Does the Distribution of Breeding Bird Species Richness in Taiwan Follow the Mid-Domain Effect?

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ABSTRACT: In this paper, we examined the breeding bird species richness along an elevational gradient in northern Taiwan. These data obtained from 144 sites were used to test the mid-domain model. We compared the species richness with expectations from the mid-domain models, and identified elevational ranges at which the species richness was excessive or depauperate in species, relative to expectations. In addition, we compared the observed spatial distributions of geographic ranges with those predicted by mid-domain models to explore how species richness deviations were produced. Along the entire elevational gradient, observed species richness in most sites obviously deviated from those predicted by mid-domain models. We hypothesize that asymmetrical hump-shaped curve of the species richness may come from the combination of the favorableness hypothesis, the productivity hypothesis, and the mid-domain effect. Comparisons between observed and predicted spatial distributions of geographic ranges indicated that the nonrandomness of the distributions of endpoints or midpoints was highly congruent with vegetation transitions along the elevational gradient. The time hypothesis may account for the nonrandomness below 500 m.

KEY WORDS: Bird species richness, Elevational gradient, Mid-domain effect, Taiwan.

INTRODUCTION

Describing and explaining spatial patterns of species diversity has been one of the main themes in ecology. The best-known pattern is the latitudinal gradient in species richness which states that species richness peaks within tropical latitudes, decreasing toward the poles (Rosenzweig, 1995). Previously, patterns of species richness along elevational gradients were considered as mirrors of species richness along the latitudinal gradients (Stevens, 1992). However, Rahbek's review (1995) of elevational diversity patterns from a variety of taxa showed that only 20% of the studies supported a monotonically decreasing curve, 49% exhibited hump-shaped curves with the highest richness at mid-elevations; and 24% had a plateau of high richness across the lower elevations.

As the diversity theory has progressed and more empirical data have been generated, it has become clear that many factors underlie large-scale diversity gradients (Brown, 2001; Lomolino, 2001), among them the mid-domain effect (Colwell and Lees, 2000).

A mid-domain effect occurs when landmass boundaries, such as oceans and mountaintops, limit species ranges, and the simple overlap of many, variously sized ranges creates a peak in species richness at mid-elevation (Colwell and Hurtt, 1994; Colwell and Lees, 2000). This prediction is based solely on geographical constraints and offers a null model against which empirical patterns can be compared. Although there are some critics of the mid-domain effect (see Zapata et al., 2003), many empirical studies support the predicted pattern (Colwell et al., 2004). In recent years, comparisons of observed biodiversity patterns with predictions based on randomizations of geographic range have become common (see review of Colwell et al., 2004).

Many local-scale studies in Taiwan found hump-shaped relationship between bird species richness (BSR) and elevation (Kano, 1940; Jai, 1977; Shiu and Lee, 2003; Ding et al., 2005). Using compiled data from all of Taiwan, Lee et al. (2004) examined distributions of BSR on a regional scale and also found a hump-shaped relationship. They hypothesized that urbanization might have decreased the BSR and changed the inverse relationship between BSR and elevation into a hump-shaped relationship. They also proposed a time hypothesis which stated that the biotic communities in the mid-elevation zone of Taiwan

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had relatively longer periods of existence during the Pleistocene glacial cycles. The diversity patterns of birds along elevational gradients have not been tested using mid-domain null models.

The objectives of this study were to (1) examine the species richness pattern in breeding birds along an elevational gradient in northern Taiwan, (2) evaluate the support for a mid-domain model by comparing the observed distribution of BSR to mid-domain predictions, and (3) compare observed spatial distributions of elevation ranges with those predicted by a mid-domain model, and identify the BSR deviations using the spatial distribution of geographic ranges.

METHODS

Study area

Taiwan is a continental island off the southeast coast of the Asian mainland. It is separated from the mainland by the Taiwan Strait, which is about 150 km wide. The lofty mountains of Taiwan include more than 200 peaks higher than 3000 m (Wang, 1980). The climate is generally subtropical at lowlands. Temperature decreases as elevation increases at a lapse rate of -5.43°C km^{-1} (Su, 1984a). Precipitation is heaviest during the summer, but rain falls year-round in northern region. Due to the high precipitation, forests are the primary type of natural vegetation in Taiwan. Broadleaf forests are dominant at lower elevations (generally under 2500 m), whereas coniferous forests are more prominent at higher elevations.

This study was conducted in northern Taiwan over an area of 11388.6 km^2 (Fig. 1). The area lies between latitudes 24°00'N and 25°18'N, and longitudes 120°27'E and 122°00'E. The greatest N-S distance is 144.9 km, and the greatest E-W distance is 150.85 km. In general, the elevation gradient increases from north to south, with mountains higher than 3000 m located primarily in the southern portion. The temperature averages 21.5°C (range: 16.7-23.0°C) and the total precipitation averages 2976.4 mm (range: 1283.0-4892.4 mm) at sea level (Taiwan Central Weather Bureau, http://www.cwb.gov.tw). Vegetation types occurring along the elevational gradient are *Ficus-Machilus*, *Machilus-Castanopsis*, *Quercus*, *Tsuga-picea*, *Abies*, and alpine (Su, 1992).

Bird data

BSR data were sampled from 144 sites during early March to the end of June in 2001-2003. Sites were chosen based on four GIS layers: ecoregion (Su, 1992), elevation, vegetation, and road
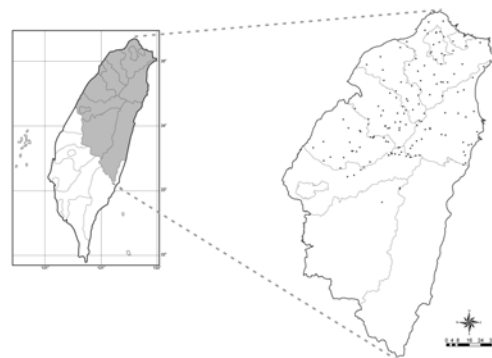

Fig. 1. Map of sampling locations in northern Taiwan.

distribution. The number of the sampling sites in each ecoregion was determined by the relative area of each ecoregion. The same criterion was used to determine the number of sites placed in each of the three elevation classes: low (0-1000 m), mid (1000-2000 m), and high (above 2000 m), and in each of vegetation type. All sites were placed in areas within the reach of road systems to make sure easy accessibility.

At each site, we established one transect with 5-10 point counts located at least 150 m apart. At each station, we recorded the bird species that were seen or heard during a six-minute sample period. We applied the variable circular plot method in these point counts (Reynolds et al., 1980). Each site was sampled one time. Sampling was conducted during sunny, windless days from sunrise to no more than 3 hours later. Geographic coordinates and elevations for each station were taken with a handheld Global Positioning System receiver (Garmin, Taipei, Taiwan).

Data analysis

BSR for each site were calculated as the cumulative species number across all the point counts at that site. Exotic species, migrants, and individuals of breeding species that were passing through the area were excluded from analyses. To evaluate potential variations in sampling effort among sites, we adjusted species richness using nonparametric randomization estimators, Chao2 and Jack2, the least biased estimates for small numbers of samples (Colwell and Coddington, 1994). The species richness was logarithmically transformed to stabilize the variances and improve the normality of the residuals. We used the lowest and highest elevations where a species occurred in this study as the lower and higher range endpoints of the species, respectively. The range extent and midpoint for a species were the difference and the mean of its higher and lower endpoints, respectively.

To test the influence of geographic boundaries, observed diversity patterns were compared to null model predictions generated by a Monte Carlo simulation procedure (Mid-Domain Null, McCain, 2004). This procedure generates species richness curves by sampling either empirical range sizes or range midpoints, and then randomizing the other within a bounded domain, based on analytical stochastic models (Colwell and Hurtt, 1994; Colwell and Lees, 2000). We model range locations as uniformly distributed among geometrically feasible values given observed range sizes, that is, we randomized the range locations within a bounded domain, but not the range sizes. Simulation boundaries were the elevations of mountain summit (i.e. 3900 m in our study site) and sea level. Richness data were generated at 100-m increments of elevation, based on 1000 simulations sampled without replacement from empirical ranges (Colwell et al., 2004; McCain, 2004). Regressions of the empirical values on predicted values, provided r^2 estimates to the fit of the null model. The Komogorov-Smirnov goodness of fit test was also applied to test the fit to the null model.

From these randomizations, we proceeded systematically from a formal statistical comparison of observed species richness patterns versus a mid-domain prediction, towards a quantitative characterization of what was responsible for the differences between the observed and predicted species richness. That is, we directly analyzed the empirical and simulated distributions of range endpoints and midpoints to understand how deviations between the observed and predicted species richness arose. This comparison indicates regions where there is a paucity or an accumulation of range endpoints or midpoints relative to the patterns expected under a mid-domain effect alone. Additionally, species range locations and sizes were jointly examined for each species.

RESULTS

BSR distribution in the elevatitonal gradient

Ninety-two breeding bird species (listed in the Appendix) were recorded over the survey period. The minimum and maximum species richness at 144 sites was 6 and 42, respectively. Species richness estimators adjusted by Chao2 and Jack2 gave similar patterns along the elevational gradient. Therefore, we used the Chao2 estimator to evaluate the support for the mid-domain null model.

Generally, the observed species richness showed a hump-shaped pattern. However, the curve was asymmetrical, and thus differed from mid-domain predictions (Fig. 2). The weak fit to the

null model predictions was demonstrated by a low r^2 value (0.242), although the hump-shaped pattern was statistically significant ($p < 0.001$). In addition, the Komogorov-Smirnov goodness of fit test indicated that the two distribution curves significantly differed ($p < 0.001$). Differences between observed species richness and that predicted by the mid-domain model revealed that the highest deviation, a positive residual, occurred in low-elevation areas (Fig. 3). Positive residuals declined sharply from sea level to about 300 m. Both positive and negative anomalies appeared between 300 and 800 m, followed by mostly negative values above 800 m.
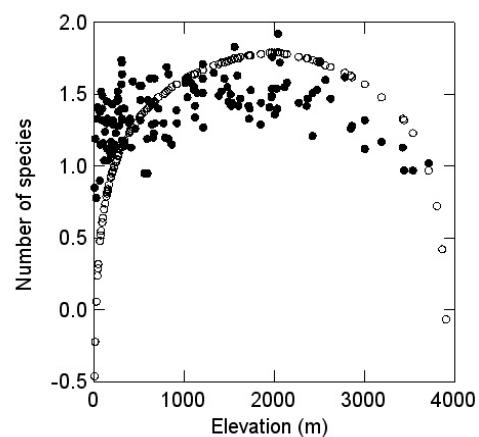

Fig. 2. Observed breeding bird species richness (black dots) along an elevational gradient in northern Taiwan, plotted with predicted values (white dots) under the mid-domain model ($y = -0.00x^2 + 0.06x-3.56$). Species richness was log-transformed. The observed values were weakly fitted to the null model ($r^2 = 0.242$, $p < 0.001$).
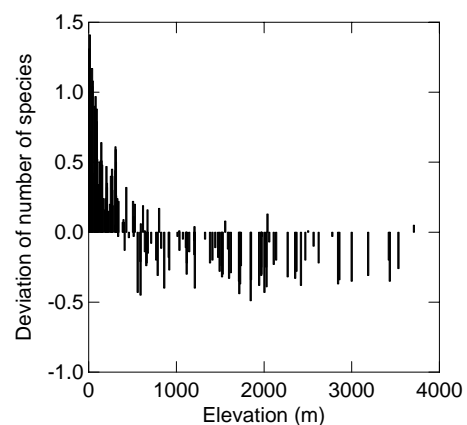

Fig. 3. Deviations of observed breeding bird species richness from that predicted by the mid-domain model. The species richness was log-transformed.

Bird elevational range endpoints and midpoints

The largest discrepancy in the lower range endpoint distributions between the observed and the expected occurred at 0-499 m (Fig. 4A). More species than expected appeared in the foothills and low-elevation mountains. A comparison of higher range endpoint

distributions between observed and expected values showed that the largest excess appeared at 500-999 m (Fig. 4B). Another excess peak appeared at 2000-2499 m. In other words, more species than expected reached their upper extents at 500-999 m and 2000-2499 m. The observed midpoint distribution showed that the largest excess occurred at 0-499 m, compared to the expected distribution (Fig. 4C). Another apparent excess occurred at 1000-1499 m. A marked paucity in the observed and expected midpoint distributions existed at 2000-2999 m. Generally, positive and negative anomalies appeared below and above 1500 m, respectively.
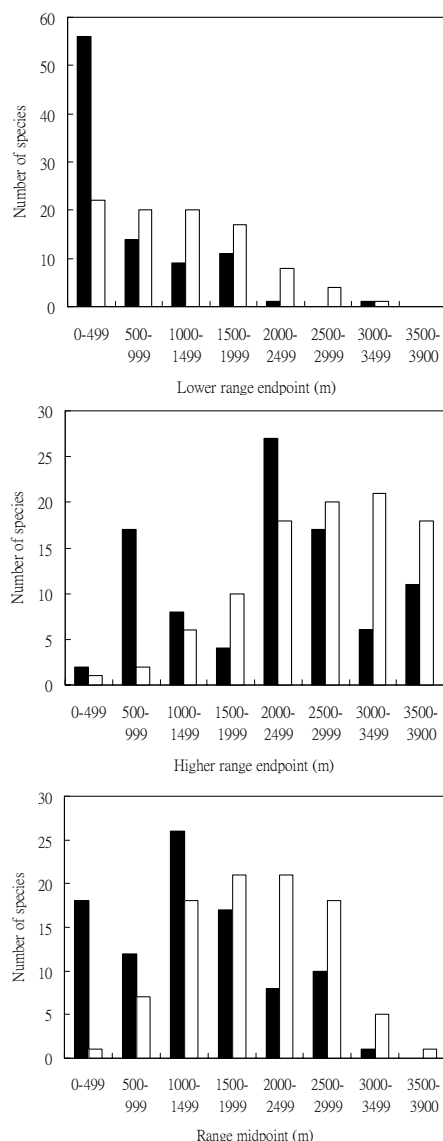

Fig. 4. Observed distribution of range locations of 92 breeding bird species (black bars), and expected distribution based on the mid-domain model (white bars). A: lower range endpoints. B: higher range endpoints, and C: range midpoint along an elevational gradient in northern Taiwan.

Bird elevational range extents

Because the total elevational range extent of mountains in northern Taiwan is around 3900 m, we classified the species into 3 groups by their extent sizes: small-ranged (smaller than 1000 m, 22.8%, 21 sp.), medium-ranged (1000-1999 m, 45.7%, 42 sp.), and large-ranged species ($\geq$ 2000 m, 31.5%, 29 sp.) (Fig. 5). A high percentage (90.5%, 19/21) of small-ranged species occurred entirely below 1000 m. In contrast, 62.1% (18/29) of large-ranged species extended from below 100 m to mid or high elevations. Compared to small- or large-ranged species, medium-ranged species occurred rather evenly from sea level to high elevations. The midpoints of most (85.7%, 18/21) of the small-ranged species were below 500 m. The midpoints of 65.5% (19/29) of large-ranged species were at 1000-1499 m, and those of 66.7% (28/42) of medium-ranged species were below 2000 m.
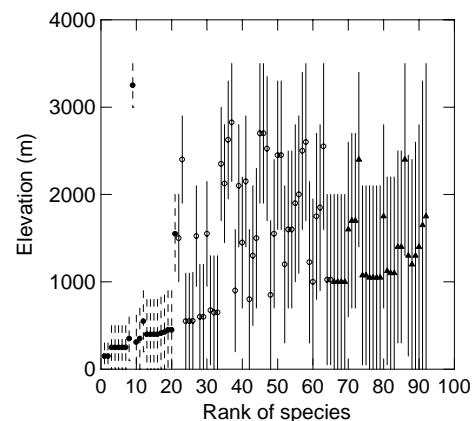

Fig. 5. Elevational range extents and midpoints of species in northern Taiwan, ranked by the size of the range extent. Dashed lines with black dots, continuous lines with white dots, and continuous lines with black triangles represent range extents of small-ranged, medium-ranged, and large-ranged species, respectively.

DISCUSSION

Deviations of the BSR curve from the mid- domain effect

The BSR demonstrated a hump-shaped curve along an elevational gradient in northern Taiwan. This pattern is consistent with previous studies in Taiwan (Kano, 1940; Jai, 197; Shiu and Lee, 2003; Lee et al., 2004; Ding et al., 2005). Despite the significant correlation between observed species richness and that predicted by the mid-domain model, the correlation is weak and many discrepancies exist. Negative anomalies in species richness appeared in the elevational ranges greater than 300 m, while positive values principally occurred at 0-300 m. The greatest excess of the empirical lower range endpoints relative

To the expected lay in the same range (Fig. 4A). An evaluation of environmental factors may explain this discrepancy.

The temperature on Taiwan's mountains generally decreases with elevation, with a lapse rate of -5.43 °C km^{-1} (Su, 1984a). Based on the favorableness hypothesis (Terborgh, 1973; Brown, 1981), an increase in air temperature should increase the physiological performance and efficiency of a bird's energy use and thus be more favorable for birds. Additionally, species in areas of higher temperature tend to have a shorter life span, and this may increase rates of speciation (Rohde, 1992). Collectively, BSR in Taiwan may be higher at lower elevations.

Primary productivity plays an important role in distribution of BSR in East Asia (Ding et al., in press). Productivity hypothesis states that species richness increases with productivity (see reviews of Rahbek, 1997). NDVI (normalized difference vegetation index), a surrogate for primary productivity (Box et al., 1989; Ustin et al., 1991), increase from low to mid elevations, followed by a decreasing trend from mid to high elevations in areas of northern Taiwan (Koh et al., in press). Therefore, BSR may have a hump-shaped curve along the elevational gradient in northern Taiwan.

As combining the favorableness hypothesis, the productivity hypothesis, and the mid-domain model, the BSR distribution in northern Taiwan will probably be an asymmetrical hump-shaped curve, which increases slowly from low to mid elevations and decreases more quickly from mid to high elevations. Our data suggest that the prediction of the favorableness hypothesis, the productivity hypothesis, and the mid-domain effect may need to be combined to yield a better fit to the empirical data.

Distributions of bird range endpoints and vegetation transitions

Comparisons of the empirical higher range endpoints to the expected revealed a great excess at 500-999 m (Fig. 4B). More species (17 species) than expected end their ranges at 500-999 m (Fig. 5).

The distribution limitation for birds may be related to a transition of vegetation types in northern Taiwan. Koh and Lee (2003) investigated the patterns of breeding birds in northern Taiwan, and proposed that a low-elevational community was restricted to areas under 1000 m. Those authors argued that a bird community's transition from low- to mid-elevation was consistent with a vegetation transition from the *Machilus-Castanopsis* zone to the *Quercus* zone. The transition zone of *Machilus-Castanopsis* to the *Quercus* in northern Taiwan generally extends from 500 to 1200 m (Su, 1984b). Birds living in the *Machilus-Castanopsis* forests may gradually disappear in this range. The vegetation transition may explain why more species than expected end their range at 500-1499 m, especially 500-999 m. Therefore, species richness at 500-999 m is not consistently higher than those at 0-499 m, and contradicts the predictions of the mid-domain model. A secondary excess of higher range endpoints clustered at 2000-2499 m. Species range midpoints and extents revealed that 27 species reached their upper extents at 2000-2499 m (Fig. 5). Again, this may have been due to a vegetation transition from the *Quercus* zone to the *Tsuga-Picea* zone (i.e., 2000-2200 m, Su, 1984b). Jai (1977) also demonstrated that a transition from a mid- (1000-2300 m) to a high- (above 2300 m) elevation bird community is consistent with the vegetation transition.

A cluster of the small-ranged species and the time hypothesis

Greatest excess in midpoints exist at 0-499 m, which is in accordance with a cluster of the small-ranged species (85.7%) in this range (Fig. 4C). The time hypothesis in which the biotic communities in the mid-elevation zone of Taiwan had relatively longer periods of existence during the Pleistocene glacial cycles (Lee et al., 2004) may offer a potential explanation for accumulations of small-ranged species below 500 m. Dramatic climatic fluctuations might have caused the biotic communities to shift up and down along the elevational gradient (Tsukada, 1967). Therefore, they might have had more opportunities to adapt to wider elevational ranges. By contrast, the biotic communities that adapted to the lower end of the elevational gradient might have been totally eliminated by the extreme climates during the Pleistocene glacial period. Thus, they might not have had a long history like mid-elevational communities and would have only been able to extend into smaller ranges. In our view, the cluster of midpoints of the small-ranged species below 500 m is congruent with the prediction of the time hypothesis.

For breeding birds in northern Taiwan, large and statistically significant differences exist between the observed species richness and those predicted by the mid-domain models. Therefore, BSR in northern Taiwan does not conform to the mid-model effect. Interestingly, the asymmetrical hump-shaped curve of BSR may come from a synthesis of the favorableness hypothesis, the productivity hypothesis, and the mid-domain effect.

Comparisons between observed and predicted spatial distributions of range endpoints and midpoints indicated a pattern of nonrandomness that was highly congruent with vegetation transitions along the elevational gradient. In addition, the nonrandomness below 500 m may be explained by the time hypothesis.

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Appendix 1. Lowest elevations, highest elevations, midpoints, and elevational ranges of species of terrestrial breeding birds surveyed in northern Taiwan from 2001 to 2003. Scientific names of species follow Monroe and Sibley (1993).

Species		Lowest elevation (m)	Highest elevation (m)	Midpoint (m)	Elevational range (m)
Family Accipitridae	鷲鷹科				
Accipiter virgatus	松雀鷹	0	2100	1050	2100
Accipiter trivirgatus	鳳頭蒼鷹	50	2000	1025	1950
Spilornis cheela	大冠鷲	0	2000	1000	2000
Family Phasianidae	雉科				
Arborophila crudigularis	深山竹雞	50	2100	1075	2050
Bambusicola thoracica	竹雞	0	2000	1000	2000
Syrmaticus mikado	帝雉	1700	3000	2350	1300
Family Turnicidae	三趾鶉科				
Turnix suscitator	棕三趾鶉	0	500	250	250
Family Columbidae	鳩鴿科				
Chalcophaps indica	翠翼鳩	0	620	310	620
Columba pulchricollis	灰林鴿	700	2300	1500	1600
Treron sieboldii	綠鳩	0	2100	1050	2100
Streptopelia chinensis	斑頸鳩	0	900	450	900
Streptopelia orientalis	金背鳩	0	1100	550	1100
Streptopelia tranquebarica	紅鳩	0	500	250	500
Family Cuculidae	杜鵑科				
Cuculus saturatus	筒鳥	0	3300	1650	3300
Cuculus sparverioides	鷹鵑	700	2200	1450	1500
Family Centropidae	鴉鵑科				
Centropus bengalensis	番鵑	0	800	400	800
Family Strigidae	鴟鴞科				
Glaucidium brodiei	鵂鶹	300	2100	1200	1800
Family Megalaimidae	鬚鴷科				
Megalaima oorti	五色鳥	0	1700	850	1700
Family Picidae	啄木鳥科				
Dendrocopos canicapillus	小啄木	0	2100	1050	2100
Dendrocopos leucotos	大赤啄木	700	2400	1550	1700
Picus canus	綠啄木	900	2800	1850	1900
Family Alaudidae	雲雀科				
Alauda gulgula	小雲雀	0	800	400	800
Family Pycnonotidae	鵯科				
Hypsipetes leucocephalus	紅嘴黑鵯	0	1600	800	1600
Pycnonotus sinensis	白頭翁	0	1200	600	1200
Spizixos semitorques	白環鸚嘴鵯	50	1300	675	1250
Family Laniidae	伯勞科				
Lanius schach	棕背伯勞	0	300	150	300
Family Certhiidae	旋木雀科				
Subfamily Troglodytinae	鷦鷯亞科				
Troglodytes troglodytes	鷦鷯	2150	3700	2925	1550

Appendix 1. (*Continued*)

Family Muscicapidae	鶲科				
Subfamily Turdinae	鶇亞科				
Brachypteryx montana	小翼鶇	1100	2900	2000	1800
Cinclidium leucurum	白尾鴝	300	2500	1400	2200
Tarsiger johnstoniae	栗背林鴝	1700	3700	2700	2000
Tarsiger indicus	白眉林鴝	1600	3400	2500	1800
Myiophoneus insularis	紫嘯鶇	50	1950	1000	1900
Turdus Poliocephalus	白頭鶇	1000	2000	1500	1000
Family Sylviidae	鶯科				
Subfamily Sylviinae	鶯亞科				
Actinodura morrisoniana	紋翼畫眉	1450	2800	2125	1350
Alcippe brunnea	頭鳥線	0	2000	1000	2000
Alcippe cinereiceps	灰頭花翼	1600	3300	2450	1700
Alcippe morrisonia	繡眼畫眉	0	2600	1300	2600
Garrulax albogularis	白喉笑鶇	1100	2000	1550	900
Garrulax poecilorhynchus	竹鳥	50	2100	1075	2050
Garrulax canorus	畫眉	0	850	425	850
Garrulax morrisonianus	金翼白眉	1600	3700	2650	2100
Heterophasia auricularis	白耳畫眉	600	2600	1600	2000
Liocichla steerii	藪鳥	700	2700	1700	2000
Pnoepyga pusilla	鱗胸鷦鷯	1400	2800	2100	1400
Pomatorhinus erythrocnemis	大彎嘴畫眉	0	2200	1100	2200
Pomatorhinus ruficollis	小彎嘴畫眉	0	2100	1050	2100
Stachyris ruficeps	山紅頭	0	2800	1400	2800
Yuhina brunneiceps	冠羽畫眉	700	2800	1750	2100
Yuhina zantholeuca	綠畫眉	0	2000	1000	2000
Abroscopus albogularis	棕面鶯	150	2450	1300	2300
Bradypterus alishanensis	褐色叢樹鶯	1300	3500	2400	2200
Cettia acanthizoides	深山鶯	1700	3500	2600	1800
Cettia fortipes	小鶯	300	2500	1400	2200
Cisticola exilis	黃頭扇尾鶯	0	300	150	300
Cisticola juncidis	棕扇尾鶯	0	828	414	828
Prinia flaviventris	灰頭鷦鶯	0	800	400	800
Prinia criniger	斑紋鷦鶯	0	2200	1100	2200
Prinia inornata	褐頭鷦鶯	0	800	400	800
Paradoxornis webbianus	粉紅鸚嘴	0	2400	1200	2400
Subfamily Muscicapinae	鶲亞科				
Ficedula hyperythra	黃胸青鶲	700	2500	1600	1800
Muscicapa ferruginea	紅尾鶲	1000	2800	1900	1800
Niltava vivida	黃腹琉璃	300	2150	1225	1850
Family Regulidae	戴菊科				
Regulus goodfellowi	火冠戴菊鳥	1900	3500	2700	1600
Family Aegithalidae	長尾山雀科				
Aegithalos concinnus	紅頭山雀	700	2700	1700	2000
Family Paridae	山雀科				
Parus ater	煤山雀	1400	3700	2550	2300
Parus holsti	黃山雀	950	2100	1525	1150
Parus monticolus	青背山雀	800	2700	1750	1900
Parus varius	赤腹山雀	200	1600	900	1400
Family Sittidae	鳾科				
Sitta europaea	茶腹鳾	1400	2900	2150	1500
Family Nectariniidae	吸蜜鳥科				
Dicaeum concolor	綠啄花鳥	200	900	550	700
Dicaeum ignipectus	紅胸啄花鳥	700	2500	1600	1800
Family Zosteropidae	繡眼科				
Zosterops japonica	綠繡眼	0	1200	600	1200
Family Fringillidae	雀科				
Carpodacus vinaceus	朱雀	1900	3700	2800	1800
Pyrrhula erythaca	灰鷽	1950	3500	2725	1550
Pyrrhula nipalensis	褐鷽	950	2150	1550	1200

Appendix 1. (*Continued*)

Family Passeridae	文鳥科				
Subfamily Passerinae	文鳥亞科				
Lonchura punctulata	斑文鳥	0	500	250	500
Lonchura striata	白腰文鳥	0	1100	550	1100
Passer montanus	麻雀	0	500	250	500
Subfamily Prunellinae	岩鷚亞科				
Prunella collaris	岩鷚	3000	3700	3350	700
Subfamily Motacillidae	鶺鴒亞科				
Motacilla alba	白鶺鴒	0	1110	555	1110
Family Sturnidae	椋鳥科				
Acridotheres cristatellus	八哥	0	500	250	500
Family Corvidae	鴉科				
Subfamily Corvinae	鴉亞科				
Corvus macrorhynchos	巨嘴鴉	0	3500	1750	3500
Dendrocitta formosae	樹鵲	0	1300	650	1300
Garrulus glandarius	松鴉	500	2100	1300	1600
Nucifraga caryocatactes	星鴉	1600	3300	2450	1700
Oriolus traillii	朱鸝	100	600	350	500
Pericrocotus solaris	紅山椒	50	2200	1125	2150
Urocissa caerulea	台灣藍鵲	0	900	450	900
Subfamily Dicrurinae	卷尾亞科				
Dicrurus aeneus	小卷尾	50	2000	1025	1950
Dicrurus macrocercus	大卷尾	0	700	350	700
Hypothymis azurea	黑枕藍鶲	0	1300	650	1300

臺灣繁殖鳥類種豐富度的分布是否具有中間區域效應?

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摘 要

　　本報告係調查臺灣北部海拔梯度上的繁殖鳥類種豐富度。我們用調查所得 144 筆資料來檢驗其是否支持中間區域模式。首先我們比較鳥種豐富度的觀察值與中間區域模式的預測值,並且指出觀察值多於或少於預測值的海拔區段。再比較鳥種海拔分布範圍的所在位置,其觀察值與預測值的差異,以探究鳥種豐富度觀察值偏離預測值的原因。結果發現大部份的鳥種豐富度觀察值明顯偏離中間區域模式的預測值,並且觀察值在海拔梯度上呈現出不對稱駝型分布,可能是由喜好假說、生產力假說及中間區域效應的合成效應所產生。鳥種海拔分布範圍之上下限及中點,其觀察值偏離預測值之所在,與海拔梯度上的植被變換帶有高度的一致性。海拔分布範圍較小的鳥種多聚集於海拔 500 公尺以下,則可能歸因於歷史因素。

關鍵詞:鳥種豐富度、海拔梯度、中間區域效應、臺灣。

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