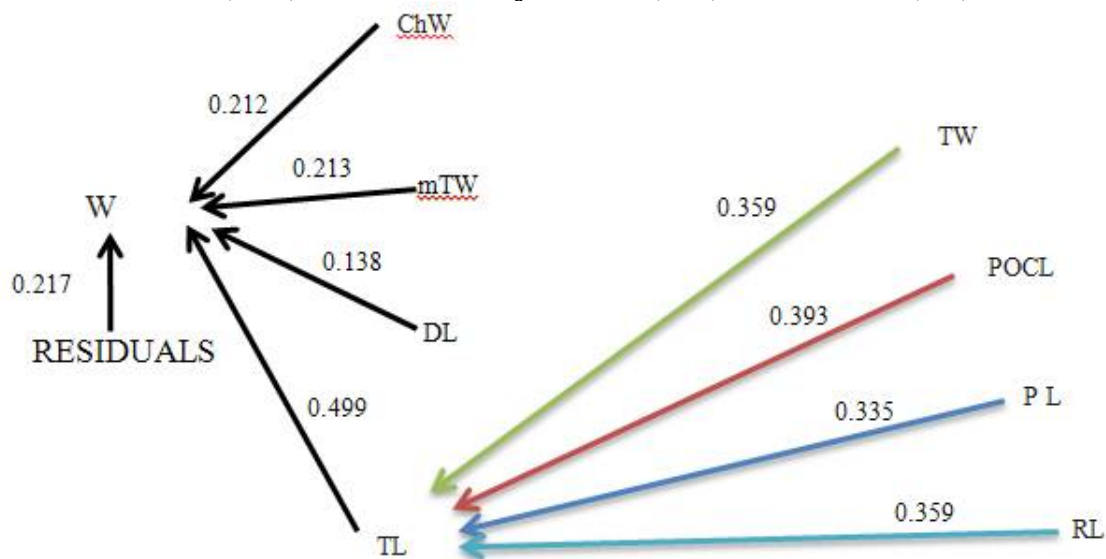


Fig. 1- Path Diagram of Some Morphometric with total weight after delete low effect
Morphometric measurements: total weight (W), total body length (TL), cephalothorax length (CTL), rostrum length (RL), post orbital cephalothorax  length (POCL), porpodus length(PL), dactylus length(DL), chela width (ChW )
maximum thoracic width (mTW), second abdomen segment width (2AW) and  telson width (TW ).

The interpretation of results was based on the following criteria: if an independent variable (x) does not present a significant correlation coefficient with the dependent variable (y), this indicates that it is not determining the variation in y, regardless of any presence or absence of any high direct effect on y; if an independent variable (x) has a significant correlation and high direct effect on the dependent variable (y), this indicates that it is determining the variation of y; and, if the independent variable (x) show a significant correlation but low direct effect on the dependent variable (y), this indicates that it should not be used alone as a determining factor for y [6].

## CONCLUSIONS
The cephalothorax length, total body length, chela width and maximum thoracic width measures by the direct effect and post orbital cephalothorax  length, porpodus length, dactylus length and rostrum length measures by the indirect effect were are important for determining the total weight of crayfish ( *Astacus leptodactylus* ). In addition, this morphometric could be used in breeding programs as a measure of direct selection for crayfish with better total weight traits, but first, it is necessary to conduct a genetic study to provide information about the heritability and genetic correlation of this variable with the total weight.

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