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INTERRELATIONSHIPS AMONG THE SPECIES OF THE GENUS PUNTIUS (TELEOSTEI : CYPRINIDAE) AS INDICATED BY THE MERISTIC AND MORPHOLOGICAL CHARACTERS.

A. B. Kotalawala and J. Jinadasa

Department of Zoology
University of Sri Jayewardenepura,
Nugegoda, Sri Lanka.

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Abstract

The studies of two morphological and fifteen meristic characters of *twelve species of Puntius* showed that the most successful characters in separating species were the counts of gill rakers, lateral line scales, vertebrae and pectoral rays. The other characters are less successful. The number of spines and rays of anal and pelvic fins are constant in the genus. Based on the 17 characters studied the twelve species of *Puntius* fall into three clusters: one containing five species, the other containing two species and the third cluster with five species. The species of the first two clusters were associated with higher meristic characters, presence of barbels and complete lateral line. The species of the third cluster were associated with low meristic features and they were without barbels with the exception of one species with two barbels. Four species of the third cluster contained with incomplete lateral line while the other one had a complete lateral line.

Key words: Taxonomy, Cyprinidae, *Puntius*, Morphological characters, Meristic charac- ters, significantly different, Mean, Mode, Range

1. Introduction

Morphological and meristic characters were used in the separation of species among fishes. The nature of lateral line and dorsal spine, colour patterns, the numbers of pairs of barbels, spines and rays of fins, scales, were used to distinguish species of Sri Lankan Cyprinids by Deraniyagala (1952), Munro (1955), Menon (1958), and Mendis and Fernando (1962). However, standard meristic characters such as the numbers of gill rakers and vertebrae were not used in previous studies. Collette and Russo (1978) used gill raker and vertebral counts in the identification of Spanish Mackerels (Genus Scomberomorus). Collette (1983) used the numbers of gill rakers with other morphometric data to separate *Grammatorcynus bilineatus* from *G.bicarinatus*

(Scombridae). The importance of gill raker and vertebral counts were evident in the systematics of Bonitos (Sarda) and their relatives (Collette and Chao 1975). O'Maoileidigh et.al., (1983) used gill raker and vertebral counts in combination with morphometric and electrophoretic data in the analysis of two Irish populations of twaite shad, *Alosa fallax* (Clupidae). In a taxonomic reappraisal of the Atlanto—Mediterranion soles, *Solea solea*, *S.Senegalensis* and *S. lascaris*, Ben—Tuvia (1990) highlighted the importance of vertebral counts as a taxonomic character. In the comparison of Spring and Fall—spawning ecotypes of Cisco (*Coregonus artedii*) the number of gill rakers of the first arch was the best character to use (Henault and Fortin 1989). Nizinski et.al., (1990) successfully separated two species of sand lances, (*Ammodytes americanus* and *A. dubius*) mainly based on vertebral and gill raker counts.

Therefore it is evident that externally visible meristic characters together with internal meristic characters were very effective in separating species. The purpose of the present study was therefore, to provide a detailed study of meristic counts and selected morphological characters of *Puntius* initially, with a view later on to encompass other genera and subfamilies so as to obtain an overview of the Family Cyprinidae. When such a broader view of other genera is obtained the generic status of *Puntius* will be easier to understand.

Deraniyagala (1952), Munro (1955), Mendis and Fernando (1962), Jinadasa and Kotalawala (1991), and Kotalawala and Jinadasa (1991) discribed thirteen species of *Puntius*. The species *Puntius melanamphyx sinhala* discribed by the above authors found to be represent a juvenile stage of *Puntius filamentosus* (De Silva et. al. 1981). Therefore in this study the species *Puntius melanamphyx sinhala* of above authors was excluded and the morphology and meristics of the remaining 12 species was studied.

2. Materials and Methods

Twelve species of *Puntius* were identified according to Deraniyagala (1952), Munro (1955), Mendis and Fernando (1962) and Pethiyagoda (1990).

Approximately 383 specimens preserved in formalin and 249 specimens cleared in KOH were examined and studied for two morphological and 15 meristic characters in this study (Table 1). Specimens were cleared in 2% KOH and stained in Alizarin Red S. These were kept in 50% glycerol. Vertebral counts, predorsal and pterygiophore counts and ray and spine counts of fins of cleared specimens were taken using a stereomicroscope under reflected light. It was difficult to define the first vertebra because the first four vertebrae of *Puntius* were fused to form the Weberian apparatus (Weitzman, 1962.; Largler, Bardach and Miller 1962). Therefore, the neural complex of the Weberian apparatus was defined as the 1st, 2nd and 3rd vertebrae and the small neural spine following the neural complex as the 4th vertebra. The urostyle is the last vertebra. Predorsals are the bony elements lying in the

Table 1. Morphological and meristic characters studied. Com-complete, Inc. - Incomplete, Se - serrate, Sm - smooth

Morphological characters	*Meristic characters*
Nature of lateral line (Com/Inc)	Gill rakers
Nature of dorsal spine (Se/Sm)	Vertebrae
	Scales along the lateral line
	Pectoral fin rays
	Anal fin rays.
	Anal fin spines
	Dorsal fin spines
	Dorsal fin rays
	Pelvic fin rays
	Pelvic fin spines
	Predorsals
	Proximal pterygiophores of Dorsal fin
	Barbels
	Scales over and below the lateral line (Tr)

sagital plane anterior to the dorsal fin (Smith and Baily, 1961). The proximal dorsal fin pteregiophores are a series of sagitally lying bony elements which contribute to the support of the dorsal fin (Smith and Baily, 1961). Specimens preserved in formaline were also used to count the gill rakers, scales, spines and rays of fins. The number of gill rakers were counted on the outer row of the first arch of the right side. When the lateral line abruptly disappear after a few scales (incomplete) from the head, the lateral line scale count was carried out from the posterior end of the opercle to the end of the caudal peduncle along the row of scales of the incomplete lateral line. The numbers of spines and rays of pectoral and pelvic fins were counted on the right side.

Statistical analysis was carried out for counts of gill rakers, lateral line scales, vertebrae and pectoral fin rays, using the SAS package on the IBM PCXT compatible Computer at the University Computer Centre. Scheffe's Range Test was carried out to show the significant differences among the species. Student Newman-Keul test was performed for grouping where means differed significantly. The characters, without variation between the individuals of a species were not statistically analysed but their means and modes were compared. Based on these results two state primary data matrices were prepared for all characters studied except Tr. In the preperation of primary data matrices the characters with multiple states were split into two states. The primary data matrices were used to prepare the similarity matrix and

this was converted into a percentage similarity matrix (Goto, 1982). The percentage similarity matrix was rearranged to show the interrelationships among the species studied.

3. Results

ANOVA tests performed on the values of gill rakers, vertebrae, lateral line scales and pectoral rays demonstrate that these characters were significantly different among the species studied and could be successfully used in separating species (Table II). Based on the results of ANOVA tests of scale counts, twelve species of *Puntius* could be separated into seven groups (Table III). *P. pleurotaenia* ($\bar{X}$=28.2) had the highest mean value and *P. titteya* ($\bar{x}$=18.74) had the lowest mean value for lateral line scale counts (Table IV). Although several species were included in one group their percentage frequency distribution of scales were species specific (Fig. 1).

Table II Results of ANOVA tests on four meristic characters

Meristic Character	*F value*	*Probability*
Gill rakers	188.07	0.0001
Vertebrae	638.65	0.0001
L. L. Scales	205.62	0.0001
Pectoral rays	67.35	0.0001

The number of gill rakers also proved to be a useful character in separating species of *Puntius*. Based on gill rakers alone the twelve species could be rearranged into seven groups (Table III). *P. amphibius* ($\bar{X}$=20.66) had the highest while *P. nigrofasciatus* ($\bar{X}$= 3.9) had the lowest mean value for gill rakers (Table IV). Although *P. filamentosus*, *P. sarana* and *P. pleurotaenia* were included in one group their pattern of percentage frequency distribution of gill rakers was species specific (Fig. 1).

Table III Grouping of twelve species of *Puntius* based on different characters The species between brackets were significantly different and the species within brackets were not significantly different and belong to the same group. amp=*P. amphibius*, bim=*P. bimaculatus*, cho=*P. Chola*, cum=*P. cumingi*, dos=*P. dorsalis* fil=*P. filamentosus* nig=*P. nigrofasciatus*, sar=*P. sarana*, tic=*P. ticto*, tit=*P. titteya*, vit=*P. vittatus*, ple=*P. pleurotaenia*, Tr=Nuber of Scales over and below the lateral line.

Character	*Grouping*
Scale counts	(ple) (sar) (cho) (bim,dos) (amp,fil, nig, tic) (vit, cum) (tit)
gill raker counts	(amp) (cho,dos) (bim) (vit) (fil,sar,ple) (tic,cum,tit) (nig)
vertebral counts	(amp) (ple) (sar) (fil,cho,dos,bim) (tic,tit,nig) (vit) (cum)
pectoral ray counts	(sar, cho, dos,) (fil) (amp, ple) (bim) (tic, vit,cum, nig) (tit)
dorsal fin spines	(amp,cho,dos,fil,ple,sar) (cum,nig,tic,tit,bim) (vit)
dorsal fin rays	(amp,cho,cum,dos,fil,nig,ple,sar,tic,vit) (tit,bim)
predorsal counts	(amp,ple,sar) (cho,cum,dos,fil,nig,tic) (bim,tit,vit)
Pterygiophore counts	(amp) (cho,cum,dos,fil,nig,ple,sar,tic,vit) (bim,tit)
brabel counts	(ple,sar) (amp,bim,cho,dos,fil,tit) (cum,nig,tic,vit)
nature of L.L.	(amp,bim,cho,dos,fil,nig,ple,sar) (cum,tic,tit,vit)
nature of d. spines	(amp,bim,cho,dos,fil,tit,vit) (cum,nig,ple,sar,tic)
Tr.	(cho) (sar,nig) (fil,dos,ple,amp,tic,bim) (cum,tit,vit)

The number of vertebrae, a successful character in separating species, divides the species into seven groups (Table III). For the genus *Puntius*, the number of vertebrae varies from 27 to 41 (Table IV). However, within a specific species the variation was very narrow (Fig 1). Out of all the species studied *P. amphibius* ($\bar{X}$=40.33) had the highest while *P. vittatus* had the lowest mean value for vertebral counts ($\bar{X}$=27.86).

Pectoral ray count was the most useful fin character in separating species. Based on this single character alone twelve species fall into six groups (Table III). *P. sarana* ($\bar{X}$= 15.923) contained the highest number of pectoral rays ranging from 15 to 17while *P. titteya* ($\bar{X}$= 11.52) had the lowest number of pectoral rays ranging from 10 to 13 (Table IV). Although the species of the same group were not significantly different in mean values their percentage frequency distribution pattern of pectoral rays is different (Fig. 2).

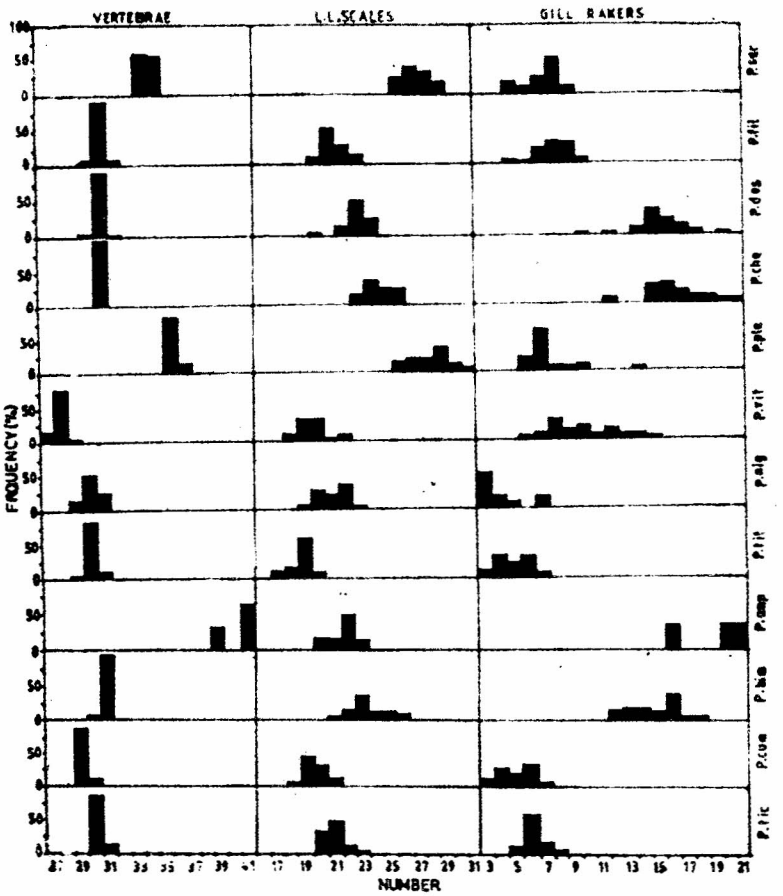


Fig. 1. Percentage frequencies of vertebrae, L.L. scales and gill rakers of twelve species *Puntius*

amp=*P. amphibius*, P.bim=*P. bimaculatus*, P.cho=*P. chola*, P.cum=*P. cumingi*, P. dos=*P. dorsalis*, P.fil=*P. filamentosus*, P.nig=*P, nigrofasciatus*, P.ple=*P. pleurotaenia*, P.sar=*P. sarana*, P.tic=*P. ticto*, P.tit=*P. titteya*, P.vit=*P. vittatus*.

The numbers of spines and rays of pelvic and anal fins were almost constant throughout the genus (Table IV). The genus *Puntius* is characterized by one pelvic spine, 9 pelvic rays, 3 anal spines and five anal rays. All species of *Puntius* studied except *P. titteya* contained 9 pelvic rays. *P. titteya* contained 8 pelvic rays. Out of 12 species studied 11 had three anal spines but in *P. vittaus* ($\bar{X}$= 2.82) 55% contained three anal spines while the other 45% contained two anal spines (Fig. 2).

Table IV The nature of lateral line, dorsal spine and the mean values of different meristic charactors of species of *Puntius*. The ranges were given within brackets. Com-complete, Inc-incomplete, Sm-smooth, Ser-serrate.

	N	*Nature of L.L*	*Nature of d. spines*	*L.L. Scales*	*Tr.*	*Gill rakers*	*Vertebr.*	*Pelvic Spines*	*Pelvic rays*	*Anal spines*	*Anal rays*	*Pecto. rays*	*Dorsal spines*	*Dorsal rays*	*Pre dorsal*	*Pteryg.*	*Barbels*
P. amphibius	6	Com	Sm	21.66 (20-23)	4.5/2.	20.66 (17-24)	40.03 (39-41)	1	9	3	5	14.75 (14-16)	4	8.3	15.5 (5-6)	11	2
P. bimaculatus	29	Com	Sm	23.41 (21-26)	3.5/3.5	14.76 (12-18)	30.94 (30-31)	1	9	3	5	13.2 (12-16)	3.23	7.53 (7-8)	3.16 (3-4)	9 or 10	2
P. chola	22	Com	Sm	24.59 (23-26)	5.5/3.5	16.63 (12-21)	31	1	9	3	5	15.26 (13-16)	4	8	4	10	2
P. cumingi	24	Inc.	Ser	19.5	3.5/3.5	4.59 (3-7)	29.1 (29-30)	1	9	3	5	12.08 (11-13)	3	8	4	10	0
P. dorsalis	41	Com.	Sm	22.93 (20-24)	4.5/2.5	15.48 (10-20)	30.97 (30-32)	1	9	3	5	15.2 (11-17)	4	8	4	10	2
P. filamentosus	42	Com	Sm	21.4 (20-23)	4.5/2.5	8 (5-10)	31.02 (30-32)	1	9	3	5	14.95 (11-16)	4	8	4	10	2
P. nigrafasciatus	31	Com	Ser	21.09 (19-23)	4,5/3.5	3.9 (3-7)	30.5 (29-31)	1	9	3	5	12 (11-14)	3	8	4	10	0
P. pleurotaenia	34	Com	Ser	28.02 (26-30)	4.5/3.5	7.63 (6-14)	36.15 (36-37)	1	9	3	5	14.14 (13-16)	4	8	5	10	4
P. sarana	14	Com	Ser	27.35 (26-29)	4.5/3.5	7.28 (5-9)	34.42 (34-35)	1	9	3	5	15.95 (15-17)	4	8	5	10	4
P. ticto	26	Inc	Ser	20.84 (20-23)	4.5/2.5	6.15 (5-8)	30.31 (30-31)	1	9	3	5	12.52 (12-14)	3	8	4	10	0
P. titteya	27	Inc.	Sm	18.74 (17-20)	3.5/3.5	4.81 (3-7)	30.07 (29-31)	1	8	3	5	11.52 (10-13)	3	7.2	3.3 (3-4)	9	2
P. vittatus	33	Inc	Sm	19.66 (18-22	3.5/3.5	10.03 (10-15)	27.86 (27-29)	1	9	2.83 (2-3)	5	12.16 (11-13)	2.35 (2-3)	8.7 (8-9)	3	10	0

The characters of the dorsal fin varied slightly between species but not between the individuals of a species and hence less effective in separating species. Based on the number of dorsal spines the twelve species of *Puntius* fall into three groups. One group containing four dorsal spines included *P. sarana, P. filamentosus, P. dorsalis, P. chola, P. pleurotaenia* and *P. amphibius.* The other group containing three dorsal spines included *P. nigrofasciatus, P. titteya, P. bimaculatus, P. cumingi* and *P. ticto.* In most of the species of these two groups there was no variation of the number of dorsal spines among the individuals of the same species. However, a small percentage of specimens of *P. bimaculatus* contained 4 dorsal spines (Fig. 2) The third group containing two dorsal spines included *P. vittatus* ($\bar{X}$= 2.35) of which 36% contained three dorsal spines.

Based on the number of dorsal fin rays the species studied can be divided into two groups (Table III). *P. titteya* and *P. bimaculatus* contained 7 dorsal fin rays while all the others contained 8 dorsal fin rays. Although species were separated into two groups there were some anomalies regarding to the number of dorsal fin rays. *P. vittatus* ($\bar{X}$=8.07) contained three types of specimens: 75% with 8 dorsal rays; 16% with 9 dorsal rays; and 9% with 7 dorsal rays (Fig. 2) In *P. amphibius* ($\bar{X}$= 8.3) 30% containd 9 dorsal rays while the others contained 8 dorsal rays. *P. titteya* ($\bar{X}$= 7.2) which was included in the group containing 7 dorsal rays had 10% specimens with 8 dorsal rays while *P. bimaculatus* ($\bar{X}$= 7.53) contained 47% of 8 dorsal rays (Fig. 2).

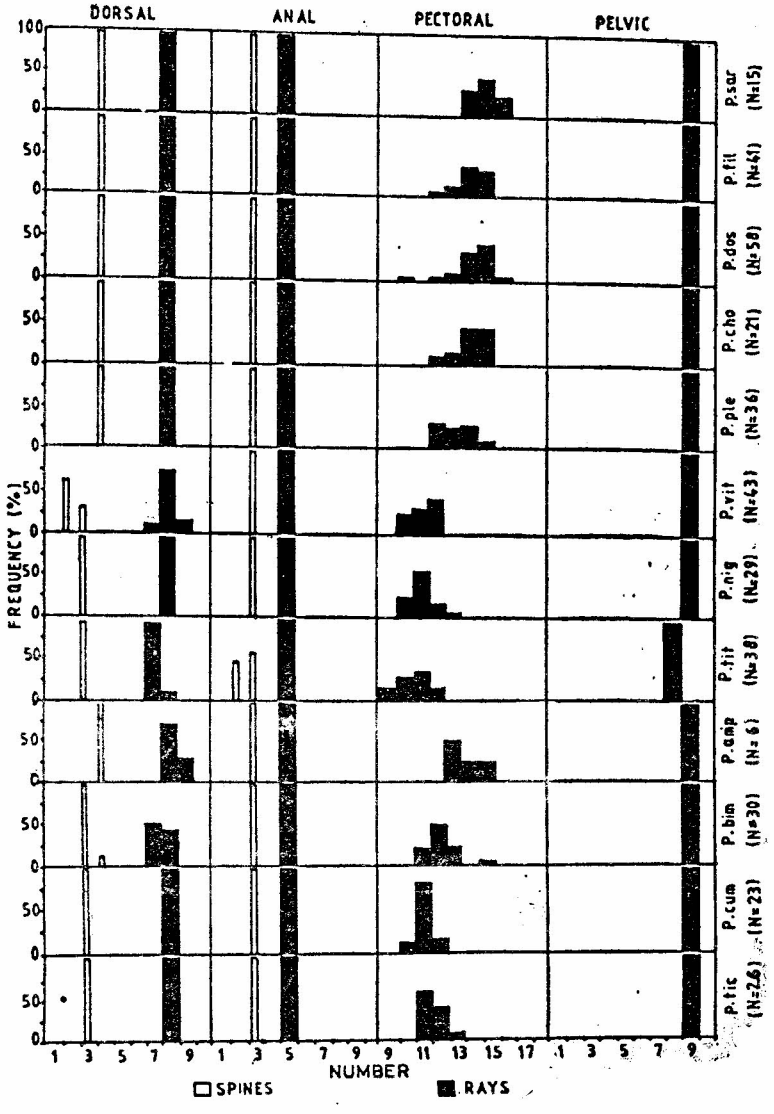


Fig. 2. Percentage frequencies of spines and rays of fins of twelve speices of *Puntius*.

P. amp=*P. amphibius*, P.bim=*P. bimaculatus*, P.cho=*P. chola*, P. cum=*P. cumingi*, P.dos=*P. dorsalis* P.fil=*P. filamentosus*, P.nig=*P. nigrofusciatus*, P. ple=*P. pleurotaenia*, P. sar=*P. sarana*, P. tic=*P. ticto* P. tit=*P. titteya*, P. vit=*P. vittatus*

The number of predorsals and dorsal pterygiophores were also less effective in separating species. Based on the number of pterygiophores the twelve species of *Puntius* studied, fall into three groups: one with 11 pterygiophores, the other with 10 pterygiophores and the third group with 9 pterygiophores

(Table III). *P. amphibius* contained 11 pterygiophores while *P. bimaculatus* and *P. titteya* contained 9 pterygiophores. All the other species contained 8 pterygiophores (Table IV). Although *P. bimaculatus* included in the group containing 9 pterygiophores, 16% of specimens contained 10 pterygiophores.

The Twelve species of *Puntius* could be separated into three groups using the number of predorsals (Table III). The first group with five predorsals included P. *sarana*, *P. pleurotaenia*, and *P. amphibius* ($\bar{X} = 5.5$). 50% of specimen of *P. amphibius* contain 6 predorsals (Table IV). The second group containing 4 predorsals included *P. filamentosus*, *P. dorsalis*, *P. chola*, *P. nigrofasciatus*, *P. cumingi* and *P. ticto* while the other two species *P. titteya* and *P. bimaculatus* contained three predorsals. However, 30% of *P. titteya* ($\bar{X}$=3.3) and 16% of *P. bimaculatus* ($\bar{X}$= 3.16) contained 4 predorsals.

gill rakers

	A	B	C	D	E	F	G	H	I	J	K	L
A	1	0	1	0	0	0	0	0	0	0	0	0
B	0	1	1	0	1	0	0	0	0	0	0	0
C	1	1	1	0	1	0	0	0	0	0	0	0
D	0	0	0	1	0	0	1	0	1	1	1	0
E	0	1	1	0	1	0	0	0	0	0	0	0
F	0	0	0	0	0	1	0	1	1	1	0	0
G	0	0	0	1	0	0	1	0	0	0	1	0
H	0	0	0	0	0	1	0	1	1	1	0	0
I	0	0	0	1	0	1	0	1	1	1	1	0
J	0	0	0	1	0	1	0	1	1	1	1	0
K	0	0	0	1	0	0	1	0	1	1	1	0
L	0	0	0	0	0	0	0	0	0	0	0	1

vertebrae

	A	B	C	D	E	F	G	H	I	J	K	L
A	1	0	0	0	0	0	0	0	0	0	0	0
B	0	1	1	0	1	1	0	0	0	0	0	0
C	0	1	1	0	1	1	0	0	0	0	0	0
D	0	0	0	1	0	0	0	0	0	0	0	0
E	0	1	1	0	1	1	0	0	0	0	0	0
F	0	1	1	0	1	1	0	0	0	0	0	0
G	0	0	0	0	0	0	1	0	0	1	1	0
H	0	0	0	0	0	0	0	1	0	0	0	0
I	0	0	0	0	0	0	0	0	1	0	0	0
J	0	0	0	0	0	0	1	0	0	1	1	0
K	0	0	0	0	0	0	1	0	0	1	1	0
L	0	0	0	0	0	0	0	0	0	0	0	1

pectoral rays

	A	B	C	D	E	F	G	H	I	J	K	L
A	1	1	1	0	1	1	0	1	1	1	0	0
B	1	1	0	1	0	0	0	1	0	1	0	1
C	1	0	1	0	1	1	0	1	1	0	0	0
D	0	1	0	1	0	0	1	0	0	1	1	1
E	1	0	1	0	1	1	0	1	1	0	0	0
F	1	0	1	0	1	1	0	1	1	0	0	0
G	0	0	0	1	0	0	0	0	0	1	1	1
H	1	1	1	0	0	1	0	1	0	0	0	0
I	1	0	1	0	1	1	0	0	1	0	0	0
J	1	1	0	1	0	0	1	0	0	1	1	1
K	0	0	0	1	0	0	1	0	0	1	1	1
L	0	1	0	1	0	0	1	0	0	1	1	1

l.l.scales

	A	B	C	D	E	F	G	H	I	J	K	L
A	1	1	0	1	1	1	1	0	0	1	0	1
B	1	1	1	0	1	0	0	0	0	0	0	0
C	0	1	1	0	0	0	0	0	0	0	0	0
D	1	0	0	1	0	0	0	0	0	1	1	1
E	1	1	0	0	1	0	0	0	0	0	0	0
F	1	0	0	0	0	1	1	0	0	1	0	0
G	1	0	0	0	0	1	1	0	0	1	0	0
H	0	0	0	0	0	0	0	1	1	0	0	0
I	0	0	0	0	0	0	0	1	1	0	0	0
J	1	0	0	1	0	1	1	0	0	1	0	1
K	0	0	0	1	0	0	0	0	0	0	1	1
L	1	0	0	1	0	0	0	0	0	1	1	1

Fig. 3. The primary data matrices of the numbers of gill rakers, vertebrae, pectoral rays and lateral line scales based on the results of Scheffe's test. Significantly different speeies were denoted by zero and similar species were denoted by one.A=*P.amphibius.* *B=P.bimaculatus,* *C=P. chola* *D=P. cumingi,* *E=P. dorsalis,* *F=P.filamentosus,* *G=P. nigrofasciatus,* *H=P. pleurotaenia,* *I=P. sarana.,* *J=P. ticto,* *K=P. titteya,* *L=P. vittatus.*

The number of rows of scales above and below the lateral line at the maximum depth of the body (Tr) was also useful to separate the groups further. Based on it, the twelve species of *Puntius* fall into four groups. *P. chola* had 5.5 rows of scales above and 3.5 rows of scales below the lateral line (Tr = 5.5/3.5). *P. sarana* and *P. nigrofasciatus* had Tr value of 4.5/3.5 while *P. filamentosus*, *P. dorsalis*, *P. pleurotaenia*, *P. amphibius* and *P. ticto* had Tr value of 4.5/2.5. Other species had a Tr value of 3.5/3.5.

The number of barbels was less effective in separating species. Based on it, the twelve species of *Puntius* could be separated into three groups. The group containing four barbels included *P. sarana* and *P. pleurotaenia*, while the group containing two barbels included *P. amphibius*, *P. filamentosus*, *P. dorsalis*, *P. chola*, *P. titteya* and *P. bimaculatus*. The other four species are without barbels (Table IV).

	amp	bim	cho	cum	dos	fil	nig	ple	sar	tic	tit	vit
amp	16/16	10/16	13/16	7/16	13/16	13/16	9/16	12/16	12/16	9/16	5/16	8/16
bim	10/16	16/16	12/16	9/16	12/16	10/16	8/16	8/16	9/16	8/16	9/16	10/16
cho	13/16	12/16	16/16	7/16	15/16	14/16	9/16	11/16	11/16	8/16	6/16	8/16
cum	7/16	9/16	7/16	16/16	7/16	7/16	12/16	7/16	8/16	14/16	10/16	13/16
dos	13/16	12/16	15/16	7/16	16/16	14/16	9/16	10/16	11/16	8/16	6/16	8/16
fil	13/16	10/16	14/16	7/16	14/16	16/16	10/16	12/16	12/16	10/16	6/16	8/16
nig	9/16	8/16	9/16	12/16	9/16	10/16	16/16	9/16	9/16	14/16	8/16	10/16
ple	12/16	8/16	11/16	7/16	10/16	12/16	9/16	16/16	14/16	9/16	4/16	6/16
sar	12/16	7/16	11/16	8/16	11/16	12/16	9/16	14/16	16/16	9/16	5/16	6/16
tic	9/16	8/16	8/16	14/16	8/16	10/16	14/16	9/16	9/16	16/16	9/16	12/16
tit	5/16	9/16	6/16	10/16	6/16	6/16	8/16	4/16	5/16	9/16	16/16	10/16
vit	8/16	10/16	8/16	13/16	8/16	8/16	10/16	6/16	6/16	12/16	9/16	16/16

Fig. 4. The similarity matrix of 16 characters. The ratio between two species indicate the similarity between those two species. amp = *P. amphibius*, bim = *P. bimaculatus*, cho = *P. chola*, dos = *P. dorsalis*, fil = *P. filamentosus*, nig = *P. nigrofasciatus*, ple = *P. pleurotaenia*, sar = *P. sarana*, tic = *P. ticto*, tit = *P. titteya*, vit = *P. vittatus*.

The two morphological characters such as the nature of the lateral line and the dorsal spine were the least effective characters studied. However, in combination with other characters these two characters are also useful in separating species. Based on the nature of the lateral line (complete/incomplete),species could be separated into two groups(Table,III). *P.vittatus*, *P. titteya*, *P. ticto* and *P. cumingi* contained an incomplete lateral line while all the others contained a complete lateral line (Table IV). The nature of the dorsal spine (serrate/smooth) also divides the species into two groups (Table III). *P. sarana*, *P. pleurotaenia*, *P. nigrofasciatus*, *P. ticto* and *P. cumingi* contained one serrated dorsal spine while the other species contained smooth dorsal spines (Table IV).

	amp	bim	cho	cum	dos	fil	nig	ple	sar	tic	tit	vit
amp	100	63	81	44	81	83	56	75	75	56	31	50
bim	63	100	75	56	75	63	50	50	44	50	56	63
cho	81	75	100	44	94	88	56	69	69	50	38	50
cum	44	56	44	100	44	44	75	44	50	88	63	81
dos	81	75	94	44	100	88	56	63	69	50	38	50
fil	81	63	88	44	88	100	63	75	75	63	38	50
nig	56	50	56	75	56	63	100	56	56	88	50	63
ple	75	50	69	44	63	75	56	100	88	56	31	38
sar	75	44	69	50	69	75	56	88	100	56	31	38
tic	56	50	50	88	50	63	88	56	56	100	56	75
tit	31	56	38	63	38	38	50	25	31	56	100	63
vit	50	63	50	81	50	50	63	38	38	75	56	100

Fig. 5. The percentage similarity matrix of 16 characters of twelve species of *Puntius* amp=*P. amphibius*, bim=*P. bimaculatus*, cho=*P. chola*, dos=*P. dorsalis*, fil=*P. filamentosus*, nig=*P. nigrofasciatus*, ple=*P. pleurotaenia*, sar=*P.sarana*, tic=*P. ticto*, *tit*=*P. titteya*, vit.*P vittatus*.

Some of the primary data matrices prepared for the above characters are shown in Fig. 3. The similarity matrix which based on 16 primary data matrices is shown in Fig. 4. It shows the similarities between the species studied. In the comparison of *P. amphibius* with *P. titteya*, out of 16 characters studied, only five were similar. In the percentage similarity matrix the ratios were converted into percentages (Fig. 5). It shows the percentage

similarities between the species studied. When the species were rearranged to obtain maximum similarities between species, the 12 species of *Puntius* fall into three clusters (Fig.6). The first cluster include *P. amphibius*, *P. chola*, *P. dorsalis*, *P. filamentosus*, and *P. bimaculatus*. The maximum similarity between species of this cluster is 94% while minimum similarity is 63%. The second cluster included *P. pleurotaenia* and *P. sarana* and they were 88% related. The third cluster include *P. nigrofasciatus*, *P. ticto*, *P. cumingi*, *P. vittatus* and *P. titteya*. The relationship between first four species of this cluster is very strong while the fifth species *P. titteya* show a lower relationship with the other four species. The overall minimum similarity between first two clusters is 44% while in all three clusters it is 25%. The species of the first two clusters were associated with higher meristic features, complete lateral line and presence of barbels (Table V). Most of the species of the third cluster were associated with low meristic features and incomplete lateral line but without barbels. However, *P. titteya* of this cluster contained two barbels and *P. nigrofasciatus* has a complete lateral line.

	amp	cho	dos	fil	bim	ple	sar	nig	tic	cum	vit	tit
amp	100	81	81	81	63	75	75	56	56	44	50	31
cho	81	100	94	88	75	69	69	56	50	44	50	38
dos	81	94	100	88	75	63	69	56	50	44	50	38
fil	81	88	88	100	63	75	75	63	63	44	50	38
bim	63	75	75	63	100	50	44	50	50	56	63	56
ple	75	69	63	75	50	100	88	69	56	40	38	25
sar	75	69	69	75	44	88	100	56	56	50	38	31
nig	56	56	56	63	50	69	56	100	88	75	63	50
tic	56	50	50	63	50	56	56	88	100	88	75	56
cum	44	44	44	44	56	40	50	75	88	100	81	63
vit	50	50	50	50	63	38	38	63	75	81	100	63
tit	31	38	38	38	56	25	31	50	56	63	63	100

Fig. 6. The rearranged percentage similarity matrix of 16 characters of twelve species of *Puntius*. amp=*P. amphibius*, bim=*P. bimaculatus*, cho=*P. chola*, dos=*P. dorsalis*, fil. *P. filamentosus*, nig.*P. nigrofasciatus*, ple=*P. pleurotaenia*, sar=*P. sarana*, tic=*P. ticto*, tit=*P. titteya*, vit= *P. vittatus*

4. Discussion

Most of the results of this study are in accordance with the results of previous studies on Sri Lankan cyprinids (Deraniyagala 1952, Munro 1955. Mendis and Fernando 1962). Two standard characters, namely, the number of vertebrae and the gill rakers, which were not used for Sri Lankan cyprinids by earlier researchers showed that they were highly successful in separating species. The number of scales and pectoral fin rays were used routinely by previous Sri Lankan workers. But they did not analyze their results statisti cally to show whether those two characters could be used to separate species. The statistical analysis carried out in the present study demonstrated that the number of scales and the pectoral rays could be satisfactorily used to separate species. The newly introduced two characters, the numbers of predorsals and pterygiohores, the fin characters other than pectoral rays and the two morphological characters used were less effective in separating species. Some of the fin characters such as one pelvic spine, 9 pelvic rays, 3 anal spines and 5 anal rays were almost constant in the genus (Table IV).

Although the majority of the results of this study were in accordance with the results of Deraniyagala (1952), Munro (1955) and Mendis and Fernando (1962), there were some discrepancies regarding to the nature of dorsal spines and the numbers of spines and rays of dorsal and anal fins of some species (Table VI). As shown by the above authors the nature of 3rd dorsal spine of *P. titteya* was serrate. However, the results of the present study consistently showed that it was smooth. The use of cleared and stained specimens in the present study helped to demonstrate that the nature of all dorsal spines of *P. titteya* were smooth.

Table V. Low meristic and high meristic groups of *Puntius* with their respective meristic values, All values given were mean values.

P. amp = *P. amphibius*, P. bim = *P. bimaculatus*, P. cho = *P. chola*, P. cum = *P. cumingi*, P. dos = *P. dorsalis*, P.fil = *P. filamentosus*, P. nig = *P. nigrofasciatus*, P.ple = *P. Pleurotaenia*, P.sar = *P. sarana*, P, tic = *P. ticto*, P. tit = *P. titteya*, P. vit = *P. vittatus*.

	LOW MERISTIC GROUP					*HIGH MERISTIC GROUP*						
Character	*P.tit* (*N*=27)	*P.cum* (*N*=24)	*P.vit* (*N*=33)	*P.nig* (*N*=31)	*P.tic,* (*N*=26)	*P.amp.* (*N*=6)	*P.ple.* (*N*=34)	*P.sar* (*N*=14)	*P.dos* (*N*=41)	*P.fil* (*N*=42)	*P.cho* (*N*=22)	*P.bim* (*N*=29)
L.L.scales	18.74	19.5	19.66	20.09	20.84	21.60	28.2	27.3	22.9	21.4	24.59	23.41
Vertebrae	30.07	29.1	27.86	30.05	30.11	40.33	36.15	34.5	30.97	31.2	31	30.94
Gill rakers	4.83	4.95	10.03	3.90	6.15	20.66	7.30	7.28	15.51	8.00	16.63	14.76
Pectoral rays	11.52	12.08	12.16	12.00	12.52	14.75	14.14	15.92	15.21	14.95	15.26	13.2
Dorsal spines	3	3	2.35	3	3	4	4	4	4	4	4	3.23
Barbels	2	0	0	0	0	4	4	4	2	2	2	2
Nature of L.L.	Inc	Inc	Inc	Com	Inc.	Com	Com	Com	Com	Com	Com	Com

According to Deraniyagala (1952), Munro (1955) and Mendis and Fernando (1962), both *P. vittatus* and *P. ticto* contained two dorsal spines (Table VI). But the results of the present study indicate that the mean value of dorsal spines of *P. vittatus* was 2.35 while that of *P. ticto* was 3.0. This increase in mean values of dorsal spines may be due to two reasons. One reason could be the sample size. The other reason could be the use of cleared stained specimens. There was no indication of sample size in earlier studies. In undigested and unstained specimens, the spines which were embedded in the muscles of the body cannot be seen or detected. The decrease in the mean value of dorsal spines of *P. bimaculatus* also may be due to the same reasons. There was an increase in mean values of dorsal rays of *P. amphibius* and *P. titteya* due to the same reasons. Similarly, the majority of *P. vittatus* had three anal spines and not two as stated by the previous workers. According to Deraniyagala (1952) the number of rays of the pelvic fin varied from species to species. However, the results of the present study showed that it is constant in the genus (Table IV). All *Puntius* species except *P. titteya* contained one spine and 9 rays in the pelvic fin while *P. titteya* contained one spine and 8 rays. As the sample size increase, the ranges of the number of pectoral fin rays and the lateral line scales of species also increased (Table VI).

Table VI. Comparison of the results of present study with the results of previous studies.

Species and Character	*Kotalawala and Jinadasa* (1991)		*Deraniyagala* (1952)	*Munro* (1955)	*Mendis and Fernando* (1962)
Doral Spine	N		N	N	N
P. titteya	27	smooth	serrate	serrate	serrate
P. vittatus	33	$\bar{x}$ = 2.5	2	2	2
P. bimaculatus	29	$\bar{x}$ = 3.23	4	4	4
P. ticto	26	$\bar{x}$ = 3	2	2	2
Dorsal rays					
P. amphibius	6	$\bar{x}$ = 8.3	8	8	8
P. titteya	27	$\bar{x}$ = 7.2	7	7	7
Anal spines					
P. vittatus	33	$\bar{x}$. 2.83	2	2	2
Pectoral rays					
P. filamentosus	41	11—16	15	15	15
P. dorsalis	41	11—17	11—13	11—13	11—13
P. chola	22	13—16	15	15	15
P. pleurotaenia	34	11—16	15	15	15
P. vittatus	33	11—13	11	11	11
P. nigrofasciatus	31	11—14	12	12	12
P. titteya	27	10—13	'0	10	10
P. amphibius	6	14—16	15	15	15
P. bimaculatus	29	12—16	15	15	15
P. ticto	26	12—14	11	11	11
P. cumingi	24	11—13	11	11	11
L.L. Scales					
P. filamentotus	42	20—30	22—23	22—23	22—23
P. dorsalis	41	20—24	23—25	23—25	23—25
P. chola	22	23—26	24—27	24—27	24—27
P. pleurotaenia	34	26—31	28—30	28—30	28—30
P. vittatus	33	18—22	20—22	19—20	20—22
P. nigrofasciaeus	31	19—23	20—22	20—22	20—22
P. titteya	27	17—20	19—20	19—20	19—20
P. amphibins	6	20—23	23—24	23—24	23—24
P. bimaculatus	29	21—26	24—25	24—25	24—25
P .cumingi	24	18—21	19—21	19—21	19—21
P. ticto	26	20—23	20—22	20—22	20—22

The grouping of twelve species of *Puntius* based on one character is different from another character. Therefore 17 characters studied gives 17 types of groupings. This problem was solved by the similarity matrix. The similarity matrix intigrate all the characters studied.

Based on the informations of the rearranged similarity matrix, the inter-relationships among the twelve species of *Puntius* studied could be shown as in the dendogram (Fig.7). The species within a cluster and clusters each other with close affinities were linked together by horizontal lines placed at the appropriate height in relation to the vertical scale representing the degree of similarity.

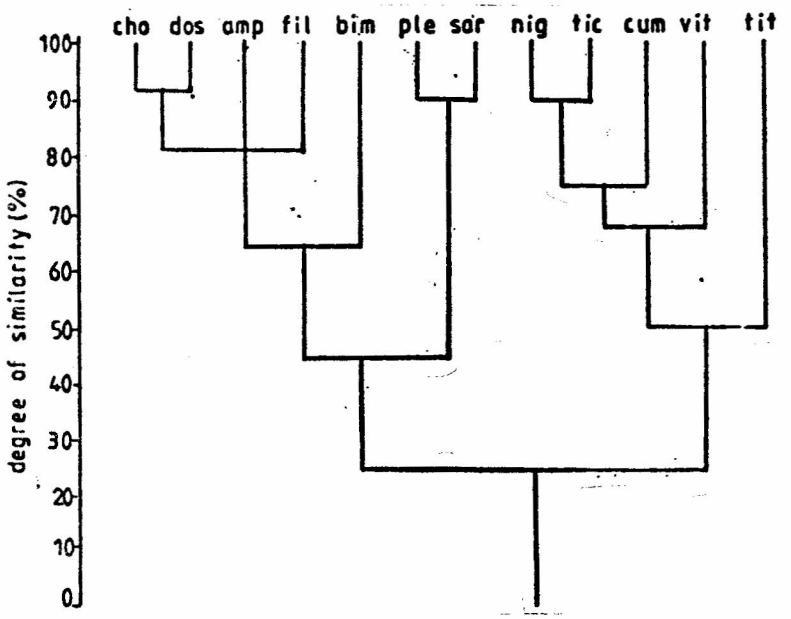


Fig. 7. The dendogram based on the informations shown in the rearranged similarity matrix. amp=*P.amphibius*, bim=*P. bimaculatus*, cho=*P. chola*, dos=*P. dorsalis*, fil=*P. filamentosus*, nig=*P. nigrofasciatus*, ple=*P. pleurotaenia*, sar=*P. sarana*, tic=*P. ticto*, tit=*P. titteya*, vit=*P. vittatus*

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