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Paradise Kingfishers *(Tanysiptera spp.)*, the Founder Effect, and Creation Research

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Abstract

The Bible provides a robust foundation for understanding the natural history of life on Earth. After Creation and again after the Flood, terrestrial animal life reproduced to fill the earth. This involved numerous founding events as new habitats were invaded and new ecosystems formed. The paradise kingfishers of New Guinea display an interesting pattern of distribution, which inspired Ernst Mayr to propose the founder principle. A previous paper discussed the founder effect in more detail; however, much work remains to be done to see what role it has played in diversification and speciation within created kinds. Here, kingfishers are examined in more detail, with a special emphasis on the paradise kingfishers (*Tanysiptera* species) of Australasia. A summary of what is known is followed by an outline of research that desperately needs to be done to better understand how various factors, including founding events, have influenced the impressive adaptive radiations within the kingfisher kind.

Introduction

The Bible provides key details regarding the natural history of life. Living things were created according to their kinds, and designed to reproduce and fill the earth (Genesis 1:11–13, 20–31). Approximately 1650 years later, a global flood destroyed all air-breathing land animals and birds except for a pair (or more for clean animals) from each kind that was preserved on the ark Noah built (Genesis 6–8; the extra clean animals were necessary for sacrifice and possibly for food for humans after the Flood; Genesis 8:20; 9:3). From this genetic bottleneck, land animals and birds again spread out over the earth. The biblical creation model rejects the evolutionary concept of universal common ancestry; nevertheless, it must account for considerable speciation in only a few thousand years.

Jeanson and Lisle (2016) have shown that by assuming diploid creatures were created with a substantial amount of heterozygosity, and that mutation rates have remained essentially equivalent to what we have measured today, it is possible to account for the majority of genetic diversity seen today within the biblical time frame. Likewise, phenotypic diversity is readily accounted for, since many domesticated kinds (e.g., cattle, horses, pigs) have more breeds, developed through human intervention (artificial selection), than species in the wild. Even evolutionists agree

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that domestication has been recent, and therefore phenotypic diversity has developed rapidly. In fact, considerable increases of phenotypic diversity have been observed to occur within the course of a 50-year experiment (reviewed in Lightner, 2011).

In a previous paper, Lightner and Ahlquist (2017) discussed the founder effect and its importance in speciation, especially following the worldwide Flood. Land animals and birds preserved on the ark spread out around the world. In the process there was an environmentally based sorting of ancestral alleles, which is believed to play an important role in speciation. They further point out that, in contrast to how the founder effect is perceived by evolutionists, animals would have chosen environments they found most suitable for breeding, thus carrying in adaptive alleles. This means that standard statistical tools for identifying founder effect are unsuitable, since it is usually assumed alleles in the founders are random with respect to fitness.

Here, we present further data on those species of paradise kingfishers (*Tanysipera*) that first attracted Mayr's (1942) attention to the idea of a founder effect and led to his further formulation (Mayr, 1954). Morphological, behavioral, and molecular data are considered to understand the relationships within this group and to develop preliminary hypotheses to account for the dispersal and adaptive radiation of the entire kingfisher kind since the Flood. Some historical aspects relating to the study of paradise kingfishers (PKs) are covered to give insight into potential future research.

Kingfishers and Kinds

The biblical creation model involves limited common ancestry, and considerable work has been done to identify which species today are derived from a single created kind. The tentatively identified kingfisher kind (Lightner 2013, p. 430), or family Alcedinidae, comprises around 105 species of small-to medium-sized birds (10–48 cm or 4–18 in). The birds are similar in having rather large heads, oversized bills, and short tails, thus giving them a top-heavy appearance. The PKs are somewhat of an exception, possessing elongate and attenuated central tail feathers (longer than the body) that culminate in a terminal spatulate tip.

As we consider kingfishers in general, and *Tanysiptera* in particular, it is important to examine characteristics and relationships above, at, and below the level of the postulated created kind. This allows us to more accurately estimate the boundaries of a kind and to attempt to trace the natural history of the kind since they left the ark. Therefore, we commence our discussion at the level of the order.

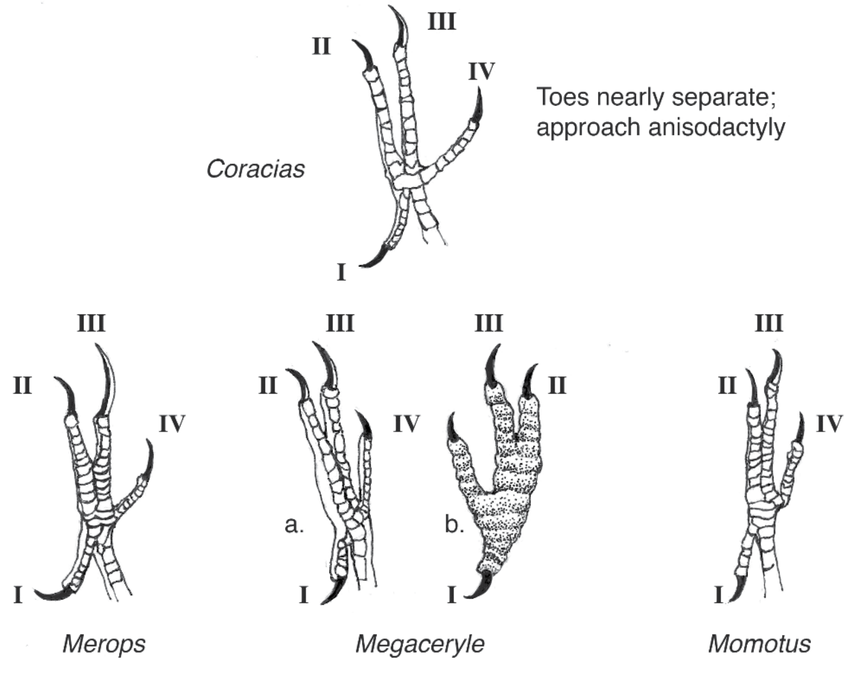


Figure 1. Syndactyl arrangement of the toes of some coraciiform birds. Shown are a roller *(Coracias)*, bee-eater *(Merops)*, kingfisher *(Megaceryle)*, and motmot *(Momotus)*. For *Megaceryle* dorsal (a) and ventral (b) aspects are shown. All other views are dorsal and depict right feet. Original drawing by JA from various sources.

Morphology and Behavior

Order Coraciiformes

Like other kinds that make up the traditional order Coraciiformes, kingfishers are characterized by a syndactyl foot in which toes three and four are united basally for part of their length (Figure 1). Whether this is a valid taxonomic character that unites the Coraciiformes is debatable in the light of conflicting morphological and molecular evidence (Hackett et al., 2008; Jarvis et al., 2014).

Perhaps of more interest is the functional design of this toe arrangement. Few have commented on this design. Many textbooks simply define syndactyly and glibly assert that it is an aid in perching, sometimes citing the work of Richard Owen (1866). Careful perusal, however, of the roughly 150 pages that Owen devotes to birds reveals no such statement.

A cogent evaluation is given by Nupen (2016, p. 37):

> In the avian world, the fleshy sheath that unites the anterior digits is thought to increase grip strength when the bird is perching, as it forces the digits to act in concert. Syndactyly is common among kingfishers, hornbills and bee-eaters (Coraciiformes) and there are many intermediate examples of birds with partly fused toes in this group. Extreme syndactyly occurs in the wood-hoopoes and hornbills and diminishes progressively through the kingfishers to only minor fusion in *Upupa* and finally the true anisodactyl feet of rollers. Similarly, among passerines it can sometimes be difficult to distinguish the syndactyl and anisodactyl conditions, as they intergrade closely.

What we can add to Nupen's statement, which was based on an examination of study skins, is that in those coraciiforms that spend the most time perching motionless, the pad, or sole, of the foot, and especially that of the fused toes, is expanded to give what one might describe as a "comfortable" grip on a perch. This is seen as an adaptation in those species that sit, only flying out to capture an insect or to seize prey from the ground. The diminished role of syndactyly in the Hoopoe (*Upupa*) and rollers is clearly related to their being more active in moving about searching for prey.

A second explanation is that the fusion of toes aids in digging the tunnel that serves as a nest. Nearly all coraciiform birds are obligate hole-nesters, using existing natural holes or those excavated by woodpeckers. Alternately, they excavate a nest hole in rotten wood, termite nests (termitaria), or mud banks of streams. The only exception is the Bucerotidae (Hornbill kind) (Lightner, 2013).

Family Alcedinidae

Ehrlich et al. (1988) assert, "The fused toes of kingfishers help in excavating nest tunnels." Initially, this appears incongruous, since the feet of kingfishers are quite small and weak. It might seem that they would be of little value for the task. Fry et al. (1992, p. 17) described the activity for bee-eaters, and presumably it can be used by kingfishers as well: "Earth is loosened by pecking with the bill, but to spade it out of the growing hole the bee-eater supports its weight on bill tip and 'wrists', lifts body and thus frees its legs to scrabble loose earth backwards with a bicycling action." Apparently, females of some paradise kingfishers utilize the beak in removing material as they burrow. The females, but not males, also employ the tail in a sweeping motion to clear debris (Woodall, 2001).

It should be noted that the family Alcedinidae has a wide distribution, as would be expected for most creatures descended from a kind preserved on the ark (Genesis 8:15–17; Isaiah 45:18). In contrast, the genus *Tanysiptera* is confined to Australasia, consistent with its representing one lineage from a created kind. This, as well as the molecular evidence mentioned previously, which does not support the monophyly of Coraciiformes (Hackett et al., 2008; Jarvis et al., 2014), is consistent with the current creationist view of kingfishers (Alcedinidae) being a created kind.

Genus *Tanysiptera*

The paradise kingfishers (PKs) nest in the mounds constructed by termites. For *Tanysiptera* the termitaria preferred are those of *Microcerotermes boroi* or related species that are abundant in their range. These termites are known as "carton termites." Their arboreal nests are ovoid structures built of "carton" (a mixture of fecal matter and wood fragments), which resembles cardboard or papier-mâché. They are fastened to the sides of trees with or without concealment. Carton may be papery and fragile, or woody and very hard. The inside of an arboreal nest consists of horizontal layers of cells and always maintains connections with the ground through covered runways (See Roisin and Pasteels, 2000).

According to Fry et al. (1992, p. 115) the birds select a termitarium on the side of a tree about 3–4.5 m from the ground. The pair flies repeatedly at the mound, striking it with their bills until they puncture a hole in the relatively hard outer surface. Once gaining a foothold, they are able to excavate the friable inner layers easily to a depth of about 15 cm with an egg chamber about 13 cm in diameter. The termites' response is to construct a sturdy wall around the burrow.

In Queensland, the Buff-breasted PK (*T. sylvia*) is said to utilize termitaria at nearly ground level (Woodall, 2001). This begs the question of the safety of the nest as it would easily be accessible to marsupial predators or snakes, yet the populations of the kingfishers seem not to be in jeopardy. The lack of nest sanitation on the part of the birds results in a characteristic odor to the termitaria. Whether this is an attractant or deterrent to potential predators is not clear.

It is interesting to note that an extensive literature exists regarding the use of termitaria as nest sites for birds. This occurs not only in forests but also in more open areas where termitaria exceed the number of excavated holes in trees. A generalization is that birds seek active termitaria. Brightsmith (2004) studied the nesting of several species of parrots, trogons, and jacamars in Peru. He noted that "all species apparently preferred to nest in termite mounds with termites and biting *Dolichoderus* ants" (Brightsmith, 2004, p. 327). Vasconcelos et al. (2015, p. 17) list 45 species of Brazilian birds in 16 families that use termitaria as nest sites and note that "nesting inside termitaria can offer advantages to birds, as protection against predators and propitious micro-climate."

The fecal build-up in the walls of termitaria can attract infestations of microorganisms, fungi, and pathogens that are harmful to the termite colony. In this regard it has been demonstrated that Actinobacteria, particularly *Streptomyces* species, provide a level of *in vivo* protection to the social group against fungal invaders (Chouvenc et al., 2013). While it would be far-fetched to suggest that such a mutualism would directly impact birds, it is worth suggesting that the characteristics of termitaria be examined for possible benefits to avian nesters.

Tanysiptera and Founding Events

Ernst Mayr (1904–2005), who proposed the founder principle over 75 years ago, spent the early portion of his career studying birds and collecting samples for the American Museum of Natural History in New York. Mayr's field expeditions in 1928–1929 took him to western New Guinea, then under control of the Dutch; eastern New Guinea, under Australian mandate; and the Solomon Islands, a part of the British Empire (Haffer, 2007; Figures 2, 3, and 4). It was in New Guinea that he became familiar with PKs and the patterns of diversity on New Guinea and the nearby islands. This pattern did not fit well with the standard explanation of natural selection being the sole driver of morphological divergence.

Mayr's (1942) original statement of the founder principle was terse. His map of the New Guinea allospecies of *Tanysiptera* (redrawn here as Figure 5) appears on page 153, yet discussion does not occur until page 236, where he observes,

> The kingfisher *Tanysiptera galatea* (Fig. 15) has only poorly defined subspecies in the large area of the mainland of New Guinea, but it has developed 6 very distinct forms (most of them regarded as species) on the small islands where it also occurs. The potentiality for rapid divergent evolution in small populations explains also why we have on islands so many dwarf or giant races, or races with peculiar color characters.

He continued:

> The reduced variability of small populations is not always due to accidental gene loss, but sometimes to the fact that the entire population was started by a single pair or by a single fertilized female. These 'founders' of the population carried with them only a very small proportion of the variability of the parent population. This 'founder' principle sometimes explains even the uniformity of rather large populations,

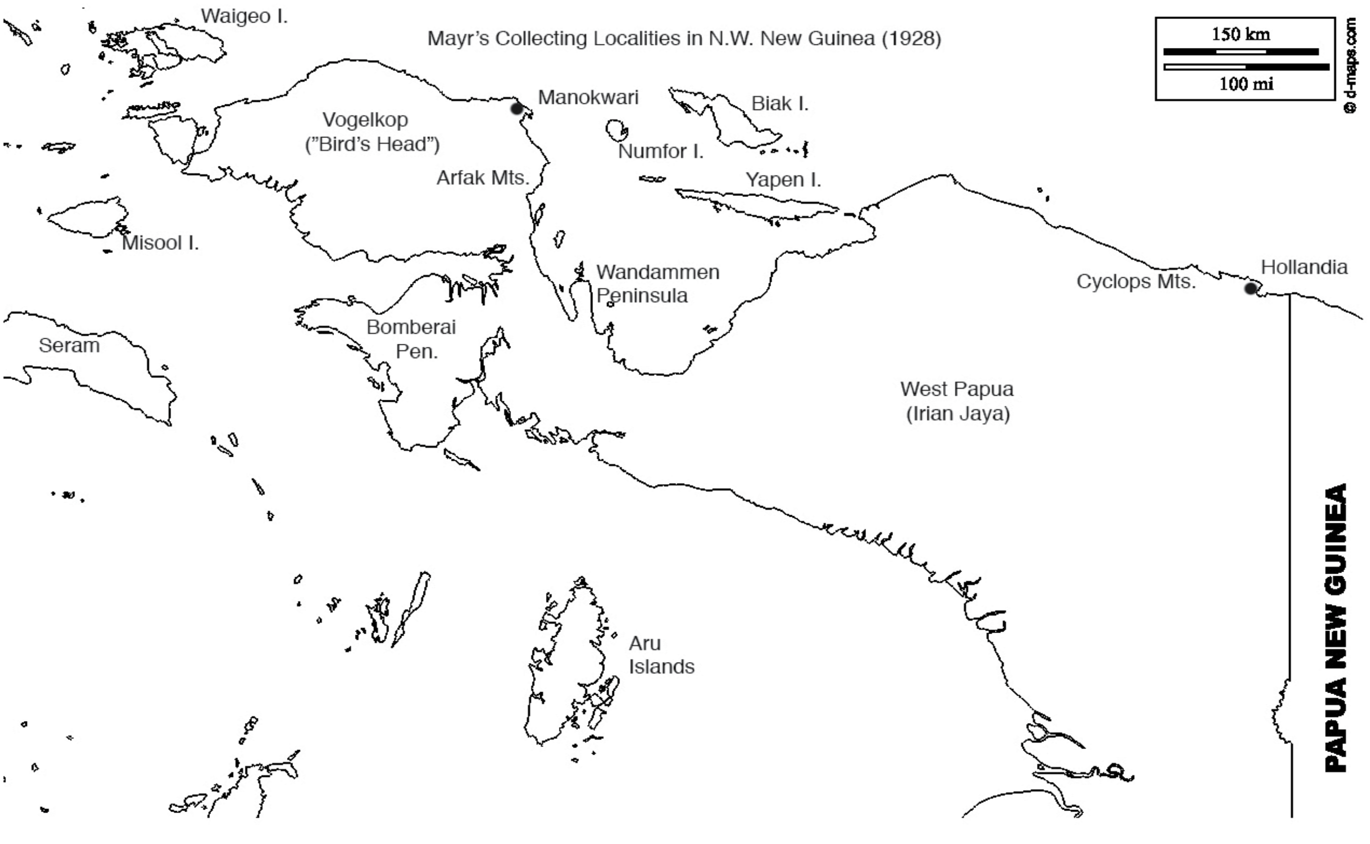


Figure 2. Map of western New Guinea showing places where Mayr collected in 1928 (Arfak Mts., Wandiwoi Mts. on Wandammen Pen., Cyclops Mts.) and other localities mentioned in text. Map used courtesy d-maps.com with locality data added.

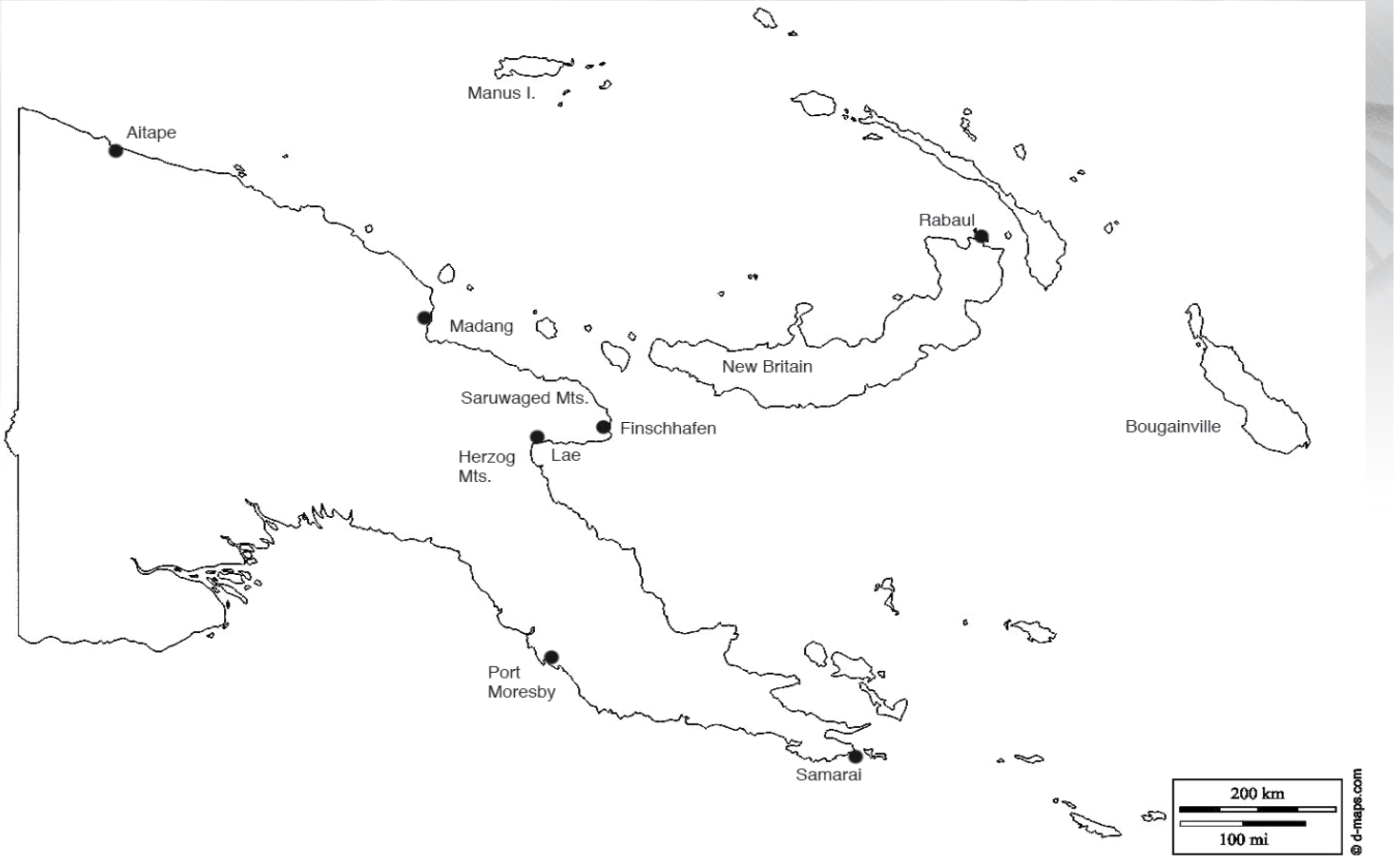


Figure 3. Map of eastern New Guinea showing places where Mayr collected in 1928 (Saruwaged and Herzog Mts.) and other localities mentioned in text. Map used courtesy d-maps.com with locality data added.

> particularly if they are well isolated and near the borders of the range of the species. (Mayr, 1942, p. 237)

As an example, Manokwari, the capital of the province of West Papua, at the western end of New Guinea (Figure 2) is located 52 minutes (0.87 degrees, slightly less than 100 km) south of the equator. It receives an average of 2,600mm (102.2 in) of rain per year, approximately 216 mm (8.5 in) per month. Exhibiting the same trend is Jayapura (Hollandia), the provincial capital of Papua, Indonesia, with average precipitation of nearly 2,400mm (94 inches) and no pronounced wet-dry periods. Port Moresby, the capital and largest city of Papua New Guinea (Figure 3), is located on the shores of the Gulf of Papua, on the southeastern coast of the Papuan Peninsula. It receives only 900mm rain (35in), most of which falls from January to March. The remainder of the year is dusty, hot, and humid (relative humidity above 75).

The islands on which the allospecies occur—Numfor, Biak, Kofiau, and Rossel—are all less than 100 miles from the coast of New Guinea, and all have a uniform tropical climate. Mayr (1954) details the differences between the island forms and *T. galatea* of the mainland. (See Figure 5 and Table 1). He emphasizes that despite drastic differences in climate, the mainland *T. galatea* are barely differentiated into subspecies from one end of the island to the other.

Taking Numfor Island as an example, Mayr proceeds to discount factors such as gene flow, a slightly different plant environment, and a somewhat impoverished fauna, and notes that the only serious predator is the same on the mainland, namely the Variable Goshawk, *Accipiter hiogaster*. What is different is the genetic environment, as he notes:

> The genetic environment is strikingly different. The Numfor population is geographically and hence genetically completely isolated from all other populations of the species … while *every New Guinea population is in the midst of a continuous stream of genes flowing back and forth cross the entire island continent*. While the number of possible contacts with other genes is exceedingly high in New Guinea, it is drastically reduced among the founders of the Numfor

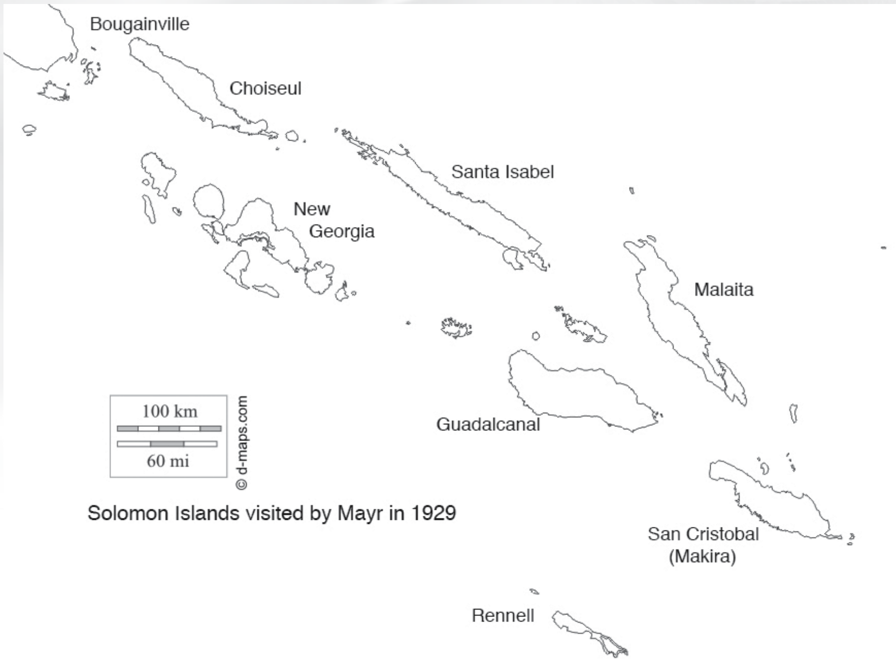


Figure 4. Map of Solomon Islands where Mayr collected in 1929. This was the first time Malaita had been accessible due to native hostility. Map used courtesy d-maps.com with locality data added.

> population. (Mayr, 1954, p. 168, emphasis in original)

While ideas on how and why founding events lead to such a pattern has shifted somewhat, Mayr's field observations of PKs clearly provided the basis for considering the importance of founding events in diversification and speciation. Other relevant observations and mathematical modeling that has further contributed to the topic was previously reviewed in Lightner and Ahlquist (2017). It is important to recognize that when the distance is considerable, each newly founded island population becomes a biological microcosm, adapting and multiplying as a separate entity with its own history, genetic structure, and destiny.

There remains a lacuna in our understanding of PKs and the founding of island populations. Mayr never studied *Tanysiptera* in the Maluku Islands (aka Moluccas) west of New Guinea (Figure 6). After his initial years of fieldwork, he took a job with the American Museum of Natural History and was to publish papers based on the specimens that had been collected. His supervisor, Frank Chapman, did not permit Mayr to do fieldwork, so he never returned to study PKs in the remaining Indonesian islands (Vuilleumier, 2005, pp. 391–392).

Other historical factors have played a role in this story. The Greater Sunda Islands have received good treatment in the form of monographs and field guides. Even the birds of somewhat ignored Sumatra have been nicely monographed (van Marle and Voous, 1988). Historically, New Guinea has received considerable attention owing to its considerable, and spectacular, endemic avifauna. The most recent works (Pratt and Beehler, 2015; Beehler and Pratt, 2016) represent decades of fieldwork and study.

In contrast the vast stretch of islands east of Java and Borneo and west of New Guinea has received less study. Here we include Sulawesi (Celebes), the Lesser Sunda islands, and the numerous smaller islands of the Moluccas, collectively termed Wallacea. Many detailed descriptive papers on collections made from individual islands were published before the Second World War. Among them were monographic studies such as those by Stresemann (1939–1941) on the Celebes and Rensch (1931) on the Lesser Sundas, but it remained until the definitive work by White and Bruce (1986) that the scattered literature, often in German, was brought together and synthesized. Based on the White and Bruce work is the field guide by Coates

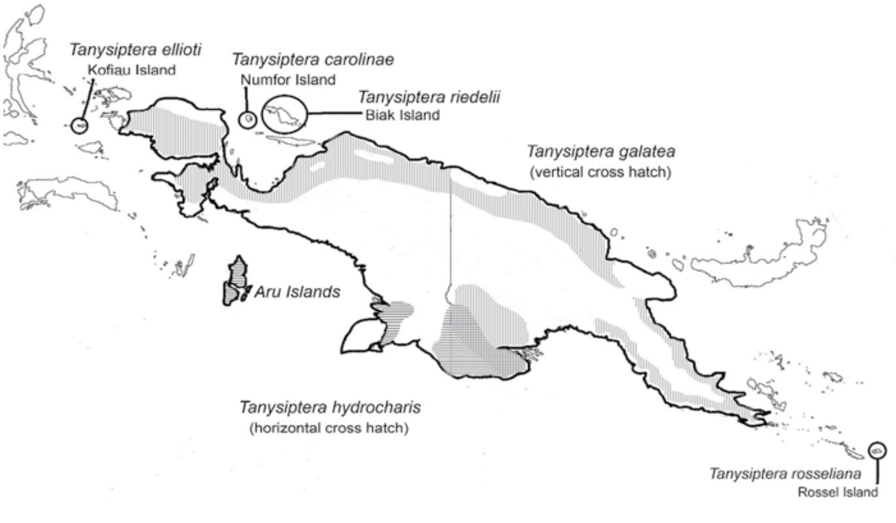


Figure 5. Map of New Guinea and outlying islands depicting the ranges of *Tanysiptera* kingfishers discussed by Mayr (1942). Map drawn by JA.

Figure 6. Detailed map of Moluccan Islands (Malukus). Author: Lencer, Maluku Locator Topography by user Sandalmelik. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

et al. (1997) with excellent illustrations of all the species. Mees (2006) filled an important gap with a comprehensive study of the birds of Flores in the Lesser Sunda Islands.

Molecular Data

The advent of molecular data has had a mixed effect on ornithology. It some cases it has confirmed what was long held to be true based on morphological, behavioral, and zoogeographic observation. Other times, it completely disrupts previously perceived relationships. It is important to note that every molecular study produces hypotheses of relationships. Our contention is that when novel ideas are suggested, if correct, they will be supported by a number of morphological, behavioral, and ecological attributes of the birds themselves. Such characters may have been overlooked, ignored, or misinterpreted in the past.

We wish to emphasize that molecular data will not replace more traditional techniques in the foreseeable future. An interesting paper by Brusaferro and Insom (2009) points to the role that traditional characters and methods can play in an increasingly molecular age. The authors carried out a morphometric analysis of characters of the skull of kingfishers, analyzing their data phenetically. Not only did they recover the same three subfamilies as other studies, but they also were able to discern how cranial differences are correlated with feeding habits and other aspects of the birds. Thus, there will continue to be an important function for the individual who lacks access to a molecular laboratory and requisite funding but who nonetheless possesses a knowledge of and curiosity about the birds.

Based on currently available data, we are able to utilize existing molecular studies of kingfishers and the knowledge of their general morphology and ecology to postulate some probable scenarios for the migration and differentiation within the kingfisher kind.

Synthesis of Relationships and Zoogeography in the Kingfisher Kind

Miller (1912) recognized and defined three subfamilies of kingfishers in what one might call the first "modern" revision of the group. Amazingly, the three subfamilies Cerylinae, Alcedininae, and Daceloninae (Halcyoninae), along with their constituent genera, have stood the test of time. The history of the systematics of kingfishers has been presented by Sibley and Ahlquist (1972, 1990), Moyle (2006), and Christidis and Boles (2008), among others, and is not repeated here, except to note that all lines of evidence—morphological, behavioral, molecular—basically point to three groups and agree as to the constituent genera of each.

Although Sibley and Ahlquist (1990, p. 845) found significant differences among the kingfisher groups to warrant family status for each, we retain the traditional subfamilies arrangement. Both Sibley and Ahlquist and Moyle (2006) identified the Alcedininae as the basal group of kingfishers, sister to the other clade comprising the Cerylinae and Halcyoninae.

Subfamily Alcedininae

Gill and Donsker (2016) recognized 35 species in four genera (*Ispidina*, *Corythornis*, *Alcedo*, *Ceyx*) of Alcedininae (Figure 7). The group is morphologically uniform, consisting of tiny kingfishers with short tails, small feet, and long bills. The vernacular epithet "dwarf" or "pygmy" is appropriate. Most species have brilliant blue or green coloration accented with red-orange or buff.

In the beginning the taxonomy of the group seemed straightforward. They were divided on the basis of ecology into piscivorous (mainly *Alcedo*) and insectivores (mainly *Ceyx*) groups. The piscivorous species usually had dark-colored bills that were laterally compressed, whereas the insectivores species tended to have orange, or brightly colored bills that were dorso-ventrally flattened ("pie shaped"). A third character that seemed taxonomically important was the reduction in many species to three toes. The second digit was lost, leaving the first (hallux, or hand toe) with toes three and four united in the syndactyl condition. As we shall see, there is a lack of concordance in the distribution of these features among species, which was solved via careful and detailed molecular analyses (Moyle et al., 2007; Andersen et al., 2013).

The Common Kingfisher (*Alcedo atthis*) has a huge range, with an estimated global extent of occurrence of 10 million square kilometers (3.8 million square miles). It is found south of latitude 60 N over much of Europe, northwestern Africa, non-arid parts of Asia, India, China, southeast Asia, the Philippines, Sulawesi, and New Guinea to Makira (San Cristobal) in the Solomon Islands. Across this vast range there is some subspecific variation but none so great as to obscure the birds' identity. This was surprisingly tracked by the molecular evidence. Moyle et al. (2007) found only a 0.2% difference in the mitochondrial ND2 gene across the range. This is consistent with a recent range expansion in this species.

Parenthetically, the scientific name for the common kingfisher derives from the Latin *alcedo*, "kingfisher" (from Greek ἀλκυών, *halcyon*) and *Atthis*, a beautiful woman of Lesbos, allegedly a favorite of Sappho. We mention the name because enterprising ornithologists have perpetrated two anagrams of *Alcedo*, namely *Lacedo* and *Dacelo*, for other genera of kingfishers.

Equally interesting from a zoogeographical point of view is *Ceyx lepidus*, commonly and accurately referred to as the Variable Dwarf Kingfisher. This species has a curious and unique distribution among birds being found in the Philippines, the Moluccas (but not the Sulawesi or Lesser Sunda districts), and New Guinea (including New Britain and Manus Island) through the Solomon Islands to Makira.

The data of Moyle et al. (2007) and Andersen et al. (2013) yielded an intermingled, paraphyletic array of the traditional genera *Alcedo* and *Ceyx* with some members of one sister to members of the other. Their data resolved four clades. The first consisted of some, but not all, members of *Alcedo*. A second clade contained *all* species possessing three toes, i.e., three-toed members of both *Ceyx* and *Alcedo*.

A third clade is comprised of *Ispidina madagascariensis* and three African members of *Alcedo*. The geographical distribution unites them, as plumage pattern, ecology, and bill color differ among the four. For this group the authors use the genus *Corythornis*. The final group includes two tiny African species of *Ispidina*, which seemingly are sister to the above, but the data are somewhat ambiguous.

The second study (Andersen et al., 2013) was devoted to clarifying the relationships within the *Ceyx lepidus* complex and details of its colonization of islands in the Philippines, Moluccas, New Guinea and the Solomon Islands. The data set included 75 individuals from 27 named taxa including the 15 diagnosed subspecies of *Ceyx lepidus*. A discussion of all the details are beyond the scope of this paper, but it is worth noting that the authors list 12 variable characters for the *Ceyx lepidus* subspecies.

In sum they propose "recognizing all 15 *C. lepidus* subspecies as species for the following reasons: (1) each subspecies is morphologically distinct; (2) these taxa exhibit a relatively uniform and high degree of genetic differentiation among lineages (2.6–6.8% in ND2…), which is higher than in the two sister taxa (*C. argentatus* and *C. flumenicolus*) that are closely related to *C. lepidus*; and (3) the 15 subspecies have allopatric distributions and, therefore, are experiencing their own evolutionary fate" (Andersen et al., 2013, p. 127).

As most of the *Ceyx* species are concentrated in the Australo-Papuan region, and *Alcedo* are in southeast Asia, a plausible hypothesis is that members of this subfamily underwent an initial radiation in that region, with later migration leading to the African species and *C. erithaca* undergoing a relatively recent range expansion westward towards India.

The molecular studies have other important implications in a creationist model. Obviously, God designed the beaks of these birds to vary according to diet, and similar adaptive changes in beak morphology have happened repeatedly within this group. Further, coloration patterns in the bill and plumage can sometimes follow a similar pattern. Traits that can vary this way are not as reliable in assessing relationships between species. We discuss further the lineage-based species concept applied by Andersen et al. (2013) below with our recommendations regarding the *Tanysiptera galatea* complex.

Subfamily Cerylinae

This is the smallest of the three subfamilies with nine species in three genera, but it is the most widely distributed, being found in North and South America,

Figure 7. Alcedininae. Small kingfishers (all *ca.* 13 cm, 5 in); considered basal, suggesting they may more closely resemble the kingfishers on the ark. Origin possibly Southeast Asia with subsequent colonization into Africa.

Ceyx—All 22 species have three toes; most inhabit the Australio-Papuan region and islands of the southwest Pacific.

The Oriental Dwarf Kingfisher *(Ceyx erithaca)* ranges from Indian subcontinent, through Southeast Asia to the islands of Indonesia

Alcedo—The seven species are piscivorous and found in the Old World.

The Common Kingfisher *(Alctedo atthis)* ranges throughout much of the Old World, including Europe, Northern Africa (mostly coastal regions), and parts of Asia. It appears this is from a recent range expansion.

Ispidina—These two insectivorous African species are weakly differentiated from the others but seem to form the basal genus of the group including *Alcedo* and *Corythornis.*

The African Pygmy Kingfisher *(Ispidina picta)* was earlier placed in *Ceyx* based on diet, but is now separate based on molecular data.

Corythornis—This genus of four species is found in Africa, including two species on Madagascar. Closely related to *Ispidina*, this genus was split off on the basis of molecular evidence.

The Malachite Kingfisher *(Corythornis cristatus)* is a common bird along watercourses of sub-Saharan Africa.

Africa, and across temperate Europe and Asia (Figure 8). Cerylines have no blue in their plumage and possess white spotting at least on the light feathers. (The Banded Kingfisher, *Lacedo pulchella*, of Halcyoninae has wing spots but much bright blue in plumage.)

It is tempting to suggest an Old World origin with one invasion into the New World, but the data preclude that. Instead, Moyle suggests two invasions of the New World as being most parsimonious. Their first clade included the members of *Megaceryle*, which invaded the New World as the Belted (*M. halcyon*) and Ringed (*M. torquata*) Kingfishers. A second clade consisted of the African and Asian Pied Kingfisher (*Ceryle rudis*), with a second New World incursion producing the four green kingfishers (*Chloroceryle*). With respect to this genus, Moyle comments (p. 494): "The two rufous-bellied species (*C. aenea* and *C. inda*) were not sister taxa, nor were the two white-bellied species (*C. amazona* and *C. americana*). Instead *C. americana* and *C. inda* were sisters, and *C. aenea* and *C. amazona* branched off successively deeper in the clade." It is not possible to suggest whether the Old-to-New World colonization was via a Bering land bridge or one in the North Atlantic.

Again, Moyle's work has creationary implications beyond just post-Flood dispersion; it clearly implies that God designed these birds with the ability to vary in plumage coloration, and similar changes sometimes have happened in several lineages. This is consistent with the patterns of variation in mammals (e.g., Lightner, 2008, 2009, 2010), although the underlying genetic basis has not been elucidated in these birds.

Subfamily Halcyoninae

This group is the largest and most diverse group of kingfishers (Figure 9). It also exhibits its greatest extent of adaptive radiation in the Australo-Papuan region. By far the most species occur within a complex of two genera, *Halcyon* and *Todiramphus*. In the Gill and Donsker (2016) list, the two account for 31 species, or nearly 30% of all kingfishers.

Sibley and Ahlquist (1990, p. 845, see fig. 360) recovered the paraphyly within *Halcyon*, with *H. senegalensis* and *H. sancta* separated by *Tanysiptera* and *Melidora*. Although they had material from many more genera of kingfishers, time prohibited them from investigating this problem further. It was the work of Moyle (2006) and Andersen et al. (2015) that unequivocally broke apart the former large genus *Halcyon* into two genera with mainly the African and some Asian forms remaining in *Halcyon*, and *Todiramphus* containing a large number of forms extending from Borneo and the Philippines to the Marquesas islands in the east and Mariana Islands to the north.

In today's scientific writing, the word "elegant" is overused to the point of banality, but if any avian study merits that appellation, it is that of Andersen et al. (2015). In many ways this paralleled their previous study of *Ceyx* (Andersen et al., 2013) in its thoroughness. The authors assembled 155 samples from *Todiramphus* of which 93 were from *T. chloris* and 63 were from other *Todiramphus* species. They lacked only six species from islands that were difficult to collect. It is significant that the authors themselves are field ornithologists as well as competent laboratory workers.

The entire story is too complex to be detailed here, but several key points deserve mention.

(1) The colonization and differentiation of *Todiramphus* occurred extremely rapidly and recently. The situation, while not unique, is the most rapid thus far discovered in birds. Parallel situations have been observed in other species such as the Red-bellied Pitta (*Pitta erythrogaster*) throughout the Philippines, fruit doves (*Alopecoenas*), reed warblers (*Acrocephalus*), whistlers (*Pachycephala*), white-eyes (*Zosterops*), and *Ceyx* kingfishers (see this paper), all involving islands of the southwest Pacific.

(2) This rapid differentiation is shown in the molecular data by short internal distances followed by relatively longer terminal branches. In other words, once a propagule reached a new island, it stayed there and exhibited an independent history.

(3) The authors found several instances of secondary sympatry; that is, instances of two separate invasions of a single island followed by subsequent differentiation in size, coloration, and feeding habits. Such character displacement is a common phenomenon. Evolutionists generally explain it as the result of natural selection from competition for resources. From a biblical creation perspective, there are probably other mechanisms involved; it happens regularly enough it appears design is involved.

(4) *Todiramphus sancta*, one species within this complex, is highly migratory, whereas others are not, with the exception of some *T. chloris*. The scenario strongly suggests that the properties of migratory *vs.* non-migratory (vagile *vs.* sedentary) behavior can be rapidly gained as well as lost. This goes far toward explaining the expansion of *Todiramphus* over such a broad area in such a short period of time, followed by the far less fluid situation that we see at present. It is also quite consistent with the biblical concept that God designed creatures to reproduce and fill the earth, and provided the means for them to settle down once that was largely accomplished.

(5) Taxonomically, the traditional *T. chloris* was found to be paraphyletic. Depending on the criteria used, the authors uncovered 11 to 26 separate species. They were unable to examine 28 of the nominal subspecies (i.e., those described in earlier literature) of *T. chloris*, which allows for the possibility that there are even more.

Figure 8. Subfamily Cerylinae. This group is the smallest of kingfishers with only three genera and nine species but is distributed in both the Old and New Worlds. Members range from small to large, lack bright colors, and have some to many white spots on the wings and/or tail. An African origin is likely with two probable colonizations to the new World.

Genus *Megaceryle*—Four species, one in Africa, one in Asia and two in the New World. The Belted Kingfisher *(Megaceryle alcyon)* of the U.S. is familiar. Medium (28 cm, 11 in) to large size (45 cm, 18 in)

Pictured: Crested Kingfisher *(M. lugubris)*. This species lives in East Asia and Japan, inhabiting fast-moving mountain streams and remaining at the highest altitudes even during winter.

Genus *Ceryle*—One species Africa to India; the only all black and white kingfisher, distinctive on morphological and molecular grounds.

Pictured: Pied Kingfisher *(Ceryle rudis)*. This species is common, noisy, and gregarious over much of its range. It is one of the few kingfishers to employ "helpers at the nest." These are males from a previous brood (primary) or non-mated unrelated birds

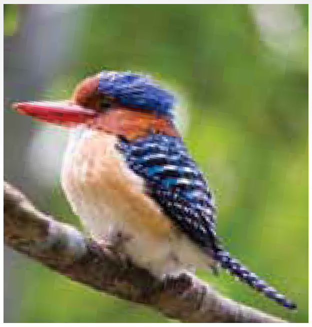
Genus *Chloroceryle*—Four species of similar green and rufous color, small to medium sized (13 cm, 5 in–30 cm, 12 in). Occur in Central and South America mainly along rivers and lakes bordered by lush vegetation. In some areas all four can be found together segregated ecologically by size.

Pictured: Green Kingfisher *(C. americana*, 20 cm, 8 in) found from extreme southern Texas through tropical Americas.

Figure 9. Subfamily Halcyoninae. Sixty-one species split into two groups, one Asian and African including *Lacedo*, *Pelargopsis*, and *Halcyon*. The Asian group includes at least nine genera occurring principally from Southeast Asia, through Australo-Papua, and to many southwestern Pacific islands. The formerly large genus *Halcyon* was split by molecular evidence into two: *Halcyon* (11 species) and *Todiramphus* (21). The latter has speciated widely and given rise to an adaptive radiation in New Guinea and Australia (see Figure 10).

Genus *Lacedo* (monotypic)

Pictured: Banded Kingfisher (*L. pulchella*); widespread in Southeast Asia and Greater Sunda Island. This species is possibly sister to the Afro-Asian *Halcyon* group.



Genus *Halcyon*—Eleven species, Africa to Southeast Asia.

Pictured: Brown-hooded Kingfisher (*H. albiventris*). Southern Africa; this species typical of the genus in open woodland.

Genus *Pelargopsis*—Stork-billed kingfishers, 3 species in Southeast Asia.

Pictured: Brown-winged Kingfisher (*P. amauroptera*), coasts of Bay of Bengal. The oversized bill likely designed for feeding on crabs.

Genus *Actenoides*—Seven species; Southeast Asia, Philippines, Sulawesi, Bougainville, and Guadalcanal. Possibly basal to the *Todiramphus* complex.

Pictured: Green-backed Kingfisher (*A. monachus*), Sulawesi. Turquoise and orange color distinctive.

Genus *Todiramphus*—Twenty-one species, Southeast Asia through Australo-Papua, but most on islands of southwestern Pacific.

Pictured: Collared Kingfisher (*T. chloris*), common and conspicuous; one of the "great colonizer" species on islands.

Genus *Cittura* (monotypic).

Pictured: Lilac Kingfisher (*C. cyanotis*) of lowland forests of northern Sulawesi. May be a sister taxon to *Tanysiptera*.

Figure 10. Adaptive radiation of kingfishers in New Guinea and Australia. This group of around 18 species in five genera seems to have split from Todiramphus and occupies montane forests to open country, embracing several niches.

Genus *Tanysiptera*—Paradise kingfishers (at least 10 species); see text for details.

Pictured: Buff-breasted Paradise Kingfisher *(T. sylvia)*. Southern New Guinea and northern Queensland.

Genus *Syma*—Mountain kingfishers. Two species in New Guinea, replace each other altitudinally.

Pictured: Yellowbilled Kingfisher *(S. torotoro)*.

Genus *Melidora* (monotypic)

Pictured: Hook-billed Kingfisher *(M. macrorrhina)*. Mountain forests of New Guinea; crepuscular and nocturnal; feeds on ground in leaf litter.

Genus *Clytoceyx* (monotypic).

Pictured: Shovel-billed Kookaburra *(C. rex)*. Mountain forests of New Guinea. Uses trowel-shaped bill to excavate soil for earthworms, etc.

Genus *Dacelo*—Kookaburras (four species in New Guinea and Australia.

Pictured: Rufous-bellied Kookaburra *(D. gaudichaud)*. Common and widespread in lowland forests of New Guinea; compare to Clytoceyx above.

Genus *Dacelo*—Kookaburras.

Pictured: Laughing Kookaburra *(D. novaeguineae)*. As symbolic of Australia as kangaroos. Inhabits open country where it feeds on snakes, lizards, large insects.

The Genus *Tanysiptera*

As far as we are aware, no complete revision of the genus *Tanysiptera* has been made, nor has a molecular assessment been attempted. Thus, we present the following detailed discussion of what is known of the geographic variation in the genus and an assessment of the problem.

The Common Paradise Kingfisher (*Tanysiptera galatea*) lives up to its name. It is a woodland kingfisher and is almost a dooryard bird in New Guinea. Ahlquist saw his first one in 1969 in the backyard of a colleague in Boroko, a suburb of Port Moresby. It fills the "wait and capture" niche of a flycatcher, such as the Eastern Phoebe or the Great Crested Flycatcher in the U.S. and flycatchers elsewhere in the Old World.

Potentially complicating the matter, and not studied by either Mayr (1954) or Beehler and Platt (2016), are forms of *Tanysiptera galatea* in Wallacea (Indonesia), extralimital to New Guinea. They are listed in the contemporary works on that region; i.e., White and Bruce (1986), Fry et al. (1992), and Coates et al. (1997). These authors do not consider any of the forms to be allospecies, nor do they address the question of founder effects. We include them here (1) for the sake of completeness; (2) because they are differentiable to a birdwatcher and not only a museum worker armed with a pair of calipers; and (3) they could form the basis for a comprehensive treatment of the *Tanysiptera galatea* group. (Tables 1 and 2.) Although these forms have been known for some time and their taxonomic recognition is not in dispute, they have not received the attention of the New Guinea forms simply because the Moluccas and associated islands have not been investigated as thoroughly.

Of this Wallacean assemblage, White and Bruce (1986, p. 272) comment:

> The extensive polytypic variation in N Moluccas is rather remarkable. The birds of New Guinea and the W Papuan Islands exhibit very little variation, but with allospecies in Biak, Numfor, and Kofiau. The S Moluccan populations also vary only slightly. This species is particularly prone to pronounced variation in small island populations.

It is probably not wise, on the basis of incomplete plumage information, to attempt to reconstruct the history of these 10 forms, except to note that a likely route of colonization from New Guinea was through Halmahera, the largest island in the Moluccas (Figures 6 and 10). Halmahera is less than 100 miles from the westernmost population of the nominate *Tanysiptera galatea galatea* on Waigeo Island, which has an irregular shape of 17,780 square kilometers (6860 square miles), a maximum altitude of 1635 meters (5464 feet), and possesses a wide range of habitats. The allospecies on Kofiau Island (*T. ellioti*) is even closer geographically. Those subspecies inhabiting islands close to Halmahera could well have colonized from there. They include *T. g. doris* (Morotai), *T. g. emiliae* (Rau), *T. g. brunhildae* (Doi), *T. g. sabrina* (Kayoa), and *T. g. margarethae* (Bacan).

The next closest large island is Seram (17,100 square kilometers, or 6,600 square miles; altitude 3027 meters, or 9731 feet), and it is only slightly more distant from the Bomberai peninsula ("Bird's Neck") of New Guinea. Misool Island, about half-way between the Vogelkop ("Bird's Head") of New Guinea and Seram has no populations of *Tanysiptera*. Three subspecies are associated with these islands: *T. g. nais* (Seram and others), *T. g. acis* (Buru), and *T. g. boanensis* (Boano). The origin of the subspecies on Obi (*T. g. obienis*) is somewhat equivocal, in our opinion, but its plumage pattern is said to be most like that of *T. g. nais* of Seram.

Defining species

Whether we are discussing the above example or the situations prevalent in the *Todiramphus* or *Ceyx lepidus* complexes, we are faced with the problem of defining a species. Many of the constituent populations are isolated on islands, thus reliance on the traditional biological species concept (BSC) places one in a conundrum. The core idea in the biological species concept is reproductive isolation, i.e., two separate species cannot interbreed and produce fertile offspring. With insular, allopatric forms there is no way to test the BSC in a natural setting.

Strict reliance on the BSC forces one to be arbitrary in species decisions. It comes down to a matter of taxonomic preference: one is either a "lumper" (considering the allopatric forms as subspecies of a mainland species) or a "splitter" (recognizing the insular populations as distinct allospecies).

The fact is that a "species" is an idea originating with man, not God; hence all species concepts are subjective to a degree, and the definition that one uses is determined to an extent by a given problem at hand and the data bearing upon it. Since considerable diversification has occurred within created kinds, it is necessary for creationists, like everyone else, to use the concept of species. It is also worth considering how species could be best understood within a biblical creation model.

In writing of the problem with respect to the *Ceyx* kingfishers, Anderson et al. (2013, p. 126) observe:

> We draw upon the details of genetic divergence, biogeography, and plumage pattern as the most prescient evidence. Application of the lineage-based species concepts to island systems is preferable to the biological species concept (Mayr 1963) because reproductive isolation between allopatric insular taxa cannot be assessed. Instead, we employ a lineage-based species concept to recognize ancestor-descendant populations with unique evolutionary histories.

The lineage-based species concept was developed by de Queiroz (1998,

1999) and further expanded by de Queiroz as the metapopulation lineage concept of species. De Queiroz (2005, pp. 6604–6605) elaborates:

> The proposal has two components. First, it retains the element common to all contemporary concepts and definitions of species by adopting the general concept of species as separately evolving metapopulation lineages. Second, it eliminates the conflicts among rival concepts by treating this property, existence as a separately evolving metapopulation lineage, as the only necessary property of species. In other words, all of the other properties that have previously been treated as necessary properties of species, which created incompatibilities among alternative species concepts, are reinterpreted as no longer being defining properties of the species category. Instead, they are interpreted as contingent properties not only of metapopulation lineages but also of species, properties that species as metapopulation lineages may or may not acquire during the course of their existence. In other words, metapopulation lineages do not have to be phenetically distinguishable, or diagnosable, or monophyletic, or reproductively isolated, or ecologically divergent, to be species. They only have to be evolving separately from other such lineages. Because the interpretation of various secondary properties of lineages as necessary properties of species is the cause of the incompatibilities among alternative species concepts, their reinterpretation as contingent rather than necessary properties also removes the incompatibilities. The result is a single, general, unified concept of species.

As it turns out, species often do not have clear boundaries. Interspecific hybridization occurs quite frequently, especially in plants. There are various species concepts that have been proposed to include this complication regarding gene flow and introgression. The lineage concept attempts to do this by classifying species by their phylogenetic lineages, allowing for the possibility of limited gene flow from one lineage to another.

Apart from the insular species, what else can we suggest regarding differentiation in *Tanysiptera*? It has already been

Table 1. Mayr's species of the *Tanysiptera galatea-hydrocharis* complex of Papuan paradise kingfishers. Data from Fry et al. (1992, pp. 114–115 and Plates 3 and 4, pp. 31–33); Pratt and Beehler (2015, pp. 385–388, and Plate 59, pp. 156–157); Beehler and Pratt (2016, pp. 222–224).

Name	Head	Back	Wing	Under-parts	Tail	Range
Common Paradise-Kingfisher ***Tanysiptera galatea***	Pale blue crown contrasts with dark blue head	Solid dark blue like cheeks and head	Pale blue coverts contrast with dark blue wing	White	Tail with long white streamers; mainly white with blue outer edges; white spatulate tip	Widespread in lowland New Guinea forest
Little P-K. ***T. hydrocharis***	Dark blue, little contrast with crown	Dark blue, like head	Coverts dark, not contrasting with rest of wing	White	Tail shorter; outer tail feathers dark blue with white spatulate tips	Local in riverine forest of s. New Guinea; Aru I. (?)
Rossel P-K. ***T. rosseliana***	Blue crown contrasts less with paler blue head	Paler blue than *T. galatea*	Uniform blue, paler than *T. galatea*	White	Tail base broad, all white; spatulate tips prominent	Rossel I. only
Kofiau P-K. ***T. elliotti***	Pale blue crown contrasts with dark blue head	Dark blue, like head	Pale blue coverts contrast with dark blue wing	White	Tail shorter with broader streamers, less prominent spatulae	Kofiau I. only
Biak P-K. ***T. riedelii***	Entire head pale blue with darker scallops and streaks	Pale blue of head extends partway down back	Strong contrast of pale blue coverts with rest of wing	White	Mainly white, edged pale blue; shafts of central pair of streamers blue with white spatula	Biak I. only
Numfor P-K. ***T. carolinae***	Uniform dark blue	Dark blue	Dark blue	Solid dark blue	Tail white with strongly spatulate tip	Numfor I. only

noted that the subspecies of *T. galatea* are poorly differentiated over its wide range in New Guinea. The separation of *T. hydrocharis* from *galatea* seems well understood as a case of classic speciation via a barrier. Mayr (1963, p. 503) has explained it thus:

> During the Pleistocene the species *T. hydrocharis* was isolated on an island that ran from the Aru Islands to the mouth of the Fly River and was separated from the mainland form *galatea* by a branch of the ocean. When this strait was filled by alluvial debris from the mountains of New

Table 2. Moluccan subspecies of Common Paradise-Kingfisher (*Tanysiptera galatea*). Descriptions from Fry et al., (1992, pp. 114–115) and White and Bruce (1986, pp. 271–272). Illustrations: *T. g. nais*, *T. g. sabrina*, and *T. g. emeliae* from Fry et al. (1992, Plate 3, p. 31); *T. g. nais*, *T. g., acts*, *T. g. obiensis*, *T. g. margarethae*, *T. g. emiliae*, and *T. g. sabrina* from Woodall (2001, Plate 9, p. 192). Other material consulted: videos and photographs from www.hbw.com.

Name	Head	Back	Wing	Under-parts	Tail	Range
Tanysiptera galatea nais	Front and center of crown bluish-violet; eyebrow paler, silvery green-azure	Black, anteriorly violet with some cobalt spotting	Wing coverts of same silvery blue as eyebrow; dark blue wing	White	Mainly white with pale blue edges; streamers white with blue shafts	Ambon, Manipa, Seram, Seram Laut (Manawoka, Gorong)
T. g. acis	Crown darker; less contrast with head	Black; some blue streaks on rump	Coverts darker; less contras with wing	White	Tail and steamers blue, edged white	Buru I. (west of Seram)
T. g. boanensis	Entire crown greenish-azure, contrasting with dark blue head	Black with violet-blue wash	Azure-blue coverts contrasting with rest of wing	White	Mainly white with pale blue edges; streamers white with blue shafts	Boano I. (northwest of Seram)
T. g. obiensis	Crown cobalt blue, nearly as dark as head	Black with violet blue wash; blue streaks on rump	Coverts nearly as dark as rest of wing	White	Streamers long, blue with white spatulae	Obi I. (between Halmahera and Seram)
T. g. margarethae	Crown dark blue; pale only on eyebrow	Dark blue; rump feathers white with broad blue edges	Coverts darker; much less contrast with wing	White	Mainly blue, with spatulae white	Bacan I. (southwest of Halmahera)
T. g. browningi	Light blue crown with head dark blue	Bluish-black	Light blue coverts much reduced; wing dark.	White	With with blue outer webs; streamers blue with white spatulae	Halmahera I.
T. g. sabrina	Entire crown ultramarine with no cobalt border	White patch in middle of upper back	Light blue coverts reduced; less contrast with wing	White	Entirely white; streamers white with dark blue blue shafts	Kayoa I. (west of Halmahera)
T. g. brunhildae	Crown dark blue; pale only on eyebrow	Dark blue; rump feathers white with blue edges	Coverts show much less contrast with wing	White	Entirely white; streamers white with dark blue blue shafts	Palau Doi (northwest of Halmahera)
T. g. doris	Pale blue crown with dark blue head	Upper back white	Light blue coverts; dark wing	White	White edged with blue	Morotai I (large island north of Halmahera)
T. g. emiliae	Crown silvery blue, prominently crested; light blue ear patch	Upper back white	strong contrast between coverts and wing	White	White with blue edges; streamers reduced and narrow	Rau I. (west of Morotai)

> Guinea, dry land joined the island with the mainland of New Guinea, and *galatea* was enabled to invade the range of *hydocharis*, where the two species live side by side without interbreeding or without obvious ecological competition.

Our understanding of the buff-bellied species of *Tanysiptera* is less obvious. The implication is that the underpart coloration renders them as a separate group, but this has not been clearly demonstrated. Two of the species, the Red-breasted PK (*T. nympha*) and Brown-headed PK (*T. danae*) are endemic to New Guinea and seem to replace each other geographically. *Tanysiptera danae* is widespread in the foothills of peninsular southeast New Guinea and occurs above the range of the Common PK (*T. galatea*). *Tanysiptera nympha* also occurs in the hill forest at higher altitudes than the Common PK, but significantly to the west of *T. danae*. Pratt and Beehler (2015, p. 387) give its range as "patchily distributed in Bird's Head and Neck [i.e., Vogelkop], Sepik-Ramu, Adelbert Mts., Huon, and northwestern SE Pen (Upper Watut, Wau, and Waria R), 500–900m."

A third species, the Buff-breasted PK (*T. sylvia*) breeds in both New Guinea and Australia. The Australian subspecies (*T. s. sylvia*) breeds in lowland forests of Queensland from north of Brisbane to Cape York. Uniquely for the genus, it migrates north in the Austral winter and is widespread in both southern and northern Papua New Guinea. The New Guinea race (*T. s. salvadoriana*), which can be distinguished in the field from the Australian migrants, breeds in a fairly limited area around Port Moresby in southeastern Papua New Guinea, where it is a year-round resident.

Coates and Peckover (2001) and Beehler and Pratt (2016) treat as a full species the Black-headed PK (*T. nigriceps*). This species is "endemic to New Britain, Umboi I, Lolobau I, Watom I, and Duke of York I. Lowlands to *c.* 1500m." (Coates and Peckover, 2001, p. 110.) The Black-headed PK shares with the Buff-breasted PK a *white upper back*. Thus, it is probable that it descended from the migratory Buff-breasted PK which moved to the Bismarcks, found an unoccupied niche, stayed to breed, and became sedentary.

If the buff-breasted species of *Tanysiptera* form a cohesive group, it is possible to generalize that they are representatives that occupy a higher altitudinal distribution than the white-breasted species.

It is interesting to note that the *white upper back* also occurs in three of the *T. galatea* group in the Moluccas, namely, *T. doris* (Morotai I.), *T. emiliae* (Rau I.), *T. sabrina* (Kayoa I.). The islands are all located west or north of Halmahera. Is this significant? It is possible, but unlikely, that the migratory *T. sylvia* colonized these islands and gave rise to the three species. It is improbable due to the distance involved and the fact that the buff-colored underparts would have to be secondarily lost. A more reasonable explanation is that the white upper-back color in *T. doris*, *T. emiliae*, *T. sabrina* is the result of an expression for that trait already present in the genes of *T. galatea* but simply masked. Thus, the occurrence of the three white-backed Moluccan species may indicate their close affinity and their descent from a single colonization by *T. galatea*.

These possibilities cannot be answered by present data but would be easily solved by a molecular study of the 26 species and subspecies of the *Tanysiptera* complex.

The remaining Halcyoninae

Without following the cladograms of Moyle (2006) slavishly, it is possible to reconstruct some of the adaptive radiation of kingfishers in New Guinea and Australia.

*Lacedo pulchell*a lies at the base of the radiation of a *Halcyon-Pelargopsis* group. There is nothing immediately in its characters that give much insight into its somewhat isolated position. The *Todiramphus* complex is one of two clades sister to *Halcyon*. At the base of this clade is *Actenoides*, a widely ranging genus of six species occurring in the Malay peninsula, Borneo, Sulawesi, and the Philippines, but not in Australia or New Guinea. Curiously it has a representative, the Moustached Kingfisher (*A. bougainvillei*) on Bougainville and Guadalcanal in the Solomons. Is this species (or two) related to the others? The species has been collected (Filardi, 2015), with samples saved for molecular analysis. Perhaps an answer will be forthcoming.

The genus *Syma* is sister to the *Todiramphus* complex. The two species, sometimes subsumed into *Halcyon* (Rand and Gilliard, 1967), are distinguished by a serrated mandibular tomium (cutting edge of the bill). *Syma* represents a movement into the mid-mountain environment of New Guinea. The two species replace each other altitudinally. *S. torotoro* ranges up to 1,200 m; *S. megarhyncha* ranges up to 2,200 m with some overlap around 900–1,000 m.

Tanysiptera is rooted basally with *Cittura cyanotis* on the second side of the clade. *Cittura* is endemic to Sulawesi. There is not much morphological evidence to support or deny this relationship.

The remaining genera—*Melidora*, *Clytoceyx*, and *Dacelo*—provide an interesting hypothesis of adaptive radiation. The Hook-billed Kingfisher (*Melidora*) and Shovel-billed Kookaburra (*Clytoceyx*) are adaptive modifications to the basic kingfisher design. As its name suggests, the Hook-billed Kingfisher possesses a flattened bill with a strong hook at the top. It is found in mid-mountain forests of New Guinea, where it feeds mainly on the ground, digging in the leaf litter for worms and other invertebrates. It is crepuscular and nocturnal. In *Clytoceyx* the bill is broadly flattened into a shovel that the bird uses to dig into mud for prey. The birds are quite aggressive in this behavior, exposing several centimeters of art over an area of several square meters. Quite often captured birds have damp mud caked on their bills.

Digging may seem bizarre behavior for a kingfisher, but it is interesting that the Shovel-bill shares a rusty ventral color pattern with its nearest relative among the kookaburras, the Rufous-bellied (*Dacelo gaudichaud*). *D. gaudichaud* is the only true kookaburra that is a forest-dweller. The remaining kookaburras (*D. leachii*, *D. tyro*, and *D. novaeguineae*) all inhabit the drier savannah country of southern New Guinea and Australia (Woodall, 2001).

Perhaps the most extreme adaptation to arid conditions is found in the Red-backed Kingfisher (*Todiramphus pyrrhopygius*), which lives in extremely dry, inhospitable areas in interior Australia. It is said to breed opportunistically when rains occur.

Conclusions and Perspectives

The evidence examined here suggests that the level of the kind in kingfishers is at the family: Alcedinidae. It also suggests that soon after the Flood three distinct lineages arose within this kind, which are represented today by the three recognized subfamilies (Alcedininae, Cerylinae, Halcyoninae). Some components of their migration and adaptive radiation can be discerned from available data, including two invasions of the New World by members of Cerylinae and apparent southeast Asian radiations in *Ceyx* (Alcedininae), *Todiramphus* (Halcyoninae), and other Halcyoninae.

The pattern of geographic dispersal and differentiation that we have presented for the kingfishers may seem to be conclusive, yet that is far from the case. Many details remain to be addressed. For example, the Moyle-Andersen group addressed the colonization of *Todiramphus* complex in the broad area of the southwest Pacific but did not examine in detail the genus *Halcyon* (*sensu stricto*), which ranges west from Wallace's Line to the Red Sea to Africa. Since the Sibley and Ahlquist data place African *Halcyon* at the base of the Halcyoninae, a biblical origin is suggested with a movement into Australo-Papua and beyond. The secular scenario would do the reverse, having the principal radiation in Australo-Papua with subsequent colonization westward across Wallace's Line. Such details point to the fact that any study is far from complete.

The most obvious need is a study of the 28 forms in the paradise kingfisher (*Tanysiptera*) complex. Both fieldwork and molecular evaluation are necessary components. A molecular study could show:

(1) how much genetic differentiation has occurred,
(2) the relationship between genetic variation and phenotypic variation,
(3) probable routes of colonization,
(4) the possibility of multiple colonizations. Did one founder population reach one of the larger islands first (e.g., Seram or Halmahera) and then subsequently colonize the small islands close to the large ones?

Additionally, there is a need for creationists to develop new statistical tools. For example, current methods to detect the founder effect fail to recognize the possibility that founders may select new habitats based on already possessing alleles adaptively matched to the environment. In some instances, such as where there are great distances between islands, carrying in adaptive alleles may be less common, but it nevertheless needs to be considered. Further, methods need to be developed to distinguish created heterozygosity from new alleles that have arisen via mutation.

This is an opportune time for creation research to advance beyond its infancy and make valuable contributions to our understanding of the natural world. As we do so, we can address questions from a biblical perspective showing that the diversification and speciation we observed within created kinds is a result of a loving and wise Creator who designed his creatures to reproduce and fill the earth.

Acknowledgments

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Photo Credits

Figure 7
Ceyx erithaca Oriental Dwarf Kingfisher
Photo by Raj Dhage
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Alcedo atthis Common Kingfisher
Photo by Ravi Vaidyanathan
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Ispidina picta African Pygmy Kingfisher
Photo by Lip Kee
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Corythornis cristatus Malachite Kingfisher
Photo by Charles J. Sharp, Sharp Photography, sharpphotography
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Figure 8
Megaceryle lugubris Crested Kingfisher
Photo by Tokumi
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Ceryle rudis Pied Kingfisher
Photo by Selvaganesh17
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Chloroceryle americana Green Kingfisher
Photo by Charles J. Sharp
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Figure 9
Lacedo pulchella
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Pelargopsis amauroptera

Photo by AjitK332
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Todiramphus chloris Collared Kingfisher
Photo by JJ Harrison (jjharrison89@facebook.com)
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Halcyon albiventris Brown-hooded Kingfisher
Photo by Derek Keats
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Actenoides monachus Green-backed Kingfisher
Photo by Ariefrahman
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Cittura cyanotis Lilac Kingfisher
Photo by A. S. Kono
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Figure 10
Tanysiptera sylvia Buff-breasted PK
Photo by Jim Bendon
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Melidora macrorrhina Hook-billed Kingfisher
Photo by William S. Peckover. Courtesy JA private collection.
Dacelo gaudichaud Rufous-bellied Kookaburra
Photo by Greg Miles
Creative Commons Attribution-Share Alike 2.0 Generic license.
Syma torotoro Yellow-billed Kingfisher
Photo by William S. Peckover. Courtesy JA private collection.
Clytoceyx rex Shovel-billed Kookaburra
Photo by markaharper1
Creative Commons Attribution-Share Alike 2.0 Generic license.
Dacelo novaeguineae Laughing Kookaburra
Photo by JJ Harrison (jjharrison89@facebook.com)
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