eKINDS Project Paper

Strategies for More Clearly Delineating, Characterizing, and Inferring the Natural History of Baramins II:

Evaluating Diversity, with Application to the Order Galliformes (Class: Aves)

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Abstract

One foundational goal of baraminology, or the study of created kinds, is to identify which creatures known today are related in that they belong to the same created kind (baramin). From this foundation, baraminology provides a robust framework for better understanding biology and the natural history of life. Once a baramin is delineated with reasonable certainty, it is important to evaluate the unity and diversity within the group. This allows well-reasoned inferences on which traits can undergo change, and which are largely fixed. In part I of this series, we examined the avian order Galliformes, or chicken-like birds. Here we evaluate each of the five galliform families and note some of the morphological and behavioral diversity in this group. This will lay a foundation for further study regarding the natural history of this baramin, and may help to uncover mechanisms involved in generating this diversity (e.g., created heterozygosity, genetic changes, migration, hybridization, etc.).

Introduction

Baraminology can be defined as the study of created kinds, or baramins. This biblically based systematic study of life begins by identifying species that are truly related because they descended from the same created kind (Genesis 1:11–12, 21–22, 24–25). As discussed in the first paper in this series (Ahlquist and Lightner, 2019), this is no small task. Multiple lines of evidence including morphologic, behavioral, and molecular characteristics should all point to the same conclusion before a baramin is considered well-established.

While clearly delimiting baramins is foundational, it is by no means the end of the subject. Characterizing baramins

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not only highlights the unity within the baramin, but points to important diversity as well. The diversity can be further assessed in an attempt to identify what portion was created, and what portion has arisen during the natural history of the baramin (e.g., through genetic changes). This is important to a proper understanding of biology and the design endowed by the Creator that allows His creatures to reproduce and fill the earth.

The result of this approach is a more robust foundation for biologic inferences and hypotheses regarding the design of life and its natural history. Currently, most biologists assume all life is related by universal common ancestry. This leads to some bizarre proposals for natural history. For example, evolutionists are often forced to infer massive gene gains, followed by massive gene losses to account for the large molecular gaps between higher level taxa (Wolf and Koonin, 2013; Rosenfeld et al., 2016). Baraminology, with its recognition of a loving Designer and limited common descent, will provide a stronger, more plausible foundation for understanding biology.

In this paper we examine the five landfowl families in more detail, noting the distribution and characteristics that make each of them unique.

Figure 1. Family Megapodiidae. Micronesian Megapode (*Megapodius laperouse*), running. Note large feet characteristic of the family. Photo by Michael Lusk. Courtesy of Wikipedia Creative Commons.

Megapodiidae

The family of Megapodes or mound builders, comprise 22 species mainly Australo-Papuan in distribution (Figure 1). The following information has been taken from the account by Elliott (1994), Jones et al. (1995), and a shorter, but difficult to find, article by Sekercioglu (1998).

"Megapode" is a reasonable substantive name for the group. The genus *Megapodius* derives from the Greek μέγας ("large") and πούς, ποδός ("foot"), and alludes to the fact that the birds have outsized feet for their size. (Figure 1) "Mound-builders" is more appropriate with respect to their biology, but not all species build mounds. The German *Thermometerhuhn* comes closest, but "thermometer fowl" doesn't reflect happily in vernacular English.

Although centered in Australia and New Guinea, megapodes have colonized distant islands including Niuafo'ou, Kingdom of Tonga, Central Polynesia; Palau and Marianas Islands in Micronesia; Nicobar Islands in the Bay of Bengal; Solomon Islands; and Vanuatu (formerly New Hebrides). In addition to Australia and New Guinea megapodes inhabit islands in Indonesia and the Philippines. The limiting factors include the presence of mammalian predators such as cats (Felidae) and civet cats (Viverridae), hence megapodes are not found on Borneo, Sumatra, Bali, or Malaysia.

Megapodes are unique among birds in that they do not directly incubate their eggs. They place their eggs in mounds of decaying vegetation—think of an avian compost pile—which is raked from the surroundings (Figure 2). Some place their eggs in warm sand or in burrows close to geothermal vents. The details of this nesting system are so remarkable that they point unambiguously to design and defy attempts to imagine, much less demonstrate, how random events could have produced them. Here we examine a few points of their remarkable breeding biology.

Mounds

The commonest "nest" is a large mound of leaf litter, twigs, and soil raked by the birds from the surrounding area. The process is carried out by the male, in

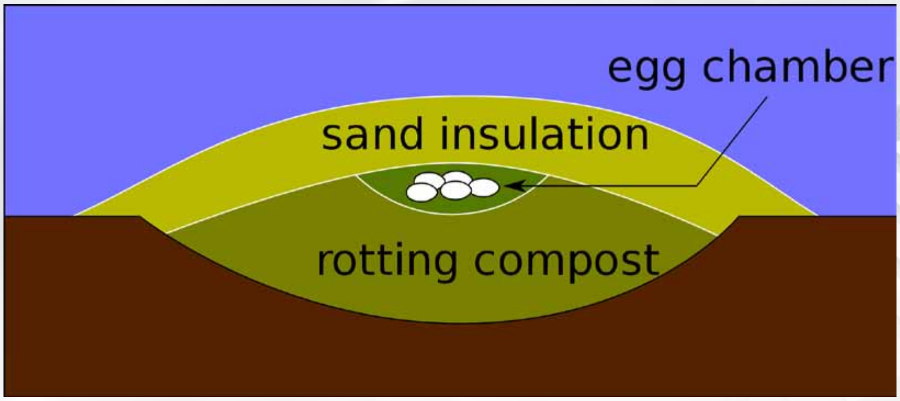

Figure 2. Cross section of a Malleefowl *(Leipoa ocellata)* mound. Artist Peter Halasz. Courtesy Wikipedia Creative Commons Share Alike 2.5 Generic License.

some species with assistance from the female, and can involve months of laborious activity. The material naturally contains a community of fungi, bacteria, and tiny microorganisms that flourish within the mound. Their metabolic activities generate heat which serves to incubate the megapodes' eggs. The birds themselves aid this by adding or removing fresh material, thus regulating the temperature and moisture levels, and keeping the soil aerated by their digging. The birds have a unique temperature-sensing mechanism probably in their tongue or palate—not conclusively demonstrated—and can adjust the incubation temperature by their activities. Ideally, the temperature is maintained around 32–35 °C. The female periodically excavates a hole into the mound into which she lays an egg, thus the breeding cycle is prolonged.

Mounds may be constructed annually, as in the Malleefowl (*Leipoa ocellata*), attain a height of approximately 1.5 meters, a diameter of around 5 meters, and contain several tons of debris. Other species, such as the Orange-footed Megapode (*Megpodius reinwardt*), build upon the same mound year after year. Such mounds can reach 5 meters in height and 12 meters across. A few have been known to be used for 40–50 years by successive generations of birds.

Of 22 species of megapodes, 19 construct mounds. Of these, five also utilize other heat sources in some parts of their range. Only three species—Maleo (*Macrocephalon maleo*), Moluccan Megapode (*Eulipoa wallacei*), and Polynesian Megapode (*Megapodius pritchardii*)—use geothermal or solar-heated sites.

Geothermal heat sources

Considering the amount of volcanic activity in the region, some megapodes, most notably the Maleo (*Megacephalon maleo*), endemic to Sulawesi, dig burrows in proximity to geothermally heated water. The birds excavate burrows around tree roots and boulders, seeking a site with the proper temperature. After laying, the egg is covered with loose dirt or sand and left entirely on its own for incubation. Favorable areas such as those on New Britain may attract thousands of birds during the breeding season.

The Maleo possesses an unusual elongated casque on its head, a rearward projection of the parietal bone. Often thought to play a role in sensing the temperature of the burrow, this appears not to be the case as individuals have been observed to take a bill full of sand while digging the nest burrow (Jones et al., 1995, p. 138), the same as other megapodes. A more likely function is that of thermoregulation, as the exposed area is richly vascularized, similar to that of the Helmeted Guineafowl, *Numida meleagris* (Crowe and Withers, 1979). Another postulated function is that of a shock absorber when the bird cracks open hard nuts (Starck, 1988).

Solar heated sources

Sand warmed by the sun is sought by a number of island-dwelling megapodes, mainly of the genus *Megapodius* that are good colonizers. The birds converge on several favored areas, sometimes by the thousands, excavate burrows to an appropriate depth, deposit their eggs, and then disappear into the inland forests while the young develop and hatch.

The egg

Because predation pressures exist on adults tending the mound, on the eggs (largely by human harvesting), and on newly emerging chicks, female megapodes lay a large number of eggs, staggered over a protracted nesting period. It is difficult to determine the number of eggs laid in a season by an individual, but an average clutch size of 12 to 24 is not unusual, and an exceptional number of 56 has been reported from a captive female. The intervals between eggs range from two to nine days in Australian Brush Turkeys (*Alectura lathami*) up to 13 days in Orange-footed Megapodes (*Megapodius reinwardt*). The interval reflects the need for the female to acquire enough nutrients for egg formation. In a season a single female Malleefowl (*Leipoa ocellata*) may produce eggs equivalent to 150–250% of her body weight, and a Maleo may lay eggs equivalent to 120–180% of female body weight.

The egg is large compared to the mass of the female, ranging from 75g in the Polynesian Megapode (*Megapodius pritchardii*) to 231g in the Maleo. A more meaningful way of expressing this value is that it represents between 10% to 22% of the female's body mass. In this respect only the flightless kiwis of New Zealand lay larger eggs.

The amount of yolk is high, occupying from 48 to 69% of egg contents, reflecting the requirements of the developing chick. Correspondingly, the water content is low.

The egg shell is remarkably thin. The pore size changes (enlarges) as incubation proceeds, the calcium being utilized by the developing embryo. These features are designed for incubation in the mound where oxygen tensions are low but carbon dioxide and moisture are high.

Incubation times are long—49–65 days being the normal range—and are related both to slower developmental rates as well as the precocity of the young at hatching.

Contrary to what one might expect, there is a definite breeding season, its length being terminated by the dry season in arid Australia or the onset of monsoonal rains in the tropical forests or sandy beaches.

The chick

Young megapodes hatch in a hyper-precocial condition with fully developed feathers. Although an egg tooth is present during development (as in other birds), it is not used in hatching. Because of the limited water loss in the egg, an air space does not form late in incubation as in other birds. Thus, there is no overlap between chorioallantoic and pulmonary respiration in megapodes. The chick hatches by resolutely kicking free of the shell, which is already thinned during development, a process that takes only minutes. This means that blood flow through the chorioallantois stops immediately after it is torn by the feet. Its lungs lose fluid immediately and aerate rapidly.

More challenging is digging its way out of the mound, a process that can take from a couple hours to a couple days, depending on the depth of the egg and the compaction of the compost.

Once out of the mound, the young immediately finds food on its own, is capable of thermoregulation between ambient temperatures of 3°C to 46°C, and can fly on the day of hatching. They receive no parental care. Little is known about the life of the young after it exits the mound, as they quickly disappear into the forest. Mortality is high, exceeding 90% in the first year of life, but this is balanced by the large number of eggs laid by each female and the staggered hatching times.

An intriguing question is how megapode chicks recognize their own species considering that they hatch out independently from other nest mates and do not see their parents. Göth and Evans (2004) investigated this using newly-hatched megapode chicks and robotic models made from megapode chicks dying from natural causes. In a test enclosure the robotic chicks were programmed to perform various behaviors and the responses of naive chicks were measured. Not surprisingly, the positive responses were toward pecking for food, something that the young chicks would instinctively look for.

Most interesting were the chicks' responses to various light regimes. Here the legs and feet of the robots reflected light strongly in the UV and elicited a strong response from the live birds. This would be a definite clue as to species identity. Furthermore, reflection of blue UV light would be invisible to an avian predator overhead, and would not be perceived by a mammalian predator on the ground. Presumably, only snakes and goannas (*Varanus* lizards) would potentially be able to see in the UV range.

The advantages of this nesting system are that it reduces the energy investment in parental care and enables the female to lay large clutches over an extended period of time. This habit could only occur in an area where predation by land animals is low enough to permit its maintenance. Evidently, in the Australo-Papuan area existing predators such as monitor lizards, snakes, and raptorial birds are not mitigating factors. Megapodes, surprisingly, are good colonizers. Even young birds have been reported flying over water miles from any land.

Cracidae

Curassows, guans, and chachalacas comprise 55 species found in Central and South America (Figure 3). Information is taken from the monograph by Delacour and Amadon (1973) and del Hoyo (1994).

We may think of cracids as being arboreally adapted pheasants. They are characterized by long tails and legs with all four toes being on the same level, unlike other landfowl. This adaptation, especially of the hallux, or hind toe, enables them easily to grasp tree limbs, even small twigs. The plumage is somber-colored, being black or barred brown in guans and curassows and uniform pale tan in chachalacas. Bright colors are restricted to the legs and feet and more especially to the facial region which is characterized by knobs, horns, dewlaps, or wattles that serve as sexual markers as well as species-specific characters.

The sexes are usually similar in plumage, and the birds are monogamous. Unlike other landfowl, they construct a nest in trees and lay small clutches of eggs, two or even one in the larger curassows and three or four in the smaller guans and chachalacas. Both sexes participate in care of the young. The young are adroit at clambering around in the trees after hatching and can fly within a few days. Also, unlike

Figure 3. Family Cracidae. Yellow-knobbed Curassow *(Crax daubentoni)*, female, captive bird. Photo by Jim Capaldi. Courtesy of Wikipedia Creative Commons.

Figure 4. Family Numididae. Helmeted Guineafowl *(Numida meleagris)*. Except for the genus *Agelastes*, the finely dotted plumage is a hallmark of the guineafowl. Photo by Lip Tee Yap. Courtesy of Wikipedia Creative Commons Attribution-Share Alike 2.0 Generic License.

other landfowl, the young are fed by both parents for a considerable time until independence is reached.

Unfortunately, cracids are good to eat and easily shot. The result has been that many species are in decline and endangered through the twin pressures of habitat loss and over-exploitation. Their low rate of reproduction simply cannot maintain viable populations under such conditions.

Odontophoridae

The New World quail contain 34 species of North, Central, and South America (Figure 4) and are apparently not closely related to their Old World ecological counterparts. Data are from Johnsgard (1988), Madge and McGowan (2002), and Carroll (1994).

The New World quail form a compact group of small to mid-sized landfowl including the familiar Bobwhite (*Colinus virginianus*) of the eastern U.S., desert species of the American southwest (*Callipepla*), to the wood-quail (*Odontophorus*) inhabiting Neotropical forests south to southern Brazil. Superficially, they resemble Old World quail but are distinguished by a toothed, or serrated, bill and the lack of tarsal spurs. The bill is of a distinctive high-arched shape, and many members possess head crests or plumes. Numerous anatomical features serve to separate them from Old World forms (Holman, 1961). Cladists consider most of these characters to be symplesiomorphic (primitive) and not indicative of true relationships.

Numididae

Guineafowl are a small group of 6 species found in south Saharan Africa (Figure 5); information is taken from Martinez (1994).

The guineafowl, along with the turacos and colies, are the only families endemic to Africa. They exhibit many characters in common with other landfowl, but can be recognized by their excessively rotund shape accented by a thin neck and relatively small head. This gives them a distinctive profile. This shape is further enhanced by the fluff of upper tail coverts. The head and neck are usually devoid of feathers, brightly colored, and with a variety of bony or fleshy protuberances or other excrescences, sometimes ornamented with a tuft of feathers on top of the head. In addition to bearing species-specific characters the bare skin is believed to function in thermoregulation. The plumage, except in *Agelastes*, is finely and exquisitely dotted with white. The best-known species is the Helmeted Guineafowl (*Numida meleagris*), which is widely domesticated.

Guineafowl are highly terrestrial birds, retiring to trees only at night. They range from open country, to grasslands, and dense tropical forests. Typical of landfowl, they lay large clutches of 6–12

Figure 5. Family Phasianidae, Subfamily Meleagridinae. Ocellated Turkey *(Meleagris ocellata)*. Photo by Dennis Jarvis. Courtesy of Wikipedia Creative Commons Attribution-Share Alike 2.0 Generic License.

Figure 6. Family Phasianidae, subfamily Tetraoninae. Rock Ptarmigan *(Lagopus muta)*, spring plumage (molting), showing fully feathered feet and toes. Photo by Friedrich Böhringer. Courtesy Wikipedia Creative Commons Share Alike 2.5 Generic License.

eggs, incubated by the female alone with the male standing guard nearby.

Phasianidae: Pheasants and Allies

This large assemblage, mainly Old World in distribution, divides into several natural groups. Here we list them for convenience as subfamilies. Most taxonomies recognize turkeys and grouse as separate groups. Beyond that, the remaining large group is either recognized as a single family or split into two subfamilies, Perdicinae and Phasianinae, which works satisfactorily, even by eye.

Meleagridinae

There are 2 species of turkeys, one in the United States and another in Mexico (Figure 6).

Turkeys hardly need an introduction (see Porter, 1994). The Wild Turkey (*Meleagris gallopavo*) is considerably sleeker than its overweight commercially produced cousin and sports an incredible plumage of coppery iridescence. A second species, the Ocellated Turkey (*Agriocharis ocellata*) of Yucatan and adjacent areas, is somewhat smaller and more strikingly arrayed in plumage of iridescent greens.

Turkeys are polygynous with a male attending a harem of females with whom he mates. Egg laying, incubation, and tending of the young is the role of the female herself.

The Wild Turkey (*Meleagris gallopavo*) is a fairly hardy omnivore, breeding into southern Canada and occupying a variety of habitats. In the eastern United States, they are primarily feeders on mast of oaks (*Quercus*), beech (*Fagus*), and chestnut (*Castanea*) during winter. The clearing of forest, chestnut blight, and over-exploitation reduced their numbers drastically. One of the great wildlife management victories of the twentieth century was the re-introduction of wild individuals (not game-farm raised birds) to areas from which they had been extirpated. This was aided by the regrowth of eastern hardwood forests and assiduous protection from landowners.

Tetraoninae

The grouse are mainly Holarctic with 17 species or more depending on the authority followed (Figure 7). Johnsgard (1983) and de Juana (1994) provide good introductory accounts. Hennigan (2000) gives valuable data on the Ruffed Grouse (*Bonasa umbellus*) from the point of view of creation biology. The data on physiology come from the monograph by Potapov and Sale (2013). Roald Potapov began studying grouse as a teen in 1947 near St. Petersburg (Potapov, 2011) and over 60 years later produced his monograph in English. This work is of paramount value as it summarizes his own research and much Russian literature unknown to us in the West. Russian biology focuses on what we might term "physiological ecology" and those species

Figure 7. Family Phasianidae, subfamily Tetraoninae. Sharp-tailed Grouse *(Tympanuchus phasianellus)*. Photo by Alan Schmierer. Courtesy of Wikipedia Creative Commons CC0 1.0 Universal Public Domain Dedication.

Figure 8. Family Phasianidae. Erckel's Francolin *(Pternistis erckelii)*. Photo by Dick Daniels (http://carolinabirds.org/). Courtesy of Wikipedia Creative Commons Attribution-Share Alike 3.0 Unported License.

of economic value such as grouse merit a great deal of attention.

We may consider grouse to be a group of boreal pheasants. Their design and adaptations rival those of the megapodes, although we are less likely to appreciate the details. The principal adaptations are to the cold and fall into four main areas.

Feet and feathers

Pectinate toes are a feature of grouse—except for the three species of prairie chicken (*Tympanuchus*)—that are unique among landfowl. The pectinations are comb-like, deciduous horny projections along the sides of the toes. They more than double the surface area of the feet and are important in enabling the bird to walk on soft snow (think snowshoes) and to dig rapidly in snow.

At the base of the tarsometatarsus are condyles for the attachment of the toes. In grouse they are so arranged that the toes can be spread more widely than in other phasianids, again an adaptation both for digging in and walking on soft snow.

The design of feathers provides further assistance in the harsh winter weather. The nostrils are covered with feathers, not a horny operculum as seen in other landfowl. The feather covering serves two purposes: protection while digging in snow and a means of retaining moisture from exhaled air. The latter is important in keeping humidity in the snow burrow low and preventing ice formation on its walls, thus depriving the bird of oxygen while incarcerated.

All grouse have feathered legs and feet to some extent. Depending on the climate, the feathering may cover only the tarsus, or in the case of the ptarmigan (*Lagopus*) may extend all the way to the tips of the toes. The feathers of the tarsus point backward. This aids in moving through snow and, more importantly, forms an effective cushion of warmth to the legs and feet while the bird is in its snow burrow.

Finally, the down feathers have a special structure that provides for more efficient insulation against the winter cold.

Beak and feeding

Grouse are designed for feeding on low-quality foods, namely buds, twigs, and conifer needles, not "good eats" even to a dedicated vegetarian. The beak and associated parts of the skull enable the birds to nip off twigs and twist off conifer needles. The maxillary and mandibular tomia (the horny cutting edges of the bill) are sharp and employed as follows. The bird begins at the end of a twig and successively nips off pieces that are slightly less than the width of the beak. The twig is held in place somewhat diagonally by ridges on the palate as it is cut. The bird simply works down the twig until its diameter precludes being easily cut, then moves to the next one. Conifer needles are seized by the bunch and are resolutely cut and torn away by a jerk of the head.

The usual foods are the commonest and consist of buds and twigs of birch (*Betula*), willow (*Salix*), alder (*Alnus*), and poplar (*Populus*). The needles of pines (*Pinus*), spruce (*Picea*), fir (*Abies*), hemlock (*Pseudotsuga*), larch (*Larix*), and cedar (*Juniperus*) are consumed. All are super-abundant. In the worst of weather conditions, the birds can fill their crops in a half-hour's time, then dive into the safety and comparative warmth of a snowbank, and proceed with digestion.

The crop itself is supplied with muscular connections to the sternum that assist in its being able to distend considerably.

Digestion

Two important questions arise concerning the diet of grouse. The first is the low quality of the food consumed. The second is the potentially hazardous nature of the secondary chemical compounds in conifer needles and other plant products eaten by the birds.

Unlike ruminate mammals or termites, grouse do not have a symbiotic micro-organismal flora to break down cellulose into its constituent sugars. The indigestible plant material is selectively passed to the large intestine where the water contents are resorbed. What is defecated is a dry and odorless pellet. The advantage of this fecal matter is twofold. It does not attract mammalian predators to the bird's igloo in the snowbank, and it does not contain excessive moisture to disturb the humidity inside. The warmth of the excreted pellets also provides heating to the burrow.

The material useful for the nutrition of the grouse is moved into large caeca, which are extensions from the small intestine and which act as a fermentation vessel to extract nutrients. The caeca of grouse average from 60–140% of the length of both small and large intestines, providing a copious chamber. The pelvis of grouse is broader than in pheasants to accommodate the mass of the digestive system.

The entrance to the caeca in the domestic fowl is shown by McLelland (1991, Figures 152, 153, p. 63) in scanning electron micrographs. One can see the caecal sphincters exercise considerable control over the products of digestion that are admitted. In grouse the muscular sphincters are enhanced by a filter system formed by thick three-cornered protuberances (Potapov and Sale 2013, Figures 14 and 15, p. 22).

Nutritional values for over two dozen food items are summarized by Potapov and Sale (2013, Table 4, p. 29). The large volume of the caeca plus the long time for bacterial fermentation ensures maximal absorption of nutrients as demonstrated by examination of caecal contents. Grouse have thus maximized a digestive system already designed in landfowl.

The burrow

Making the burrow is greatly facilitated by the adaptations of the feet described previously. A grouse being pursued by an aerial predator like a Goshawk (*Accipiter gentilis*), can plunge into the snow and excavate a burrow within seconds. For the more leisurely task of digesting food, rapid burrowing is also an advantage to escape detection by predators in general.

The burrow is more than a hole in the snow. The bird digs a tunnel of suitable length and depth to provide for warmth. It is critical that the air temperature of the burrow is between -3°C (27°F) and -1°C (30°F). Much lower and the bird is below its thermo-neural zone and risks hypothermia; above freezing will cause moisture to form, endangering the insulating capabilities of its feathers. The bird is able to sense the temperature and poke its head through the snow to let in cooler air, or dig in deeper if necessary. The temperature receptors are located in the palate and tongue, as they are in megapodes (above). Domestic fowl are quite sensitive to temperature differences (Freeman, 1983; Kare and Mason, 1986), and it is possible that this ability is even more finely tuned in grouse.

A burrow is used only once, but may be occupied for 22 hours or even longer. During this period the night temperatures outside can drop to -40°C (-40°F). The temperature inside the burrow is maintained by the heat of the bird, the heat from the excreted droppings, and heat of exhaled air from the nostrils.

If the bird leaves voluntarily, it pokes its head through the snow to check for possible predators, then breaks through, and walks away, leaving a few feet distant the caecal droppings, which are odoriferous.

Phasianinae

The Old World partridges include 108 species. Their distribution is entirely Old World and represent quail, partridges, francolins, and spurfowl. Pheasants, of which 51 species are recognized, include tragopans, pheasants, and peafowl, all Old World. (Figures 8–10)

The remaining landfowl run the gamut from tiny quail to the large peafowl (*Pavo*) and argus pheasants (*Argusianus*). We are used to marveling at the array of striking plumages displayed by the males of many pheasants, but one would do well to observe—whether in museum skins or close-up photographs on the Internet—the subtler patterns in tans, browns, grays, and white shown by the less gaudy members of the group. Here, the delicate patterns of individual feathers are so varied as to be different from one species to another. What the Creator has set aside in bright colors, He has more than made up for with intricacies of design.

The Phasianidae live in habitats from desert to rain forests and in alti-

Figure 9. Family Phasianidae. Temminck's Tragopan *(Tragopan temminckii)*, male. During courtship the bright blue skin around the face and neck can be inflated into an impressive structure. Photo by "Fr. Ted." Used courtesy of Wikipedia Creative Commons Attribution-Share Alike 2.0 Generic License.

tudes from sea level to alpine grasslands above the timber line. Likewise, the breeding habits vary from monogamy to extreme polygyny in which the only pair-bond occurs during mating.

The typical pheasants with their extreme development of extravagant male plumages are often cited by evolutionists as examples of extreme "run-away" sexual selection (Andersson, 1984) augmented with the idea of the "handicap principle." This latter postulate put forth initially by Zahavi (1975) and later popularized by Zahavi and Zahavi (1997) suggests that the elaborate (and cumbersome) train of feathers—of which the Peacock (*Pavo cristatus*) is a premier example—represents a severe handicap to the survival of its possessor; hence a bird bearing such a "handicap" must be *ipso facto* the carrier of "superior" genes and thus extremely desirable to a female.

The bright plumages and colorful fleshy facial adornments of many male pheasants similarly fall into this category, although not as such extreme examples. Biblical creationists were quick to point out fallacies in the theory. Burgess (2001) discussed in detail the complexities of color and structural features of the peafowl feathers and such represented an example irreducible complexity, not something that could have arisen by random chance without a designer. Such an analysis could be repeated for at least three dozen pheasants whose plumage is of similar, but less striking complexity.

Burgess asks the reasonable question of why a peahen would be attracted to tail feathers in the first place, thus highlighting the improbability of the evolutionary scenario. Further, one might ask why a female tragopan should be attracted to the brilliant blue air sacs adorning the head and neck of her prospective mate.

Takahashi et al. (2008), over a seven-year study, found that peacocks with the most elaborate tails did not have a higher rate of mating success, thus calling into question its importance in female choice. They were, however, countered by Loyau and coworkers (2008), and so the debate goes on.

There are many puzzles of relationships yet to be resolved, as we will see in the taxonomic section.

Assessing Current Diversity

Mating systems

Generally, monogamy prevails in this taxon until we get into the Phasianinae proper. Evidence is somewhat equivocal for megapodes where there seems to be a pair-bond established and with both sexes participating in mound maintenance. However, given the nature of females being less closely tied to the mound than males, there exists the possibility of polygamy.

Grouse are derivative of pheasants and are polygynous except for ptarmigan where a pair-bond is maintained and the sexes participate in care of young. One pattern is for the male to act as a decoy or lookout for predators; he will be chased, for example, by a Gyrfalcon while the female disappears into cover with her brood.

Since grouse and turkeys are closely related, turkeys also have a harem mating system. Within pheasants it is variable, although the life histories of many species, common in captivity, are not well known in the wild. Probably monogamous are Blood Pheasant

(*Ithaginis*), trogopans (*Tragopan*), and eared-pheasants (*Crossoptilon*, 4 spp., no sexual dimorphism either).

Figure 10. Family Phasianidae. Palawan Peacock-Pheasant *(Polyplectron napoleonis)*. The iridescent ocelli ("eyes") on the wing and tail feathers are reminiscent of those of peafowl and are an indication of relationship between the two groups. Photo by markaharper1. Used courtesy of Wikipedia Creative Commons Attribution-Share Alike 2.0 Generic License.

Nesting

We have discussed the megapodes with the use of natural heat sources to incubate their eggs: mounds of decomposing vegetation; location of nest near a naturally occurring heat source in the forest such as a hot spring, thermal vent, or similar; the use of burrows in the sand heated by the sun. In the last-named site, the birds gather, sometimes in large groups (thousands reported in New Britain), in favored areas of sandy beach on islands, lay their eggs in burrows, and disappear back into the forest.

The cracids are nearly unique in being arboreal nesters. With few exceptions all build a nest from a few feet to as much as 40' above the ground. The smaller species, such as chachalacas, tend to nest lower in a mass of tangles, brush, or vines. Clutch size is remarkably small (two-to four eggs) for any landfowl. This may be facilitated by the fact that the young are extremely agile at getting around in trees and are safe from ground predators.

Most of the rest of landfowl, as far as is known, nest on the ground in greatly concealed locations and have moderate to large clutch sizes, 6–8 as a minimum, up to ~20. Blood Pheasant (*Ithaginis*) and tragopans are said to nest in trees, and some montane pheasants in China are imperfectly known.

Facial ornamentation

As Bernard Stonehouse would have put it, "Landfowl take their facial ornamentation very seriously." Ridgway and Friedman (1946) list a number of terms in describing them: wattles, dewlaps, caruncles, combs, wrinkles, warts, protuberances, lappets, papillae, etc.

These excrescences are usually brightly colored; some may be erectile (via blood supply) or inflatable, attached to the cervical air sac system. Some involve extensions of the rhamphotheca (horny covering of the bill). A few are bony extensions, usually of the frontal bone, as seen in the Maleo (Megapodiidae, *Megacephalon*), the Helmeted Guineafowl (*Numida meleagris*), and in the Horned Guan (*Oreophasis*). Galliformes are unique in indulging themselves in such structures.

Megapodes have them, as do cracids. They are present in grouse, turkeys, and the "crown" pheasants (those of the "erectile clade"). The only groups in which they are reduced or almost absent are the odontophorines and Old World quail, and even here one sees the presence of some bare skin around the eye.

Bill structure

The "chicken bill" is amazingly uniform. It has a generalized, all-purpose design for picking up food items, with virtually no specializations. Landfowl are prokinetic, meaning that the upper beak (maxilla) rotates on a naso-frontal hinge, or a pivot point where the bill meets the skull. This is usually not a suture but a flattening of the bones that gives some flexibility. This permits a grasping or cutting motion between the maxillary and mandibular tomia (sharp edges of the bill). A prokinetic bill is found in other birds, including many passerines (e.g., cardinal, chickadee, titmouse). It allows for proficiency in opening seeds, and also permits the beak to exhibit some ornamentation, as we see in the cracids, for example. The opposing condition is rhynchokinesis in which there is an additional flexible point along the upper mandible. This is most easily seen in a woodcock or other sandpipers which can open the bill at the tip to grasp a prey item in the mud.

One consistent beak difference within landfowl is the arched culmen and presence of a tomial notch in the bills of the New World quail, hence the name *Odontophorus*, "tooth-bearing." It is unknown what the function is for this shape. Otherwise, Galliformes are unusual in the uniformity of the beak; most avian groups are more variable.

In grouse the rhamphotheca (horny covering of the bill) is deciduous, shed in the spring and replaced during the summer. This is an advantage in having a fresh, sharp cutting edge for winter. During the summer the birds can feed on insects and berries. It would be worth investigating if this correlated in any way hormonally with feather molt. Such shedding and replacement of bill sheaths is seen in puffins which lose the bright outer covering of the bill in the non-breeding season.

Foot structure

Again, a basic form designed for running and digging in substrate is prevalent. The "oversized" feet of megapodes are clearly designed for scraping up piles of compost for the nesting mounds or burrowing in sand. A major adaptation in the Cracidae is to have the hallux (hind toe) on the same level as the other three toes. This aids in climbing about in trees.

The modifications of feet seen in grouse seem fairly minor, involving the growth of lateral dermal papillae on the toes and the more lateral positioning of the inner and outer toes to create a better mechanism (wider shovel) for digging snow burrows.

Many species have tarsal spurs (1–3) which presumably are used in fighting. Attempts have been made to use the presence or number of tarsal spurs as a taxonomic character, but have not been successful.

Tails

The tails come in various sizes and shapes and seem to correspond to natural groups. The megapodes *Alectura*, *Aepyodius*, *Talegalla*, *Leipoa*, *Macrocephalon* have moderate to large tails; whereas they are small and stubby in *Eulipoa* and *Megapodius*. This may be correlated with increased vagility in the smaller species (*Megapodius*).

Tails are long in all Cracidae. This is correlated with arboreal habits, both in flying and in balance as they are very agile in moving about treetops.

Short, stubby tails characterize Odontophoridae and Old World quail (Perdicinae). Definite trends are seen in the pheasants (Phasianinae), especially in species that are polygamous/polygynous and tails become an important part of display.

In pheasants we can recognize several types of tail morphology. Monals (*Lophophorus*), of which there are three species, have large, broad square tails of 18 rectrices; bright orange-rust color in *L. impeyanus*. Gallopheasants and firebacks (*Lophura*), which includes nine species, have somewhat diverse tails of 16 feathers; arched somewhat like that of a domestic fowl. Eared-pheasants (*Crossoptilon*), including four species, are non-dimorphic, both sexes mostly gray and white; tail of 20–24 feathers vaulted into a huge soft bustle; other plumage similarly soft-textured; the "ear" consists of several white spike-like feathers. Genera *Catreus* (Cheer Pheasant), *Syrmaticus*, *Phasianus*, *Chrysolophus* are ones we think of as "typical" pheasants with long, graduated tails, barred and otherwise with bright flashy plumage. Reeve's Pheasant (*S. reevesi*) has a tail up to 1.6 meters long. The final group consists of the peacock-pheasants (*Polyplectron*), the peafowl (*Pavo*), Great Argus (*Argusianus*), Crested Argus (*Rheinardia*), and Congo Peacock (*Afropavo*)—in other words those with oversized tails and "eye-spots" (ocelli) of one sort or another.

Wings

Landfowl are heavy-bodied and have short, broad rounded wings with a deep camber. This aids in explosive rapid take-off to escape enemies and short burst of rapid flight. Most will fly just far enough for escape and then run to cover as necessary. Pectoralis minor (supracoracoideus) is fairly large compared to pectoralis major, suggesting a possible lift force on upstroke in flight.

The very large snowcocks of the genus *Tetraogallus* are said to run rapidly uphill and then launch into a long glide across a valley; they are not good at all in powered flight. A few such as *Megapodius* and *Coturnix* are dispersive or migratory and have longer wings and lower wing loading to aid in longer flight distance. Even megapodes that are not fully grown have been seen flying across water out of sight of land. This may explain why megapodes have spread to numerous islands in the southwest Pacific.

Conclusions

The above pages have reviewed the *dramatis personae* of the landfowl. From possibly humble and unspecialized precursors on Noah's Ark the landfowl have filled the created avian world with great diversity and beauty. The beak-foot-body *bauplan* built into these birds by our Creator has proved amazingly resilient in accommodating to a diversity of habitats and life styles. From this foundation, further research can answer other important questions such as: which features are ancestral and which are derived? Or, what is the genetic basis for various adaptations seen in different lineages of landfowl?

The extent to which our flow-chart outlined in Part I of this series can explain the morphological changes and dispersal history of the landfowl will be explored in Part III.

"But ask the animals, and they will teach you, or the birds of the air, and they will tell you. To God belong wisdom and power; counsel and understanding are his." (Job 12:7, 13 NIV)

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