การประมาณค่าทางพันธุกรรมและการพัฒนาดัชนีการคัดเลือกสำหรับปลาบู่ (*Oxyeleotoris marmoratus* Bleeker)

Estimation of Genetic Parameters and the Development of Selection Indices for Sand Gody Fishes (*Oxyeleotoris marmoratus* Bleeker)

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บทคัดย่อ

ปลาบู่ที่ใช้ในการทดลอง จำนวน 72 ตัว เป็นปลาบู่ที่เกิดจากการจัดการผสมพันธุ์แบบ hierarchical ของพ่อจำนวน 13 ตัว ที่ผสมกับแม่ จำนวน 28 ตัว การประมาณค่าอัตราพันธุกรรมของพี่น้องร่วมพ่อแต่ต่างแม่ พบว่า ค่าอัตราพันธุกรรมของน้ำหนักตัวเมื่ออายุ 9 เดือน (BW) เปอร์เซ็นต์ความสม่ำเสมอของฝูงเมื่ออายุ 2 เดือน (UP) และเปอร์เซ็นต์การเลี้ยงรอดเมื่ออายุ 2 เดือน (SP) มีค่าอยู่ในระดับต่ำถึงปานกลาง ค่าสมสัมพันธ์ของลักษณะปรากฏระหว่าง BW กับ UP (-0.14) และระหว่าง UP กับ SP (-0.16) มีความสัมพันธ์กันในทางลบอย่างมีนัยสำคัญ (P<.01) ค่าสมสัมพันธ์ทางพันธุกรรมระหว่าง BW กับ UP มีค่าเท่ากับ 0.17 ขณะที่ค่าสหสัมพันธ์ทางพันธุกรรมระหว่าง UP กับ SP มีค่าเท่ากับ -0.12 ดัชนีการคัดเลือกที่มีค่าสหสัมพันธ์ระหว่างดัชนีกับคุณค่าการผสมพันธ์ที่แท้จริงสูงที่สุด คือ I = 23.89BW (r_{HI}=0.61) และ I = 0.36BW + 0.26SP (r_{HI}=0.61)

คำสำคัญ : ปลาบู่ อัตราพันธุกรรม สหสัมพันธ์ทางพันธุกรรม ดัชนีการคัดเลือก

ABSTRACT

A total of 72 heads of pedigree-hatched sand gody fishes (*Oxyeleotoris marmoratus* Bleeker) obtained from a mating population of 13 sires and 28 dams were used in this study. Heritability estimates based on paternal half-sib of body weight at 9 months old (BW), uniformity percentage (UP) and survival percentage (SP) were found to be lowly to moderately heritable. Negative phenotypic correlations (P<01) were found in BW with SP (-0.14) and UP with SP (-0.16). Positive genetic correlation was found between BW and UP (0.17). Whereas, genetic correlation between UP and SP was negative (-0.12) Out of 7 selection index formulas developed, the following indices considering the number of trials showed the highest coefficient of determination (r_{HI}) : I (1 trait) = 23.89BW (r_{HI} = 0.61); I (for 2 traits) = 0.36BW + 0.26SP (r_{HI}=0.61).

Keywords : sand gody fishes, *Oxyeleotoris marmoratus,* heritability, genetic correlation, selection index

INTRODUCTION

Sand gody fish one of the most popular fish are preferred by many Thais because of the taste and their suitability for special dishes. The raising of sand gody fishes in Thailand is primarily intended for export to Singapore, Hong Kong and Malaysia which requires large size of fish. However, one of the major constraints of the sand gody fish industry in Thailand is the lack of locally developed quality stocks. The varying body size, high mortality rate and low uniformity percentage result in high production cost.

The modern breeding programs for domestic animal species have put emphasize on decreasing production cost and increasing productivity. In any breeding program, it is important to have reliable estimates of important genetic parameters using the existing population. Heritability provides information to the proportion of genetic variance in relation to the total variances for a particular trait which will serve as guide to the selection method to be used. On the other hand, correlation estimate among traits will likewise serve as guide as to what selection parameters will be used simultaneously in improving two or more traits (Mohiuddin, 1993). In most animal improvement programs, there is a need to develop more than one trait at a time. It is recognized that development of one trait may cause improvement or deterioration in associated traits. Selection indices provide one method to improve two or more traits in a breeding program (Legates and Warwick, 1990).

In other species of animals such as number of studies on the development and utilization of selection indices have been reported. However, in sand gody fishes, no documented information is available. Hence, this study was conducted to develop selection indices for sand gody fishes.

MATERIALS AND METHODS

Experimental Stocks

A total of twenty-eight (28) ready-to-lay dams and thirteen (13) contemporary sires of vigorous sand gody fishes were selected as parental stocks. The parental stocks were collected from Chonburi, Suphanburi and Ayutthaya.

Experimental Design

There were thirteen (13) sire families established. Each family was assigned at random with five (5) dams and one (1) sire following hierarchical design in the mating ponds. The five (5) unit individual egg-tray were installed in a pond. After the dams had laid egg on the egg tray, the egg-trays were tranfered and incubated in the growing ponds. The ponds were assigned the number to properly identify fishes according to their parents. At 2 months old, ten (10) of vigorous fishes in a pond were selected as experimental stocks and raised until 9 months old for measurement of body weight.

Statistical Analysis

A statistical model of the nested classification for each trait considered was assumed as follows (Becker,1975):

$Y_{ik} = \mu + S_i + e_{ik}$

where:

Y_{ik} = the phenotypic measurement of the trait in the k^{th} progeny of i^{th} sire

μ = general mean of measurement of the trait

S_i = random effect of the i^{th} sire, with i = 1, 2... p, where p is the number of sires

e_{ijk} = random error

The assumptions made in the above model for the analysis of variance are the data set followed normal distribution and all errors are normally and independently distributed among the mean of zero and error variance.

Phenotypic Parameters

Analysis of variance and covariance of body weight, uniformity percentage and survival percentage were made by using General Linear Model and Pearson's Correlation Procedures of the Statistical Analysis System (SAS, 1991).

It was assumed that individual fish were chosen at random from the population and their inbreeding coefficient (F) is zero.

Genetic Parameters

Estimation of heritability. Heritability was estimated following the method of Becker (1975).

The components σ^2_W, σ^2_D, and σ^2_S and coefficients of variance component k_1, k_2 and k_3 in this study were taken from variance components estimation procedure of PROC VARCOMP of the Statistical Analysis System (SAS, 1991).

Heritability estimates were calculated from the components of variance of the paternal half-sib (PHS) using the following equation (Becker, 1975) :

$$h^2_S = \frac{4\,\sigma^2_S}{\sigma^2_S + \sigma^2_W}$$

Standard errors of heritabilities (S.E. (h^2)) were computed using the following equation (Dickerson, 1967).

$$S.E.(h^2_S) \approx \frac{4\sqrt{var(\sigma^2_S)}}{\sigma^2_S + \sigma^2_W}$$

Estimation of genetic correlation. The estimation of genetic correlation between two traits was obtained by method similar to those used in estimating genetic variance (Becker, 1975). Genetic correlations (r_G) from sire component of variance and covariance were calculated using the following equation (Becker, 1975):

$$r_G = \frac{4\ COV_{S(xy)}}{\sqrt{4\sigma^2_{S(X)} \cdot 4\sigma^2_{S(Y)}}}$$

Standard deviation of genetic correlation (S.E.(r_G)) was computed using the following equation (Falconer, 1981):

$$S.E.(r_G) = \frac{1 - r_G^2}{\sqrt{2}} \sqrt{\frac{S.E.(h^2_1)\ S.E.(h^2_2)}{h^2_1 h^2_2}}$$

Estimation of Economic Value

Economic values of the traits used in the different selection indices were estimated following the procedure reported by Melton et al. (1979), Brascamp et al. (1985), Smith et al. (1986) and Bondoc et al. (1999). In economic terms, production of fishes was achieved by combining a number of inputs, including feed, labor and capital plus the capacity of the fish. The technical relationship between products (outputs) and resources (inputs) was expressed by a production function such that inputs were partitioned into two categories those inherently embodied in the animal, namely EW40, EN40, EM40, BW40, ASM, FCR, SI, HU, SW and ST and those exogenously supplied by the firm as expressed by its cost of production (COP). The animal entity production function is defined as the body weight per fish (Y),

$Y = f$ (EW40, EN40, EM40, BW40, ASM, FCR, HU, SI, ST, SW)

With the corresponding profit function (π) of:

$$\pi = P_y Y - \sum^{n}_{i=1} P_i X_i - FC$$

where: P_y = price per unit of fish output per fish (Y)

P_i = price per unit of the i^{th} input

X_i = units of the i^{th} input used

FC = fixed cost

It was assumed that the producer wanted to maximize profits. Maximizing the profit function mathematically involved equating the partial derivatives of that function with respect to each variable to zero and simultaneously solving the resulting system of first-order condition for optimal levels of the variables. The simultaneous relations yielded by this are expressed as:

$$\frac{\delta\pi}{\delta X_i} = P_y \frac{\delta_y}{\delta X_i} - P_i = 0$$

$$\text{or} \quad P_{\text{body weight}} = P_y \frac{\delta_y}{\delta(\text{body weight})} ,$$

$$\text{or} \quad P_{\text{uniformity percentage}} = P_y \frac{\delta_y}{\delta(\text{uniformity percentage})} ,$$

$$\text{or} \quad P_{\text{survival percentage}} = P_y \frac{\delta_y}{\delta(\text{survival percentage})} ,$$

The economic values of each trait were determined by substituting average values of all traits considered. The relative economic values of an increase of one standard deviation in one trait to the economic values of an increase of standard deviation in another trait were calculated by multiplying each economic value with its standard deviation (Van Vleck et al., 1987).

Selection Index

The selection indices were developed in this study using the procedure described by Hazel (1943) as follows:

$$I = b_1 X_1 + b_2 X_2 + \dots\dots\dots + b_k X_k$$

where: b_i = the coefficients of i^{th} trait, i = 1, 2,…,k

X_i = the phenotypic values of i^{th} trait, i = 1, 2,…,k

To obtain a set of values for the b_i's which maximizes the correlation between I and H, the desired solution to the b_i's was obtained from a set of simultaneous linear equations. These could conveniently be represented by matrix notation as follows:

$$P\underline{b} = G\underline{a}$$

where: P = the phenotypic variance – covariance matrix

G = the genotypic variance – covariance matrix

a = the vector relative economic values

b = the vector of partial regression coefficient of x's in the index

The accuracy of selection index, r_{HI} (Konanta, 1968) is:

$$r_{HI} = \sqrt{\frac{\sigma^2_I}{\sigma^2_H}}$$

Single trait index was calculated by multiplying heritability with the phenotypic value of the trait. The accuracy (r_{HI}) was computed as the square root of the trait's heritability (Van Vleck, 1993).

Selection indices were compared using the accuracy of the selection index (r_{HI}). The best selection index is one with the highest accuracy of predicting breeding value, thus maximizing annual genetic progress realized from selection. All calculations were carried out through Microsoft Excel to facilitate matrix operations.

RESULT AND DISSCUSSION

Means and Standard Deviations

The means and standard deviations of sand gody fishes are shown in Table 1. The means and standard deviations of body weight, uniformity percentage and survival percentage were 263.06±90.775 g, 38.743±15.694 % and 14.615±10.423 %, respectively. The variability in body weight, uniformity percentage and survival percentage as indicated in the standard deviation, were high indicating high potential for improvement through selection.

Table 1. Means and standard deviations of the traits of sand gody fishes

TRAIT	MEAN ± SD
Body weight (g) [1/]	263.06±90.775
Uniformity (%)[1/]	38.743±15.694
Survival (%)[2/]	14.615±10.423

[1/] at 2 months old [2/] at 9 months old and n = 72 observations

Genetics Parameter Estimates

The genetic parameter estimates of the traits of sand gody fishes are shown in Table 2. The heritability and standard error estimates of body weight, uniformity percentage and survival percentage based on sire component of variance (h^2_S) were 0.37±0.21, 0.21±0.18 and 0.17±0.09, respectively. This result tend to suggests that the body weight at 9 months of age, uniformity percentage and survival percentage at 2 months old that can be improved through the use of appropriate selection and breeding system. The estimate for genetic correlation of body weight with uniformity of percentage (r_G = 0.17±0.04) was low and positive. The genetic increase in uniformity of percentage at 2 months old partially increases the body weight at 9 months old. A low and negative correlation was found between body weight and survival percentage (-0.12±0.03) and also evident between uniformity of percentage and survival percentage (-0.07±0.040). In this study, body weight was found to be uncorrelated with uniformity percentage (0.08). This result implies that body weight at 9 months old of sand gody fish has no influenced at all on the uniformity percentage at 2 months old. Negative and highly significant phenotypic correlation was noted between body weight at 9 months old and survival percentage at 2 months old (-0.14). Similarly, uniformity percentage at 2 months old was found to be negatively correlated with survival percentage at 2 months old (0.146) indicating that the higher the survival percentage value, the lower is the uniformity percentage.

Table 2. Heritabilities (diagonal) phenotypic[1/] (above diagonal), genetic (below diagonal) correlations among traits in sand gody fish

TRAIT [3/]	Body weight at 9 months old	Uniformity percentage at 2 months old	Survival percentage at 2 months old
Body weight at 9 months old	0.37	0.08^{ns}	-0.14^{**}
Uniformity percentage	0.17±0.04	0.21	-0.16^{**}
Survival percentage	-0.12±0.03	-0.07±0.040	0.17

[1/] Values greater tan 0.09 are significantly different from 0 (P<.05) and values greater than 0.12 are highly significant different from 0 (P<.01)

^{ns} = P> .05 and ** = P< .01

Economic Values and Relative Economic Weights

The means and standard deviations taken from 72 observations were 263.06±90.775 g, 38.743±15.694 % and 14.615±10.423 % for body weight, uniformity percentage and survival percentage, respectively. The price per unit of sand gody fish output was 320.00 baht per kilogram in year 2007. A total of 48 economic values and relative economic weights were computed. The economic values and relative economic weights of the traits are presented in Table 3.

The economic values of two traits combination of body weight at 9 months old and uniformity percentage were 1.13 and 0.49 baht, respectively while the relative economic weight for body weight at 9 months old is 1 and 0.49 for uniformity percentage at 2 months old. In terms of genetic improvement, each gram increase in body weight at 9 months old entails a gain of 1.13 baht while and uniformity percentage increase entails 0.49 baht. On the other hand, the economic values of body weight at 9 months old and survival percentage at 2 months old were 0.88 and -0.53 baht, respectively and their relative economic weight was 1 and -0.6, respectively. While, the economic values of uniformity percentage at 2 months old and survival percentage at 2 months old were -0.57 and -1.97 baht, respectively and their relative economic weight was 1 and 3.46, respectively The economic values for three traits combination of body weight at 9 months old, uniformity percentage and survival percentage were 0.82, -0.51 and -1.50 baht, respectively and their relative economic weight was 1, -0.61 and -1.81, respectively.

Table 3. Economic values and relative economic weights of the traits of sand gody fishes

TRAIT COMBINATION[1]	TRAIT	ECONOMIC VALUE (baht)	RELATIVE ECONOMIC WEIGHT
BW-UP	BW	1.13	1
	UP	0.49	0.44
BW-SP	BW	0.88	1
	SP	-0.53	-0.6
UP-SP	UP	-0.57	1
	SP	-1.97	3.46
BW-UP-SP	BW	0.82	1
	UP	-0.51	-0.61
	SP	-1.50	-1.81

[1] BW = body weight at 9 months old UP = uniformity percentage at 2 months old SP = survival percentage at 2 months old

Selection Indices for Sand Gody Fishes

A total of seven (7) selection indices are shown in Table 4. The first three indices (I_1 to I_3) corresponded to single trait indices. These were I_1 = 23.89BW (r_{HI} = 0.61), I_2 = 0.60UP (r_{HI} = 0.41), I_3 =29.71SP (r_{HI} = 0.46). It was noted that index I_1 would provide the highest r_{HI} value and therefore expected to give the greatest possible genetic gain as a result of selection. The indices (I_4 to I_6) were constructed based on two traits which were I_4 = 0.31BW - 0.12UP (r_{HI} = 0.49), I_5 = 0.36BW + 0.26SP (r_{HI} = 0.61) and I_6 = 0.19UP + 1.85SP (r_{HI} = 0.50). The indices I_7 was constructed for three economic traits. The index I_7 = 0.32BW – 0.11UP – 0.92SP had the accuracy of 0.55.

Table 4. Selection indices constructed for sand gody fishes

INDEX [1]	r_{HI}
I_1 = 23.89BW	0.61
I_2 = 0.60UP	0.41
I_3 = 29.71SP	0.46
I_4 = 0.31BW - 0.12UP	0.49
I_5 = 0.36BW + 0.26SP	0.61
I_6 = 0.19UP + 1.85SP	0.50
I_7 = 0.32BW – 0.11UP – 0.92SP	0.55

[1] BW = body weight at 9 months old UP = uniformity percentage at 2 months old SP = survival percentage at 2 months old

SUMMARY

Data were collected from pedigree hatched of 72 heads of fish which hatching eggs collected from hierarchical mating of 13 sires and 28 dams. These data were analyzed to estimate the phenotypic, genetic and economic parameters of the traits and to use these information in the development of selection indices. The summaries of results are presented as follows:

1. The means and standard deviations of body weight, uniformity percentage and survival percentage were 263.06±90.775 g, 38.743±15.694 % and 14.615±10.423 %, respectively.

2. The heritability and standard error estimates of body weight, uniformity percentage and survival percentage based on sire component of variance (h^2_S) were 0.37±0.21, 0.21±0.18 and 0.17±0.09, respectively. The genetic correlation of body weight with uniformity percentage was low and positive. A low and negative correlation was found between body weight and survival percentage and also evident between uniformity percentage and survival percentage. Body weight was found to be uncorrelated with uniformity percentage (0.08). Negative and highly significant phenotypic correlation was noted between body weight at 9 months old and survival percentage at 2 months old (-0.14). Similarly, uniformity percentage at 2 months old was found to be negatively correlated with survival percentage at 2 months old (0.146).

5. Seven (7) selection indices were developed using three (3) traits on body weight, uniformity percentage and survival percentage traits. Considering only one trait, the selection index formula found with the highest accuracy (r_{HI}=0.61) was I=23.89BW. Considering combination of 2 or more traits, the following index formulas were found to have the highest coefficient of determination; I_5 = 0.36BW + 0.26SP (r_{HI}=0.61).

This study showed that the fishes have the phenotypic and the genetic variabilities that would warrant improvement through selection. The parameter obtained in this study could serve better as input to a genetic improvement of the body weight at 9 months old, uniformity percentage and survival percentage at 2 months old of the sand gody fishes toward improving their genetic potential. The selection index formulas developed could very well help the raisers on improving their flocks of sand gody fishes.

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