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Proposed Revision of the Standard Weight (*Ws*) Equation for Redear Sunfish

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ABSTRACT

Weight-length data were compiled from 289 redear sunfish Lepomis microlophus populations. We applied the regression-line-percentile (RLP) technique to weight-length data for 150 redear sunfish populations to develop a new 75th-percentile standard weight (Ws) equation. The proposed RLP Ws equation, $\log_{10}Ws = -4.968 + 3.119\log_{10}TL$ where Ws is the standard weight in grams and TL is the total length in millimeters, is valid for fish ≥70 mm TL. The English-unit equivalent, $\log_{10}Ws = -3.263 + 3.119\log_{10}TL$ where Ws is the standard weight in pounds and TL is the total length in inches, is valid for fish ≥3 in TL. We used the remaining 139 independent populations to evaluate the current $[\log_{10}Ws = -5.164 + 3.227(\log_{10}TL)]$ and RLP Ws equations for any length-related biases. We confirmed that the current Ws equation is length-biased. That is, relative weight (Wr) values significantly decreased with increasing fish length for far more populations (N=45) than they increased (N=7). We tested the proposed RLP Ws equation with the same 139 populations, and found no consistent length-related bias in Wr values calculated with the proposed RLP Ws equation (N=38, 29). Thus, we recommend the use of the proposed RLP Ws equation for redear sunfish.

INTRODUCTION

Since its development, relative weight (Wr; Wege and Anderson 1978) has been used to assess fish condition for several species (Murphy et al. 1991). The index is $Wr = 100 * W/Ws$; where W is the weight of an individual fish and Ws is the standard weight for fish of that species and total length (TL). The primary advantage of Wr is that, in theory, it avoids the length-related bias of Fulton condition factors, which increase with increasing fish length (Anderson and Gutreuter 1983). If Ws equations are free of length bias (i.e., Wr does not consistently increase or decrease with increasing fish length), any trends in Wr with respect to length should be indicative of environmental influences (Murphy et al. 1990). However, several original Ws equations developed using the 75th-percentile mean weights from Carlander (1969, 1977) have been found to contain length-related biases (e.g. Neumann and Murphy 1991, Kolander et al. 1993). Thus, the purposes of this investigation were to (1) develop a new Ws equation for redear sunfish Lepomis microlophus using the regression-line-percentile (RLP; Murphy et al. 1990) technique and (2) to evaluate the current and RLP Ws equations for any length biases.

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DATA BASE

Weight-length data for redear sunfish were solicited from biologists in nineteen states (Figure 1). When data from more than one sample year for a particular population were received, we used the year that contained the most observations. Some populations were excluded from analyses due to insufficient sample size (<10 fish) or poor coefficient of determination for $\log_{10}$-transformed weight-length regressions (r^2<0.80). Anyone wishing to obtain weight-length regressions for individual populations can contact the authors.

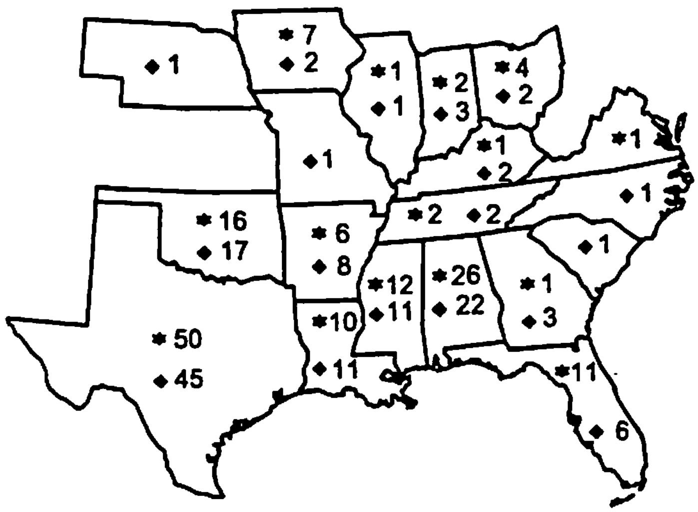

Figure 1. Geographic distribution of 289 redear sunfish populations used to develop (stars) the proposed standard weight (Ws) equation and to test (diamonds) the current and proposed Ws equations.

DEVELOPMENT OF RLP Ws EQUATION

Determination of Minimum Length

The minimum length for weight precision was determined by plotting the variance/mean ratio for $\log_{10}$weight by 1-cm groups as suggested by Murphy et al. (1990). The minimum acceptable TL was the inflection point that occurred as the ratio declined (70 mm; Figure 2). At lengths shorter than this inflection point, weight measurements were likely imprecise.

Proposed RLP Equation

Log_{10}weight-$\log_{10}$length regression equations were calculated for 70-mm and longer fish from each redear sunfish population. We randomly selected 150 populations whose $\log_{10}$weight-$\log_{10}$length regression slopes where not on the extremes of the range of population regression slopes. Mid South in

Arizona, Shawnee Twin #2 in Oklahoma, and Waxahachie in Texas (Figure 3) were eliminated for development purposes because they contained weights and lengths for fish in a narrow length range with few larger fish, which influenced their weight-length regressions. However, these three populations were used in the testing of the current and proposed RLP Ws equations.

Mean weights were predicted for the midpoints of 1-cm length intervals from the minimum length determined from the variance/mean analysis (i.e., 70 mm TL; Figure 2) to world-record length (i.e., 444 mm TL; Smokie Holcomb, Florida Game and Freshwater Fish Commission, personal communication) for each population, and the 75th-percentile of the means in each interval was determined. Then, the 75th-percentile weights were regressed on length to develop the proposed Ws equation as suggested by Murphy et al. (1990).

Application of the RLP technique provided the 75th-percentile Ws equation

$$\log_{10} \underline{Ws} = -4.968 + 3.119(\log_{10} TL),$$

where Ws is the standard weight in grams and TL is the total length in millimeters. The English equivalent of this equation is

$$\log_{10} \underline{Ws} = -3.263 + 3.119(\log_{10} TL),$$

where Ws is the standard weight in pounds and TL is the total length in inches.

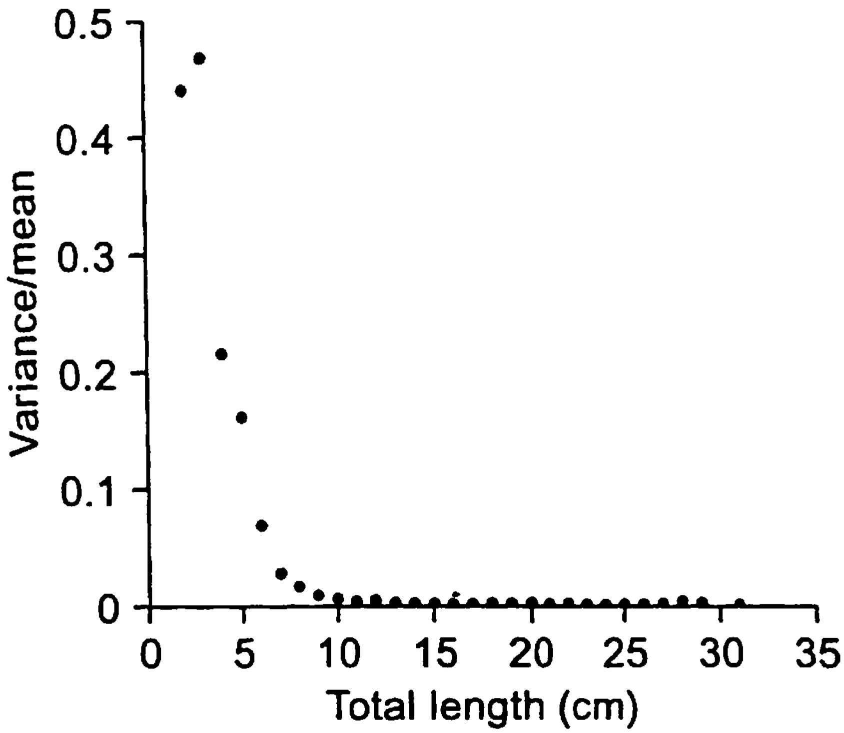

Figure 2. Variance/mean for $\log_{10}$weight by 1-cm length groups for 28,875 redear sunfish.

EVALUATION OF CURRENT Ws EQUATION

The current metric Ws equation [$\log_{10}$Ws = -5.164 + 3.227($\log_{10}$TL); Murphy et al. 1991] was evaluated with the remaining 139 populations (i.e., those populations not used to develop the RLP Ws equation) to determine whether Wr values calculated with the current Ws equation had a consistent length-related bias. The Wr values of individual fish were regressed on length for each test population. The consistency of Wr values across length for each test population was evaluated by assessment (t-test) of significant (H_0: β_0=0; P<0.05) slopes of regressions of Wr as a function of length (Murphy et al. 1990) for the current Ws equation. The total numbers of significant positive and negative population slopes were compared using chi-square (goodness of fit) analysis to detect consistent length-related bias for the current Ws equation.

When Wr values calculated with the current Ws equation were regressed on length, 52 of 139 test populations exhibited significant slopes for the relationship between Wr and TL. Chi-square analysis showed the number of negative (N=45) slopes was significantly greater than the number of positive (N=7) slopes (P<0.001); that is, Wr decreased with increasing length for far more populations than it increased with length. Thus, we concluded that the current Ws equation contained a length-related bias.

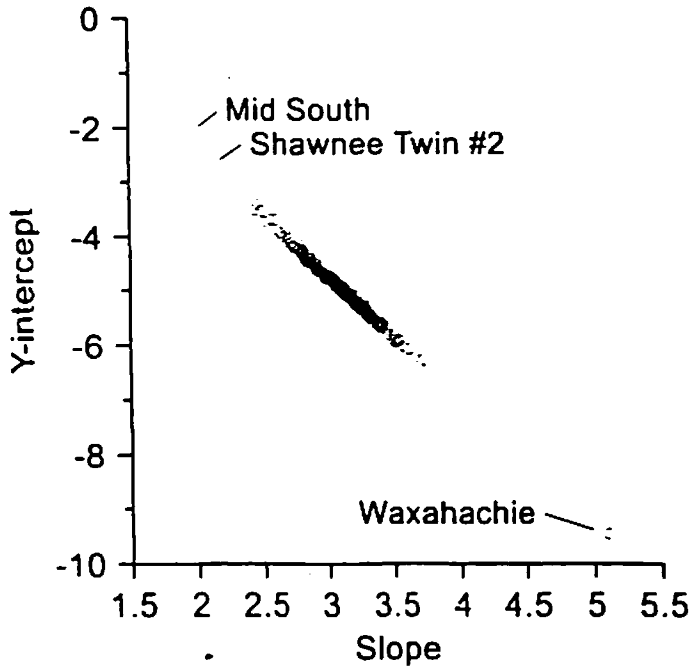

Figure 3. Plot of y-intercept as a function of slope for weight-length regressions from 289 redear sunfish populations used in the present study. Redear populations from Mid South in Arizona, Shawnee Twin #2 in Oklahoma, and Waxahachie in Texas are indicated.

EVALUATION OF RLP Ws EQUATION

We used the independent data set (N=139) and the same testing procedure used to evaluate the current Ws equation to determine whether Wr values calculated with the RLP Ws equation had a length-related bias. When Wr values calculated with the proposed RLP Ws equation were regressed on length, 67 of the 139 test populations exhibited significant slopes for the relationship between Wr and TL. Chi-square analysis showed no significant difference ($P>0.25$) in the number of significant positive (N=29) and negative (N=38) slopes with the proposed RLP equation.

A functional comparison of Wr values calculated with the current and proposed RLP Ws equations is presented in Table 1. A Wr of 100 was difficult to attain with the current Ws equation, and was less likely to occur as fish length increased.

Table 1. A comparison of relative weight (Wr) calculated for 10 redear sunfish using the proposed regression-line-percentile (RLP) standard weight equation and the current standard weight equation.

Total length (mm)	Weight (g)	Proposed RLP Wr	Current Wr
100	18.6	100	95
125	37.3	100	93
150	66.0	100	91
175	106.7	100	90
200	161.8	100	89
225	233.6	100	87
250	324.5	100	87
275	436.8	100	86
300	573.0	100	85
325	735.5	100	84

CONCLUSION

We recommend the use of the proposed RLP Ws equation for assessment of redear sunfish condition. This equation avoids the problem of length-related bias associated with the current Ws equation. If the proposed RLP Ws equation is used, we believe that trends in Wr across length in individual redear sunfish populations will be attributable to specific ecological factors rather than a length-biased Ws equation.

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