Pakistan J. Zool., vol. 47(2), pp. 417-426, 2015.

Status and Phylogenetic Analyses of Endemic Birds of the Himalayan Region

M.L. Thakur* and Vineet Negi
Himachal Pradesh State Biodiversity Board; Department of Environment, Science & Technology, Shimla-171 002 (HP), India

Abstract.- Status and distribution of 35 species of birds endemic to Himalayas has been analysed during the present effort. Of these, relatively very high percentage *i.e.* 46% (16 species) is placed under different threat categories. Population of 24 species (74%) is decreasing. A very high percentage of these Himalayan endemics (88%) are dependent on forests. Population size of most of these bird species (22 species) is not known. Population size of some bird species is very small. Distribution area size of some of the species is also very small. Three species of endemic birds *viz.*, *Callacanthis burtoni, Pyrrhula aurantiaca* and *Pnoepyga immaculata* appear to have followed some independent evolutionary lineage and also remained comparatively stable over the period of time. Three different evolutionary clades of the endemic bird species have been observed on the basis of phylogenetic tree analyses. Analyses of length of branches of the phylogenetic tree showed that the three latest entries in endemic bird fauna of Himalayan region *i.e. Catreus wallichii, Lophophorus sclateri* and *Tragopan blythii* have been categorised as vulnerable and therefore need the highest level of protection.

Key Words: Endemic birds, Himalayan region, conservation status, phylogeny**.**

INTRODUCTION

The Himalayas, one of the hotspots of biodiversity, include all of the world's mountain peaks higher than 8,000 meters, are stretched in an area of over 3,000 kilometres in northern Pakistan, Nepal, Bhutan and the north-western and north-eastern states of India. This immense mountain range, covers nearly 750,000 km^2, has been divided into two regions, the Eastern Himalayas, which covers parts of Nepal, Bhutan, the north eastern Indian states of West Bengal, Sikkim, Assam, and Arunachal Pradesh, southeast Tibet (China), and northern Myanmar; and the Western Himalayas, covering the Kumaon-Garhwal, Himachal Pradesh, northwest Kashmir, and northern Pakistan. While these divisions are largely artificial, the deep defile carved by the antecedent Kali Gandaki River between the Annapurna and Dhaulagiri mountains has been an effective dispersal barrier to many species (Conservation International, 2012).

Himalayas encompass a diversity of ecosystems that range from alluvial grasslands (among the tallest in the world) and subtropical broadleaved forests along the foothills to temperate broadleaved forests in the mid hills, mixed conifer and coniferous forests in the higher hills, and alpine meadows above the treeline mainly due to abrupt rise of the Himalayan mountains from less than 500 meters to more than 8,000 meters (Conservation International, 2012). Location and great expansion in latitude and altitude in the Himalayan region offer a wide variety of habitats, each supporting its own distinctive type of fauna and its abundance. Faunal diversity in the Himalayan region is very rich and diversified, primarily due to varied climatic conditions ranging from tropical in the foothills to arctic environment in the trans-Himalayan region. Moreover, historical influx of fauna from adjacent bio-geographical regions and subsequent speciation in relation to local environment has greatly enriched the animal resources of the area. There is a pronounced dominance of Palaearctic and Endemic animals above timber line (3000 m), and largely Oriental and some Palaearctic and some Ethiopian elements at lower and middle altitudes (Mani, 1981; Mehta and Julka, 2002). Importance of Himalayas is further increased by the fact that there are 74 restricted range species, of which, 39 are confined to the geographical boundaries of India (Stattersfield *et al.,* 1998).

In recent years, the Himalayan region has come under a strong threshold of development. Natural ecosystems have been over-exploited and even destroyed by the rapidly increasing human

* Corresponding author: mlthakur75@gmail.com, vinegi@yahoo.co.nz
0030-9923/2015/0002-0417 $ 8.00/0

population. Many endemic and restricted range species found in the region are facing threat to their existence. Many a taxa are presently endangered in the Himalayan region (Meinertzhagen, 1928; Martens and Eck, 1995; Vedwan and Rhodes, 2001). Nest-site selection is an important factor influencing the survival and reproductive success of birds which in turn is influenced by the level of disturbance (Yi-qun and Nai-fa, 2011). Furthermore, conservation measures could not be sufficiently effective as policy makers and conservationists do not have the access to reliable data upon which to base conservation strategies. In addition, keeping in view the relatively small distribution area of the endemic species found in the Himalayan region importance of present communication becomes more relevant.

In addition, efforts have been made by many researchers to unfold the mystery behind different biodiversity patterns and also different spatial patterns of species originating from the same ancestor. Manifestation of a single gene into different cells, organs and individuals is a very interesting phenomenon. It is the need of the hour to study such phenomena so as to get to a common consensus about why species are different. There are many theories regarding different evolutionary rate of species and why they are different in one region than their sister species found in another geographic region. Therefore, during present study efforts have been made to analyze the phylogeny of endemic bird species found in the Himalayan region.

METHODOLOGY

Status

Around 980 bird species have been recorded in the Himalayan region (Conservation International, 2012), out of which 35 species of birds are endemic to the Himalayan region (BirdLife International, 2014). Conservation status and population trend of each species has been given according to International Union for Conservation of Nature and Natural Resources red data list (2014). Population size and distribution area size have been gathered from BirdLife International data zone (2014). Habitat preference of each species has been categorised as given by Kazmierczak (2000).

Phylogeny

Bioinformatics tools were used to carry out the phylogenetic characterisation of some endemic bird species found in Himalayan region. Initially, protein-gene sequences of 18 endemic species were identified using publicly available databases. The sequences were analysed by using National Centre for Biotechnology Institute (NCBI) website (http://www.ncbi.nlm.nih.gov), following taxonomy and homoloGene search tools. PubMed link was also explored for previously cited literature review, EST (Expressed Sequence Tags database) and Uniprot. Protein sequences of interest were exported in fasta text format, in order to be used later for phylogenetic analysis using Clustal X, tree view and Geneious.

After gathering sufficient information about the sequence, fasta text was extracted from NCBI. These files were used as input for Clustal X, where sequence homology and multiple alignment were performed for protein sequences. Output format options for alignment was chosen both as clustal and Nexus format, slow and accurate pairwise parameters were chosen for alignment and after choosing bootstrap labels from branch to nodes in output format options for trees, a complete alignment was performed. For such analysis multiple alignment is very critical as the bad alignment can give an incorrect phylogenetic tree and the major drawback of using Clustal X is that it does not allow users to edit the sequences manually and in order to edit the fasta text sequences it becomes very tough and time consuming effort, therefore trial version of geneious was used alongside Clustal software. So, for a good alignment the gap regions which did not align were chopped off before performing phylogenetic analysis. Sequence homology search, multiple sequence alignment, and consensus tree construction was performed using the free trial versions of Geneious Pro 5.1.3 (Biomatters, Ltd.) It is important to note that the tree produced and analysed in this study is a gene tree not species tree. Protein sequences give better information than nucleotide hence for the present analysis protein sequences were taken and analysed.

After analysing the protein sequences, the phylogenetic analysis was done by analysing Cytochrome b gene. This gene has been chosen due to the fact that it constitutes of large amino acids, plays vital role in cell as it is involved in electron transport chain. This region is normally intolerant to mutations so hereditary record is kept safe in this region and for this reason cyt-b gene is widely used in phylogenetic studies to study and resolve divergence at various taxonomic levels.

RESULTS

Status

Status and distribution of 35 species of birds which are endemic to Himalayas has been analysed during the present effort. Of these, relatively very high percentage *i.e.* 46% (16 species) is placed under different threat categories by IUCN (Fig. 1A). Of these, Himalayan quail (*Ophrysia superciliosa*) has been placed under critically endangered category by IUCN (version 2013.2). Further, white-browed Nuthatch (*Sitta victoriae*) has been categorised as endangered. Another 10 species namely Western tragopan (*Tragopan melanocephalus*), cheer pheasant (*Catreus wallichii*), Kashmir flycatcher (*Ficedula subrubra*), Chestnut-breasted partridge (*Arborophila mandellii*), Blyth's tragopan (*Tragopan blythii*), Sclater's Monal (*Lophophorus sclateri*), dark-rumped Swift (*Apus acuticauda*), rusty-throated wren-babbler (*Spelaeornis badeigularis*), Tawny-breasted wren-babbler (*Spelaeornis longicaudatus*) and snowy-throated babbler (*Stachyris oglei*) have been declared vulnerable. Moreover, another four species namely Tytler's leaf-warbler (*Phylloscopus tytleri*), Ward's trogon (*Harpactes wardi*), Rufous-throated wren-babbler (*Spelaeornis caudatus*) and rusty-bellied shortwing (*Brachypteryx hyperythra*) have been placed under near threatened category.

Further, another 19 endemic birds have been categorised as least concern species (Table I).

Analyses of population trends of these Himalayan endemic species revealed that one species *i.e.* Himalayan Quail is probably extinct. In addition, population of 24 species (74%) is decreasing and of one species *i.e.*, Grey Sibia (*Heterophasia gracilis*) is unknown (Fig. 1B). Population trends of only 9 species are stable. It has been reported that most of these endemic birds found in the Himalayas are forest dwelling species (31 species). Therefore, a very high percentage of these Himalayan endemics (88%) are dependent on forests (Fig. 1C). Further, only two species are found in grassy, and one each in scrub and cliff areas (Table I).

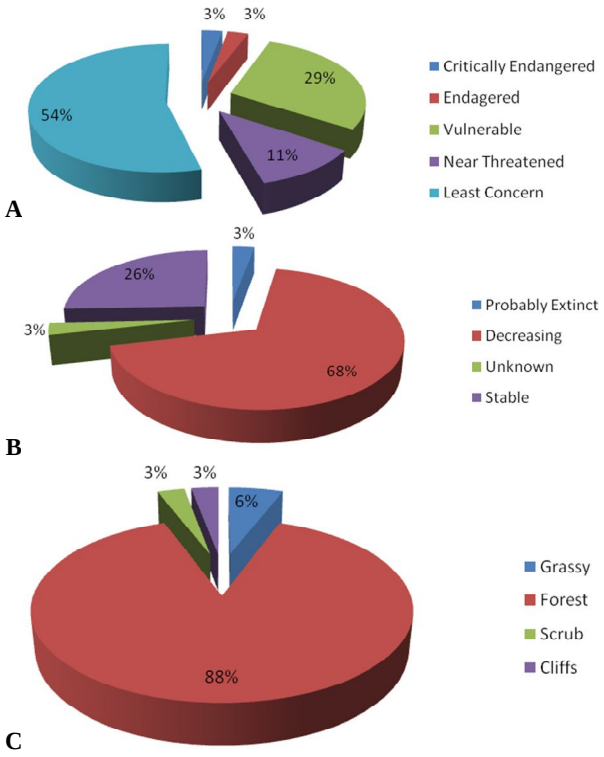

Fig. 1. Conservation status (A), population trends (B) habitat preference (C) of endemic birds of Himalayan region.

Population size of most of these bird species (22 species) is not known. Population sizes of some birds like Himalayan Quail (1 to 49 mature individuals) and Dark-rumped Swift (150-700 mature individuals) are critical keeping in view the small number of mature individuals assessed. Also distribution area size of some of the species like White-browed Nuthatch (820 km^2), Himalayan Quail (1600 km^2), Dark-rumped Swift (5200 km^2), Rusty-throated Wren-babbler (5200 km^2) and Kashmir Flycatcher (8300 km^2) is also not large enough (Table I), therefore some concrete measures

Table I.- Endemic birds found in the Himalayan region

Taxon	IUCN Status (2013.2)	Population trends (IUCN, 2013.2)	Population size (Birdlife Int.) and Habitat (Kazmierczak, 2000)	Distribution size
Western Himalayan endemics (http://www.birdlife.org/datazone/ebafactsheet.php?id=124)				
Himalayan quail (*Ophrysia superciliosa*)	Critically endangered (D)	Probably extinct	• 1-49 mature individuals • Grass and brushwood on steep hill sides	1,600 km^2
Western tragopan (*Tragopan melanocephalus*)	Vulnerable C2a(i)	Decreasing	• 3300 mature individuals • Thick undergrowth in mixed coniferous forest and alpine shrubbery on steep slopes	21,600 km^2
Cheer pheasant (*Catreus wallichii*)	Vulnerable C2a(i)	Decreasing	• 2000-2700 mature individuals • Steep, rugged, south facing grassy hillsides, also scrub with scattered trees, wooded ravines.	149,000 km^2
White-cheeked tit (*Aegithalos leucogenys*)	Least concern	Stable	• Unknown mature individuals • Open forest undergrowth, tamarisks and juniper	172,000 km^2
White-throated tit (*Aegithalos niveogularis*)	Least concern	Stable	• Unknown mature individuals • Open forest, secondary growth	181,000 km^2
Brooks's leaf-warbler (*Phylloscopus subviridis*)	Least concern	Stable	• Unknown mature individuals • Summer: Coniferous and mixed forest • Winter: Acacia, bushes and olives	107,000 km^2
Tytler's leaf-warbler (*Phylloscopus tytleri*)	Near threatened	Decreasing	• Unknown mature individuals • Summer: Forest edges, conifers, hedges, dwarf willows, birches (above treeline post breeding) • Winter: dwarf broadleaved forests	213,000 km^2
Kashmir nuthatch (*Sitta cashmirensis*)	Least concern	Decreasing	• Unknown mature individuals • Coniferous and mixed forests	130,000 km^2
Kashmir flycatcher (*Ficedula subrubra*)	Vulnerable B1ab (i, ii, iii, iv, v)	Decreasing	• 1500-7000 mature individuals • Summer: Mixed forest • Winter: forest, forest edges and gardens	8,300 km^2
Spectacled finch (*Callacanthis burtoni*)	Least concern	Stable	• Unknown mature individuals • Open coniferous forest	47,500 km^2
Orange bullfinch (*Pyrrhula aurantiaca*)	Least concern	Stable	• Unknown mature individuals • Open fir, birch and mixed forest	126,000 km^2
Central Himalayan endemics (http://www.birdlife.org/datazone/ebafactsheet.php?id=148)				
Nepal wren-babbler (*Pnoepyga immaculata*)	Least concern	Stable	• Unknown mature individuals • Dense undergrowth and clearings in mixed forests.	20,900 km^2

Continued

Taxon	IUCN Status (2013.2)	Population trends (IUCN, 2013.2)	Population size (Birdlife Int.) and Habitat (Kazmierczak, 2000)	Distribution size
Spiny babbler (*Turdoides nipalensis*)	Least concern	Stable	• Unknown mature individuals • Dense secondary scrub	30,800 km^2
Hoary-throated barwing (*Actinodura nipalensis*)	Least concern	Decreasing	• Unknown mature individuals • Evergreen forest with good undergrowth	109,000 km^2
Eastern Himalayan endemics (http://www.birdlife.org/datazone/ebafactsheet.php?id=129)				
Chestnut-breasted partridge (*Arborophila mandellii*)	Vulnerable C2a(i)	Decreasing	• 2500-9999 mature individuals • Dense undergrowth in evergreen forest	67,100 km^2
Blyth's tragopan (*Tragopan blythii*)	Vulnerable C2a(i)	Decreasing	• 2500-9999 mature individuals • Dense undergrowth in evergreen forest, often on steep slopes.	42,400 km^2
Sclater's monal (*Lophophorus sclateri*)	Vulnerable C2a(i)	Decreasing	• 2500-9999 mature individuals • Forest with thick undergrowth of rhododendron and bamboo; rhododendron scrub; usually in steep rocky terrain	45,500 km^2
Dark-rumped swift (*Apus acuticauda*)	Vulnerable D1	Stable	• 150-700 mature individuals • High cliffs around waterfalls	5,200 km^2
Ward's trogon (*Harpactes wardi*)	Near threatened	Decreasing	• Unknown mature individuals • Mixed broadleaved evergreen forest; bamboo	136,000 km^2
Yellow-vented warbler (*Phylloscopus cantator*)	Least concern	Stable	• Unknown mature individuals • Dense evergreen forests	519,000 km^2
Broad-billed warbler (*Tickellia hodgsoni*)	Least concern	Decreasing	• Unknown mature individuals • Forest edge; dense scrub; bamboo	483,000 km^2
Rufous-throated wren-babbler (*Spelaeornis caudatus*)	Near threatened	Decreasing	• Unknown mature individuals • Undergrowth and mossy rocks in dense broadleaved forest	56,800 km^2
Rusty-throated wren-babbler (*Spelaeornis badeigularis*)	Vulnerable D2	Decreasing	• 1500-7000 mature individuals • Wet forests	5,200 km^2
Tawny-breasted wren-babbler (*Spelaeornis longicaudatus*)	Vulnerable B1ab (i, ii, iii, iv, v);C2a(i)	Decreasing	• 2500-9999 mature individuals • Gullies and undergrowth in wet evergreen forest on rocky hillsides	15,100 km^2
Snowy-throated babbler (*Stachyris oglei*)	Vulnerable B1ab (i, ii, iii, iv, v)	Decreasing	• 2500-9999 mature individuals • Primary forest, bamboo, moist dense scrub in rocky ravines	16,500 km^2
Striped laughingthrush (*Garrulax virgatus*)	Least concern	Decreasing	• Unknown mature individuals • Undergrowth in humid forest, secondary growth	111,000 km^2
Brown-capped Laughingthrush (*Garrulax austeni*)	Least concern	Decreasing	• Unknown mature individuals • Oak and rhododendron forest, bushes, bamboo	41,400 km^2
Hoary-throated barwing (*Actinodura nipalensis*)	Least concern	Decreasing	• Unknown mature individuals • Evergreen forest with good undergrowth	109,000 km^2

Continued

Taxon	IUCN Status (2013.2)	Population trends (IUCN, 2013.2)	Population size (Birdlife Int.) and Habitat (Kazmierczak, 2000)	Distribution size
Streak-throated barwing (*Actinodura waldeni*)	Least concern	Decreasing	• Unknown mature individuals • Mossy forest	351,000 km^2
Ludlow's fulvetta (*Alcippe ludlowi*)	Least concern	Decreasing	• Unknown mature individuals • Bamboo and rhododendron forest	33,200 km^2
Grey sibia (*Heterophasia gracilis*)	Least concern	Unknown	• Unknown mature individuals • Moist montane Forest	240,000 km^2
Beautiful sibia (*Heterophasia pulchella*)	Least concern	Decreasing	• Unknown mature individuals • Mossy forest	180,000 km^2
White-naped yuhina (*Yuhina bakeri*)	Least concern	Decreasing	• Unknown mature individuals • Moist evergreen and secondary forest	391,000 km^2
White-browed nuthatch (*Sitta victoriae*)	Endangered B1ab (i, ii, iii, v)	Decreasing	• 2500-9999 mature individuals • oak and rhododendron forest	820 km^2
Rusty-bellied shortwing (*Brachypteryx hyperythra*)	Near threatened	Decreasing	• 6000-15,000 mature individuals • Forest undergrowth, scrub and reeds •	19,800 km^2

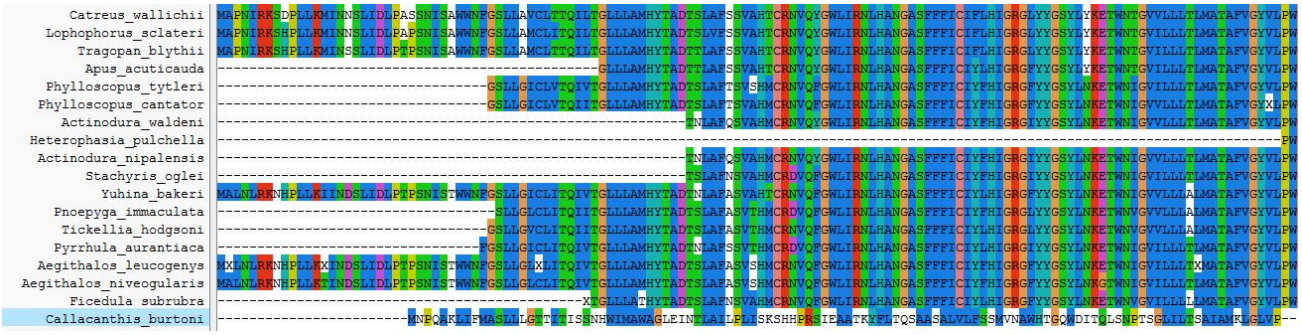

Fig. 2. Sequence alignments in Himalayan endemic birds

need to be taken to ensure the continuous survival of these species in nature.

Phylogeny

The gene tree analyses performed for studying the evolution of homologous genes coding for various proteins revealed that species like *Apus acuticuada, Phylloscopus tytleri, Phylloscopus cantator, Actinodura waldeni, Heterophasia pulchella, Actinodura nipalensis, Stachyris oglei, Pnoepyga immaculata, Tickellia hodgsoni, Pyrrhula aurantiaca, ficedula subrubra* and *Callacanthis burtoni* were dissimilar from the rest of the group, whereas other six (6) remaining species displayed significantly more similarities with one other (Fig.2).

It has been reported that three species of endemic birds *viz.*, *Callacanthis burtoni*, *Pyrrhula aurantiaca* and *Pnoepyga immaculata* showed very interesting positions in the gene tree. These appear to have followed some independent evolutionary lineage and also remained comparatively stable over the period of time (Fig. 3). It would be of great value to study and analyse sequences of these species along with protein coded regions and conserved domains to know more about their positioning in the gene tree.

Three different evolutionary clades of the endemic bird species under consideration can be observed on the basis of phylogenetic tree analyses.

It has been observed that species like *Heterophasia pulchella, Ficedula subrubra, Aegithalos leucogenys, Aegithalos niveogularis, Lophophorus sclateri* and *Caterus wallichii* have originated from the same ancestor therefore form a monophyletic clade. Moreover, species like *Stachyris oglei, Actinodura nipalensis, Actinodura waldeni, Tragopan blythii, Phylloscopus tytleri, Lophophorus sclateri* and *Caterus wallichii* appear to belong to paraphyletic clade. In addition, other endemic bird species like *Apus acuticauda, Heterophasia pulchella, Ficedula subrubra, Callacanthis burtoni, Phylloscopus cantator, Phylloscopus tytleri, Aegithalos leucogenys, Aegithalos niveogularis* and *Yuhina bakeri* belong to polyphetic clade (Fig. 4).

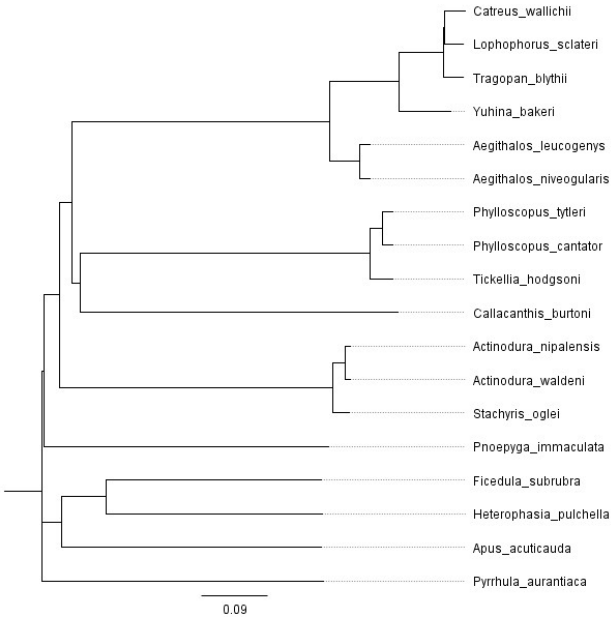

Fig. 3. Phylogenetic tree of Himalayan endemic birds.

Phylogenetic analyses of the endemic bird species taken for the present study showed that these birds have evolved through different patterns. Presence of orthologous and paralogous genes has also been noticed in these birds. Excepting *Callacanthis burtoni, Pyrrhula aurantiaca* and *Pnoepyga immaculata* all other species appear to have evolved on three different lines/patterns. First line is represented by three species, *Stachyris oglei, Actinodura waldeni* and *A. nipalensis.* Moreover,

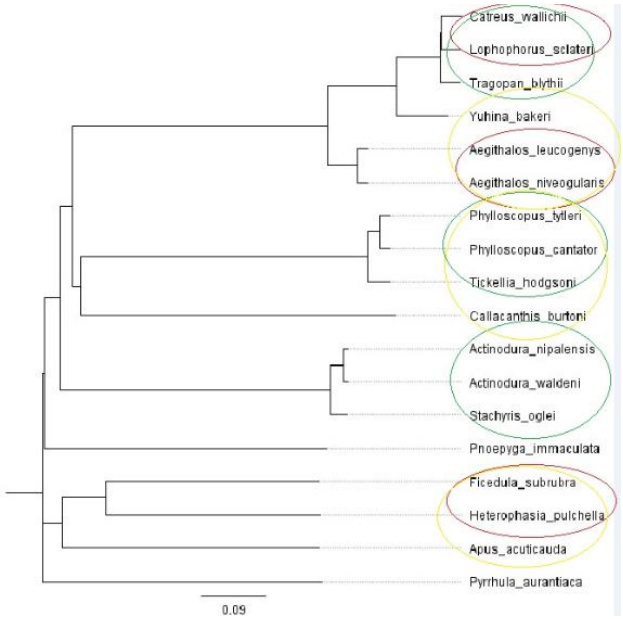

Fig. 4. Clades observed (Red: Monophyletic; Green: Paraphyletic; Yellow: Polyphyletic)

Tickellia hodgsoni, Phylloscopus cantator and *P. tytleri* represent the second line of evolution. In addition, *Aegithalos niveogularis, A. leucogenys, Yuhina bakeri, Tragopan blythii, Lophophorus sclateri* and *Catreus wallichii* represent the third line/pattern of evolution (Fig. 5). Further, there are three groups of sister species which appear to have evolved by gene duplication in the genetic history (Fig. 6).

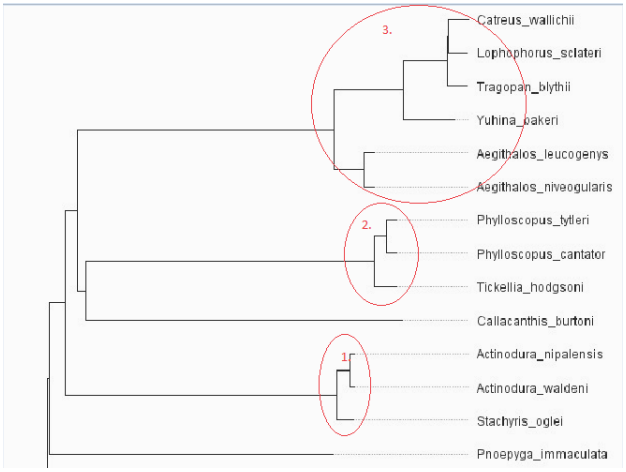

Fig. 5. Lines of evolution in Himalayan endemic birds.

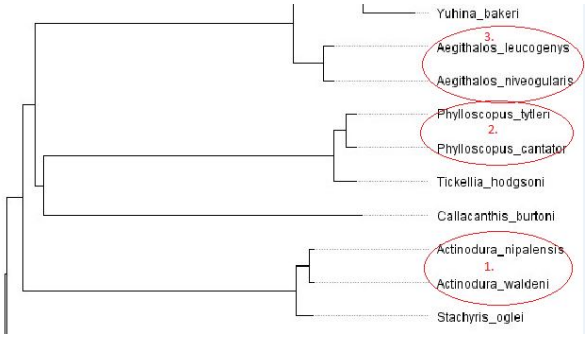

Fig. 6. Gene duplication in some Himalayan endemic birds.

Analyses of length of branches of the phylogenetic tree showed that the three latest entries in endemic bird fauna of Himalayan region *i.e.*, *Catreus wallichii*, *Lophophorus sclateri* and *Tragopan blythii* have been categorised as vulnerable and therefore need the highest level of protection (Table I) as, these species are relatively new to the Himalayan environment (Fig. 3), therefore had less time to get perfectly adapted to the climate/habitat. In addition, habitat degradation, modification, fragmentation, hunting etc. have also been listed as the major threats to these species by IUCN (2014).

DISCUSSION

Out of around 980 bird species found in the Himalayan region, 35 are known to be endemic to the Himalayan region. Of these, relatively very high percentage *i.e.*, 46% (16 species) is placed under different threat categories by IUCN (Fig. 1A). In addition, population of 74% of the Himalayan endemic bird species is either decreasing or is unknown (Fig. 1B). Further, a very high percentage of these Himalayan endemics (88%) are dependent on forests (Fig. 1C). These alarming situations are further worsened by the fact that the rate of human-induced biodiversity loss is very high in the Himalayan region even with their apparent remoteness and inaccessibility. Himalayas have sustained human populations for thousands of years. In recent decades, greater access to the global market has increased the demand for natural resources in the area. This has encouraged both immigration from outside and movement within the region. As a result, populations are growing in the most productive ecosystems, which are also some of the richest in biodiversity. Today, remaining habitat in the Himalaya is patchy. The steadily increasing population in the hotspot has led to widespread logging, and extensive clearing of forests and grasslands for cultivation (Conservation International, 2012).

Evaluation of threats being faced by populations of these endemics shows that habitat degradation, modifications, fragmentation, illegal hunting etc. are the main pressures being faced by these birds in the Himalayan region (IUCN, 2014). According to Conservation International (2012) both legal and illegal logging often occurs on extremely steep slopes, resulting in severe erosion in the Himalayan region. The land is also often cleared in the summer months for livestock; the use of fire to clear the land poses an additional threat to forest land, as fires sometimes spread out of control. The conversion of forests and grasslands for agriculture and settlements has led to large-scale deforestation and habitat fragmentation in Nepal, and in the Indian States of Sikkim, Darjeeling and Assam.

It is worth mentioning that there are certain endemic species of birds *e.g.* Himalayan quail has not been sighted with certainty since 1876. However, according to IUCN this species is probably extant, because thorough surveys are still required, and the species may be difficult to detect. In addition, there is a recent set of possible sightings around Naini Tal in 2003 (Negi, 2006). It has been analysed that six percent of the Himalayan endemic bird species are dependent on grassy habitat which are also highly degraded. According to Conservation International (2012) overgrazing by domestic livestock, including cattle and domesticated yak, is widespread in the lowlands and alpine ecosystems which are the preferred habitat types of many endemic species. In addition, the flora of fragile alpine meadows has been overexploited for traditional medicine.

Higher anthropogenic pressures in the Himalayan region have resulted in collection of fuel-wood and non-timber forest product extraction, which has inflicted severe damage to some forest ecosystems. Unplanned and poorly managed tourism has led to environmental deterioration.

Political unrest, often in the form of insurgencies, also threatens the integrity of some protected areas. In addition it has been estimated that only 25% of the original vegetation in the Himalayan region is intact due to habitat loss and degradation. Poaching is a serious problem in the Himalayan Mountains. Other threats to biodiversity and forest integrity include mining, the construction of roads and large dams, and pollution due to the use of agrochemicals (Conservation International, 2012).

Although, about 113,000 km^2 (15% of the land area), is under some form of protection in the Himalayan region, only 78,000 km^2 (around 10%) are in protected areas according to IUCN categories and most of these protected areas in the region are relatively new, having been established only in the last three or four decades. However, many hill-tribe communities have traditionally recognized and protected sacred groves, which have served as effective refuges for biodiversity for centuries. In addition, several protected areas (Corbett National Park, Manas National Park, Kaziranga National Park (India): Chitwan National Park, and Sagarmatha National Park (Nepal)) have been declared as World Heritage Sites for their contribution to global biodiversity. In the northern and eastern Himalayan states of India, a network of protected areas was established in the 1970s and 1980s. In Nepal, 21 protected areas cover at least 26,666 km^2 of land. Although a protected area system was established in Bhutan as early as the 1960s, this system was dominated by the Jigme Dorji Wangchuck National Park. In 1995, the protected area system was revised to include all nine of the current protected areas (five national parks, three wildlife sanctuaries, and one strict nature reserve) accounting for almost 26% of the total land area in Bhutan. Trans-boundary conservation areas offer an important opportunity for conservation in the Himalayan region; the adjoining Manas National Park in Bhutan and Manas Tiger Reserve in Assam, India, is one such complex. Another important initiative is the plan to create a tri-national peace park with the Kanchanjunga Conservation Area in Nepal, the Kanchendzoga National Park in Sikkim, India, and an extension of the Qomolungma Nature Reserve in the Tibet Autonomous Region of China (Conservation International, 2012). Protected areas network in the Himalayan region of Pakistan includes 18 National Parks including Chitral Gol National Park, Khunjerab National Park and Central Karakoram National Park which are rich repositories of the endemic birds. Besides the national Parks some Important Bird Areas have also been included in the Protected areas network that include Wildlife Sanctuaries and game Reserves in the Pakistan Himalayas (Chaudhry, 2011). Some of the main issues related to the effective management of these protected areas in Pakistan include lack of management plans for protected areas, conflicts between park staff and local communities, lack of inter-agency cooperation/coordination and conflicts due to dual/multiple ownership of protected areas, illegal hunting and collection, lack of financial resources and weak institutional capacity and lack of awareness (Khan, 2012) which may pose serious threats for survival of endemic species of birds and animals.

Although, conservation status of almost all endemic bird species found in the Himalayan region is very important but keeping in view the relatively recent evolution of *Catreus wallichii*, *Lophophorus sclateri* and *Tragopan blythii* which means less genetic variability and less time for better adaptability, some concrete steps are required to be taken to protect these from extinction. Whereas population status of *Phylloscopus cantator* found in eastern Himalayas is stable. *Phylloscopus tytleri* found in western Himalayas has been placed under 'near threatened' category with significantly decreasing population.

Analysis showed that four species namely *Pyrrhula aurantiaca, Apus acuticauda, Pnoepyga immaculata* and *Callacanthis burtoni* were the most genetically divergent from rest of the group (Fig. 5) and therefore might have been constantly and consistently evolving and adapting to their environment and their population was comparatively stable. However, they are not untouched by increased pace of habitat loss, degradation, fragmentation etc.

Phylogenetic analyses showed that excepting *Callacanthis burtoni, Pyrrhula aurantiaca* and *Pnoepyga immaculata* all other species appeared to have evolved on three different lines/patterns (Figs. 6, 7). The occurrence of different lines of evolution

can be justified on the basis of differential gene duplication for better adaptability and suitability with respect to varied habitat and environment. These speciation events are possibly the main reason behind the divergence in endemic group of birds of the Himalayan region. These findings could be related to Red Queen Hypothesis (RQH), Red Queen Race or Red Queen Effect according to which in order for an organism to survive in an ever changing environment it must consistently evolve by constantly adapting in a dynamic environment so as to have better reproductive advantage and to give rise to better, suitable and superior progeny (Van Valen, 1973; Bell, 1982).

REFERENCES

BELL, G., 1982. *The masterpiece of nature: The evolution and genetics of sexuality*. University of California Press, Berkeley, pp. 378.

BIRDLIFE INTERNATIONAL, 2014. *Country/territory profile*. Downloaded from http://www.birdlife.org/datazone/

CHAUDHRY, A.A., 2011. Role of protected areas in the conservation of species and ecosystems *Proc. Pakistan Congr. Zool*., **31**: 11-29.

CONSERVATION INTERNATIONAL, 2012. *Biological diversity in the Himalayas*. Retrieved from http://www.eoearth.org/view/article/150643

IUCN, 2014. *IUCN Red List (version 2013.2)*. Downloaded from http://www.iucnredlist.org/

KAZMIERCZAK, K., 2000. *A field guide to the birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives*. Om Book Service, New Delhi, pp. 352.

KHAN, M.S.H., 2012. Islamic Republic of Pakistan: Collaborative management of protected areas. *First Asia Parks Congress*, Sendai, Japan, 13-17 November, 2012. Retrieved from http://asia-parks.org/pdf/wg2/APC_WG4-07_Muhammad%20Samar%20Hussain%20Khan.pdf on 20.9.2014

MANI, A., 1981. *The Himalayan aspects of change*. India International Centre, New Delhi.

MARTENS, J. AND ECK, S., 1995. Towards ornithology of the Himalayas: systematics, ecology and vocalisations of Nepal birds. *Bonn. Zool. Monogr*., **38**: 1-445.

MEHTA, H.S. AND JULKA, J.M., 2002. Mountains: Northwest Himalaya. In: *Ecosystems of India* (ed. The Director). Zoological Survey of India, Kolkata, pp. 51-72.

MEINERTZHAGEN, R., 1928. Some biological problems connected with the Himalayas. *Ibis*, (12) **4**: 480-533.

NEGI, I.S. 2006. Is mountain quail extinct? *Cheetal*, **45**: 48-51.

STATTERSFIELD, A.J., CROSBY, M.J., LONG, M.J. AND WEGE, D.C., 1998. *Endemic bird areas of the World: Priorities for biodiversity conservation* (Conservation Series 7). BirdLife International, Cambridge, UK.

VAN VALEN, L., 1973. A new evolutionary law. *Evolut. Theor.*, **1**: 1-30

VEDWAN, N. AND RHODES, R.E., 2001. Climate change in the Western Himalayas of India: a study of local perception and response. *Clim. Res.*, **19**: 109-117.

YI-QUN, W. AND NAI-FA, L., 2011. Nest-site characteristics of the blue-eared pheasant in Northwest China. *Pakistan J. Zool.*, **43**: 563-567.

(Received 15 April 2014, revised 20 September 2014)