Basic Course in Ornithology
Dr. Rajah Jayapal
Salim Ali Centre for Ornithology and Natural History

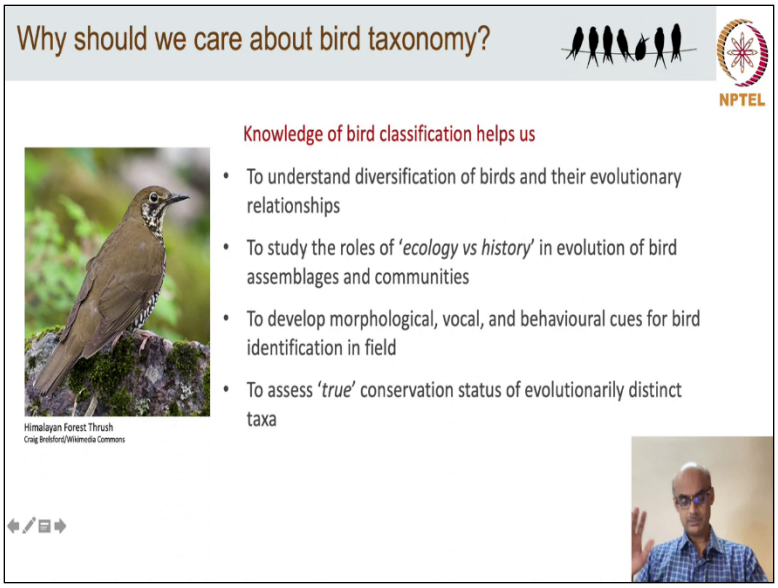
Lecture -2
Diversity and Classification Part 1

Hello viewers, welcome back to NPTEL's Basic Ornithology course. In this session we will explore diversity of birds and how birds are classified on the basis of taxonomic principles. In the past taxonomy used to be a science of classification based on studying museum specimens but with the arrival of genetic tools and techniques molecular taxonomy has taken the root over the last three to four decades.

And today the word systematics is preferred to taxonomy as a reflection of this progress and expansion of the scope of the science of taxonomy. The protein and DNA signatures have tremendously changed the world view of how birds are related to each other. Interestingly, we find that morphological similarities are often superficial; for example we now realize that Falcons are not true raptors, but instead they are more closely related to Parakeets.

And even at a lower-level species limits often pose a great challenge and with the molecular tools species limits are being increasingly resolved. For example, erstwhile Purple Swamphen, a very common water bird is now thought to comprise six species globally. This is an outcome of how we define a species based on genetic similarities and this is precisely what we will learn in this video. We will first get ourselves familiar with some fundamental principles of avian taxonomy, species concepts, and different schools of thoughts. Then, we will move on to modern classification of birds with reference to Indian avifauna.

(Refer Slide Time: 02:11)



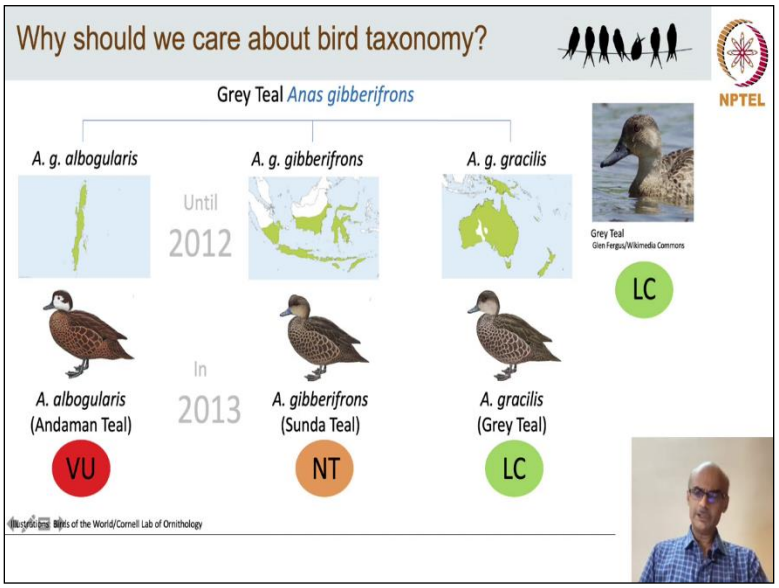
So, why should we care about bird taxonomy? So, taxonomy has been traditionally viewed as an esoteric discipline left to taxonomists to discuss and resolve issues in classification. So, it is natural to ask this question. So, what does a bird ecologist or conservationist or a bird watcher benefit from knowledge of taxonomy.

Well, there are over 10,000 species of birds in the world of which over 1,300 species are found in India. This amazing diversity naturally raises several questions. How are these species related to each other and when and where did they speciate? So, knowledge of taxonomy and classification is critical to understanding these questions of evolutionary relationships. And a knowledge of family and genus level relationships is also very important in interpreting the findings of ecological studies on birds. For example, are phylogenetically closer species also ecologically similar? What plays a major role in structure of avian assemblages, evolutionary history or ecology and so on.

Interestingly, a good understanding of bird classification greatly helps us in developing species identification skill in the field. This is because bird species belonging to a particular genus or family or even order often share similar morphological, vocal and behavioral traits. So, a basic knowledge of a family, genus, or order to which a species belong will also help us to identify that particular species, or the group to which that species belongs, right in the field. So, that actually makes us a much better and informed bird watcher.

And finally, one of the critical applications of taxonomic knowledge is in identifying threatened populations of bird taxa. As you know threat status of species is generally assessed across its global distribution range. This is based on assumption that all the populations in the range belong to one single species but what if some isolated and distinct populations turn out to be different species and may need immediate conservation intervention because they are low in number, or because they face some ecological threats in their local level? We will see next a real-world example.

(Refer Slide Time: 04:56)

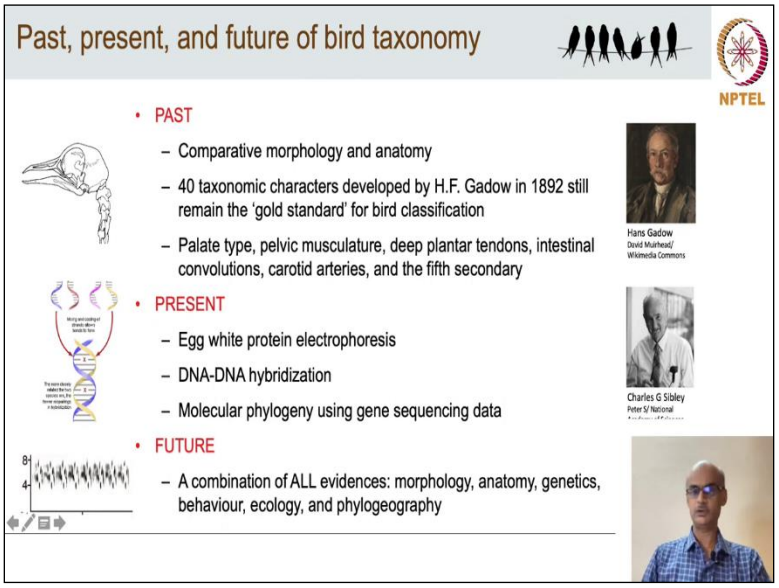


Grey Teal is a small resident duck found in all types of wetlands mostly brackish water and distributed through Oriental and Australasian regions. Till 2012, it was considered as a single species with three subspecies as you can see from these maps. So, *albogularis* in Andamans, *gibberifrons* in southeast Asia and *gracilis* in Australasian region. Since the range was pretty large, its population size was considered good enough to be classified as Least Concern in IUCN assessment, in other words the population was considered as safe.

But in the year 2013, the species was split into three distinct species based on re-assessments of the species limits mostly based on morphology. So, this resulted in the Indian population becoming Andaman teal endemic to the Andaman island and the re-assessment of their conservation status led to Andaman teal designated as Vulnerable and the Indonesian Sunda teal as Near-threatened.

This shows how change in species limits could result in cascading effect on our conservation assessment. A species that was once considered as safe across its global range is now considered comprising two populations one of which is Vulnerable and another is Near-threatened.

(Refer Slide Time: 06:31)



Let us now see a brief history of bird taxonomy. In the past, taxonomy used to be solely based on similarities and dissimilarities in morphological and anatomical characters in birds - an approach commonly called as comparative anatomy. It was the German ornithologist, Hans Gadow who first proposed in late 19th century, 40 taxonomic characters for bird classification. In fact, these 40 anatomical characters still remain the gold standard in avian systematics, largely corroborated with molecular evidences today.

They mainly include a typology based on palette type, pelvic musculature, deep plantar tendons and so on. So, for a very long time comparative anatomy ruled the field of taxonomy but it was Charles G Sibley the American Ornithologist from Yale University, who first applied the electrophoresis of egg white proteins in 1960s as a molecular technique to ascertain evolutionary relationships between taxa and to infer taxonomic relationships.

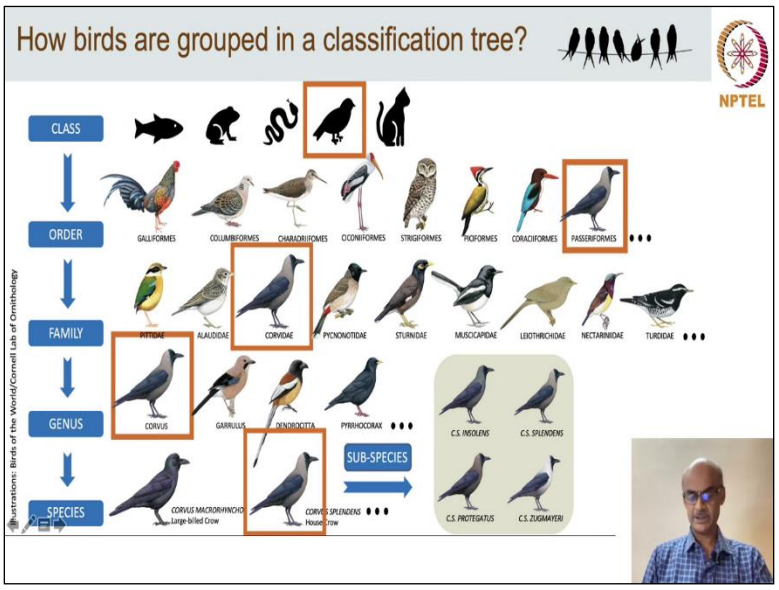
Shortly afterwards, Sibley began applying DNA-DNA hybridization technique to compute genetic similarity between a given pair of bird taxa. You can actually refer to key references that will be provided as supplementary readings to know more about the DNA-DNA hybridization technique.

So, following the next two to three decades of intensive sampling and molecular analysis, Sibley along with his colleague Ahlquist, developed the first modern classification of birds.

DNA-DNA hybridization very soon gave way to gene sequencing as genetic tools and techniques became more accurate and affordable. Today, molecular taxonomy has become an established field covering various taxa from plants to mammals and birds paved the way for other taxa as well.

So, of late, you can see a plethora of gene sequencing papers in molecular taxonomy being published every now and then in different journals. But systematists also cautions that results of these molecular evidences or techniques are not as robust as they are often made out to be. There are still several gaps or grey areas in analysis of gene sequencing data that remain unresolved or at best contentious. Therefore, biologists now strongly pitch for an integrated taxonomy wherein reliable evidences from multiple approaches are gathered to build a strong case. These approaches include morphology, anatomy, genetics, behaviour, ecology or phylogeography and that is increasingly applied in bird taxonomy.

(Refer Slide Time: 09:49)



So, how birds are grouped in a classification tree? Let us see a simplistic explanation of how organisms are grouped in the hierarchy of taxonomy using birds. Among the vertebrates, that is, organisms with the backbone, the topmost group is called class. So, there are five classes

representing fishes, amphibians, reptiles, birds and mammals. Of course, our interest here is the class Aves that represent birds in Latin.

So, remember all taxonomic names are traditionally written in Latin or Greek that is derived from Latin. So, among the class Aves, there are diverse groups of birds sharing common ancestry therefore showing some similarities within each group. These groups are called Orders. For example, we see some Orders displayed here from Galliformes that include all game birds and fowl like birds. Columbiformes with pigeons and doves, Charadriiformes with waders or shorebirds, Strigiformes with all the owls and Passeriformes with all the songbirds or passerines. And note that the names of the Order always end in the suffix -formes. Thats the taxonomic tradition and all the birds of the world have been grouped under 44 orders. Well, some authorities treat it under more than 44 or 46 orders.

Now let us see just one Order among these: Passeriformes, -that is the song birds or the perching birds or passerines, the largest group among the birds. When we look into the Passeriformes there are again similar groups of taxa arranged within Passeriformes. They are called Families like, for example, here some representative families have been given like pittas from Pittidae, larks from family Alaudidae, crows of family Corvidae and so on.

So, note that the suffix of Family ends with -idae. So, now we will choose one family of Corvidae that is the family of crows and when we go deeper into the family of Corvidae, we find again the family has several genera or in singular form genus. That is the next level of similarity among the members of the family Corvidae. The Corvidae family has crows belonging to the genus *Corvus*, jays belonging to the genus *Garrulu*s and treepies belonging to *Dendrocitta* and Chough of the alpine mountain areas under genus *Pyrrhocorax* and so on.

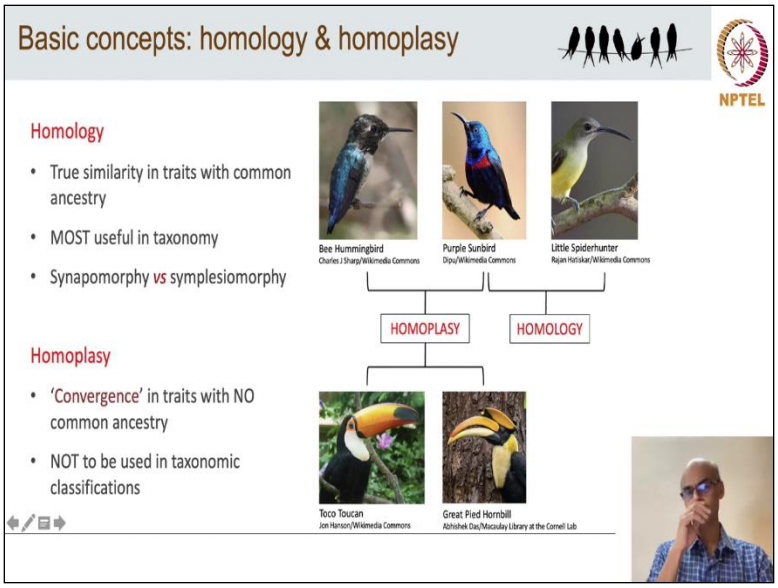
We will now select one genus that is *Corvus* that is the typical crows. The next level of taxa below the genus is the actual species - the last unit of taxonomic classification. So, two species of crows are shown here in the genus *Corvus* - large-billed crow and house crow. Actually, there are 45 species in these genera around the world. In India we have probably seven species or 7 to 8 species of crows in the Indian subcontinent.

You can see that a species is written as a combination of both genus and species names. So, this practice is called binomial nomenclature in taxonomy. The scientific name of a species, for example, *Corvus macrorhynchos* is for large-billed crow. This is to ensure unambiguous communication over the id of a taxon across languages or region. So, the house crow is known as *Corvus splendens*.

As per the International Code for Zoological Nomenclature, the most basic unit of any taxonomic hierarchy is the species and no further groupings are recognized. But, however in some taxa including birds, species are often grouped into subspecies or races, based on geographic differences in morphology. For example, house crow comprises four subspecies as shown here each occurring in different parts of its distribution range.

Like *Corvus splendens splendens* in mainland India, *Corvus splendens zugmayeri* in north-west India, *protegatus* in southern India and Sri Lanka. So, you can notice subtle morphological differences among these taxa. They are called subspecies in the sense that they still belong to same species that is house crow. If you now wonder why some levels of similarity give rise to Families and others genera, the answer lies in the degree of evolutionary relationship among the taxa.

This degree of evolutionary relationship determines whether this relationship has to be termed or grouped under Order or Family or Genus. So, taxonomists have accordingly developed several criteria in this regard of course which are still debatable and would also vary between authorities.
(Refer Slide Time: 15:52)



We will now see some of the basic concepts in taxonomy. One such key criterion of assessing evolutionary relationship is whether the absolute similarities between two taxa are true or not. Biologists call the true similarity as homology and the false similarity as homoplasy. So, homology refers to true similarity in a trait between two taxa as the similarities arise out of common ancestry. They are true because they have same evolutionary origin.

Homologous characters are the most useful in taxonomic classification and they are further divided into symplesiomorphy and synapomorphy whether they are shared primitive or whether they are shared derived and of course the shared derived homologous characters that is synapomorphic characters. So, they are the ones which biologists are actually looking for while classifying and grouping these species.

In contrast, homoplasy refers to false similarity in a trait between two taxa. These similarities are considered false because they do not have common ancestry. So, they perhaps evolved independently in response to some ecological requirements or as adaptations in a process called convergence. Since, homoplasy infers false similarity such characters are not useful in taxonomy. In fact, interestingly the traditional taxonomy which is largely based on morphological comparative morphology, often fails to detect this convergence and in fact we are increasingly detecting convergence or false similarity using molecular tools. We will see one example, let us see these two pictures of nectar feeding birds with a long bill as an adaptation to feed on nectars

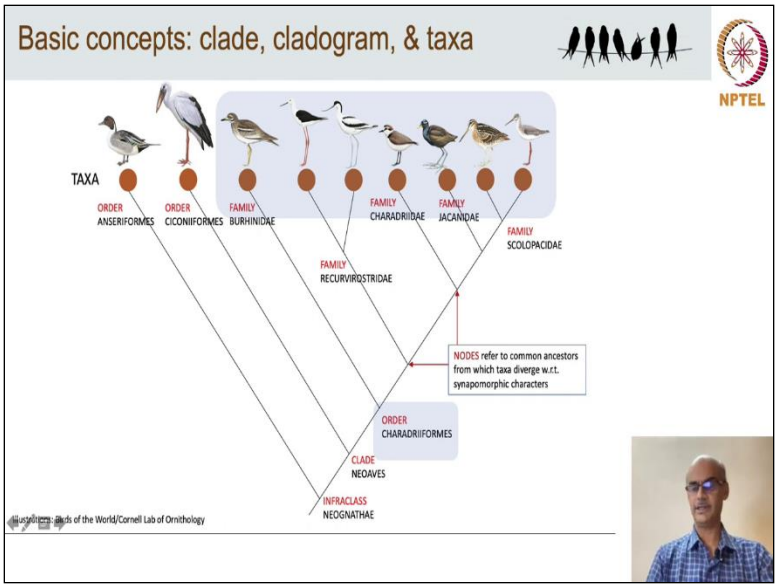
of flowers. One is the Bee hummingbird of the New World, second is the Purple sunbird in the Old World.

They look very similar, very colourful with iridescent colours and a very long bill to enable to feed on the nectar. There is another pair: one is the Toco toucan and the other Great pied hornbill. Toucans are from the central and southern America where the hornbills are from Oriental region. Now these are the classical examples of what we call as homoplasy because they are completely unrelated to each other.

For example, Bee hummingbirds, actually they are more related to swifts, and sunbirds are actually passerines with common ancestors; in fact, they are on the extremes of the classification tree. And toucans and hornbills, though they are not as distant as hummingbirds and sunbirds, nonetheless they are still not directly related to each other; they are probably separated by more than two or three ancestors.

The adaptation of the bill colour and bill structure probably evolved independently in response to some local ecological requirements. But, if you see the Little Spiderhunter which is again an Oriental species, also has a long bill which enables to feed on nectars. So, but that is what we call as homology, because Little spiderhunter and Purple sunbird belong to the same family and probably have the same ancestor from which they derived this long bill which is adapted to feeding on nectar. So, it is a true taxonomic character that is what we call as homology.

(Refer Slide Time: 19:52)



Now we will go on to see clade, cladogram and taxa - the terms, which you often come across while assessing taxonomy or studying taxonomy of birds. We will see this here and you can see the tree-and-branches diagram this is conventionally used to describe the evolutionary relationships among birds. The red circles at the end of the branches refer to taxa; they could be genus, family, or species.

And the nodes from where they branch off. So, they refer to common ancestors from which the taxa diverged with respect to synapomorphic characters, that is, the shared derived characters that we see in the earlier slide. Let us assume these three covers water birds from ducks to waders and storks. The first group is called Anseriformes with ducks and the next one is the Ciconiiformes comprising the stocks of the old world.

Now the third group is the order Charadiiformes. That consists of the Waders and Shorebirds. Now see the highlighted region all grouped under one order Charadiiformes. This highlighted taxa constitute one evolutionary group, right. So, this is called a clade. And this tree diagram is called a cladogram because it shows how different clades are arranged on an evolutionary tree.

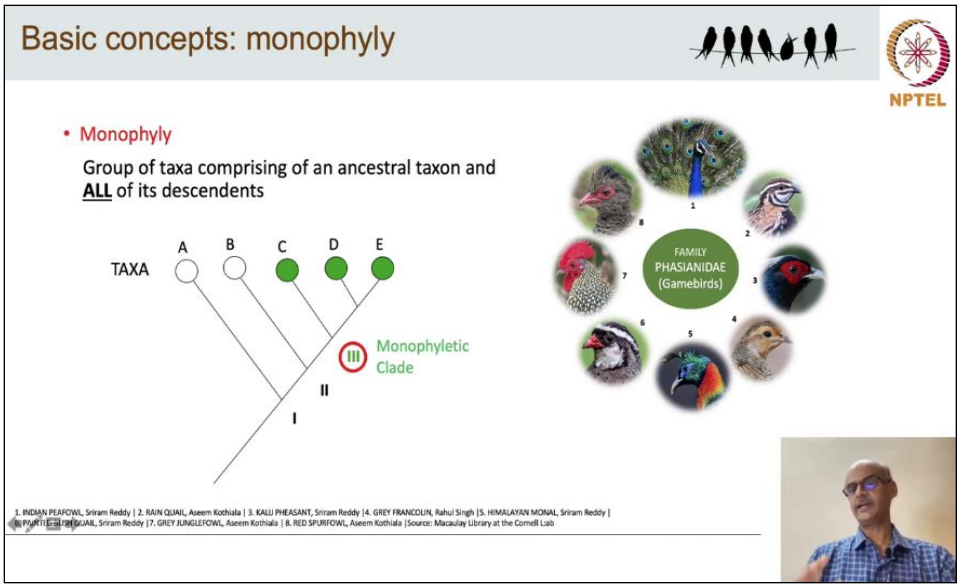
A clade can be any group within this with a common node. In fact even the order Charadiiformes is one clade, order Ciconiiformes is another clade, order Anseriformes is another clade. This

particular order Charadiiformes can have multiple sub-clades which themselves form separate clades like families Recurvirostridae or Charadiidae or Jacanidae of Jacanas.

So, each family again forms a clade within the larger clade of Charadiiformes. Note that this cladogram is much simplified one to demonstrate its concepts. In real analysis, you may need to develop cladograms equally across the clades; because here, we have treated Charadiiformes much more in detail than compared to Anseriformes or Ciconiiformes.

So, this is the basic concept of the cladogram and what is called a clade; in fact, the entire things belonging to the infra-class Neognathae can also be called a clade.

(Refer Slide Time: 22:57)



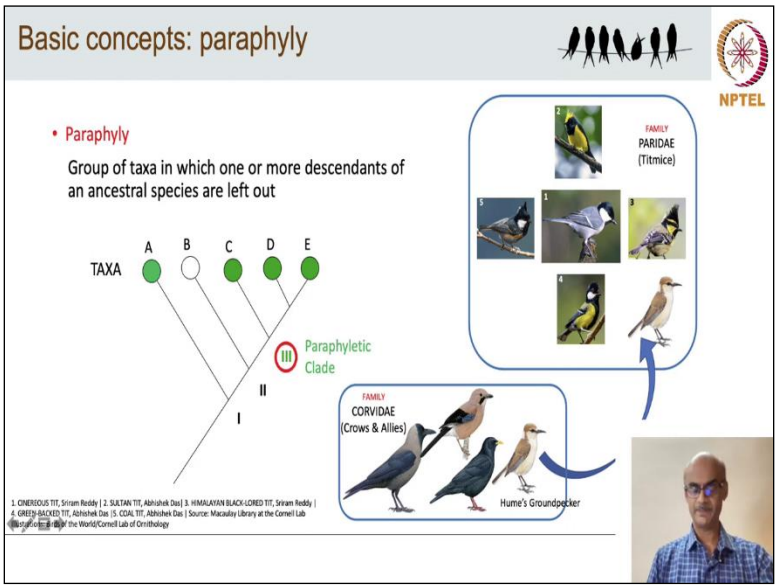
The next one is the concept of the monophyly. So, a clade, theoretically speaking, should be monophyletic in the sense that a clade should comprise all its descendants and their ancestor. This phenomenon is termed monophyly in systematics. By this definition, each order, family, or even genus should be monophyletic in theory. But mostly they are not, in fact, that is the purpose of the whole molecular studies/molecular taxonomic studies.

We will see one example. In this example, it is a very simple cladogram. The green circle C D E share the same ancestor III. So, the ancestor III is the monophyletic clade. It is actually

monophyletic because it has all the descendant species C D E and the ancestor together; so it is called a monophyletic clade. And one example is the family Phasianidae of game birds or the fowl like birds.

As per the current knowledge this family has all the known members and we do not suspect any member that has been placed in other bird families. So, we consider family Phasianidae of game birds as a monophyletic family.

(Refer Slide Time: 24:31)



So, now we will see the other type, i.e. paraphyly. Suppose if any member is left out of the clade it is termed as paraphyly. See this example; in this example, the taxon A is left out of the supposed clade III, making the clade III as paraphyletic because the taxon A has been placed in some other clade, i.e., clade number I, instead of clade number III. So, the clade number III now becomes paraphyletic as it is no longer monophyletic.

Of course, taxonomists assume each designated order, family, or genus as monophyletic, until someone discovers the phenomenon of paraphyly and undertakes the course correction. For example, this is the family Paridae of tits - a group of tiny insectivorous birds of forest canopy and

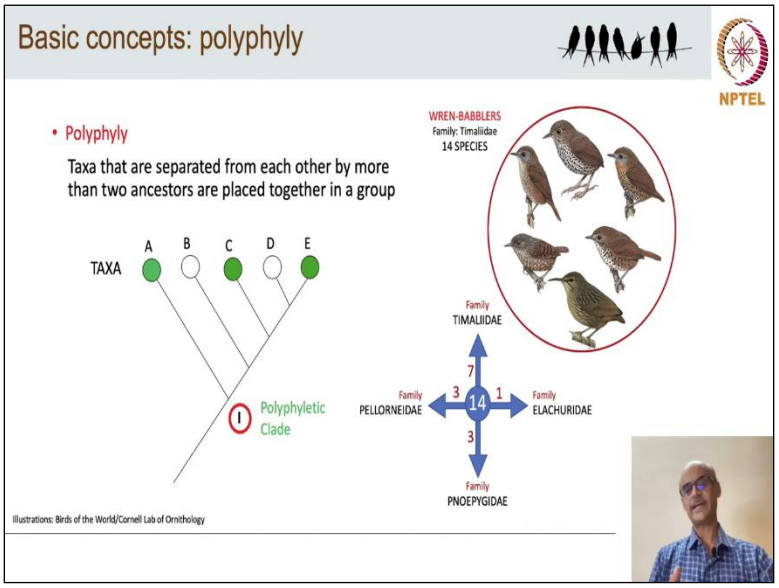
the family Paridae was long thought to be monophyletic because they all look very similar behaviorally, vocally and ecologically.

And there is no reason to suspect any other bird as belonging to this one. There is also the second family Corvidae, of crows and allies. The family Corvidae has one species in the high altitudes… Hume's groundpecker it is called. For a very long time, it was considered as a Corvid very closely related to crows because it behaves more like chough which is also in the crow family.

So, everything was fine, till Helen James and her colleagues in 2003, discovered through molecular studies that Hume's groundpecker was actually a tit. It was an accidental discovery through molecular studies on the phylogeny. Suddenly, both the families have now become paraphyletic because Corvidae has one member which does not actually belong to them; and Paridae did not have that member, which actually was a parid which was put in Corvidae.

So, Hume's groundpecker was subsequently moved to Paridae and renamed as Ground tit in line with other tits in the family. Now after moving Hume's groundpecker to Paridae both the families became monophyletic. Now this is the purpose of the taxonomical studies; they always try to strive for making all the orders, families, and genera as monophyletic as possible because that is what makes the arrangement of evolutionary relationships correct - more accurate.

(Refer Slide Time: 27:38)



So, if you look at the polyphyly, that is other extreme form of non-monophyly, in which taxa are separated by more than two ancestors, placed together in a group. In earlier paraphyly, we saw taxa being separated by more than one ancestor but in the polyphyly by more than two ancestors. Let us see this example of clade I, this one clade is polyphyletic. So, here in this example the taxa A B C D E all of them have been grouped together under the clade.

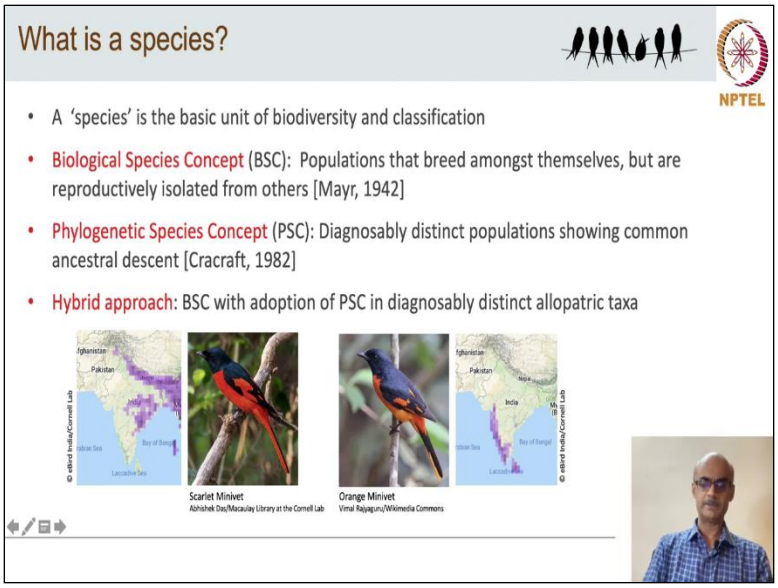
But, someone discovers that taxon B and D do not belong to this clade and they probably belong to two completely different clades. In that scenario, this clade becomes polyphyletic because it contains two species or two taxa which actually belong to two other clades. One classic example is the group of wren-babblers. So, Indian subcontinent has 14 species of these wren-babblers.

A group of very tiny insectivorous birds of the dense undergrowth in the wet evergreen forest of the Himalaya. They are very extremely shy birds, but can easily be detected through their song and calls which are very distinct. They are brown in colour with very short to almost non-existent tails. So, morphologically they look confusingly similar for a long time that all the wren-babblers were placed in the typical babbler family of Timaliidae and no one suspected their identity of to be of any different.

But a series of molecular studies combined with analysis of vocalizations revealed that wren-babblers as a group are polyphyletic. They actually belong to three different families and in fact one species, i.e., Spotted Wren-babbler, was found to be a unique taxon actually warranting erection of new family that is called Elachuridae. So, it was the Spotted Wren-babbler.

Spotted Wren-babbler is such a unique taxon that it is now found to be closely related to waxwings and kinglets rather than babblers. So, this is called polyphyly and this has been quite common because our traditional taxonomy is always based on morphological characters which fail to detect convergence in morphology.

(Refer Slide Time: 30:32)



We will now explore a more fundamental question in biology that has immense ramifications for taxonomy as well. What exactly is a species - the fundamental unit of biodiversity and classification? For example, two species of minivets – an insectivorous group of woodland birds are shown here: Scarlet Minivet and Orange Minivet along with their distribution ranges taken from ebird. While Scarlet Minivet is spread across central and northern India, Orange Minivet is confined to south-western India and Sri Lanka.

So, till some years ago, both were treated as subspecies of a single species, the larger, Scarlet Minivet but differences in morphology, vocalization, and allopatric distribution - that means they have been distributed in two disjunct populations, led to the split. So, what are the criteria that define a species? Well, the answer varies with different species concepts. The most popular and long-held view was the Biological Species Concept shortly known as BSC sometimes referred also to as Evolutionary Species Concept.

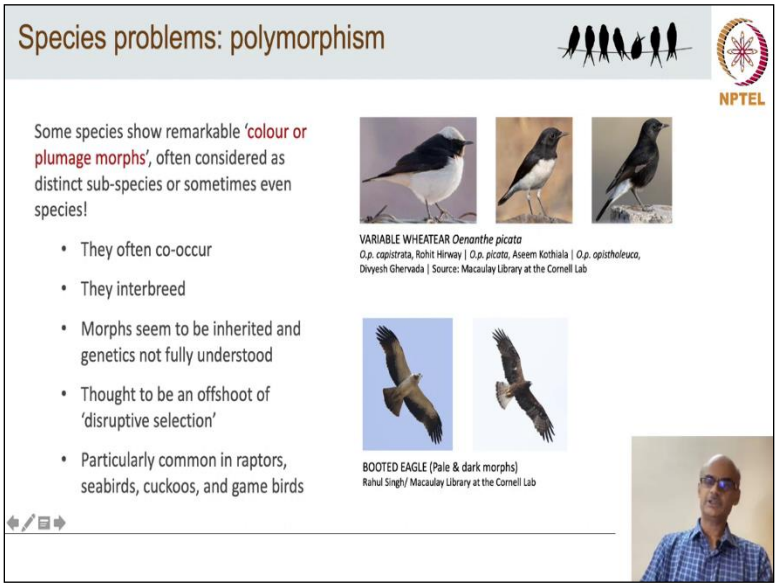
It was formalized by Ernst Mayr in 1942. As per this definition, the species refers to a group of interbreeding natural populations that are reproductively isolated from each other or from other such groups. One of the weaknesses of BSC is that it cannot be applied to asexually reproducing taxa or even to sexually reproducing taxa like birds that are geographically disjunct like the case of the minivets shown here.

When two populations are geographically isolated how do we ascertain if they would mate? Like the case of these two minivets shown here. Perhaps, they were treated as a single species earlier on the assumption that they would mate if they were together. But that is quite speculative; to circumvent this issue, Phylogenetic Species Concept was proposed by Joel Cracraft in 1982. PSC sometimes called as Cladistic Species Concept emphasizes on two components: species diagnosability and common descent.

As such, Phylogenetic Species Concept does not recognize subspecies as any diagnosably distinct subspecies would merit a species status. Though PSC is progressive and accommodative of all forms of taxa including asexually reproducing organisms, evolutionary history of most of the species still remains unknown. So that is the issue with applying Phylogenetic Species Concept across board. Considering these, a hybrid approach is increasingly used in systematics like Biological Species Concept remains the mainstay of species limits.

But in case of allopatric, that means geographically disjunct and diagnosably distinct populations, phylogenetic species concept is applied like the case of these two minivets.

(Refer Slide Time: 34:26)



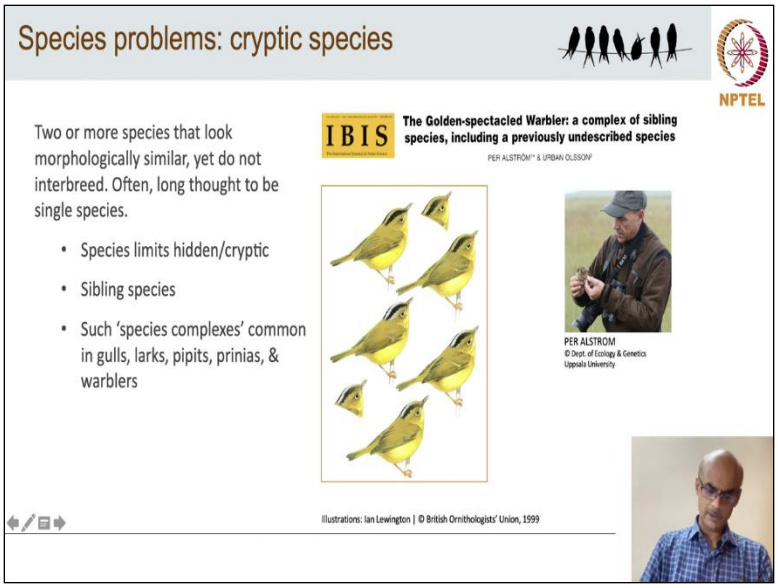
Besides the very philosophical issue of defining a species, there are also other challenges from the real world organisms and birds are no exception. One such challenge is the polymorphism where a species occurs in different plumage or colour morphs and these morphs often live together, they readily mate with each other and the colour morphs seem to be heritable in most cases if not all; these attributes defy a conventional definition of species.

Genetic models show that polymorphism may arise out of disruptive selection - a selection driven by particular environmental factors. But we have just begun to explore the biology of polymorphism as it is not yet fully understood. Polymorphism is particularly common in bird taxa like raptors, sea birds, cuckoos and game birds. One of the classical example among the Indian avifauna pertains to Variable Wheatear, a species of insectivorous birds in north-western India of semi-arid tracts.

Variable Wheatear occurs in three morphs as you can see from these three distinct pictures. They look like completely three different species but then the females look very much alike and often they interbreed and they occur together. So, for a very long time, all the three morphs – *capistrata, picata* or *opistholeuca* been treated sometimes as subspecies sometimes even as separate species; also take the case of raptors like Booted Eagle.

So, most of these raptors have very distinct dark morphs and very distinct pale morphs; it is now increasingly known that the same individuals may adopt the pale morph plumage and dark morph as well. So, this poses a great challenge to species identification or even definition of your species.

(Refer Slide Time: 36:40)

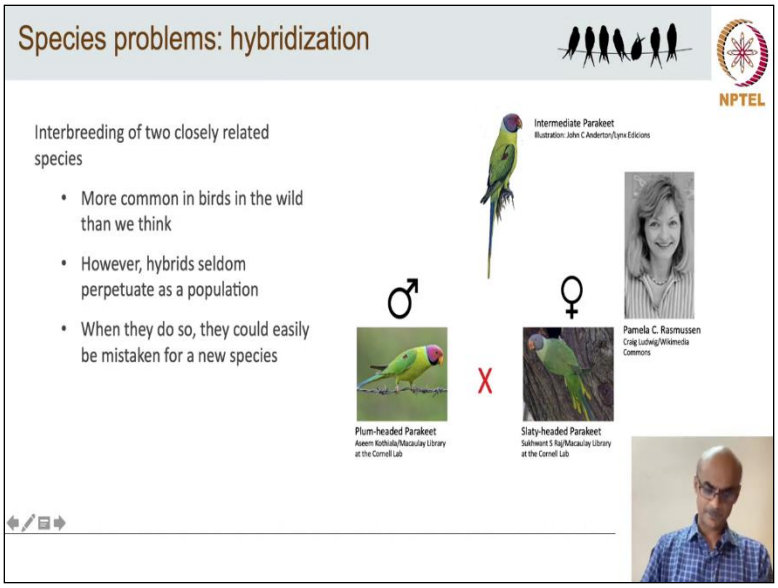


Another challenge in species designation in birds stems from what we call as cryptic species. Cryptic species refers to two or more species that look morphologically similar yet do not inter breed. Often, they were long thought to be single species till someone discovers them to be a complex involving two or more species; for these reasons, they are also known as sibling species. Cryptic species are very common in birds that are normally challenging for bird watchers to identify.

These include gulls, larks, pipits, prinias and warblers. The example shown here is that of the Golden-spectacled warbler of the Himalayas, long believed to be a single species. Per Alstrom, the Swedish ornithologist and taxonomist in 1999 discovered, through extensive analysis of vocalizations, that this single species of Golden-spectacled warbler actually comprised no less than six species

.

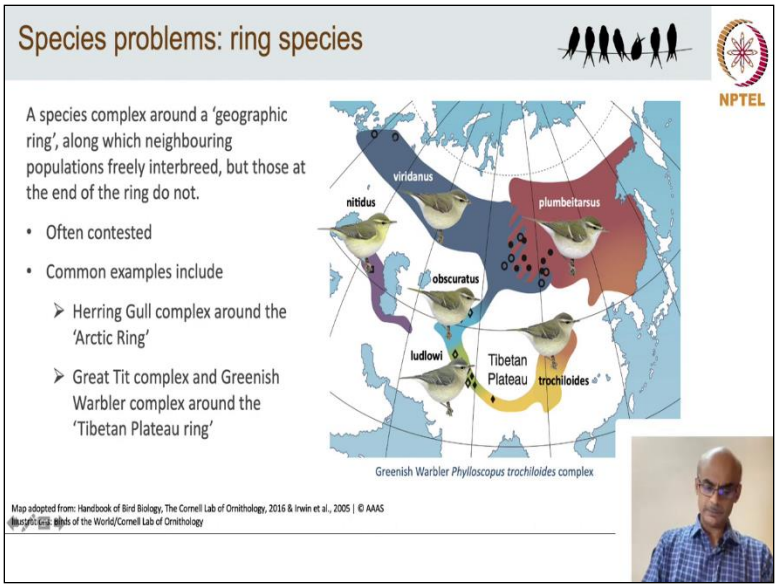
(Refer Slide Time: 37:52)



And the other issue is the hybrids which cause problems in identifying species. Contrary to our perception, birds do hybridize in the wild and quite often. Hybridization between two closely related species often results in hybrids with plumage patterns distinct from the parent taxa. So, normally hybrids do not survive beyond F2 generation but when they do perpetuate to small localized populations on some rare occasions, they are often mistaken as new species.

A classic example among Indian avifauna is the case of the Intermediate parakeet also known as Rothchild's parakeet. It was never seen in the wild but was known only from a handful of live specimens in captivity from sub Himalayan Gangetic plains of UP and Bihar. It remained a mystery bird for very long. It was American ornithologist Pamela C Rasmussen, who demonstrated that Intermediate parakeet was actually a hybrid between Plum-headed parakeet and Slaty-headed parakeet and most likely in captivity.

(Refer Slide Time: 39:19)

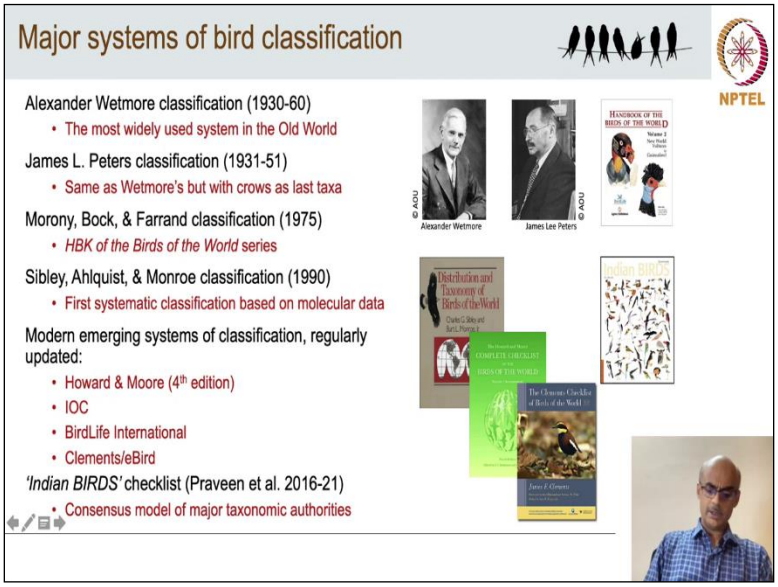


Other intricate problem of species concepts in Ornithology is what is commonly termed as ring species. A very peculiar phenomenon. Ring species refers to a species complex around a geographic ring; neighbouring populations along this ring freely interbreed but those at the end of the ring do not and behave as if they belong to different species. Though the phenomenon of ring species has been reported from several bird taxa, it has been very hotly debated among the biogeographers.

Some of the common examples from birds include Herring gull around the Arctic ring and Great tit and Greenish warbler around the Tibetan Plateau ring. So, this example shows the ring distribution of Greenish warbler complex around the Tibetan Plateau from *viridanus* in the west to *trochiloides* in the south. Four interbreeding taxa are involved as in a ring-shaped distribution. But the *plumbeitarsus* which is in the eastern Asia, when they meet *trochiloides*, they behave as if they do belong to two distinct species tand hey do not recognize each other.

So, the erstwhile singles species of Greenish warbler is now treated as a complex of three species including *nitidus* which branched off from *viridanus* and *plumbeitarsus*.

(Refer Slide Time: 41:00)



So, these are some of the major issues of species definition in birds and ornithology. WE will just see briefly of what are the major systems of bird classification that exist in the past and today. Several classification schemes were proposed for birds all along the course of the history of ornithology. However, two classifications ruled the world of ornithology through most part of 20th century: the first was developed by Alexander Wetmore, an American ornithologist in 1930s.

Wetmore's classification put finches as the last terminal taxa among the birds, and widely followed in the whole world including India. So, if you look at the Salim Ali and Ripley's classic Handbook, they actually followed Alexander Wetmore's classification. The second major classification was that of the British ornithologist James Peters, who proposed in 1931. Peters list had crows as the last taxa contrary to Wetmore's but otherwise it was quite similar to what Wetmore had proposed.

Curiously Peters classification was more popular in the New World though it originated from Europe. Morony et al then published an updated classification of birds in 1975 taking into consideration all the published works on avian taxonomy and species limits in the second half of the 20th century. This was followed by the iconic series "Handbook of the Birds of the World" - a 17 volume reference book.

Then arrived the Sibley and Monroe's first modern system of classification of birds in 1990 based on molecular data using DNA-DNA hybridization. As I noted earlier, this was truly a turning point in the history of systematic ornithology, as it laid the basis for the molecular taxonomy. Several new proposals of avian relationships and taxonomic positions proposed by Sibley, Ahlquist and Monroe have been subsequently corroborated by more intensive genetic analysis.

These include recognition of Australian origin and radiation of crows, separation of Buttonquail from cranes and rails, recognition of New World vultures as evolutionarily distinct from the Old World vultures, and identification of Paradise-flycatchers as closely related to crows rather than flycatchers. Post Sibley numerous phylogenetic studies have been conducted on a wide range of taxa bird using gene sequencing and other molecular techniques.

These studies have tremendously contributed to our current understanding of species limits and higher order taxonomy. Riding on the wave of these new findings, four major systems of bird classification have emerged in recent times. Among these Howard and Moore 4th edition by Edward Dickinson is the most scholarly work. However, Howard and Moore fourth edition became static with no further annual updates.

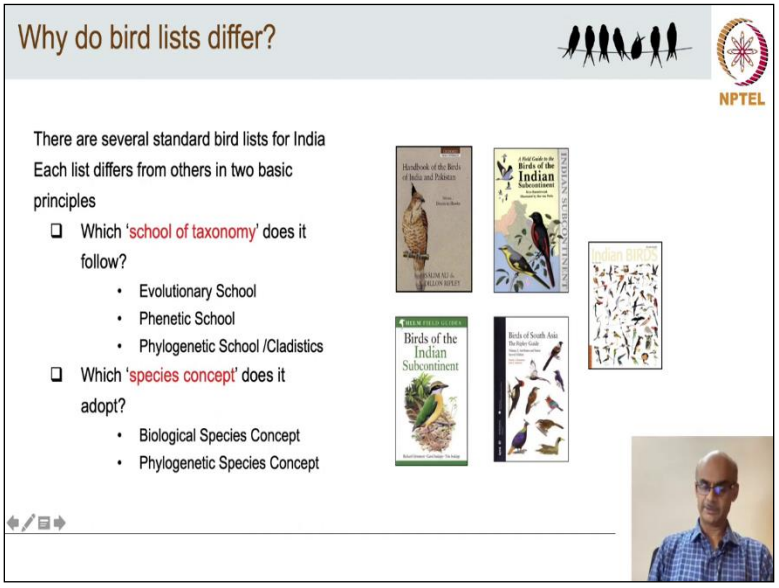
Then next major system of classification is the IOC (International Ornithological Council) world bird list. This is maintained by a panel of leading systematists and gets regularly updated; in fact, it has recently been adopted by British Ornithologists' Union. The next major list is by BirdLife International, which is perhaps the most controversial among these, because it is based on Tobias et al, who published a new methodology of scoring of similarities in morphology and vocalization to assess species limits.

And since they did not consider genetic or molecular evidences, it was quite controversial; it is not really very well accepted by most other taxonomists. But nonetheless, since BirdLife International undertakes the Red List assessment of birds for IUCN, this taxonomy is also followed by IUCN by default. And the fourth one originates from America as it is based on annual updates of the American Ornithologists Union - the Clements list.

And it is perhaps the most popular classification today, as it is also the base for eBird platform used by millions of birdwatchers around the world. Back in India, Praveen et al who maintain the India Birds Checklist of the Indian BIRDS journal began with Howard and Moore 4th edition classification, but since there was no further annual updates to Howard and Moore, they later adopted a consensus model of taxonomic authorities particularly the IOC and the Clements and eBird classification.

So, and yes, existence of the four major systems of the classification does pose lots of issues particularly in conservation circles and also for communication among birdwatchers and ornithologists. So, which one to follow? Every country has ornithological organizations, who choose to follow one among these things. Now there are attempts to forge consensus among them. So that a single uniform system of bird classification nomenclature can evolve but we hope it will happen soon; even in the last IOC congress these attempts were made but it did not meet much success.

(Refer Slide Time: 47:33)



By the way, but why do these bird lists differ? For example, in India we have several standard bird lists, right. Right from Ali and Ripley Handbook and Grimmett and Inskipps, and also Krys Kazmierczak Field Guides, then Birds of South Asia Ripley guide by Rasmussen and also the Praveen et al India Birds Checklist. So, they essentially differ in terms of two basic principles.

First is that which school of taxonomy do they follow whether it is Evolutionary school or Phenetic school or the modern Phylogenetic or Cladistic school.

They may not explicitly acknowledge such allegiance; but you can see traces to that effect. For example, Rasmussen's Ripley Guide and Praveen et al India checklist both favour Phylogenetic or Cladistic evidences. The second principle pertains to the species concepts that they adopt. Most do follow the traditional Evolutionary Species Concept or the Biological Species Concept.

However, Ripley Guide and Indian Birds Checklist seem to embrace Phylogenetic Species Concept for some select problematic taxa particularly where the species are geographically disjunct and morphologically dissimilar.
Thank you.