穿著顏色對大卷尾(*Dicrurus macrocercus*)驚飛距離的影響

Effects of Clothing Color on Flight Initiation Distance of Black Drongo (*Dicrurus macrocercus*)

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摘 要

人類活動爲影響鳥類生存及繁殖的干擾之一，其中一項影響因子爲鳥類對觀察者衣物顏色的容忍度可能不同，除了影響鳥類活動，亦會使鳥類調查結果產生偏差。本研究以驚飛距離作爲容忍度的指標，於國立臺灣大學農業試驗場以黑色、迷彩、白色、紅色及橘色穿著測試大卷尾的驚飛距離。結果發現以紅色穿著測得之驚飛距離顯著高於黑色及迷彩穿著之測值。彩度高的穿著之測值顯著高於彩度低者；亮度高的穿著之測值顯著高於亮度低者。結果支持物種信賴假說，大卷尾對與其羽色相近的黑色穿著，以及與背景相仿的迷彩服的容忍度較高；與其羽色相異甚大的紅色穿著的容忍度較低。賞鳥或調查時，應穿著彩度低、亮度低，或與背景相仿的顏色，以降低對鳥類造成的干擾。保護區經營管理方面，亦應該將鳥類對人類活動的容忍距離納入規劃核心區、緩衝區及遊憩區配置的考量。

Abstract

Human activities are a known disturbance affecting the survival and reproduction of wild birds. For instance, clothing color can affect bird activities as well as cause discrepancies in bird surveys. As such this study uses flight initiation distance (FID) as an indicator to investigate bird tolerance in different clothing colors. Five clothing colors (black, military camouflage, white, red and orange) were used to measure the FID of Black Drongo (*Dicrurus macrocercus*) in an experimental farm of National Taiwan University, Taiwan. The FID of Black Drongo when encountering red clothing was significantly larger than black clothing and military camouflage clothing. The FIDs triggered by high colorfulness were significantly greater than that of low colorfulness ones. The FIDs caused by high brightness were significantly greater than low brightness ones. The results support the species-confidence hypothesis. The Black Drongo showed higher tolerance in black and military camouflage clothing and lower tolerance in red clothing. The results suggest that it is important to wear clothes of low colorfulness, low brightness, or in colors similar to the surrounding environment during bird watching and surveys. The results also show that when managing a conservation area, it is important to take the degree of bird tolerance into consideration before designating core zone, buffer zone and recreation area.

關鍵詞：衣著顏色、驚飛距離、最適逃跑理論、物種信賴假說、臺灣

Key words：clothing color, flight initiation distance, optimal escape theory, species-confidence hypothesis, Taiwan

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緒　言

人類及其伴侶動物與交通工具的活動已經被視爲影響鳥類生存的干擾之一(van der Zande and Verstrael 1985; Fox and Madsen 1997; Delaney *et al.* 1999)。人類活動對鳥類的影響，輕則暫時影響鳥類的棲地利用、覓食與繁殖，嚴重時可能導致繁殖失敗(Şekercĭoğlu 2002; Weston *et al.* 2012)。經營管理方面，適當配置核心區、緩衝區及遊憩區，盡可能降低人類活動對野生動物的影響就顯得相當重要(Şekercĭoğlu 2002; Weston *et al.* 2012)。

天敵出現時，野生動物必須在適當的時機採取應對策略，以降低被捕食的風險，其中逃脫反應是鳥類中常見的應對策略(Ydenberg and Dill 1986; Hockin *et al.* 1992)。獵物逃脫

時，獵物與天敵之間的距離稱爲驚飛距離(flight initiation distance)(Ydenbery and Dill 1986)。以驚飛距離分析逃脫行爲的成本效益分析，已經相當成功的建構獵物逃脫取捨關係(trade-off)的最佳策略模型 (Ydenbery and Dill 1986; Lima and Dill 1990; Cooper 1999; Cooper 2000; Broom and Ruxton 2005; Cooper and Frederick 2007)。最佳逃脫理論(optimal escape theory)(Ydenbery and Dill 1986)預測：當獵物被捕食的風險等於逃脫所付出的代價時，獵物就會採取逃脫策略，此時獵物與天敵的距離，稱爲最適驚飛距離(optimal flight initiation distance)。因此，掌握適當的驚飛距離，是獵物生存的重要策略。最佳逃脫理論不僅成爲探討逃脫行爲的基本概念，亦深入探討各種因子對驚飛距離的影響(Cooper *et al.* 2003)，例如天敵的種類(McLean and Godin 1989)、天敵接近的速度(Cooper 1997)、天敵的來向以及避難處的距離(Bulova 1994)。

顏色是許多鳥類溝通的重要訊息之一(Osorio and Vorobyev 2008)，鳥類身體各部位的顏色是辨識同種個體(Gill 1995)和潛在競爭者(Metz and Weatherhead 1991)的依據，也可能影響該個體在群體中的位階(Rohwer 1985)、配偶選擇(Noble 1936; Burley 1981; Burly 1986a; Burly 1986b; Ballentine and Hill 2003)與維持配對關係(Frankel and Baskett 1963; Goforth and Baskett 1965)、繁殖成功率等(Weatherhead *et al.* 1991; McGraw *et al.* 2001)。Burley(1986b)提出物種信賴假說(species-confidence hypothesis)，認爲鳥類較偏好與羽色相近的個體活動，而傾向排斥羽色差異甚大的個體。物種信賴假說也廣泛應用於研究鳥類行爲(*e.g.* Rockwell *et al.* 1985; Weltry and Baptista 1988; Gould *et al.* 2004)，尤其是躲避天敵的相關研究(McLean and Godin 1989; Bulova 1994; Cooper 1997; Cooper *et al.* 2003)。Gutzwiller and Marcum (1993)發現卡羅山雀(*Parus cardinensis*)、美洲鳳頭山雀(*Parus bicolor*)與美洲金翅雀(*Carduelis tristis*)對鮮艷橘色的穿著有強烈的排斥性。經營管理方面，許多研究以鳥類的驚飛距離作爲鳥類對遊客容忍度的指標(Knight and Temple 1995; Larson 1995; Riffell and Riffell 2002; Şekercïoğlu 2002)。不僅是遊客的穿著與行爲會影響鳥類的生存與繁殖，鳥類調查員衣著的顏色也會使調查結果產生偏差(Gutzwiller and Marcum 1993; Riffell and Riffell 2002)。

綜上所述，本研究目標在於以驚飛距離作爲容忍度的指標，探討不同顏色、彩度與亮度的穿著，對鳥類驚飛距離的影響。本研究以大卷尾(*Dicrurus macrocercus*)爲研究對象，2008年於國立臺灣大學農業試驗場執行。以驚飛距離爲依變數(dependent variable)，並分別以觀察者穿著的顏色、彩度高低、以及亮度高低爲獨立變數(independent variables)，測試衣著顏色對大卷尾驚飛距離的影響。

材料與方法

研究地點

國立臺灣大學農業試驗場(25°02' N, 121°53' E)（圖 1）位於臺北市大安國立臺灣大學校總區東南隅，面積 5.77 ha，海拔 20 m（陳等，2008）。場內包含生態池與試驗田兩部份，主要試驗作物包含玉米、高莖作物、水稻、甘藷及草坪。場內景觀呈破碎區塊狀分布，路徑系統發達，無高大樹木或建築物等障礙遮蔽，適合追蹤及觀察鳥類行爲。

研究對象

大卷尾屬於臺灣特有亞種，分類上屬燕雀目(Passeriformes)、卷尾科(Dicruidae)、卷尾屬(*Dicrurus*)，廣泛分布於臺灣平地及海拔 1,000 m 以下的淺山地區，離島有少數紀錄，爲低海拔及平地地區的優勢鳥種。通常單獨或成小群出現於樹林、竹林之上層或邊緣，鮮少於樹林內部活動。常於犁田時飛捕土壤中被驚起的無脊椎動物，在食物豐盛的地區會群聚覓食。大卷尾以大型昆蟲爲主食，偶而捕食小型的鳥類或哺乳動物。繁殖期間的領域性強，對入侵領域內的生物攻擊性高，亦有攻擊體型較大的巨嘴鴉(*Corvus macrorhynchos*)、鳳頭蒼鷹(*Accipiter trivirgatus*)，甚至人類的紀錄(林 2012)。由於大卷尾時常停棲於明顯的突出物上，適合測量驚飛距離。

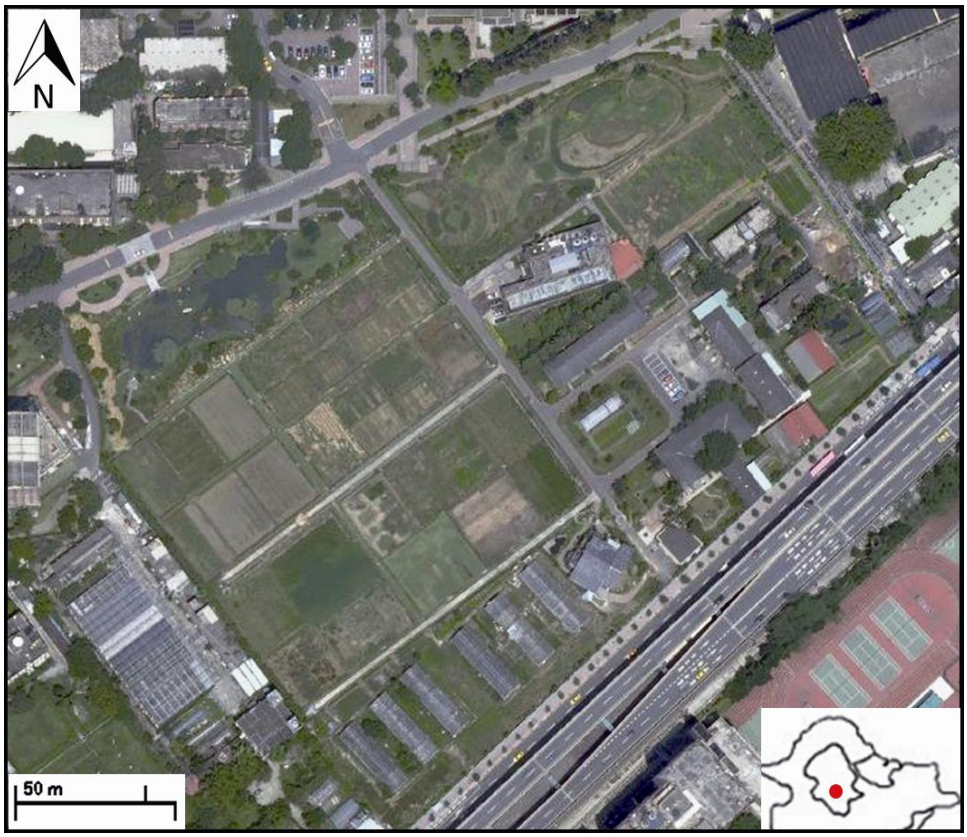

圖 1. 國立臺灣大學生物資源暨農學院農業試驗場航空照片圖。

Fig. 1. Aerial photo of the experimental farm, College of Bioresources and Agriculture, National Taiwan University.

野外資料蒐集方法

本研究於 2008 年 11 月 27 日至 12 月 12 日間，於上午 7 時至 9 時之間進行試驗。首先於農場外圍以雙筒望遠鏡(Canon: 15 × 50, IS UD 4.5°)尋找停棲高度不超過 2 m 的大卷尾。於五種顏色（紅色、橘色、黑色、白色及迷彩）的穿著中，逢機選擇一種作爲待測試的顏色。其中迷彩服爲美國 Crye Precision 設計的多環境迷彩(Multi Environmental Camouflage)，該設計使用七種色調，適用於不同環境、季節、海拔及亮度的變化。穿著長度自領口至下緣固定爲 100 cm，並超過穿著者的腰部以下，穿著者皆爲同一人，下半身均穿著相同黑色長褲、黑襪及黑色運動鞋。發現目標個體後換上測試顏色的穿著，在無遮蔽物的狀況下，自距離大卷尾約 30 m 處以時速約 1 km 的緩慢穩定步伐，直向目標個體靠近。當大卷尾飛離停棲處時，使用皮尺(Yamayo Million, 50 m)測量測試者到大卷尾原停棲處之水平距離，此距離即爲驚飛距離，並記錄測試時間、驚飛距離以及衣著顏色。

統計分析

影響大卷尾驚飛距離的獨立變數包含衣著的顏色、彩度及亮度。紅色及橘色合併爲高彩度色，黑色、白色及迷彩則合併爲低彩度色；紅色、橘色及白色合併爲高亮度色，黑色及迷彩則合併爲低亮度色；驚飛距離則爲依變數。統計分析採用 R 2.15.3 版執行單因子變異數分析、成對 t 檢定及杜凱氏檢定(Tukey's test)；繪圖則採用繪圖軟體 Sigma Plot 10.0 版繪製。

結　果

本研究共測得 90 筆驚飛距離資料，各顏色穿著所測得之驚飛距離如下：黑色(mean = 6.45, SE = 0.71, N = 24)、白色(mean = 9.57, SE = 1.17, N = 14)、紅色(mean = 12.19, SE = 1.58, N = 17)、橘色(mean = 9.33, SE = 1.27, N = 18)、迷彩(mean = 6.76, SE = 0.61, N = 17)；高彩度色(mean = 10.72, SE = 1.02, N = 35)、低彩度色(mean = 7.34, SE = 0.49, N = 55)；高亮度色(mean = 10.39, SE = 0.80, N = 49)及低亮度色(mean = 6.57, SE = 0.48, N = 41)。

五種顏色穿著所測得的驚飛距離之間具顯著的差異(圖 2, one-way ANOVA, $F = 4.833$, $p < 0.010$)。紅色穿著所測得之驚飛距離顯著高於黑色(圖 2, Tukey's test, $p < 0.010$)及迷彩穿著(圖 2, Tukey's test, $p < 0.010$)者；與橘色穿著(圖 2, Tukey's test, $p = 0.362$)及白色穿著(圖 2, Tukey's test, $p = 0.517$)者之間則無顯著差異。橘色穿著之測值與黑色(圖 2, Tukey's test, $p = 0.269$)、迷彩(圖 2, Tukey's test, $p = 0.470$)及白色(圖 2, Tukey's test, $p = 1.000$)者之間無顯著差異。白色穿著之測值與黑色(圖 2, Tukey's test, $p = 0.267$)及迷彩穿著(圖 2, Tukey's test, $p = 0.447$)之間無顯著差異。黑色穿著之測值與迷彩穿著者之間無顯著差異(圖 2, Tukey's test, $p = 0.999$)。彩度高的穿著之測值顯著高於彩度低者 (圖 3, Paired t-test, $p < 0.010$)。亮度高的穿著之測值顯著高於亮度低者 (圖 4, Paired t-test, $p < 0.001$)。

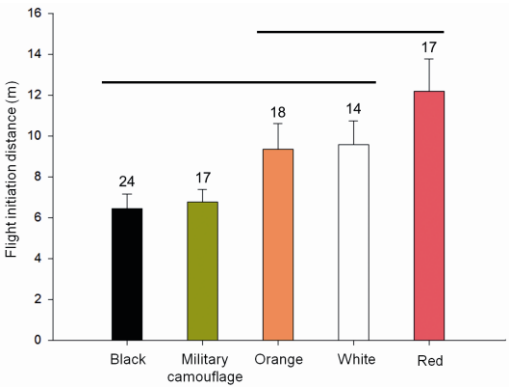

圖 2. 大卷尾對人類穿著 5 種顏色服裝的驚飛距離(flight initiation distance)之差異水平線下方之長條表示其間無顯著差異，誤差長條(error bar)爲樣本的標準機差，樣本數標示於長條圖上方。

Fig. 2. Variation of flight initiation distances of Black Drongo when encountering researchers with five different clothing colors. The bars of different colors under the same horizontal line indicate non-significant differences among them. Each error bar indicates standard error, and the numbers above the bars are sample size.

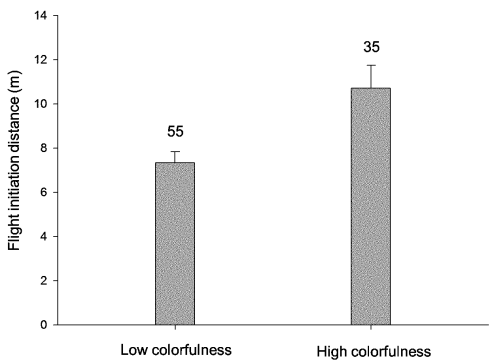

圖 3. 大卷尾對人類穿著高、低彩度服裝之驚飛距離(flight initiation distance)。圖中直條代表一個標準機差，樣本數標示於長條圖上方。

Fig. 3. Variation of flight initiation distances of Black Drongo encountering researchers with high clothing colorfulness. Each error bar represents standard error, and the numbers above each bar indicate sample size.

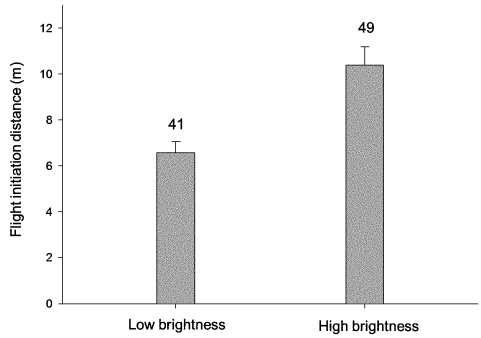

圖 4. 大卷尾對人類穿著高、低亮度服裝之驚飛距離(flight initiation distance)。圖中直條代表一個標準機差，樣本數標示於長條圖上方。

Fig. 4. Variation of flight initiation distances of Black Drongo when encountering researchers with high clothing brightness. Each error bar represents standard error, and the numbers above each bar indicate sample size.

討 論

分析結果顯示，以紅色穿著所測得之驚飛距離，顯著高於黑色及迷彩穿著的測值。彩度高的穿著所測得之驚飛距離顯著高於彩度低者。亮度高的穿著所測得之驚飛距離顯著高於亮度低者。在穿著者相同、接近速度相同的狀況下：大卷尾對衣著顏色爲紅色、高彩度、以及高亮度的警戒程度較高、容忍度較低，傾向與上述顏色穿著的觀察者保持較遠的距離；對衣著顏色爲黑色、迷彩、低彩度、以及低亮度

的警戒程度較低、容忍度較高，傾向與上述顏色穿著的觀察者保持較近的距離。

物種信賴假說(Burley 1985; Burley 1986b)認爲鳥類較青睞相同物種或與其顏色相似的個體，反之則較排斥。斑胸草雀(*Poephila guttata*)的雄成鳥具有橘紅色的喙與爪，Burley (1986a)發現比起繫上藍色或綠色腳環的雄鳥，雌鳥顯著較青睞繫上橘紅色腳環的雄鳥。Wilson *et al.* (1990)發現阿德利企鵝(*Pygoscelis adelae*)也會主動接近與自己羽色相似的鳥類模型。Johnson *et al.* (1993) 發現美洲金翅雀的雄鳥的喙會在繁殖季轉變爲鮮艷的橘色，繁殖季期間，雌鳥明顯較青睞繫上橘色腳環的雄鳥，但非繁殖季時則無此現象。

大卷尾羽色爲略帶光澤的黑色，紅色穿著不僅與其羽色大相逕庭，彩度與亮度亦較高，因此所測得之驚飛距離顯著最遠。黑色穿著可能因與其羽色相近，而測得之的驚飛距離最短；迷彩的效果使其與背景顏色相仿的程度更高，而測得較短之驚飛距離。本研究結果支持物種信賴假說，觀察者不同顏色的穿著對鳥類所測得之驚飛距離顯著不同，很可能表示鳥類對不同顏色穿著的有不同的容忍度。

若以鳥類的驚飛距離、偵測距離或警戒距離作爲鳥類對遊客容忍度的指標，在不同環境、鳥種以及各種影響因子的狀況下，所測得的驚飛距離並不盡相同(葛與鄭 2011; Glover *et al.* 2011; Weston *et al.* 2012)。穿著彩度高或亮度高的衣服，不僅較容易使鳥類警戒，尤其繁殖季期間更容易造成影響(Şekercïoğlu 2002)。執行鳥類調查時，彩度或亮度較高的穿著也容易使調查結果產生偏差(Gutzwiller and Marcum 1993; Riffell and Riffell 2002)。因此，賞鳥或鳥類調查時，確實應穿著彩度低、亮度低，或與背景相仿的顏色，以降低對鳥類造成的干擾。經營管理方面，爲同時兼顧保育以及教育遊憩的功能，核心區、緩衝區、遊憩區的配置規劃，亦應將驚飛距離納入規劃中，使遊客與野生動物保持適當地距離。

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