International Journal of Zoology Studies
ISSN: 2455-7269; Impact Factor: RJIF 5.14
Received: 02-08-2019; Accepted: 04-09-2019
www.zoologyjournals.com
Volume 4; Issue 5; September 2019; Page No. 11-18

Cladistics analysis of species infesting (Ischnocera: Philopteridae) Fowls of District Hyderabad, Sindh, Pakistan

Farheen Shaikh[1*], Saima Naz[2], Nadir Ali Birmani[3]
[1-3] Department of Zoology, University of Sindh, Jamshoro, Pakistan

Abstract
The present research work covers the phylogentic relationship of four species belonging to a family Philopteridae (Ischnocera: Phithraptera), recovered from variety of fowls as host from district Hyderabad, Sindh Pakistan. These are analyzed caldistically by cladogram, using of their apomorphic characters. The Key to the four species of family Philopteridae has also been developed for the four genera. This is the first attempt to cladistics analysis of the family Philopteridae from district Hyderabad, Sindh, Pakistan.

Keywords: Mallophaga, Ischnocera, Philopteridae, Cladistic Analysis, Hyderabad

Introduction
The suborder Ischnocera (Insecta: Phthiraptera) has been considered as primitive and paraphyletic group of chewing lice (Lakshminarayana, 1986) [14]. It comprises of more than 3000 species from 150 genera. The lice are permanent obligatory parasites of about 2300 avian fauna consists of four families of chewing lice Goniodidae, Philopteridae, Trichodectidae and Heptapsogasteridae (Vincents. Smith, 2001) [25]. Ischnocera lice belong to the family Philopteridae, are dorso-ventrally flattened, wingless, highly host specific than other louse, direct life cycle and having three nymphal instars before developing into adult lice by (Lyal, 1985 and Hafner, *et. al*., 1994) [8]. It is a comparative study based on morphological characteristics of adult avian lice producing 40 characters from 04 species of 04 genera and the cladogram of the grouped lice based on diversity and distribution of characters appears as a result of coevolution throughout the clade. Beside the morphological phylogeny, molecular phylogenetic has also supported the relationship between philopterid genera (Page, Price and Hallenthal, 1995; and Spradling, 1997) [21] have studied the phylogenetic of Ischnocera using both morphological and molecular data. A preliminary surveys, classification and keys to the genera of avian Ischnocera lice were described in detailed by (Ferris, 1951; Clay, 1969; Keler, 1938; 1971; Kim and Ludwig, 1978 and Kim, Prath, and Stojanovich, 1986) [7, 6, 12, 13]. Philopteridae (Phthiraptera: Ischnocera) of chewing lice are parasitic on birds.
The family is the largest in the Ischnocera, and its members differ from others in not having an entire front margin of the head. All species feeds on fragments of feather and dead skin. Many male Philopterid use their antennae to clasp the female during copulation (Clay, 1969) [6]. Phylogeny and classification of the Psocodea with reference to lice (Phthiraptera) was studied by (Lyal, 1985) in which he described the apomorphies of both Psocodea and Phthiraptera and placed Psocoptera as separate group and are considered to be holophyletic. Mallophagan lice should be valuable evidence on the phylogeny of their hosts; they discussed three factors in the principle of host–parasite co-evolution, discontinuous distribution, secondary infestation and parallel evolution (Chandler, 1916; Clay, 1950) [4, 5]. They also have considered the Ischnocera to be the primitive group of lice, their ancestors may start to live as ectoparasites of warm blooded animals in Cretaceous (135–65 million years ago) or even in the Jurassic Period (Howard, 1950; 1955; Wappler, *et. al.*, 2004) [9, 23]. By the phylogenetic and cladistic analysis, it is believed that the chewing lice have evolved from an ancestral stock before the division into Amblycera, Ischnocera and Anoplura (Kim, *et. al.*, 1973; Marshall, 2002) [11, 16].
The purpose of the present research was to know the fauna of Mallophaga from host galliform birds of Hyderabad region and to observe new facts and findings thus could obtained which contribute to the existing knowledge of phylogeny of Ischnoceran lice. The morphological characters and characterstats have been derived from (Clay, 1969 and Marshall, 2002) [6, 16]. The line drawing of the specimens was made with the help of U-DA, Drawing tube attachment, fixed with Olympus Microscope (CH 20). The species diagram was made on the white paper sheet in which the whole mounts were drawn at 10 X whereas the different parts of body of chewing lice were drawn at 100 to 400X. The diagram was traced on tracing paper sheet of 80gm with the help of water proof black ink using rotering pens of diameters of the nibs ranging from 0.5 mm.

Key to the Species of Family Philopteridae (Ischnocera) of Hyderabad District, Sindh, Pakistan.

1. Body elongated, narrow; abdomen oblong; antennae always heteromorphic, scape elongated with a thumb like process; abdominal tergites butterfly shape, not fused with pleurites----------*Lipeurus tropicalis* Peters, 1931
2. Body oval or oblong, broad; abdomen rounded to oval; antennae homomorphic or heteromorphic, scape with or without thumb like process; abdominal tergites fused with pleurites, form tergo-pleurites----------2
3. Temples short, quadrate, not beyond the occipital margin; genitalia simple, rod shaped----------3

4. Temples of head expanded posteriorly beyond the occipital margin; antennae heteromorpohi, scape very elongated with a lateral process in male; sternites VIII expended outgrowth; genitalia hook shaped---------- *Chelopistes meleagridi* (Linnaeus, 1758)
5. Head anterior margin broadly convex with thick carina; antennae heteromorphic; preantennal nodus blunt and elongated; pterothorax partially divided; abdomen with median tergal setae; female terminalia bear lateral setal brushes and conical processes; subgenital plate of female is armed with 5 short spine like setae with hook----------*Goniodes dissimilis* Denny, 1842
6. Head anterior margin relatively less broad, convex with thin carina; antennae homomorphic; preantennal nodus bulb like and short; pterothorax completed, undivided; abdomen without median tergal setae; female terminalia without lateral setal brushes; female subgenital plate armed with 8 short thorn like setae---------- *Goniocotes gallinae* (De Geer, 1776)

Cladistics analysis of chewing lice of family philopteridae upto generic level from Hyderabad, sindh, Pakistan List of characters.

A^0 Body small and wide.
A^1 Body elongated and narrows (*Lipeurus*)
A^2 Body wide and rounded (*Goniodes, Goniocotes, Chelopistes*)

B^0 Head otherwise.
B^1 Head anterior margin is circumfasciate (*Goniocotes, Goniodes, Chelopistes*)
B^2 Head anterior margin is not circumfasciate (*Lipeurus*)

C^0 Head anterior margin is plane.
C^1 Head anterior margin is wide (*Chelopistes, Goniodes, Goniocotes*) C^2 Head anterior margin thin with median bump (*Lipeurus*)

D^0 Marginal carina reduced or not present.
D^1 Marginal carina in the form of complete band along the head margin (*Chelopistes, Goniocotes, Goniodes*)
D^2 Marginal carina is not complete band and separated variously with the head margin (*Lipeurus*)

E^0 Preantennal nodus absent.
E^1 Small development of preantennal nodus (*Lipeurus*)
E^2 Large development of preantennal nodus (*Goniodes, Goniocotes, Chelopites*)

F^0 Preantennal nodus tapering to pointed.
F^1 Weakly development of preantennal nodus (*Lipeurus*)
F^2Long and smooth development of preantennal nodus (*Chelopistes, Goniodes, Goniocotes*)

G^0 Plane mid – dorsal region of head.
G^1 Presence of median groove on mid – dorsal region of head (*Goniodes, Chelopistes*)
G^2 Absence of median groove on mid – dorsal region of head (*Goniocotes, Lipeurus*)

H^0 Anterior region of head at ventral plane.
H^1Anterior region of head is thin and without ventral plate (*Goniodes, Lipeurus, Goniocotes, Chelopistes*)

I^0 Ventral carina not present.
I^1 Presence of ventral carina in the shape of complete band (*Chelopistes, Goniocotes, Lipeurus, Goniodes*)

J^0 Dorsal preantennal suture across antennal sockets.
J^1 Absence of dorsal preantennal suture across antennal socket (*Chelopistes, Goniodes, Goniocotes*)
J^2 Presence of dorsal preantennal suture across the premarginal carina (*Lipeurus*)

K^0 Pulvinus not present.
K^1 Pulvinus in complete portion (*Chelopistes, Goniocotes, Goniodes, Lipeurus*)

L^0 Torma not present.
L^1 Torma is close with ventral carina (*Lipeurus*)
L^2 Torma is not close with ventral carina (*Goniocotes, Goniodes, Chelopistes*)

M^0Antennae filliform.
M^1Male and female antennae are homoporphic (*Goniocotes*)
M^2Male and female antennaeare not homomorphic but heteromorphic (*Chelopistes, Lipeurus, Goniodes*)

N^0 Male antenna scape bearing a slight sign of sclerotization.
N^1Male antenna scape bearing side process (*Lipeurus, Chelopistes, Goniodes*)
N^2 Male antenna scape is short and without of side process (*Goniocotes*)

O^0 Male antenna flagellomere I is modest and unchanged.
O^1 Male antenna flagellomere I thick but without lateral processes (*Goniocotes*)
O^2Male antenna flagellomere I is strong bearing short processes (*Lipeurus, Chelopistes, Goniodes*)

P^0 Thin and membranous gular region.
P^1 Thin and small gular region with gular plate (*Goniocotes, Chelopistes, Goniodes*)
P^2 Thick and large gular region bearing thick plate (*Lipeurus*)

Q^0 Temporal margins smooth.
Q^1 Temporal margins smooth, rounded and expanded (*Lipeurus*)
Q^2 Temporal margins angulated and not beyond occipital margin (*Goniocotes, Goniodes*)
Q^3 Temporal margins pointed and not beyond occipital margin (*Chelopistes*)

R^0 Temporal marginal setae less than three.
R^1 Temporal marginal setae are three (*Lipeurus*)
R^2 Temporal marginal setae are five (*Goniodes, Goniocotes*)
R^3 Temporal marginal setae are more than five (*Cheopites*)

S^0 Postocular nodus not present.
S^1 Weakly development of postocular nodus (*Lipeurus*)
S^2 Moderately development of postocular nodus (*Chelopistes*)
S^3 Highly development of postocular nodus (*Goniocotes, Goniodes*)

T^0 Absence of postero – lateral setae on prothorax.
T^1 Presence of postero- lateral setae on prothorax (*Chelopistes, Goniocotes, Goniodes, Lipeurus*)

U^0 Lateral margins parallel and straight on pterothorax.
U^1 Lateral margins slightly parallel to little divergent on pterothorax (*Lipeurus*)
U^2Lateral margin is extremely divergent on pterothorax (*Chelopistes, Goniocotes, Goniodes*)

V^0 Posterior margins are straight on pterothorax.
V^1 Posterior margins are slightly concave on pterothorax (*Lipeurus*)
V^2Posterior margins are deeply concave with V- shaped on pterothorax (*Goniocotes, Goniodes, Chelopistes*)

W^0 Pterothoracic posterior –lateral setae not present.
W^1 Pterothoracic postero –lateral setae four pairs, collected as 4+4 (*Lipeurus*)
W^2 Pterothoracic postero –lateral setae four pairs collected as 2, 2+2, 2 (*Chelopistes, Goniocotes*)
W^3 Pterothoracic postero –lateral setae five pairs (*Goniodes*)

X^0 Proepimeron bearing pointed ends.
X^1 Proepimeron bearing smooth ends (*Lipeurus*)
X^2 Proepimeron expended upward and downward (*Chelopistes, Goniocotes, Goniodes*)

Y^0 Developed and divided meso-metasternal plate.
Y^1 Weakly development of meso–metasternal plate (*Goniodes, Goniocotes*)
Y^2 Highly development of meso–metasternal plate (*Chelopistes, Lipeurus*)

Z^0 Legs very simple and modest.
Z^1 Sterno –coxal legs (*Chelopistes, Goniodes, Goniocotes*)
Z^2 Sterno –pleuro –coxal legs (*Lipeurus*)

AA^0 Tergite I present.
AA^1 Tergite I is attached with tergite II, invisible (*Lipeurus, Chelopistes, Goniodes, Goniocotes*)

BB^0 Median to submedian tergal setae archaic.
BB^1 Median to submedian tergal setae is present (*Chelopistes, Goniodes, Goniocotes, Lipeurus*)

CC^0 Fused but undivided tergopleurites.
CC^1 Medially development of tergopleurites which is separated by small gap (*Lipeurus*)
CC^2 Medially development of tergopleurites which is separated by thin and narrow gap (*Goniocotes*)
CC^3 Medially development of tergopleurites which is separated by wide gap (*Chelopistes, Goniodes*)

DD^0 Absence of abdominal sternal plates.
DD^1 Weakly development of abdominal sternal plates (*Goniodes, Chelopistes, Goniocotes*)
DD^2 Well development of abdominal sternal plates (*Lipeurus*)

EE^0 Absence of median to submedian sternal setae.
EE^1 Presence pf median to submedian sternal setae (*Goniocotes, Goniodes, Chelopistes, Lipeurus*)

FF^0 Sclerotization of abdomin on tergites and pleurites.
FF^1 Sclerotization of abdomin on tergites only (*Lipeurus*)
FF^2 Sclerotization of abdomen on tergopleurites (*Chelopistes, Goniodes, Goniocotes*)

GG^0 Development of small and condensed pleural ribs.
GG^1 Elongation of pleural ribs but not expansion to pleural knots (*Lipeurus*)
GG^2 Expansion, development and elongation of pleural into pleural heads (*Chelopistes, Goniodes, Goniocotes*)

HH^0 Presence of somple and modest trichoid seta on abdominal segment VIII. HH^1 Absence of trichoid seta on abdominal segment VIII (*Lipeurus*)
HH^2 Presence of modified trichoid seta on abdominal segment VIII (*Chelopistes, Goniodes, Goniocotes*)

II^0 Dorsal terminal plate of female alienated not complete.
II^1Dorsal terminal plate of female is formed by merging of both tergites IX to X only (*Lipeurus*)
II^2 Dorsal terminal plate of female is formed by merging of tergites IX to X and pleurites (*Goniocotes*)
II^3Dorsal terminal plate of female is formed by tergopleurites (*Goniodes, Chelopistes*)

JJ^0 Abdominal segment IX of male inwards the posterior margin.
JJ^1Abdominal IX segment of male equally found along the posterior abdominal margin (*Goniocotes, Goniodes*)
JJ^2Abdominal IX segment of male extruded behind the posterior abdominal margin (*Lipeurus, Chelopistes*)

KK^0 External genitalia of male small size.
KK^1 External genitalia of male is small size, reaching up to VI or VII segment (*Chelopistes*)
KK^2 External genitalia of male is large size, reaching up to IV segment (*Goniocotes, Lipeurus, Goniodes*)

LL^0 Male genitalia framework condensed.
LL^1 Male genitalia framework modest or simple (*Goniodes, Goniocotes*)
LL^2 Male genitalia framework complex and composite (*Chelopistes, Lipeurus*)

MM^0 Sclerotization of basal apodeme moderatelly.
MM^1 Thickly sclerotization of basal apodeme (*Lipeurus, Chelopistes, Goniodes*) MM^2 Slight sclerotization of basal apodeme (*Goniocotes*)

NN^0 Vulval margin of female is simple, smooth shape and modest.
NN^1 Vulval margin of female is generally fringed with one row of setae (*Goniocotes, Chelopistes, Goniodes*)
NN^2 Vulval margin of female is without setal fringe (*Lipeurus*)

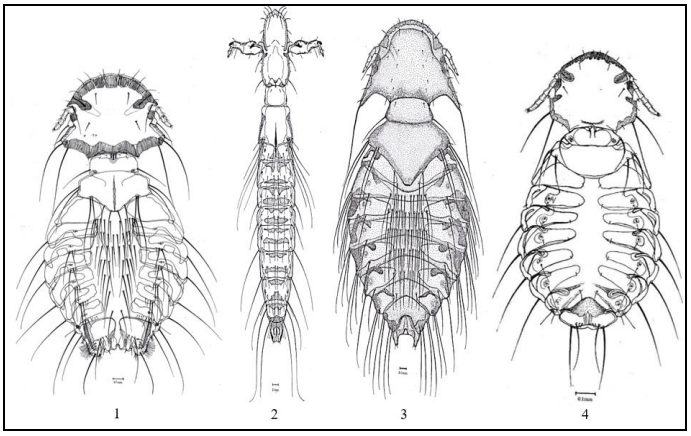

Fig 1: 4-1- *Goniodes dissimilis*, Denny, 1842; 2- *Lipeurus tropicalis*, Peters, 1931; 3-*Chelopistes meleagridis* (Linnaeus, 1758) and 4-*Goniocotes gallinae* (De Geer, 1776).

Table 1: Raw Data Matrix Chart for character and characterstates of the genera of Family Philopteridae (Ischnocera) collected from Fowls.

Characters	*Lipeurus*	*Goniocotes*	*Goniodes*	*Chelopistes*
Structure of body (A)	1	2	2	2
Type of Head (B)	2	1	1	1
Head Anterior Margin (C)	2	1	1	1
Marginal Carina of Head (D)	2	1	1	1
Proportions of Preantennal Nodus (E)	1	2	2	2
Structure of preantennal Nodus (F)	1	3	2	2
Dorsal Median Groove of Male (G)	1	1	2	2
Ventral anterior Plate (H)	1	2	1	2
Development of Ventral Carina (I)	1	1	1	1
Preantennal Dorsal Suture (J)	2	1	1	1
Pulvinus (K)	1	1	1	1
Position of Torma (L)	1	2	2	2
Antenna filiform (M)	2	1	2	2
Structure of Male Antennal Scape (N)	1	2	1	1
Flagellomere I of male Antenna (O)	2	1	2	2
Occurrence of Gular Plate (P)	2	1	1	1
Margins of Temporal region (Q)	1	2	2	3
Marginal Temporal Setae (R)	1	2	2	3
Development of Postocular Nodus (S)	1	3	3	2
Occurrence of Postero-lateral Setae on Prothorax (T)	1	1	1	1
Lateral Margins of Pterothorax (U)	1	2	2	2
Posterior Margin of Pterothorax (V)	1	2	2	2
Postero-lateral Setae on Pterothorax (W)	1	2	3	2
Proepimeron Ends (X)	1	2	2	2
Occurance of Meso-metasternal Plate (Y)	2	1	1	2
Legs Articulation (Z)	2	1	1	1
Tergite I (AA)	1	1	1	2
Medially to Submedially Occurrence of Tergal Setae (BB)	1	2	2	2
Tergopleurites (CC)	1	2	3	3
Sternal Plates of Abdomen (DD)	2	1	1	1
Medially to submedially Occurrence of Sternal Setae (EE)	1	1	1	1
Abdominal Sclerotization (FF)	1	2	2	2
Pleural Ribs of Abdomen (GG)	1	2	2	2
Presence of Trichoid Seta on Abdominal Segment VIII (HH)	1	2	2	2
Dorsal Terminal Plate of Female (II)	1	2	1	3
Abdominal Segment of Male (JJ)	2	1	1	2
Length of Male Genitalia (KK)	2	2	2	1
Male Genital Armature (LL)	2	1	1	2
Basal Apodeme Sclerotization (MM)	1	2	1	1
Vulval Margin of Female (NN)	2	1	1	1

Character States and Analysis.

Structure of body (A)

The structure of body of *Lipeurus* is thin, narrow and long, which shows its autapomorphic condition (A^1), while the structure of body of *Chelopistes*, *Goniodes* and *Goniocotes* are wide, broad and smooth, which is showing their synapomorphic condition (A^2).

Type of Head (B)

The anterior head margin of *Goniodes*, *Goniocotes* and *Chelopistes* are circumfaciate type, which is showing their autapomorphic condition (B^1), while in *Lipeurus*, the

anterior head margin is not circumfaciated type, which shows the synapomorphic condition (B^2).

Head Anterior Margin (C)
The head anterior margin of *Goniocotes*, *Goniodes* and *Chelopistes* is wide, which shows their autapomorphic condition (C^1), while in *Lipeurus*, the head anterior margin is thin with bump medially, which is showing the synapomorphic condition (C^2).

Marginal Carina of Head (D)
The marginal carina in *Goniocotes*, *Goniodes* and *Chelopistes* is in the form complete band, with the head margin which is showing their autapomorphic condition (D^1), while in *Lipeurus*, the marginal carina is not complete and broken variously with the head margin, which shows its synapomorphic condition (D^2).

Proportions of Preantennal Nodus (E)
The proportions of preantennal nodi are short in *Lipeurus*, which shows its autapomorphic condition (E^1), while in *Chelopistes*, *Goniodes* and *Goniocotes*, The proportions of preantennal nodi are elongated, which is showing their synapomorphic condition (E^2).

Structure of Preantennal Nodus (F)
Preantennal nodi in *Lipeurus* are weakly developed, which shows its autapomorphic condition (F^1), while in *Goniocotes*, *Goniodes* and *Chelopistes*, the preantennal nodi are long and smooth, which is showing their synapomorphic condition (F^2).

Dorsal Median Groove of Male (G)
In *Chelopistes* and *Goniodes*, the head mid-dorsal region bearing median groove of males, which is showing their autapomorphic condition (G^1), while in *Lipeurus* and *Goniocotes*, the head mid-dorsal region is not bearing median groove of male, which shows their synapomorphic condition (G^2).

Ventral Anterior Plate (H)
The ventral anterior plate is not present in *Lipeurus*, *Goniocotes*, *Goniodes* and *Chelopistes*, which showing their autapomorphic condition (H^1).

Development of Ventral Carina (I)
Development of ventral carina in *Lipeurus*, *Goniocotes*, *Goniodes* and *Chelopistes*, as a complete band arround pulvinus, which is showing their autapomorphic condition (I^1).

Preantennal Dorsal Suture (J)
The preantennal dorsal suture is not present in *Chelopistes*, *Goniocotes* and *Goniodes*, which is showing their autapomorphic condition (J^1), while in *Lipeurus*, the preantennal dorsal suture is present and complete across the premarginal carina, which shows its synapomorphhic condition (J^2).

Pulvinus (K)
Pulvinus is a complete lobe in *Goniocotes*, *Goniodes*, *Chelopistes* and *Lipeurus*, which is showing their autapomorphic condition (k^1).

Position of Torma (L)
Torma is close with ventral carina in *Lipeurus*, which is showing its autapomorphic condition (L^1), while in *Chelopistes*, *Goniocotes* and *Goniodes*, the torma is not connected with from ventral carina, which shows its synapomorphic, condition (L^2).

Antennae of both Sexes (M)
The antennae in male and female individuals are homomorphic in *Goniocotes*, which shows its autapomorphic condition (M^1), while in *Chelopistes*, *Goniodes* and *Lipeurus*, the antennae in male and female antennae are not homomorphic but heteromorphic, which is showing their synapomorphic condition (M^2).

Structure of Male Antennal Scape (N)
The structure of male antennal scape is bearing side process in *Lipeurus*, *Chelopistes* and *Goniodes*, which is showing their autapomorphic condition (N^1), while in *Goniocotes*, the structure of male antennal scape is short and without of side process, which is showing its synapomorphic condition (N^2).

Male Antennal flagellomere I (O)
Male antennal flagellomere I in *Goniocotes*, is thick and not evidence of lateral processes, which shows its autapomorphic condition (O^1), while in *Lipeurus*, *Chelopistes* and *Goniodes*, the male antennal flagellomere I is strong with short processes, which is showing their synapomorphic condition (O^2).

Occurraence of Gular Plate (P)
The gular region of *Goniocotes*, *Chelopistes* and *Goniodes* is with thin gular plate, which is showing their autapomorphic condition (P^1), While in *Lipeurus*, the gular region is with thick gular plate, which is showing its synapomorphic condition (P^2).

Margins of Temporal region (Q)
Margins of temporal region are smooth, rounded and expended in *Lipeurus*, which shows its autapomorphic condition (Q^1), while in *Goniodes* and *Goniocotes*, the margins of temporal region are angulated and not beyond occipital margin, which shows their synapomorphic condition (Q^2), while in *Chelopistes* the margins of temporal region pointed and beyond the occipital margin, which showing its derived synapomorphic condition (Q^3).

Temporal Marginal Setae (R)
There are three temporal marginal setae in *Lipeurus*, which is showing its autapomorphic condition (R^1), while in *Goniocotes* and *Goniodes*, there are five temporal marginal setae, which are showing their synapomorphic condition (R^2), while in *Chelopistes*, and the temporal marginal setae are more than five, which is showing its derived synapomorphic condition (R^3).

Development of Postocular Nodus (S)
Weakly development of postocular nodi in *Lipeurus*, which shows its autamorphic condition (S^1), while in *Chelopistes*, the moderately development of postocular nodi, which is showing its synapomorphic condition (S^2), While in *Goniocotes* and *Goniodes*, the well development of postocular nodi, which is showing their derived

synapomorphic condition (S^3).

Occurrence of Postero-lateral Setae on Prothorax (T)
Presence of postero-lateral setae on prothorax in *Chelopistes, Goniocotes, Goniodes* and *Lipeurus*, which is showing their autapomorphic condition (T^1).

Lateral Margins of Pterothorax (U)
Lateral margins of pterothorax are parallel to little divergent in *Lipeurus*, which is showing its autapomorphic condition (U^1), while in *Chelopistes*, *Goniodes* and *Goniocotes*, the lateral margins of pterothorax are extremely divergent, which is showing their synapomorphic condition (U^2).

Posterior Margin of Pterothorax (V)
Posterior margin of pterothorax is slightly concave in *Lipeurus*, which shows its autapomorphic condition (V^1), while in *Chelopistes, Goniocotes* and *Goniodes*, the posterior margin of pterothorax is deeply concave and V-shaped, which is showing their synapomorphic condition (V^2).

Postero-lateral Setae on Pterothorax (W)
The postero-lateral setae of pterothorax are in four pairs, collected as 4+4 in *Lipeurus*, which shows its autapomorphic condition (W^1), while in *Goniocotes* and *Chelopistes*, the postero-lateral setae of pterothorax are four pairs collected as 2, 2+2, 2, which is showing their synapomorphic condition (W^2), while in *Goniodes*, the postero-lateral setae of pterothorax are in five pairs, which is showing its derived synapomorphic condition (W^3).

Proepimeron Ends (X)
Proepimeron with smooth ends in *Lipeurus*, which shows its autapomorphic condition (X^1), while in *Chelopistes, Goniocotes* and *Goniodes*, the proepimeron ends are expanded upward and downward, which is showing their synapomorphic condition (X^2).

Occurance of Meso-metasternal Plate (Y)
The weakly development meso-metasternal plate in *Goniocotes* and *Goniodes*, which shows their autapomorphic condition (Y^1), while in *Chelopistes* and *Lipeurus*, the well development of meso-metasternal plate with sclerotization, which is showing their synapomorphic condion (Y^2).

Legs Articulation (Z)
The articulation of legs are sterno-coxal position in *Chelopistes, Goniodes* and *Goniocotes*, which is showing their autapomorphic condition (Z^1), while In *Lipeurus*, the articulation of legs are sterno-pleuro-coxal, which is showing its syntapomorphic condition (Z^2).

Tergite I (AA)
The tergite I is not divided with tergite II and invisible all philopterids, including *Lipeurus, Chelopistes, Goniodes* and *Goniocotes*, which is showing their autapomorphic condition (AA^1).

Medially to Submedially Occurrence of Tergal Setae (BB)
Presence of medially to submedially occurrence of tergal setae in *Chelopistes, Goniocotes, Goniodes* and *Lipeurus*, which is showing their autanpomorphic condition (BB^1).

Tergopleurites (CC)
The moderately development and separation of tergopleurites medially by small gap in *Lipeurus*, whih shows its autapomorphic condition (CC^1), while in *Goniocotes*, the development and separation of tergopleurites medially by thin and narrow gap, which is showing its synapomorphic condition (CC^2), While in *Chelopistes* and *Gonides*, the well development and separation of tergopleurites medially by wide gap at, which is showing their derived synapomorphic condition (CC^3).

Sternal Plates of Abdomen (DD)
The weakly development of sternal plates of abdomen in *Goniodes, Chelopistes* and *Goniocotes*, which is showing their autapomorphic condition (DD^1), while in *Lipeurus*, the well development of sternal plates of abdomen, which shows its synapomorphic condition (DD^2).

Medially to Submedially Occurrence of Sternal Setae (EE)
Presence of medially to submedially occurrence of sternal setae in *Lipeurus, Chelopistes, Goniocotes* and *Goniodes*, which is showing their autapomorphic condition (EE^1).

Sclerotization of Abdomen (FF)
The sclerotization of abdomen on tergites only in *Lipeurus*, which shows its autapomorphic condition (FF^1), while in *Goniocotes, Goniodes* and *Chelopistes*, the sclerotization of abdomen on tergo-pleurites, which is showing their synapomorphic condition (FF^2).

Pleural Ribs of Abdomen (GG)
Elongation but not expansion of pleural ribs of abdomen to pleural heads in *Lipeurus*, which shows its autapomorphic condition (GG^1), while in *Chelopistes, Goniodes* and *Goniocotes*, the elongation, expansion and development of pleural ribs of abdomen into pleural heads, which is showing their synapomorphic condition (GG^2).

Presence of Trichoid Seta on Abdominal Segment VIII (HH)

The trichoid seta not present on abdominal segment VIII in *Lipeurus*, which shows its autapomorphic condition (HH^1). While in *Chelopistes, Goniocotes* and *Goniodes*, the trichoid seta is present and modified on abdominal segment VIII, which is showing their synapomorphic condition (HH^2).

Dorsal Termainal Plate of Female (II)
The dorsal terminal plate of female is developed by the attachment of of tergites IX and X only in *Lipeurus*, which shows its autapomorphic condition (II^1), while in *Goniocotes*, the dorsal terminal plate of female is developed by the attachment of tergites IX-X and pleurites, which is showing its synapomorphic condition (II^2), while in *Goniodes* and *Chelopistes*, the dorsal plate of female is developed by tergo pleurites, which is showing their derived synapomorphic condition (II^3).

Abdominal Segment IX of Male (JJ)
The abdominal IX segment of male is parallel along the posterior margin of abdomen in *Goniocotes* and *Goniodes*,

which shows their autapomorphic condition (JJ^1), while in *Chelopistes* and *Lipeurus*, the abdominal segment IX of male is extruded behind the posterior margin of abdomen, which is showing their synapomorphic condition (JJ^2).

Length of Male Genitalia (KK)

The genitalia of male is small and simple reaching up to the segment VI or VII in *Chelopistes*, which showing its autapomorphic condition (KK^1), while in *Goniocotes*, *Lipeurus* and *Goniodes*, genitalia of male is large and complex reaching up to the segment IV, which is showing their synapomorphic condition (KK^2).

Male Genitalial Frame work (LL)

The framework of male genitalia is complex and composite, in *Lipeurus* and *Chelopistes*, which is showing their autapomorphic condition (LL^1), while in *Goniodes* and *Goniocotes*, the frame work of male genitalia is modest to simple, which is showing their synapomorphic condition (LL^2).

Basal Apodeme Sclerotization (MM)

The presence of thickly sclerotized basal apodeme in *Lipeurus*, *Chelopistes* and *Goniodes*, which is showing their autapomorphic condition (MM^1), while in *Goniocotes*, the presence of thin basal apodeme sclerotization, which is showing its synapomorphic condition (MM^2).

Vulval Margin of Female (NN)

The vulval margin of female is fringed with one row of setae in *Chelopistes*, *Goniocotes* and *Goniodes*, which is showing their autapomorphic condition (NN^1) while in *Lipeurus*, the vulval margin of female is not having setal fringe, which shows its synapomorphic condition (NN^2).

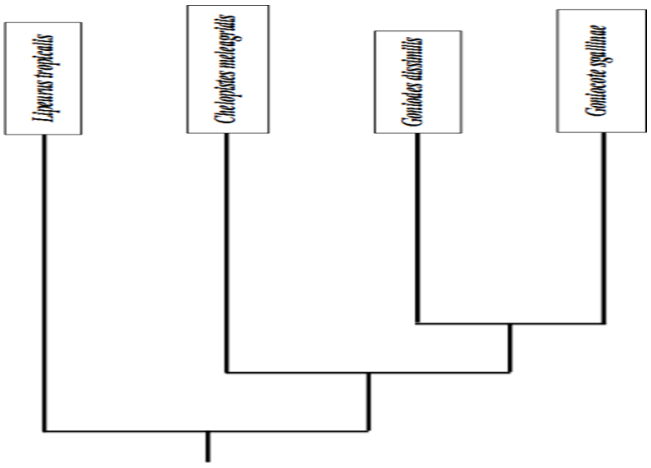

Fig 5: Cladogram of the genera of Family Philopteridae collected from Fowls in District Hyderabad, Sindh, Pakistan, showing their phylogenetic relationship.

Discussion

Fowls of family Phasianidae (Galliformes) are important group of game birds, used as main source of food, sports, recreation, ecotourism and an ecological bio-factor. Family Phasianidae includes patridges, fowls, quails and phaesants (Sychra *et. al.*, 2008) [22]. Family Philopteridae Burmeister, 1838 (Suborder: Ischnocera) comprised of eleven genera, includes *Anaticola* Clay, 1936, *Brueelia* Kéler, 1936, *Campanulotes* Kéler, 1939, *Chelopistes* 1939, *Cuclotogaster* Carriker, 1936, *Columbicola* Ewing, 1929, *Lipeurus* Nitzsch, 1818, *Goniodes* Nitzsch, 1818, *Goniocotes* Burmeister, 1838, *Neopsittaconirmus* Conci, 1942 and *Sturnidoecus* Eichler, 1944 (Price and Emerson 1975) [18]. During present investigation, 04 species of family Philopteridae were recovered belonging to 04 genera which including *Lipeurus tropicalis* (Peters, 1931), *Chelopistes meleagridis* (Linnaeus, 1758), *Goniodes dissimilis* (Denny, 1842), and *Goniocotes gallinae* (De Geer, 1776). The cladogram of Ischnocera species shows that *G. gallinae* and *G. dissimilis* are the sister group I, outgroup I of sister group I include *C. meleagridis.* The sister group II includes, *C. meleagridis*, *G. dissimilis* and *G. gallinae*, outgroup II of sister group II, include *L. tropicalis* (Figure. 5). Group I includes *Goniocotes* and *Goniodes* which appear to be closely related two groups (Figure.5) and play sister group relationship to each other by having apomorphies of anterior margin of head which is convex with more or less developed carina, presence of preantennal nodus and pterothorax which is complete or divided and female subgenital plate is armed with short spine like setae. Group II which is sister group II and out group I includes *Chelopistes* and *Goniodes* and *Goniocotes* which appear to be closely related three group relationship to each other by having apomorphies of anterior margin of head is broadly convex, antennae monomorphic to heteromorphic and genitalia is hooked shaped spines. Group III which is sister group III and out group II (Figure. 5) includes *Lipeurus* and *Chelopistes* which appears to be closely related two groups and play sister group relationship to each other by having apomorphies of anterior margin of head is thick, smooth and rounded, antennae always heteromorphic, scape is elongated, tergites not fused with pleurites.

The chewing lice of Phasianid birds have studied, in different parts of the world (Ansari, 1944 and 1947) [3] but in Pakistan there is no thorough study on chewing lice especially of fowls in Hyderabad Sindh, Pakistan. The review of literature revealed that some work has been done on the chewing lice particularly in the province of Sindh (Naz, *et. al.*, 2010a; Naz, *et al*, 2010b and Naz and Rizvi, 2012) [18, 18, 17] however, sporadic investigations were carried out in Faisalabad (Punjab) before partition of indo- pak region only by (Ansari, 143 and 1947) [3].

The cladistic relationship of chewing lice species was analyzed to understand the evolutionary aspect of their morphologies as well as their host specificity by using the key characters of lice. This is the first investigation of its kind on various types and breeds of fowls from Sindh, Pakistan, made a valuable contribution to the chewing lice fauna of Pakistan.

References

1. Aansari MAR. Mallophaga found on domestic fowl Gallus domesticus Linnaeus, in the Punjab, Indian J. Entomol. 1943; 5(1-2):129-142.
2. Aansari MAR. Mallophaga found on Domestic fowl Gallus domesticus Linnaeus, in the Punjab, Indian J. Entomol. 1943; 5(1-2):129-142.
3. Aansari MAR, Mallophaga (Ischnocera) infesting birds in the Punjab (India), Proc. Nat. Inst. Sci. India. 1947; 13(6):253-303.
4. Chandler AC. A study of the structure of feathers with reference to their taxonomic significance, University of California Publications in Zoology. 1916; 13:243-446.
5. Clay T. A preliminary survey of the distribution of the

Mallophaga (Feather lice) on the class Aves (Birds), J Bombay Natu. Hist. Soc. 1950; 49:430-44.
6. Clay T. A key to the genera of the Menoponidae (Amblycera: Mallophaga: Insecta), Bull. Brit. Mus. (Natu. Hist.) Entomol. 1969; 24:3-26.
7. Ferris GF. The sucking lice, Memoirs of the Pacific Coast Entomological Society. 1951; 1:1-320.
8. Hafner MS, Sudmann PD, Villablanca FX. Spradling, T. A., Demastes, J. W., and Nadler, S. A. Disparate rates of molecular evolution in cospeciating hosts and parasites, Science. 1994; 265:1087-1090.
9. Howard H. Fossil evidence of avian evolution, Ibis. 1950; 92:1-21.
10. Howard H. A new wading bird from the Eocene of Patagonia, Am. Mus. Novitates. 1955; 1710:1-25.
11. Kim KC, Emerson KC, Price RD. Lice, 376-397. In R. J. Flynn [ed.], Parasites of laboratory animals, Iowa State University Press, Ames, Iowa, U. S. A, 1973.
12. Kim KC, Ludwig HW. Phylogenetic relationships of Parasitic Psocodea and taxonomic position of the Anoplura, Ann. Entomol. Soc. Am. 1978; 71910-922.
13. Kim KC, Pratt HD, Stojanovich GJ. The Sucking Lice of North America. Pittsburgh: Pennsylvania State University, 1986.
14. Lakshminarayana KV. Data book for the study of chewing lice (Phthiraptera: Insecta), Records of the Zoological Survey of India, Miscellaneous publication, occasional papers. 1986; 81:1-63.
15. Layal CHC. Phylogeny and classification of the Psocodea, with particular reference to lice (Psocodea: Phthiraptera), Syst. Entomology. 1985; 10:145-165.
16. Marshall IK. Congruence and Cospeciation. Morphological and Molecular Phylogenetics of the Amblycera (Phthiraptera), Ph. D. Thesis, Univ. Glasgow, 2002.
17. Naz S, Rizvi SA, Sychra O. The high rate of infestation of chewing lice (Phthiraptera) in Rock Pigeons (Cloumba livia Gemlin, 1789) in Pakistan, Trpical Zoology. 2010a; 23:21-28.
18. Naz S, Rizvi SA. First record of Anaticola crassicornis (Scopoli) from Goose, from Sindh, Pakistan. Zootaxa. 1763; 2693:60-66.
19. Page RDM, Price RD, Hellenthal RA. hylogeny of Geomydoecus and Thomomydoecus pocket gopher lice (Phthiraptera: Trichodedidae) inferred from cladistic ana- lysis of adult and first instar morphology. Systematic Entomology. 1995; 20:129-143.
20. Price RD, Emerson KC. The Menacanthus (Mallophaga: Menoponidae) of the Piciformes (Aves), Ann. Entomol. Soc. Am. 1975; 68(5):779-785.
21. Spradling TA. Relative rates of molecular evolution in rodents and their symbionts (Coevolution,p hylogenetic). Ph. D. thesis, Louisiana State University and Agricultural and Mechanical College, 1997.
22. Sychra O, Harmat P, Literak I. Chewing Lice (Phthiraptera) on chickens (Gallus gallus) from small backyard flocks in the eastern part of Cech Republic; Vet. Parasitology. 2008; 152 (2008):344-348.
23. Wappler T, Smith VS, Dalgleish RC. Scratching an ancient itch: An Eocene bird, 2004.
24. Louse fossil. Proceedings of the Royal Society of London; B (suppl.); Biology Letters; 03bl0387, S2.
25. Vincents Smith, Avian louse. Phylogeny (Phthiraptera: Ischnocera): a cladistic study based on morphology, Zoological Journal of the linnean society. 2001; 132(1):81-144.