

SUPPORTING INFORMATION

Binary matrices and checkerboard distributions of birds in the Bismarck Archipelago

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Appendix S1 Congeneric checkerboards of birds in the Bismarcks and possible explanations.

1. *Accipiter*

All five checkerboards in the genus *Accipiter* include *A. rufitorques*, widespread in the Solomons but found in the Bismarcks only on Feni (New Ireland group), the easternmost outlier nearest the Solomons (Mayr & Diamond, 2001). *Accipiter gentilis* is found only on New Britain and Umboi in the New Britain group [although Mayr & Diamond (2001) suggest that further exploration may show it to be on New Ireland]. *Accipiter luteschistaceus*, a sedentary species loath to cross water (Mayr & Diamond, 2001), is found on the same two islands in the New Britain group as *A. gentilis*, though again Mayr & Diamond (2001) raise the possibility that further exploration will show it to be on New Ireland. *Accipiter poliocephalus* is restricted to New Britain. *Accipiter cirrhocephalus* is only on New Britain and New Ireland, and none of the New Ireland outliers. Thus, though *A. rufitorques* and *A. cirrhocephalus* are both in the New Ireland group, their ranges are disjunct by 50 km. Additionally, for the above four pairs, with one species on just one island and the other on one or two, the null probability of a checkerboard even if

species did not affect one another is high. For *A. novaehollandiae*, a strong disperser (Mayr & Diamond, 2001) on 15 islands including New Ireland outliers, there is no plausible historical geographic explanation for the checkerboard with *A. rufitorques*, but the null probability of a checkerboard by a two-species balls-in-boxes model even without an interaction is 0.52.

2. *Ducula*

Similarly, all four checkerboards in the genus *Ducula* include the supertramp *D. pacifica*, found only on five small islands in the St. Matthias and Northwest groups. Three of the four species with which it forms checkerboards (*D. myristicivora*, *D. rufigaster*, and *D. pinon*) are not found in these island groups. As most colonization of the Bismarcks appears to have proceeded from New Guinea through the island chain towards the St. Matthias and Northwest groups, which are colonized last (Mayr & Diamond, 2001), it is not inconceivable that these three species simply have not reached these islands yet. Holyoak & Thibault (1978) argue that *D. pacifica* is restricted to small islands because these lack predatory hawks; in the Bismarcks, *D. pacifica* occupies no islands that contain an *Accipiter* hawk. The fourth checkerboard is between *D. pacifica* and *D. bicolor*, which is found in the Northwest group, but on Manus and Nauna, 160 km east of the islands occupied by *D. pacifica*. When *D. pacifica* is excluded from the analysis, the checkerboard score for this genus is not significant ($P = 1.0$). The key to understanding the *Ducula* checkerboards in the Bismarcks therefore may lie in historical biogeography plus determining what restricts *D. pacifica* to small or remote islands.

3. *Myzomela*

Of the 10 checkerboards in the genus *Myzomela*, four include *M. pulchella*, a sedentary, non-water-crossing species restricted to mountains of New Ireland (Mayr & Diamond, 2001). Three of these checkerboards consist of *M. pulchella* plus species found only in the New Britain group (*M. eques*, *M. cardinalis*, and *M. sclateri*). At least for *M. cardinalis* it is plausible that historical geography explains the checkerboard, as this species is unusual in having invaded the Bismarcks from the east and may not have had time to spread further within the archipelago (Mayr & Diamond, 2001). Although *M. sclateri* is highly vagile (a supertramp by the classification of Diamond, 1975), for the checkerboards between *M. pulchella* and both *M. eques* and *M. sclateri*, it is possible that *M. pulchella* has not yet had time to reach New Britain. It is also noteworthy that *M. pulchella*, *M. cardinalis*, and *M. eques* occur on no more than two islands each, yielding a high null probability that each pair of them would form a checkerboard. The fourth checkerboard of *M. pulchella* is with the supertramp *M. lafargei*, which occurs on many islands in the St. Matthias and Northwest island groups, on several small, volcanically disturbed islands west of New Britain, and on Tingwon, the westernmost island in the New Ireland group. No other *Myzomela* occurs in the St. Matthias or Northwest island group, and *M. lafargei* is involved in three other of the 10 *Myzomela* checkerboards. When *M. lafargei* and *M. sclateri* are excluded from the analysis, *Myzomela* no longer exhibits a significantly high number of checkerboards ($P = 0.812$). In sum, the large number of *Myzomela* checkerboards is largely driven by the presence of two supertramps on small, remote islands, the fact that many species occupy very few islands, and the

existence of largely allopatric ranges that may reflect barriers to dispersal between island groups.

4. *Rhipidura*

The two checkerboards in the genus *Rhipidura* each include *R. rufifrons*, a species restricted to two islands in the Northwest group. Neither of the other species in the checkerboards (*R. leucophrys* and *R. rufidorsa*) is found in the Northwest group – the species are regionally allopatric. As the Northwest group is believed, for most species, to be the last colonized in the archipelago (Mayr & Diamond, 2001), it is possible that the latter two species simply have not reached the Northwest islands yet.

5. *Tyto*

The checkerboard formed by the two species of *Tyto* may also reflect history. *Tyto novaehollandiae*, a highly sedentary species not seen crossing water (Mayr & Diamond, 2001), is found only on New Britain and Manus (in the Northwest group). This distribution is hypothesized to reflect independent colonizations from New Guinea, and the species is believed to have disappeared from other islands in the New Britain group because they are now too small (Mayr & Diamond, 2001). *Tyto alba*, by contrast, is believed to have recently colonized Long (volcanically defaunated in the 17th century, but geographically in the New Britain group) from New Guinea and Tanga (a small island east of New Ireland and adjacent to the Solomon Islands) from the Solomons (Mayr & Diamond, 2001).

6. *Pachycephala*

The Bismarcks harbour two morphologically and ecologically similar species of *Pachycephala*: *P. pectoralis*, on 11 islands in all four groups, and *P. melanura*, on four islands in the New Ireland and New Britain groups plus two recently volcanically defaunated islands west of New Britain. Diamond (1975; Mayr & Diamond, 2001) attributed their checkerboard distribution to interspecific competition. Diamond (1975) considers *P. melanura* a supertramp in the Bismarcks, but by our test, it does not qualify. However, off the coast of New Guinea west of the Bismarcks, *P. pectoralis* is absent, yet *P. melanura* continues to occupy predominantly small islets. Similarly, in the Solomon Archipelago, *P. pectoralis* continues to occupy larger islands and *P. melanura* smaller ones (Simberloff & Collins, 2010). Lomolino (1999) has also pointed to possible habitat differences between these two species, and Mayr & Diamond (2001) suggest that these different habitat preferences could have evolved, for whatever reason, before colonization of the Bismarcks. Without additional data, there is insufficient evidence to attribute the exclusive distribution of *P. pectoralis* and *P. melanura* to competitive exclusion.

7. *Macropygia*

Macropygia mackinlayi and *M. nigrirostris* are morphologically and ecologically similar daughter species of a recent, largely allopatric speciation and overlap only in the Bismarck Archipelago (Mayr & Diamond, 2001), where they exhibit a checkerboard distribution. *M. nigrirostris* occurs on five islands in the New Britain and New Ireland island groups and *M. mackinlayi* occupies 15 islands mostly spread across the north and west. Diamond (1975) considers *M. mackinlayi* a supertramp in the Bismarcks, but it

does not qualify statistically. Diamond (1975; Mayr & Diamond, 2001) argues that *M. nigrirostris* competitively excludes *M. mackinlayi* from larger islands. While competitive exclusion is a possible explanation, the pattern may also be influenced, at least in part, by their recent, largely allopatric speciation and the fact that *M. nigrirostris* is the younger invader and may not have had time to reach other islands (Mayr & Diamond, 2001). Mayr & Diamond (2001) also note that, in regions off the New Guinea coast where *M. nigrirostris* is alone, it still eschews small islands, and they suggest this indicates that habitat differences may have arisen even before these species achieved regional sympatry. Lomolino (1999) also notes this habitat difference.

8. *Zosterops*

Two relatively uncommon species represent *Zosterops* in the Bismarcks, *Z. atriceps* and *Z. griseotinctus*. They form a checkerboard, with *Z. atriceps* on six islands (all but one of them large; the sixth is immediately off the coast of New Britain) and *Z. griseotinctus* on four islands that are small, volcanically disturbed, or both. Diamond (1975) termed *Z. griseotinctus* a supertramp, but it does not qualify statistically. With such low incidences, many islands harbour neither species, and the existence of the checkerboard alone does not provide strong evidence for competitive exclusion.

9. *Aplonis*

In the genus *Aplonis* the supertramp *A. feadensis* occurs only in the St. Matthias and Northwest groups and forms a checkerboard with *A. metallica*, found in the Northwest group and on most other islands tabulated by Mayr & Diamond (2001) except for several

very small ones. Because *A. feadensis* also exists in the Solomon Islands, it seems unlikely that its distribution in the Bismarcks is restricted by dispersal barriers within the archipelago. *Aplonis feadensis*, is endemic to the Bismarck and Solomon archipelagoes, is found only on small, depauperate, or remote islands throughout its range, and this fact, combined with the predominance of larger islands among those occupied by *A. metallica*, suggests that differing habitat preferences may at least partly explain the checkerboard. It is also possible that diffuse competition within the genus plays a role. Mayr & Diamond (2001) argue that the distribution of *A. feadensis* may be limited by competition with *A. cantoroides*, a morphologically and ecologically similar species.

10. *Falco*

Falco berigora is a recent colonist of the Bismarcks from New Guinea found only on Long, a medium-sized, volcanically disturbed island west of the New Britain group. It forms a checkerboard with *F. subbuteo*, found on three islands – New Britain, a New Britain satellite, and a small island far east of New Ireland (Mayr & Diamond, 2001). With such small numbers of islands occupied by each species, the null probability of a checkerboard would have been great even if the two species had no effect on one another, and the recent colonization by *F. berigora*, found only in the westernmost island of those tabulated, suggests historical factors may play a role in the distributions.

Appendix S2 Intraguild checkerboards of birds in the Bismarcks and possible explanations.

The cuckoo-dove guild contains the two previously discussed congeners, *Macropygia nigrirostris* and *M. mackinlayi* [which Mayr & Diamond (2001) consider a supertramp], plus *M. amboinensis* and one species in the genus *Reinwardtoena*. The sole checkerboard is between *M. nigrirostris* and *M. mackinlayi*. As noted above, both historical factors and possible habitat differences may explain this checkerboard.

The gleaning flycatcher guild has three checkerboards, all including *Pachycephala melanura*, a sedentary supertramp according to Mayr & Diamond (2001). Above we suggested that habitat preferences may at least partially explain the checkerboard with its congener, *P. pectoralis*, which is found on larger islands than those occupied by *P. melanura*. The other intraguild checkerboards are *P. melanura* with two other quite sedentary species (Mayr & Diamond, 2001) both found primarily on larger islands, *Monarcha manadensis* and *M. chrysomela*.

The myzomelid-sunbird guild has 11 checkerboards; ten of these consist of pairs of *Myzomela* congeners. Above we noted that all but two of these include one species classed as a supertramp by Mayr & Diamond (2001), and either historical biogeography or the statistics of small numbers of occurrences can help explain all of them (including the two lacking a supertramp). The only heterogeneric checkerboard in the guild consists of the supertramp *M. lafargei* and *Nectarinia sperata*, which occupies 14 islands of all sizes.

Lastly, the fruit-pigeon guild has ten checkerboards. Four of these include the supertramp *Ducula pacifica* with congeners, and above we noted that historical factors could contribute to all of these and that *D. pacifica* may be restricted to small islands by predation. Four other intraguild checkerboards consist of *D. pacifica* plus species of *Ptilinopus*: *P. superbus*, *P. hyogaster*, *P. rivoli*, and *P. viridis*. Historical geography may play a role in all of these. In the Bismarcks, *D. pacifica* occupies four islands in the Northwest group, but each is at least 160 km west of the main island of Manus. It also occupies Tench in the St. Matthias group, but this island is 60 km east of the main islands in the group, St. Matthias and Emirau. *Ptilinopus superbus* is found on several islands in the New Britain and New Ireland groups, but not in the St. Matthias group and only on Manus and an eastern satellite in the Northwest group. *Ptilinopus hyogaster* is also found on several islands in the New Britain and New Ireland groups, but not in the Northwest group and only on St. Matthias and Emirau in the St. Matthias group. *Ptilinopus rivoli* is not found in the Northwest or St. Matthias groups. *Ptilinopus viridis* arrived in the Bismarcks from the Solomon Islands and was restricted to two eastern outliers of New Ireland adjacent to the Solomons until *c.* 1989, when it colonized Manus (Mayr & Diamond, 2001). The final two checkerboards in this guild are between *P. viridis* and two other species of *Ducula*, *D. rufigaster* and *D. pinon*. The former rarely crosses water (Mayr & Diamond, 2001) and is restricted to New Britain and a satellite plus New Ireland and a western satellite, Dyaul. The latter is a montane species (Mayr & Diamond, 2001) restricted to New Britain and a satellite, plus New Ireland.

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