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RESEARCH PAPER

Morphometric and Meristic Variation of Indigenous and Thai Koi, *Anabas testudineus* Available in Coastal Region of Bangladesh

Md. Belal Hossen [1*], Md. Rajib Sharker [1], Md. Arifur Rahman [1] and Md. Sazedul Hoque [2]

[1]Department of Fisheries Biology and Genetics, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.
[2]Department of Fisheries Technology, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.

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*Corresponding author:
blshah@pstu.ac.bd

ABSTRACT

Morphological variation between indigenous and Thai koi (*Anabas testudineus*) was investigated by univariate analysis of 19 morphometric and 12 meristic characters. Sample of indigenous koi was collected from different household pond of Dumki upazilla under Patuakhali district and Thai koi from port road fish market of Barisal sadar upazilla under Barisal district. A number of 20 individuals from each stock were randomly selected and morphometric and meristic data were recorded. Allometric method was used for size adjustment of morphometric characters. Univariate analysis of variance revealed significant variation ($p<0.01$) between indigenous and Thai koi in respect of morphometric characters i.e SL, HL, HBD, PostOL, ED, HDF, HPcF, HPvF, HAF, LDFB, LAFB and UJL as well as meristic characters i.e. DFS, DFR, PvFR, AFS, and SOLL. Nonparametric Kruskal wallis (H) test also revealed significant variation both in morphometric and meristic characteristics of indigenous and thai koi. Hierarchical cluster analysis of morphometric characters showed a high divergence between the populations while the meristic characters did not show such type of divergence. The morphometric and meristic differences appeared between the two populations may be due to their genetic differences and/or environmental factors or these are two sub species of the genus *Anabas*.

Key words: Meristic, Morphometric, Indigenous koi and Thai koi (*Anabas testudineus*)

Introduction

Morphometric and meristic characters are used widely to identify fish stocks (Turan *et al.*, 2004) and it has often been used in discrimination and classification studies by statistical techniques (Avsar 1994). In spite of the initiation of techniques which directly examine biochemical or molecular genetic variation, these conventional methods play an important role in stock identification even today (Swain and Foote 1999). The study of differences and variability in respect of morphometric and meristic characters of fish stocks is important in phylogenetics and in providing information for subsequent studies on the genetic improvement of stocks (Shola *et al.*, 2015).
The climbing perch, (*Anabas testudineus*) locally known as koi and it naturally occurs in Bangladesh, India, Pakistan, Ceylon, Myanmar, Srilanka, Thailand, Souththern China, Philippines, Polynesia, and Malaysia (Sen, 1985; Talwar and Jhingram, 1991). Body of *A. testudineus* is slender with a long-based dorsal fin and large regularly-arranged ctenoid scales; greenish to brownish, more dusky to olive-green above, pale below; head with longitudinal stripes below eye, iris golden, dark spot on margin of gill cover (Talwar and Jhingran, 1991). Once upon a time, koi was very much abundant in almost all freshwater systems of Bangladesh (Mahmood, 2003). In the recent years the availability of this fish is decreasing from natural system due to ecological degradation, indiscriminate use of pesticides, destruction of habitats, obstruction of breeding migration and fishing pressure etc. But it has a great demand in the market for its high nutritive value, good taste and low market price. Since the natural production of indigenous koi is decreasing, fisheries biologists are thinking of its cultivation through intensive farming (DoF, 2002). However, the growth rate of indigenous koi is not so high to that of other koi species available in Thailand and Vietnam. Therefore,

an exotic koi was introduced from Thailand in 2002 by Bangladesh Fisheries Research Institute (BFRI) and developed its induced breeding and culture technology (Kohinoor and Zaher, 2006). Although Thai koi show high growth performance compared to indigenous koi species of Bangladesh but consumers prefer indigenous koi for its good taste. Thai Koi looks like indigenous koi but its body covers with gray color and small black spots (Roy et al., 2013). A number of studies have been done on the biology and aquaculture of climbing perch (*A. testudineus*), *i.e.* Kottelat *et al.* (1993) and Talwar and Jhingran (1991) reported the distinguishing characteristics of *A. testudineus*, Hassan *et al.*(2005) compared the taxonomy of five population of *A. testudineus* from five region of Bangladesh, Kasi *et al.* (2009) worked on the fecundity of *A. testudineus* in Malysia, Kohinoor *et al*. (2007) studied the monoculture of Thai koi under different stocking densities, Alam *et al.* (2007) studied the growth performance and morphological variation of local and Thai koi in Mymensingh district of Bangladesh, Atal *et al.* (2009) studied breeding performance of Thai koi in different months of the breeding season and Begum and Minar (2012) studied the length-weight relationship of koi. According to Robert (1989) both indigenous koi of Bangladesh and Thai koi are the same species. Though Thai koi and indigenous koi belongs to the same taxonomic position; however, Alam *et al.* (2007) observed some variations in some of their morphological characters as well as in their growth performance. As they belong to the same taxonomic position so, why do they vary? Information in this regard is still inadequate. Therefore, there are some scopes to do research in this area. So the present study was conducted to find out morphological variation in respect of morphometric and meristic characters between indigenous and exotic stock of *A. testudineus* available in the coastal region of Bangladesh and hence to come to a conclusion that whether this two populations of *A. testudineus* are morphologically similar or not.

Materials and Methods

The study was conducted for the period of five months from November 2016 to March 2017 in the laboratory of the Faculty of Fisheries, Patukhali Science and Technology University, Dumki, Patuakhali, Bangladesh. Samples of indigenous koi and Thai koi were collected from different household ponds of Dumki upazila under Patuakhali district and port road fish market of Barisal sadar upazila under Barisal District respectively. A number of 20 individuals from each stock were randomly selected and the morphometric and meristic characters data were recorded separately from both the samples by using measuring scale, needle, and magnifying glass.

Collection of Data

A total of 31 morphological characters were used which included 19 morphometric variables and 12 meristic variables which were directly measured and counted, respectively. The morphometric variables were measured to the nearest 0.1 cm using a measuring board.

The morphometric variables included Total Length (TL), Standard Length (SL), Head length (HL), Head Depth (HD), Pre-Orbital length (PrOL), Eye diameter (ED), Post-orbital length (PostOL), Highest Body Depth (HBD), Lowest Body Depth (LBD), Height of Dorsal Fin (HDF), Height of Pectoral Fin (HPcF), Height of Pelvic Fin (HPvF), Height of Anal Fin (HAF), Base length of Dorsal Fin (BDF), Base length of Pectoral Fin (BPcF), Base length of Pelvic Fin (BPvF), Base length of Anal Fin (BAF), Upper Jaw Length (UJL), and Lower Jaw Length (LJL) (Fig. 1).

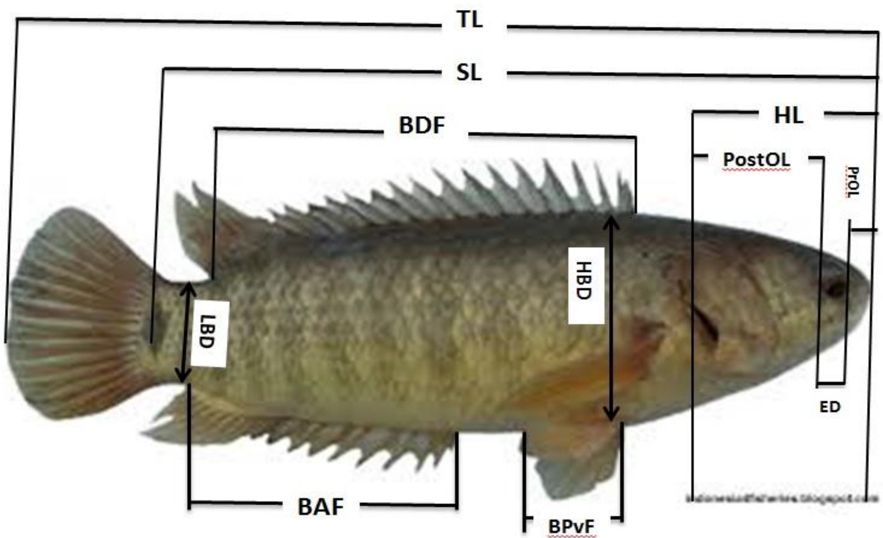

Figure 1. Indication of different morphometric measurements on *A. testudineus.*

Meristic characters included; number of Branchiostegal Ray (BR), number of Spines in the Dorsal Fin (DFS), number of the Rays in the Dorsal Fin (DFR), number of Rays in the Pectoral Fin (PcFR), number of Spine in Pelvic Fin (PvFS), number of Rays in Pelvic Fin (PvFR), number of Spines in the Anal Fin (AFS), number of Rays in the Anal Fin (AFR), number of Rays in Caudal Fin (CFR), number of Scales on Lateral Line (SoLL), number of Scales Above Lateral Line (SALL), and number of Scales Below Lateral Line (SBLL).

Analysis was carried out separately for morphometric and meristic characters. Morphometric characters can be susceptible to environmental factors while most meristic characters are fixed early during the development. Since meristic characters were independent of size of the fish and did not change during growth (Strauss, 1985; Murta, 2000) the raw meristic data were used in analysis. However, to avoid possible biases produced by size effects on the morphometric variables, all morphometric characters were standardized by the formula

ACi = log OCi – [β × (logTLi – logMTL)] (Claytor & MacCrimmon, 1987)

where,

ACi is the adjusted logarithmic character measurements of the i^{th} specimen (i=1,2,3..);

OCi is the unadjusted character measurement of the i^{th} specimen (i=1,2,3..);

β is the common within-group regression coefficient of that character against total length after the logarithmic transformation of both variables;

TLi is the total length of the i^{th} specimen (i=1,2,3..); and MTL is the overall mean total length.

Efficiency of allometric formula in removing size effect from the data was justified by using correlation between total length and adjusted characters. That is why total length was excluded first and not transformed because using this parameter as standard all other parameters were standardized following the similar technique performed by Mollah *et al.*(2012) for *Glossogobius giuris*.

Data Analysis

Univariate analysis of variances (ANOVA) was performed to examine the significant differences between the populations. Kruskal–Wallis test was used to compare means between the groups. Cluster analysis was done separately for morphometric and meristic data. Two dendrogram were constructed by ward linkage method to show the clustering pattern of these two populations. Morphometric and meristic data of the fish belonging to each group were analyzed using SPSS (version 22) and MS excel (version 10).

Results and Discussion

Morphometric characteristics

Univariate analysis of variance (ANOVA) revealed significant variation (p<0.01) in case of SL, HL, HBD, PostOL, ED, HDF, HPcF, HPvF, HAF, LDFB, LAFB, and UJL (Table 1).

Alam et al. (2007) and Alam et al. (2014) also reported significant variation (*P*<0.01) between indigenous and thai koi in TL, SL, HL, HBD, LBD, PCFL, PELFL, AFL, UJL and LJL. In their study they reported no difference in case of postOL and ED which showed significant difference in present study, indicating some new variation is appearing in morphometric characters of indigenous and Thai koi in coastal region of Bangladesh. The causes of morphological differences between populations are often quite difficult to explain (Poulet *et al.*, 2004) but it is well known that morphometric characters can show a high degree of plasticity in response to environmental conditions (Wimberger, 1992). Again the observed morphological differences may be due to the fact that their genetic quality might be different (Alam *et al.* 2014).

Table 1. Morphometric characters showing significant and insignificant difference between indigenous and Thai koi

Morphometric Characters	Wilks' Lambda	F*	*P* value
SL	0.116	288.898	0.000**
HL	0.610	24.345	0.000**
HD	1.000	0.007	0.934
HBD	0.731	13.986	0.001**
LBD	0.986	0.545	0.465
PreOL	0.951	1.958	0.170
PostOL	0.817	8.518	0.006**
ED	0.018	2027.339	0.000**
HDF	0.628	22.524	0.000**
HPcF	0.711	15.455	0.000**
HPvF	0.785	10.434	0.003**
HAF	0.537	32.748	0.000**
LDFB	0.468	43.180	0.000**
LPcFB	0.932	2.761	0.105
LPvFB	1.000	0.004	0.948
LAFB	0.536	32.912	0.000**
UJL	0.770	11.324	0.002**
LJL	0.884	4.990	0.031

** Values of the parameter differs significantly (p<0.01)
*F value of Univariate ANOVA test.

A Kruskal-Wallis (H) test showed that indigenous koi and thai koi are significantly different from each other (P<0.01) in respect of SL (χ^2 = 29.282 with mean rank 10.50 for indigenous koi and 30.50 for thai koi), HL (χ^2 = 14.769 with mean rank 13.40 for indigenous koi and 27.60 for thai koi), HBD (χ^2 = 10.994 with mean rank 14.38 for indigenous koi and 27.63 for thai koi), Post-OL (χ^2 = 12.372 with mean rank 14.00 for indigenous koi and 27.00 for thai koi), ED (χ^2 = 29.296 with mean rank 30.50 for indigenous koi and 10.50 for thai koi), HDF (χ^2 = 15.922 with mean rank 13.13 for indigenous koi and 27.88 for thai koi), HPcF (χ^2 = 18.625 with mean rank 12.53 for indigenous koi and 28.48 for thai koi), HPvF (χ^2 = 13.339 with mean rank 13.75 for indigenous koi and 27.25 for thai koi), HAF (χ^2 = 18.74 with mean rank

12.50 for indigenous koi and 28.50 for thai koi), LDFB (χ^2 = 29.288 with mean rank 10.50 for indigenous koi and 30.50 for thai koi) ,LPcFB (χ^2 = 8.308 with mean rank 15.18 for indigenous koi and 25.83 for thai koi), LAFB (χ^2 = 28.702 with mean rank 10.60 for indigenous koi and 30.40 for thai koi) and UJL (χ^2= 10.553 with mean rank 14.50 for indigenous koi and 26.50 for thai koi) (Table 2)

Table 2. Kruskal-Wallis (H) test for comparison of morphometric characters of indigenous and Thai koi (*A. testudineus*).

	Mean rank				
Morphometric Characters	**Indigenous koi**	**Thai koi**	**Chi-Square (χ^2)**	**df**	***P* value**
SL	10.50	30.50	29.282	1	0.000**
HL	13.40	27.60	14.769	1	0.000**
HD	19.13	21.88	0.554	1	0.457
HBD	14.38	26.63	10.994	1	0.001**
LBD	17.48	23.53	2.681	1	0.102
PreOL	18.90	22.10	0.750	1	0.387
PostOL	14.00	27.00	12.372	1	0.000**
ED	30.50	10.50	29.296	1	0.000**
HDF	13.13	27.88	15.992	1	0.000**
HPcF	12.53	28.48	18.625	1	0.000**
HPvF	13.75	27.25	13.339	1	0.000**
HAF	12.50	28.50	18.746	1	0.000**
LDFB	10.50	30.50	29.288	1	0.000**
LPcFB	15.18	25.83	8.308	1	0.004**
LPvFB	20.40	20.60	0.003	1	0.957
LAFB	10.60	30.40	28.702	1	0.000**
UJL	14.50	26.50	10.553	1	0.001**
LJL	17.33	23.68	2.955	1	0.086

** Values of the parameter differs significantly ($p<0.01$)

Meristic characteristics

Univariate analysis of variance (ANOVA) revealed significant variation ($p<0.01$) in case of DFS, DFR, PvFR, AFS, SOLL (Table 3).

A Kruskal-Wallis (H) test showed that indigenous koi and thai koi are significantly different from each other ($P<0.01$) in respect of BSR (χ^2 = 39.000 with mean rank 30.50 for indigenous koi and 10.50 for thai koi), DFS (χ^2 = 8.815 with mean rank 15.35 for indigenous koi and 25.65 for thai koi), DFR (χ^2 = 23.542 with mean rank 11.90 for indigenous koi and 29.10 for thai koi), PvFR (χ^2 = 9.697 with mean rank 16.50 for indigenous koi and 24.50 for thai koi), AFS (χ^2 = 32.933 with mean rank 30.00 for indigenous koi and 11.00 for thai koi) and SOLL (χ^2 = 21.770 with mean rank 12.05 for indigenous koi and 28.95 for thai koi) (Table 4). Mollah *et al.* (2012) also used Kruskal-Wallis (H) test to find out morphological variation among three population of *Glossogobius giuris* and reported significant variation ($p<0.05$) in case of DFR, CFR, TSOLL, TSALL and TSBL.

Table 3. Meristic characters showing significant and insignificant difference between indigenous and thai koi.

Meristic Characters	Wilks' Lambda	F*	*P* value
BSR	.[a]		
DFS	0.781	10.674	0.002**
DFR	0.430	50.294	0.000**
PcFR	0.990	0.370	0.547
PvFS	.[a]		
PvFR	0.774	11.072	0.002**
AFS	0.256	110.451	0.000**
AFR	0.981	0.734	0.397
CFR	0.995	0.208	0.651
SOLL	0.491	39.416	0.000**
SALL	0.995	0.192	0.664
SBLL	1.000	0.000	1.000

.[a] cannot be computed because this variable is constant in each group
** Values of the parameter differs significantly (p<0.01)
*F value of Univariate ANOVA test.

Table 4. Kruskal-Wallis (H) test for comparison of meristic characters of indigenous and Thai koi (*A. testudineus*).

	Mean rank				
Meristic Characters	**Indigenous koi**	**Thai koi**	**Chi-Square (χ^2)**	**df**	***P* value**
BSR	30.50	10.50	39.000	1	0.000**
DFS	15.35	25.65	8.815	1	0.003**
DFR	11.90	29.10	23.542	1	0.000**
PcFR	19.50	21.50	0.310	1	0.577
PvFS	20.50	20.50	0.000	1	1.000
PvFR	16. 0	24.50	9.697	1	0.002**
AFS	30.00	11.00	32.933	1	0.000**
AFR	21.20	19.80	0.208	1	0.648
CFR	21.70	19.30	0.535	1	0.464
SOLL	12.05	28.95	21.770	1	0.000**
SALL	21.00	20.00	0.222	1	0.638
SBLL	20.00	21.00	0.222	1	0.638

** Values of the parameter differs significantly (p<0.01)

Variation in the meristic counts as obtained in the present study more or less agreed with those of Alam *et al.* (2007) and Alam *et al.* (2014). However they reported significant difference in case of CFR, SALL and SBLL which was found insignificant in the present study. Fish are very sensitive to environmental changes and quickly adapt themselves by changing necessary morphometrics (Hossain *et al.*, 2010). In general, fish demonstrate greater variances in morphological traits both within and between populations than other vertebrates, and are more susceptible to environmentally induced morphological variations (Allendrof *et al.*, 1988; Thompson, 1991; Wimberger, 1992). Hence the difference between the indigenous koi and thai koi may have been due to environmental as well as genetic variations.

Cluster Analysis

A dendrogram based on the hierarchial cluster analysis using size adjusted morphometric characters for *A. testudineus* are shown in (Fig. 2) The dendrogram formed two main clusters indigenous koi in one cluster and Thai koi remained in another cluster. It indicates that these two stocks were separated in respect of morphometric characters.

The results obtained from hierarchical cluster analysis for meristic characters are presented as a dendrogram in (Figure 3). The two populations did not cluster together according to the group as observed in the dendrogram obtained for the morphometric characters. Therefore, a complete separation of the two populations could not be obtained.

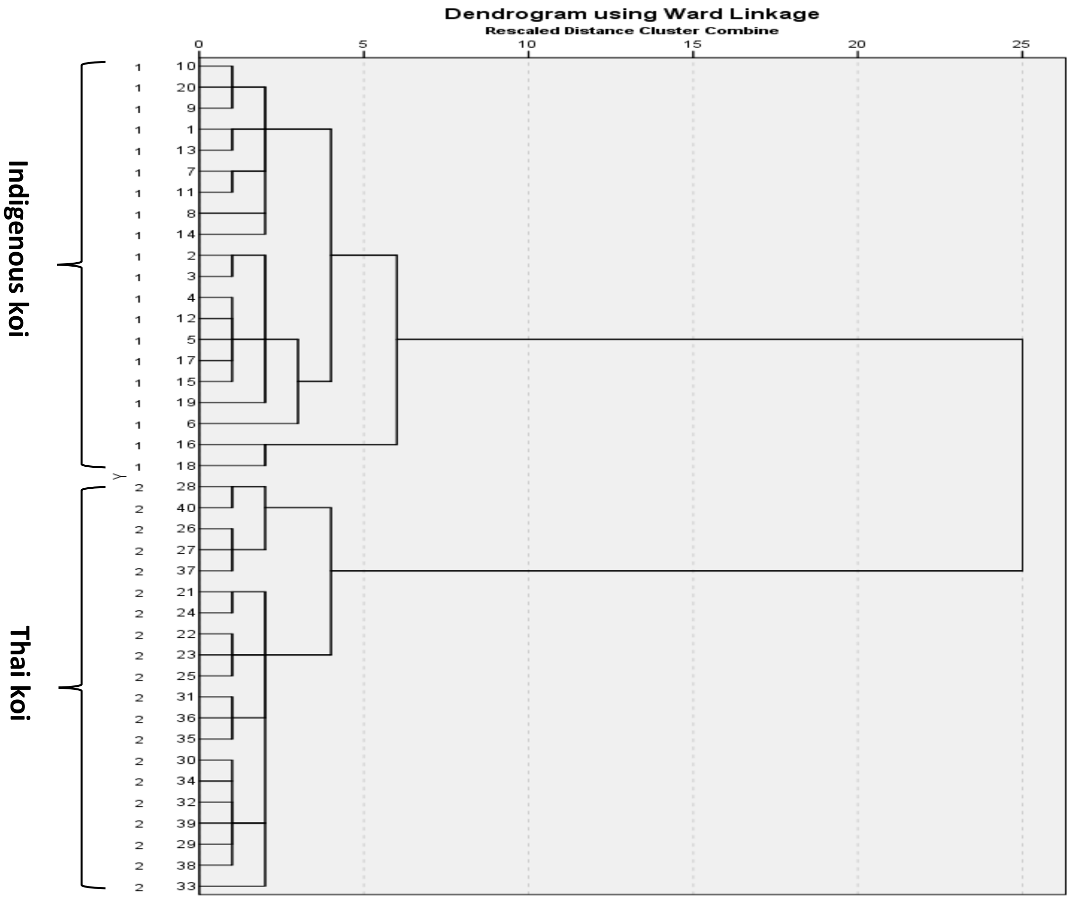

Figure 2. Dendrogram obtained for morphometric characters of indigenous and Thai koi, *A. testudineus.*

It indicates that these two stocks were not completely separated, rather related, in respect of some meristic characters. Hirimuthugoda *et al.* (2012) used similar dendrogram to demonstrate morphological divergence of four tilapia population in Sri- Lanka. On the other hand Mollah *et al.* (2012) also used such dendrogram to show the clustering pattern of three population i.e. pond, *haor* and river population of *Glossogobius giuris* collected from three region of Bangladesh. The findings of those two studies were found more or less similar with that of the present study. The taxonomic formula as well as morphological characters should have within the same range for individuals of every species (Alam *et al.,* 2014). However in the present study, somevariation was observed both in morphometric and meristic characters. Since both local and Thai koi belongs to the same species (Robert, 1989) the observable difference found in local and Thai koi may be due to the origin of samples from two different geographical regions. Variations in the morphometric and meristic characters of a species from different regions can result from differences in genotypes, environmental factors operating on one genotype, or both of these acting together (Parish and Sharman 1958).

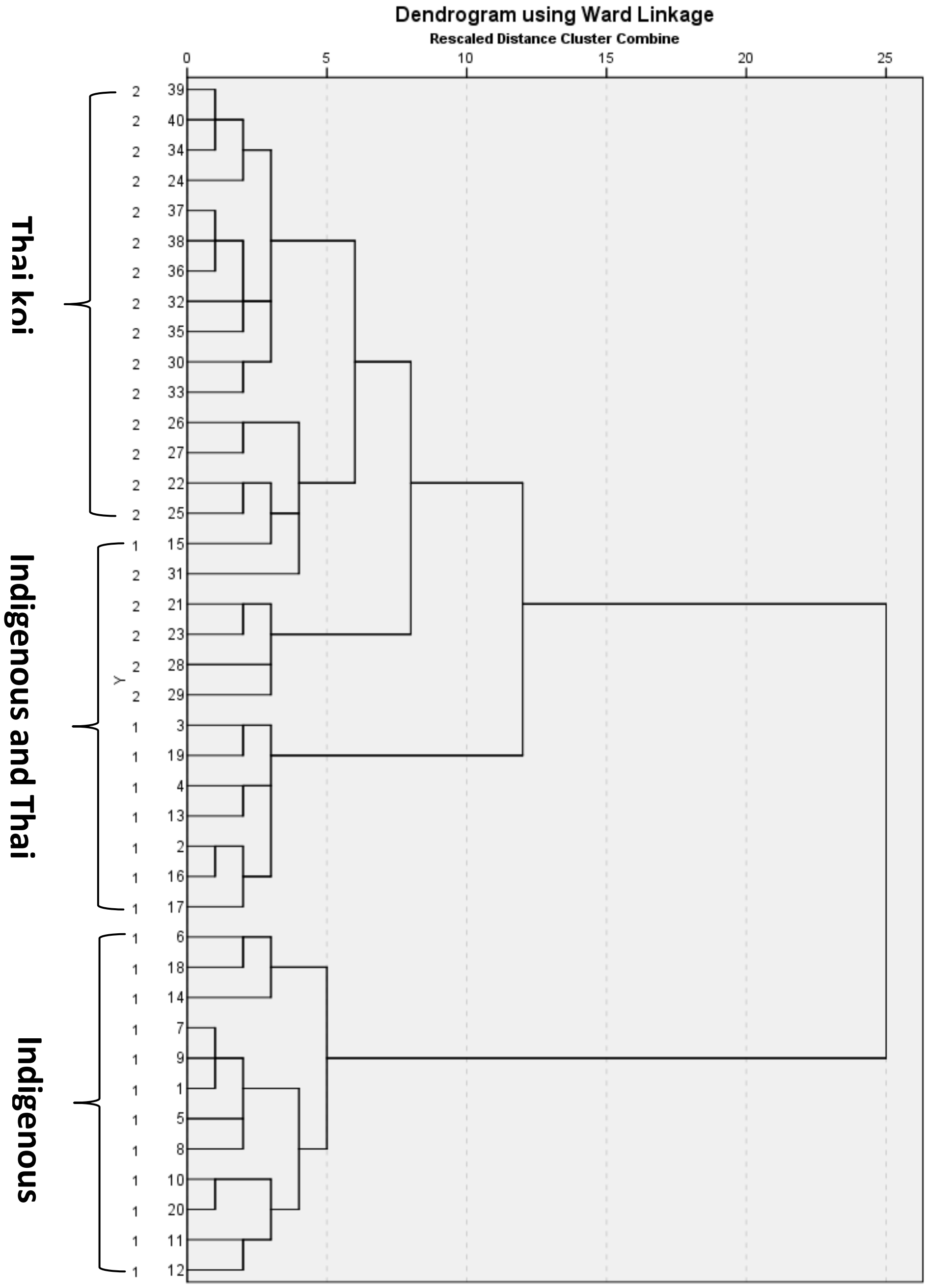

Figure 3. Dendrogram obtained for meristic characters of indigenous and Thai koi, *A. testudineus.*

Conclusion

The present study revealed the significant ($p<0.01$) morphometric and meristic variation between indigenous and exotic stock of *A. testudineus* indicating this two stocks are morphologically dissimilar though they belong to the same taxonomic position. However, present study was not designed to investigate the actual causes due to which morphometric and meristic variation occurs in different stocks of same species and to determine whether the morphological variations are environmentally induced or due to genetic factors or both. More research, especially genetic studies are needed to find out actual causes of variation. The findings of the present study might be used as base line information for further experiment in this field.

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