玉山國家公園研究叢書

玉山國家公園
帝雉族群動態及不同生育地生態學之研究(三)

Population Dynamics and Ecology of Mikado Pheasants in

Two Contrasting Habitats inside Yushan National Park,
Taiwan

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摘要

雖然我們已經擁有一些黑長尾雉（*Syrmaticus mikado*）的分佈以及行為記錄，在生物學上對於黑長尾雉仍然知之甚少。本研究的目的是使用捕捉、觀察以及無線電遙測技術來增進對於黑長尾雉的認識。我們特別關心的是：1) 黑長尾雉的生殖潛能以及其模式；2) 導致其死亡之原因； 3) 壽命；4) 棲地的使用；5) 裝置無線電發報器之個體的分佈及其相互影響；以及 6) 兩個研究地以及玉山國家公園區內的黑長尾雉數量。

我們研究的重心是在玉山國家公園區內的兩處研究地上。郡大研究地位於郡大林道，靠近觀高；對關研究地則位於觀高坪以及對關之間的八通關古道上。本研究的所有資料都是來自這兩個研究地。

雖然黑長尾雉具有很高的生殖潛能（每一隻雌性個體可擁有一到五隻幼鳥； Severinghaus 1977, Bridgman 1994），牠們在 1996 ~ 1999 年之生殖力卻非常低落（生殖力指標：每小時目擊的幼鳥少於 0.09）。目前已知猛禽以及小型肉食性動物會捕食黑長尾雉，而人類的威脅也不斷增加；從 1992 到 1999 年，狩獵活動呈倍增狀態。若不考慮導致死亡的因素，黑長尾雉可存活十年、甚至更久的時間。

身上配戴著無線電發報器的黑長尾雉使用之棲地環境以混合林佔優勢，而不論是砍伐過的森林或者是原始林。這些黑長尾雉有著互相重疊的活動範圍，顯示牠們的行為並不具有領域性。一般而言，牠們的活動範圍非常小，或為平行於地勢的橢圓形；這表示黑長尾雉在垂直方向的遷移很有限，也

代表黑長尾雉各有其喜好的地點，並不隨意走動。

以郡大研究地而言，使用林道的黑長尾雉估計有 53 **隻，族群密度為** 59 **隻** / km^2**；而在對關研究地使用八通關古道的黑長尾雉則估計有** 101 **隻，族群密度為** 69 **隻**/ km^2**。玉山國家公園區內約有** 320 km^2 **的棲地環境類似於兩個研究地。假設黑長尾雉在這些棲地環境之中的密度是一個常數、並且不在其它類型的棲地環境當中出現；我們也假設黑長尾雉僅活動於海拔** 1,600 - 3,300 m **之間。基於這些假設條件，玉山國家公園區內至少擁有** 11,000 **隻黑長尾雉。根據相對數量（目擊指標）的比較數據，這個族群仍維持穩定、或者是衰退。雖然玉山國家公園擁有一個龐大族群的黑長尾雉，我們仍然必須監測其生殖力模式以及狩獵所造成的影響。**

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簡介

黑長尾雉，學名 *Syrmaticus mikado*（Hume），是台灣高海拔地區的特有種類。在不久之前，牠仍被 IUCN（國際自然資源保育聯盟）歸類為瀕臨絕種之物種（International Union for Conservation of Nature and Natural Resources 1966），主要的原因在於捕獵以及棲地的破壞（Severinghaus 1977）。然而自從 1993 年以後，黑長尾雉就被認為安全而沒有滅絕的威脅（McGowan & Garson 1995）。不論如何，關於這種鳥類在自然棲地之中的生命循環，我們還有許多知識必須學習。

對於黑長尾雉的系統性研究開始於 1975 年（Severinghaus 1977）。該次調查的結論是，黑長尾雉居住在高海拔的原生或次生森林當中。一項延續性的黑長尾雉研究計劃在玉山國家公園成立不久之後在園區內展開（Severinghaus and Severinghaus 1986）。接下來的研究則開始於 1989（Alexander et al. 1990）；該次研究的調查重點在位於郡大林道的次生棲地環境，並首度捕捉黑長尾雉並加以繫標，但直到 1991 年才開始進行無線電遙測研究（Bridgman 1994）。在這些研究當中、尤其是最後一項研究，徹底的說明了黑長尾雉能夠、並且的確利用次生棲地環境。台灣省特有生物研究保育中心的研究員姚正德從 1992 年開始在瑞岩溪自然保留區的闊葉及混合林棲地當中進行黑長尾雉的觀察以及遙測研究。這是第一個在原生森林棲地當中進行的黑長尾雉研究。

1996 年，玉山國家公園同意支援公園區內的第四次黑長尾雉研究計劃。這個研究是兩種棲地型態互相比較的基礎：郡大林道的次生棲地環境以及

位於對關和觀高之間、八通關古道的原生棲地環境。我們的目標是利用捕捉、觀察、以及無線電遙測技術來進一步瞭解黑長尾雉。特別要關切的是：1) 黑長尾雉的生殖潛能以及模式；2) 導致其死亡之原因； 3) 壽命；4) 棲地的使用；5) 裝置無線電發報器之個體的分佈及其相互影響；以及 6) 兩個研究地以及玉山國家公園區內之黑長尾雉數量。

研究地描述

我們選擇這兩個區域作為研究地（圖 4：23° 30' N，121° 00' E）是因為容易接近這些地點，而且根據過去的研究（Severinghaus 1977, Severinghaus & Severinghaus 1987, Alexander et al. 1990），在這些區域經常可以觀察到黑長尾雉。這兩處研究地的海拔都在 2,000 ~ 2,700 m 之間。其中郡大研究地（圖 5）的林型恰恰符合了 Severinghaus（1977）所描述之受干擾的混合林。此處臨近玉山國家公園北緣，位於郡大林道 65.7 ~ 68.1 km 之間。對關研究地的位置（圖 4）則在八通關古道上，介於對關（距東埔村 10.16 km）與觀高坪（距東埔村 14.3 km）之間，擁有符合 Severinghaus（1977）所描述之原生森林（圖 5）。

郡大研究地（圖 5）基本上面朝東方。其地勢極為陡峭，坡度可達 30° 至 80°。圍繞著林道四週、已遭砍伐的區域原本是台灣紅檜（*Chamaecyparis formosana*）森林；過去二十年來則重新種植了紅檜及台灣赤楊（*Alnus japonica*）。

對關研究地和郡大研究地之間的差異相當大。此處面朝西方，因為午後雲霧遮蔽的關係，可獲得的直接日照可能少於郡大研究地。它距離郡大研究地（圖 5）不足一公里，是一個高度成熟的森林社群。此處坡度在 30° 到 80° 之間，如同郡大研究地，非常陡峭。森林林型為混合的紅檜、鐵杉以及松樹，屬於潮濕的溫帶林（海拔 1,500 ~ 2,500 m）以及亞高山地帶（海拔 2,500 ~ 3,000 m）之間的過渡區域。因為自然形成的崩坍以及火焚的影響，造成這些樹木的年齡各有不同。有許多樹，特別是紅檜，樹齡可達 1,000

~ 3,000 **年（**Wang 1968**）。此處陡峭的地勢造成了許多自然的崩坍地，也有很多小規模的次生林和郡大研究地類似。**

研究方法

製圖

我們使用平板儀以及照準儀來繪製郡大林道研究區（距信義 65.5 ~ 67.5 km）的詳圖；昔日的觀高伐木站正位於 67.5 km 處。位於觀高坪（14.3 km）及對關（10.16 km）之間的八通關古道，則以皮尺以及指北針來製圖。在兩個研究區內，每隔 20 m 設置一個測量點；這些測點也都繪製在地圖裡。我們在步道以及測量點上使用的座標系統是 Taiwan Grid（類似 UTM 座標系統），並將其整合在 GIS 系統（圖 5）之中。

研究地的維護

在研究計劃進行當中，每年將郡大林道修剪出二到三公尺寬的通道一至三次（圖 1A）。為了讓道路易於通行、有利於觀察黑長尾雉，這是必要的措施。在整理林道之後，能見度可增加約三十公尺，大大提高了看見黑長尾雉的機會。

1996 年 7 月~ 1999 年 5 月之間國家公園派員將八通關古道上修剪了兩次，整理出一公尺寬的通道。迂迴的步道使得視野受到限制，能見度通常在五到二十公尺之間。

捕捉

在大部份時間裡，兩處研究地各放置十到三十個陷阱（圖 1B）在路中間或者路邊，而在研究結束後加以破壞。巡視陷阱的時間在清晨 5:30 到夜晚 19:00 之間，每隔一個小時進行。

捕捉之黑長尾雉以羽色及體型來分辨性別以及成年與否。任何重量等於或大於 600 g、並擁有成鳥羽翼的個體，我們就認定其為成鳥。體重係以彈簧秤來秤量，其它如喙（可張開部份長度）、前翅長、尾長（最長尾羽）、體長、距長、跗蹠長、跗蹠徑以及跗蹠寬（圖 1C）也都一一丈量，並記錄捕捉日期、時間以及陷阱所在位置（記錄表 4）。每一隻黑長尾雉在拍照之後都繫上二到四個塑膠色環和一個鋁製號碼環於腿部。

日常記錄

1996 年 7 月~ 1999 年 5 月之間，每月在.山區的日數約 15 天；其中停留於郡大研究地以及對關研究地的時間約各半。

我們將每日在野外的所有活動、氣候、步行距離以及其它雜項都登錄在記錄表（記錄表 1）之中。氣候資料諸如溫度、雲覆蓋度、降雨以及風力，每日記錄三到六次（通常在早晨、午間以及夜晚）；從 1996 年開始，每日記錄兩次雨量計的讀數。此外，每日行進里程、野外觀察時數以及目擊黑長尾雉次數則登錄於記錄表 2。雜項如登山客數量、大型動物及其它雉類的行蹤、小型鳥類的巢位、發現陷阱的種類及數量等，我們記錄了一切有

意義的事件。

觀察

針對於黑長尾雉的活動狀況，我們記錄了目擊時刻、日期、性別、年齡以及其腳環。我們盡可能地尾隨步道上活動的黑長尾雉，並描述其行為（記錄表 2 & 3）。

巢穴調查

在繁殖季節裡，我們花費許多時間於跟蹤無線電訊號、尋找可能正在孵蛋之雌性黑長尾雉（圖 1D，2A），期望可以尋獲其巢穴。

生殖力

黑長尾雉的生殖力指標是根據 1991 年、1996 ~ 1998 年之七月與九月當中每小時可見到之幼體以及亞成鳥數量來決定。選擇七月與九月來計算生殖力指標，是因為此時亞成鳥的體型已經相當大，可以輕易的觀察；同時在這幾年當中的這些月份裡都有其觀察記錄。

壽命

黑長尾雉的壽命是依據 1991 ~ 1992 年的研究期間內曾經捕獲、而在最近再次捕捉到的個體來做推估。

死亡

當無線電發報器發出“死亡訊號”（ 發報器靜止一定時間後所發出的特殊訊號）後，須藉由無線電定位將其尋獲之後才能決定其死亡原因並確認捕食者。

狩獵指標

狩獵指標係將 1989 ~ 1992 年以及 1996 ~ 1999 年之間每年所看見之陷阱、動物殘骸以及聽到之槍擊次數總和（表 1, 圖 3），除以該年進行調查的總天數而得（可以去除調查人員的主觀認定偏見）。

無線電遙測系統的誤差

我們將發報器放置在步道上方或下方 20 ~ 150 公尺來估算遙測系統的誤差。在郡大研究地放置了十個測試用發報器，對關研究地則有八個。在最常使用的一些無線電測量點上針對每個測試發報器進行方位角測量之後，

將資料加以分析（White & Garrott 1990, Lee et al. 1985），可檢驗無線電遙測定位之精確度。

遙測

經由黑長尾雉身上裝置的無線電發報器，我們得以獲知 1996 年 7 月~ 1999 年 5 月所捕獲個體之季節性及年度活動範圍。本研究使用之無線電發報器由 Hi-Tech Services 公司所製造，型號 WL300，發射頻率在 150 ~ 151 MHz 之間。它具有微動偵測開關，保持靜止達 11 個小時之後便會改變發射訊號。包括繩圈在內，發報器重量為 20 g，約為黑長尾雉體重的 3%；我們僅在體重超過 600 g 的黑長尾雉身上放置發報器。無線電接收裝置則為 AVM 公司生產之 LA12-Q 型可攜式接收器以及可折疊的手持天線（AVM 公司之 Yagi 天線以及 Telonics 公司之 RA-14 型天線）。我們使用頸圈、胸掛式以及背負式三種方法將發報器固定於黑長尾雉身上。

我們以四小時的間隔在步道上每 20 m 設置的測量點上進行三角測量（Kenward 1987, White & Garrott 1990，記錄表 5）以取得黑長尾雉的位置，每日最多可以完成四次定位。通常是每日進行二到三次無線電定位，每月為每隻黑長尾雉定位十次。

三角測量的方法是在 30 分鐘內，在至少三個不同的測點上量出方位角；方位角之間的夾角必須在 30° 以上方為有效。然而在研究區內，30° 的差異通常仍不足以決定黑長尾雉的位置，因此我們需要三個以上的方位角。此外因為訊號反彈的問題，測量點之間經常有數百公尺之遙，而每一次定

位都必須求出 3 ~ 10 個方位角。通常我們在 500 m 之內可以完成一次三角測量，然而也經常發生測量點之間遠達一公里以上的例子。

發報器掉落後，我們必須使用無線電遙測技術將其取回：隨著目標的接近，接收之訊號會增強，直至尋獲發報器為止。因為發報器遺落位置之地形障礙，尋找它們所耗費的時間可能長達八小時（圖 1D）。我們試著找回所有發出 " 死亡訊號 " 之發報器；這種訊號代表兩種可能狀況：發報器掉落，或者攜帶發報器的黑長尾雉已經死亡。

我們利用三角遙測資料來估算每一隻黑長尾雉之 95% MCP（最小凸面多邊型）範圍。使用電腦程式 TELEM（Coleman 1987）計算出遙測位置座標之後，以 ArcView（1994）描繪、再利用 CALHOME（Kie 1994）計算 95% MCP 範圍。因為大部份研究使用此法，所以能夠以 95% MCP 進行不同研究以及不同物種之間的比較。當黑長尾雉在一季（三個月）之中有六次以上之定位資料，我們即計算其 95% MCP。我們將一年區分為四部分：冬季（12 月 1 日 ~ 隔年 2 月 28 日)、春季（3 月 1 日~ 5 月 31 日)、夏季（6 月 1 日~ 8 月 31 日）以及秋季（9 月 1 日~ 11 月 30 日)。這個季節分類約略與氣候的更替、以及黑長尾雉活動及行為的年度循環相符合。

棲地分析

我們使用地理資訊系統（Geographic Information Systems, GIS）來進行棲地分析。土地利用型以及海拔高度之 GIS 資料係來自林務局（1995)，然後將研究地路徑圖、研究範圍（即 100% MCP；是無線電遙測資料有六筆

以上之黑長尾雉（圖 6）活動範圍總合）資料覆疊其上（圖 5）。黑長尾雉的海拔分佈資料來自四份台灣鳥類圖鑑（Severinghaus & Blackshaw 1976, Wang et al. 1991, Chang 1995, and Jan 1996）以及世界鳥類手冊（Handbook of the Birds of the World, del Hoyo et al. 1994）。這些資料來源大致上認為黑長尾雉出現於海拔 1,600 ~ 3,300 m 之間（表 2）。

玉山國家公園區內的黑長尾雉棲地圖，係根據海拔 1,600 ~ 3,300 m 之間、棲地型態類似於研究地之區域而來。利用這個 GIS 模型，可以決定黑長尾雉的棲地面積，並求出玉山國家公園區內黑長尾雉之族群估計值：假設黑長尾雉僅出現於海拔 1,600 ~ 3,300 m 之間，且牠們僅出現於類似研究區之棲地環境。

族群估算

族群之估算係根據郡大研究地 1991 年 7 月~ 1992 年 6 月、1996 年 7 月~ 1999 年 5 月以及對關研究地 1996 年 7 月~ 1999 年 5 月的資料而來。透過電腦程式 NOREMARK（White 1996）中之 Bowden 模型估算法（Bowden's Model Estimation），可由目擊和捕捉之個體數求出該研究區之黑長尾雉族群估計值，但無法求出族群密度。在本例之中，郡大研究地為長度二公里之林道（66.0 ~ 68.1 km），而對關研究地為長度三公里之八通關古道（11.3 ~ 14.3 km）；所有黑長尾雉的目擊以及捕捉都發生在林道及古道上，而且僅使用發生在圖 6 區域中的目擊記錄。黑長尾雉數量則包括在步道上捕獲、目擊（無繫標）、重覆目擊（繫標）之個體；重覆捕獲之個體則視為重覆目擊。Bowden 模型產生了族群估計值及其最大、最小建議值。要算出族群密度，

則必需須將族群估計值除以無線電遙測得到之研究區 100% MCP 面積。

整個玉山國家公園區內黑長尾雉的族群大小，是根據 1996 ~ 1999 年之間族群密度估計值之最大、最小值（圖 24）以及研究地棲地型態資料而來（圖 5)。其前提如下：1) 研究區內各類型棲地環境中，黑長尾雉的密度相同； 2) 玉山國家公園區內棲地類似於研究區的所有地點都有黑長尾雉存在； 3) 任何與研究區棲地類型不同的地點，即沒有黑長尾雉的存在； 4) 黑長尾雉只在海拔 1,600 ~ 3,300 m之間出現（Table 2)。將屬於郡大研究地棲地類型的族群大小以及屬於對關研究地棲地類型的族群大小分別計算並加總，便得到玉山國家公園黑長尾雉的族群總估計值；這個估計值呈現了一個最大值以及最小值的區間。在此例中，我們在 GIS 裡面應用林務局（1995）的棲地型態分類資料來計算各種類型棲地的面積。

相對數量

相對數量的內涵就是目擊次數指標，即每小時目擊黑長尾雉的次數；這個指標可以排除觀察人員的偏見。從 1991 年 7 月~ 1992 年 7 月以及 1996 年 7 月 ~1999 年 5 月，我們計算每年、在每個研究地之目擊指標 1996 ~ 1999 年與 1991~ 1992 年的相對數量作一比較，便可以檢視黑長尾雉族群變動的趨勢。

結果與討論

捕捉

在每個月的陷阱捕捉之下，郡大研究地共捕獲 21 隻黑長尾雉，包括 1991 ~ 1992 年捕獲的 4 隻在內（表 3）；對關研究地捕獲之黑長尾雉也是 17 隻（表 4）。

1990 年之後在玉山國家公園區內所捕獲黑長尾雉之平均大小以及重量參見表 5；這兩個地區捕獲之黑長尾雉體重小於瑞岩溪自然保護區所捕獲之個體（Yao et al. 1998)。這些比較數據顯示，玉山國家公園區內之黑長尾雉體型，一般而言，小於瑞岩溪自然保護區之個體。然而這些差異可能是因為研究技術不同所致。

性別比例

在郡大林道捕獲之黑長尾雉性別比例為 1：1（表 3)；大多數為成鳥，3 隻為未成年雄性個體。在對關研究區內，雌雄比例約為 10：9（表 4)，其中僅有一隻未成年雄性。幼齡黑長尾雉之大小及重量在夏季末期便已經和成年雌鳥相當（Bridgman 1994)、且未成年雌鳥和成年雌鳥有相同的外觀，因此我們無法完全確定雌性個體的年齡。雄性黑長尾雉的年齡就比較容易判定，因為未成年雄性個體在一歲之前都會擁有些許類似於雌鳥的羽毛。

繁殖

本研究之中，繫有無線電發報器的雌性黑長尾雉共有 19 隻（表 3&4），但從未尋獲其巢穴。營巢行為可由無線電遙測資料推論出來：正在孵蛋的雌性黑長尾雉，其位置應該總是在相同地點（Bridgman 1994）；然而僅有一隻雌性個體表現出這樣的行為。我們兩度嘗試接近該雌性黑長尾雉及其巢穴，都因為在找尋途中、該雌性個體再度移動，遂無功而返。然而這並不代表身上攜有無線電裝置的雌性黑長尾雉沒有孵蛋；事實上，我們曾看見其中 3 隻雌雉與幼年個體一起活動，另外則有 5 隻個體在腹部有孵蛋痕（圖 2A）。

生殖力

所謂生殖力就是目擊未成年黑長尾雉的頻率指標（表 6）。1996 ~ 1998 年，兩個研究區的黑長尾雉生殖力指標和 1991 年比較起來顯得微不足道。此時仍然很難決定黑長尾雉 5 之平均年生殖力是如何，但 1991 年的確是很好的一年。該年的兩隻未成年個體（表 3）在 1997 年和 1998 年分別再度被捕獲並繫上無線電發報器；而在本研究期間，黑長尾雉之生殖力相當低落，僅觀察到少量的未成年個體（表 6）；捕捉到的個體當中，亦僅有 4 ~ 6 隻為未成年個體。

關於 1996 ~ 1998 年生殖力低落的原因，我們的假說是氣候因素。在這三年之黑長尾雉繁殖季節裡，研究區內有非常頻繁的大量雨水：1996 年夏天，兩個重大颱風造訪南投縣；1997 年以及 1998 年春季則經常下著雷雨

以及豪雨。黑長尾雉的幼鳥很可能因為暴露在大雨當中而失溫死亡。1991 年的春季和夏季則非常甘燥，僅有微量的降雨。為了瞭解黑長尾雉之生殖力模式是否和年度氣候模式有關，仍有必要做進一步的研究。

壽命

在 1991 ~ 1992 年之間捕獲捉的 24 隻黑長尾雉當中（Bridgman 1994），有四隻（17%）在本次研究裡再度被捕獲（表 3）。其中兩隻雄性是當年捕捉到的未成年個體，猜測牠們是在 1991 年春季或夏季孵化；其中一隻在 1997 年被小型肉食性動物獵食（表 3）時，約有六歲大。其他個體在本研究截止時都依舊存活：一隻八歲雄性，其餘一雄一雌至少有九歲。我們無法確定這兩隻黑長尾雉的年紀，因為牠們被捕捉時已是成鳥。牠們大約是在 1990 年或更早之前出生。

死亡

在本研究計劃的前半年裡，黑長尾雉的死亡率相當高。其中至少有兩隻黑長尾雉的死亡是歸因於無線電發報器的配戴方式（Bridgman et al. 1997），而其它死亡的黑長尾雉可能也有部份與無線電發報器有關。前半年研究的主要結論，就是評估放置無線電發報器的方法（Bridgman & Lin 1997）。我們在研究的後兩年半裡（1996 年 12 月之後）使用 Dwyer 法（Dwyer 1972）或是「背負法」來為黑長尾雉裝置無線電發報器。其中四隻黑長尾雉的死亡可能是因為狩獵，或遭到小型肉食性動物、猛禽所掠食（表 3&4），與

無線電發報器無關。事實上另有八隻黑長尾雉配戴了無線電發報器一年、甚至兩年以上。

至於其它被發現的雉類屍體（未攜帶無線電發報器），皆屬意外收穫。1989 ~ 1999 年之間，在郡大林道拾獲三個雉類殘骸；1996 ~ 1999 年之間，則在對關研究地的營火堆附近拾獲兩個雉類殘骸（其中之一是藍腹鷴，圖 3C）。我們認為這兩隻雉類是因狩獵活動而死亡。

為了觀察黑長尾雉並進行無線電追蹤，我們必須清除路面的雜草；明顯的步道也會吸引黑長尾雉前來。但是這個吸引黑長尾雉的因素（便於行動），也同樣吸引了人類。清理之後的郡大林道使得獵人能夠輕易進入研究區域，對於黑長尾雉可能有負面的影響。研究期間所記錄之狩獵活動，幾乎都發生在步道或者是近旁。

狩獵活動的確仍發生於玉山國家公園界內。我們並沒有國家公園成立之前的狩獵指標資料；而事實上在過去十年當中（1989 年以來），郡大及對關研究區內的狩獵事件則呈倍增狀態（表 7）。在前三年（1989 ~ 1992）裡，狩獵指標等於或小於 10%（表 7）；而在本研究之三年（1996 ~ 1999）當中，狩獵指標則大於或等於 10%。狩獵指標之相關資料列於表 1。

狩獵使用的器材主要是繩圈或獵槍，其中大多數繩圈是在研究地的路上或路邊被發現的。繩圈的使用尤其需要關切：在獵人離去很久之後，繩圈仍然具有獵捕作用。然而我們也在距離郡大林道 500 公尺之遙，沒有路徑、亦無人跡之處發現少數繩圈；這顯示只要是人類可以到達的地點，都有可能被放置繩套。

活動模式

從 1991~ 1992 年，我們總共花費 1,499 個小時在郡大研究地觀察黑長尾雉（表 F；Bridgman 1994)；這些觀察時間分佈於一年之中的 152 天(Bridgman 1994)。因為八通關古道是前往郡大研究地的必經之地，該年間花費在對關的觀察時間亦有 36 小時（表 8；Bridgman 1994)。1996 年 7 月~ 1999 年 5 月，每年在對關研究地觀察黑長尾雉的時數有 216 ~ 423 小時 (表 8)，在郡大研究地則有 343 ~ 396 小時（表 8)；每年在研究地的總天數則分別有 100、69、以及 113 天（表 7)。這些觀察時數並不包含在步道上進行棲地分析或尋找無線電發報器時所花費的時間。

1991~ 1992 年之間，我們有四位工作人員在郡大林道上巡視，所以才得到如此高的觀察時數。目擊指標即來自這些觀察資料：步道上的觀察時數，以及目擊黑長尾雉的次數。然而在 1996 ~ 1999 年之間，僅有一人（本文主要作者）持續記錄了觀察黑長尾雉所耗費的時間，其餘工作人員則記錄了目擊黑長尾雉的事件。他們的觀察記錄並不列入目擊指標或生殖力指標的計算當中。

研究人員觀察黑長尾雉的時間，並非平均的分配於每一天或每個月裡；某些日子有其它關注的目標，有些月份則因氣候或其它因素而缺乏觀察記錄（例如 1996 年 8 月)。因此所有的觀察資料一律以目擊指標——研究人員每小時看見的黑長尾雉數量——來呈現。

我們依照目擊指標來歸納黑長尾雉的每日活動模式（圖 7&8)。這些活動模式和 Bridgman（1994）之觀察（每日清晨有一個活動高峰，其它時間

的活動頻率較低）結論並不相同。以郡大林道為例（圖 7），黑長尾雉的活動高峰在清晨發生一次，下午則另有三次高峰；八通關古道的黑長尾雉則在一天裡有著較為平均的活動頻率分佈（圖 8）：頻率逐漸增加，直到 09:00；中午時分有一短暫高峰；下午在 15:00 ~ 17:00 為最高（圖 8）。整體而言其目擊指標並不高，在 0.3 以下。

至於黑長尾雉在郡大林道上的每月目擊指標，和 1991~ 1992 年的研究有類似的模式（Bridgman 1994）。在圖 9 我們可以看到除了冬季月份之外，林道上整年都有黑長尾雉的活動；而在對關研究地之內的八通關古道，黑長尾雉並沒有相同的活動模式。除了 6 月有一個高峰之外，大多數月份之目擊指標都很類似（圖 10）。這個六月高峰值資料僅來自 1998 年，這表示 6 月是一個很重要的觀察期。因為撰寫國家公園期末報告的緣故，我們在 1997 年以及 1999 年的 6 月並沒有前往研究地；另因氣候的因素，尤其是 1996 年蹂躪南投縣的颱風，使得我們在 1996 年以及 1997 年的 8 月亦無法接近研究地。要研究大多數鳥類的繁殖行為以及生殖力，5 ~ 8 月是非常重要的月份。

另有兩份研究報告（Alexander et al. 1990, Yao 1996）也記錄了步道上黑長尾雉每日及年度的活動模式，但是其資料係目擊黑長尾雉的次數，而非目擊指標。這兩個研究都顯示出黑長尾雉每日活動在清晨以及傍晚的兩個高峰。而在 Bridgman（1994）的研究當中，黑長尾雉的活動模式是以其數量及目擊指標來呈現。其中黑長尾雉數量亦顯示出清晨以及傍晚兩個高峰之活動模式（Bridgman 1994）；但若以目擊指標檢視之，傍晚的活動高峰便消失了。這代表實際上黑長尾雉在步道等開闊區域的活動，主要是發生在清晨（Bridgman 1994）。

所有研究（包括本研究）都指出在較暖和的月份（5 ~ 9 月）當中，步道上有較高的黑長尾雉活動現象，而與觀察時間之長短無關。然而對關研究地的模式並不相同──黑長尾雉整年都使用著步道。這個模式或許也代表步道並不影響黑長尾雉之活動。

以觀察時數來調整目擊資料是非常重要、也是必要的。在我們的研究當中，黑長尾雉活動的呈現，必定伴隨著我們自己的活動記錄，才能確定真正的黑長尾雉活動模式。我們的調查活動並非平均的在每天的每一小時、或者每年的每一個月裡進行；其它的研究活動亦然。事實上，在 Alexander et al.（1990）的研究當中，黑長尾雉每日在午間的低度活動模式很可能是因為午間的調查時間減少了（Bridgman，個人觀察）；在同一個研究計劃裡，冬季期間的調查強度也降低了（Bridgman，個人觀察）。然而 Alexander et al.（1990）使用了目擊指標以及數量來描述黑長尾雉的年度活動模式，因此能夠推斷黑長尾雉冬季期間在步道上的活動大幅降低。以郡大林道而言，後來的研究（Bridgman 1994 以及目前之研究）也支持了這個推論。

活動範圍之遙測

針對每一隻配戴無線電發報器的黑長尾雉，我們計算其每一季的 95% MCP 遙測範圍（表 9&10）。每一季的活動範圍以及位置圖參見圖 11-22。

1996 年秋季（圖 11），我們在對關研究地對五隻黑長尾雉進行無線電追蹤，郡大研究地則有一隻。除了一隻雄性個體（#272）外，牠們只擁有很小的

活動範圍。對關研究地的雌性個體分佈很有趣：活動範圍完全沒有重疊。當然，我們不可能捕捉到所有的雌性個體。

#272 雄性個體的活動範圍在 1997 年冬季略微的減少了（圖 12）。在對關研究地追蹤的三隻黑長尾雉都是雄性，其活動範圍相重疊。而當季在郡大研究地所追蹤的雌性個體，其活動範圍大於 1996 年秋季所追蹤之雌性個體。

1997 年春季（圖 13）共追蹤了六隻黑長尾雉。#272 雄性個體大大擴展了牠的活動範圍，同時也與另一隻雄性個體（#369）重疊。在郡大研究地中，所有雄性或雌性個體的活動範圍都不互相重疊。這並不代表牠們擁有互斥性的領域；相反的，我們曾在其活動範圍中觀察到其它雄性或雌性、沒有配戴無線電發報器的個體。在這個時期，郡大研究地黑長尾雉的活動範圍遠小於對關研究地之個體。

所有黑長尾雉在 1997 年夏季（圖 14）的活動範圍都非常小（小於一公頃），原因之一是無線電遙測取樣的不足。基本上無線電定位次數愈多，所得到的活動範圍愈大；該季所做之無線電定位次數遠少於其它季節（表 9&10）。#1189 雌性個體在當時遺失了無線電發報器，而一年之後又在林道上看見牠；最後在 1999 年春季再度將其捕獲（表 3）。

1997 年秋季（圖 15），#949 雄性黑長尾雉是唯一仍配戴無線電發報器之個體。牠的活動範圍較夏季時大，但位置約略相同。其無線電發報器於 1998 年冬季掉落，所以在該季沒有任何無線電遙測資料。

1998 年春季，我們捕捉、或再度捕捉到七隻以上黑長尾雉（包括 #949 雄性個體），並放置新的無線電發報器。因為所有黑長尾雉都是在該季所捕獲，我們只取得少量的無線電定位資料（表 9&10），並影響了活動範圍的計算。對關研究地的兩隻黑長尾雉擁有各自的活動範圍（圖 16）；而郡大研究地的#949 雄性個體活動範圍和兩隻雌性個體重疊（圖 16）。 #1209 雄性與 #869 雌性個體的活動範圍內曾觀察到其它未攜戴無線電發報器的個體，其活動範圍並不與其它黑長尾雉互斥。

1998 年夏季期間，我們追蹤了 12 隻黑長尾雉。在對關研究地的四隻黑長尾雉（圖 17）當中，三隻雄性個體的活動範圍與其它黑長尾雉重疊。而郡大研究地三隻雄性黑長尾雉之活動範圍不但有相當大的重疊（圖 18），也和四隻雌性個體有所重覆（圖 19）。

1998 年秋季，黑長尾雉的活動範圍增加了（圖 20）。尤其在郡大研究地，似乎所有的黑長尾雉都使用相同的區域。#869 雌性個體轉移、並大大地擴展了其的活動範圍；#949 雄性以及 #707 雌性個體之間、#833 雄性以及 #869、#288 兩隻雌性個體之間的活動範圍大小、位置都相當接近。在對關研究地，#187 雌性個體（在該季因小型肉食性動物的獵捕而死亡）的活動範圍增加、並且和 #487 雄性個體相重疊。在 #187 死亡數天之後，我們很幸運的捕捉到 #228 雌性個體，使得本區裝置有無線電發報器的黑長尾雉數量保持穩定。#228 之活動範圍也和 #487 相重疊。

1999 年冬季，我們追蹤的是相同的七隻黑長尾雉；牠們的活動範圍大小以及位置和秋季的狀況類似（圖 21）。在郡大研究地，所有黑長尾雉都擁有一些共同的活動範圍；而在對關研究地之中，#487 雄性個體的活動範

圍縮小，因而降低了與 #228 **雌性個體的重疊範圍。**

1999 **年春季，我們持續追蹤秋季以及冬季所研究的黑長尾雉。在郡大研究地將近兩年的追蹤之後，我們失去了** #949 **雄性個體的行蹤。以往經常可以在林道上看見牠；在本季的研究當中，不但不見其蹤影，亦無法聽見其無線電訊號. 當時我們在郡大研究地** #949 **經常出沒的路上曾發現陷阱；因此** #949 **可能係遭獵人捕殺，或僅僅是無線電發報器掉落。此外，**#707 **雌性個體也在此時遺失了無線電發報器。但稍後我們尋獲了無線電發報器，也再次目擊到牠。**#1169 **雌性個體則在本季再度被捕獲。剩下的五隻黑長尾雉無線電遙測資料列於圖** 22**。在郡大研究地之中，黑長尾雉的活動範圍降低，並轉移到林道之外；黑長尾雉在對關研究地的活動範圍則與從前類似，但位置稍有移轉。**

Bridgman（1994）**曾發現黑長尾雉在冬季月份之活動會避開郡大林道；在本次研究中它們呈現了相同的模式。然而在對關研究地，無論季節為何，黑長尾雉的活動範圍似乎都包含了八通關古道在內。**

Bridgman（1994）**過去發現黑長尾雉在冬季的** 95% MCP **比其它季節小了許多；此模式在本研究（**1996 ~ 1999 **年）之兩處研究地都沒有發生。在黃腹角雉（***Tragopan caboti***）（**Young et al. 1991**）以及環頸雉（**Hill & Robertson 1988**）的研究當中也有這種冬季活動範圍限制現象的描述。**

這些活動範圍資料呈現的是高度重疊的狀況。那些活動範圍看起來有排斥性的黑長尾雉，其實與其它未配戴無線電發報器的黑長尾雉仍共有著活動範圍；並沒有任何徵候顯示黑長尾雉具有領域性。Bridgman（1994）**曾例**

舉一隻雌性黑長尾雉可能和其它兩隻配戴無線電發報器的雄性個體共用活動範圍。在本次研究當中也是如此：雄性個體與雌性個體之間互享活動空間。

郡大研究地裡的某些黑長尾雉，在捕捉之後就再也沒有被看見過；其活動範圍資料顯示出牠們的活動地點位於林道下方。有些無線電定位資料相當靠近林道，但是並沒有徵候顯示這些黑長尾雉會同時使用林道兩側的森林；這在本次研究中尤為真確。然而在對關研究地，攜帶著無線電發報器的黑長尾雉同時在八通關古道的兩側活動著。

一般而言，黑長尾雉的 95% MCP 範圍是「小型、圓形」或者「橢圓型、平行於等高線」；這顯示黑長尾雉僅做有限度的垂直方向移動。這些觀察結果和 Young et al.（1991）對於中國東南部黃腹角雉（*Tragopan caboti*）的研究發現是一致的。

棲地的使用

根據林務局的資料（1995），郡大研究地的棲地環境以人造混合林佔有優勢，其間雜有台灣紅檜（*Chamaecyparis formosensis*）人造林以及鐵衫林（圖 5）。在對關研究地則以天然混合林具有優勢，其中有闊葉森林以及檜木林（圖 5）。攜帶無線電發報器的黑長尾雉，其 95% MCP 絕大部份位於人造混合林（郡大研究地）或天然混合林（對關研究地）之中。

Bridgman（1994）曾明確的描述黑長尾雉能夠使用受干擾的棲地。在本次

研究當中（1996 ~ 1999 年），研究地區分為郡大研究地（受干擾棲地）以及對關研究地（未受干擾棲地），如此我們便可以檢視黑長尾雉在不同環境下棲地之使用、族群數量以及活動模式的相似和相異之處。雖然仍無法決定哪一種棲地環境較適於黑長尾雉，但我們可以說黑長尾雉能夠使用多種類型的棲地，並有能力在原始、或受干擾的棲地之中生存。

族群估算

利用研究計劃三年（1996 ~ 1999 年）之間所搜集的捕捉、目擊資料，我們計算出兩個研究地黑長尾雉的族群估算值。另外我們也估計了 1991 ~ 1992 年郡大研究地的族群大小（圖 23）。

1991 年 7 月 ~ 1992 年 6 月之間，估計有 50 隻黑長尾雉經常造訪郡大林道。在七年之後，估算值大致相同：1996 年 9 月 ~ 1999 年 5 月之間，約有 53 隻黑長尾雉經常使用郡大林道。在這兩個不同時期的研究當中，調查了相同二公里區段的林道。至於對關研究地，則約有 101 隻黑長尾雉經常造訪八通關古道。這個研究區的步道長度為三公里（11.3 ~ 14.3 km）。

1991 ~ 1992 年之間，在郡大研究地共捕獲 26 隻黑長尾雉，並目擊黑長尾雉 887 次，重見率（重覆看見可辨識之個體）為 50%（Bridgman 1994）。由於樣本大小以及重見率的因素，其 95% 信賴區間頗為狹窄（圖 23），代表族群估計值相當精確。然而在 1996 ~ 1999 年之中，資料樣本數很小，且黑長尾雉之重見率低落。以郡大研究地而言，林道上目擊黑長尾雉 179 次，重見率 15%；在對關研究地的八通關古道上，目擊黑長尾雉 101 次，

重見率 17%。三個研究段落當中所捕捉的黑長尾雉為 17 ~ 26 隻，數量相當。

不論如何，本計劃是第一個使用繫放的方式來估算黑長尾雉族群大小的研究。雖然本研究的再捕捉率太低，並不符合標準的「捕捉-再捕捉」技術，卻可以使用 Bowden 模型估算法，經由被標記的黑長尾雉來估算族群大小。大多數黑長尾雉在被捕捉之後就再也沒有目擊紀錄，有些則有數次重見紀錄（#949 雄性個體的重見次數達 27 次）。這個估算法考量了不同個體間重見率不相同的問題，因此適合應用於本研究。這個模式同樣也適用於 1991 ~ 1992 年的研究。該年 #16 雌性個體的重見次數高達 122 次（Bridgman 1994）。

這些族群數量的估計值是有誤差的。根據估算，過去三年間活動於郡大林道研究地的黑長尾雉族群在 26 ~ 107 隻之間，而在對關研究地的八通關古道上則有 55 ~ 183 隻。這些族群估算之 95% 信賴區間可用來計算研究區以及整個玉山國家公園內黑長尾雉的族群密度。

如同「研究方法」一節當中所述，我們將研究地所有黑長尾雉的 95% MCP 合併以求得研究區面積（圖 6）。這些黑長尾雉全部都是在郡大林道或八通關古道被捕獲，是各研究地當中具有代表性的個體。牠們的 95% MCP 範圍顯示出許多黑長尾雉的活動範圍並不包含林道或是古道（圖 11-22）。

郡大研究地之面積為 0.674 km^2（圖 6），是對關研究地（1.482 km^2，圖 6）的一半大。這些面積可能只是保守估計值；亦即這些在步道上活動之黑長尾雉的遊走範圍實際大於圖 6 所示。如果我們真的低估了研究地面積，族

群密度估計值便顯得太高。因為族群密度係以一個區間來表示（圖 24），我們應該使用最低估計值來呈現黑長尾雉族群的健康狀態。

郡大研究地的黑長尾雉族群密度（29 ~ 119 隻/ km^2）稍低於對關研究地（38 ~ 125 隻/ km^2），對關研究地的估計值下限則與郡大研究地 1991 ~ 1992 年的估計值（37 ~ 86 隻/ km^2）下限差不多。一般而言，研究區內之黑長尾雉族群密度相當高。這些地點原本便以黑長尾雉而聞名，所以我們才將其選擇為研究地；這些地區有著較高的黑長尾雉族群密度估計值，也就顯得相當合理。

我們使用三年研究期間（1996 ~ 1999 年）的族群密度資料來估算產生整個玉山國家公園區內的黑長尾雉族群大小（表 11）。公園區內棲地型態類似於研究地（圖 5）的區域，其位置標示於圖 25。估計在玉山國家公園範圍內，黑長尾雉的數量在 11,000 ~ 39,000 隻之間。

在這個模型當中，我們假設黑長尾雉活動區域的棲地環境和研究地必然相同，而這些地區都具有相同的黑長尾雉族群密度。我們同時也假設黑長尾雉僅出現在海拔 1,600 ~ 3,300 m 之間。然而我們曾在上述條件之外的地區觀察到黑長尾雉，其族群密度也可能具有很大的差異。圖 25 所展示的某些地區也許根本沒有黑長尾雉的存在，而在某些空白地區則毫無疑義的擁有一些黑長尾雉族群。

一但估算了族群密度，我們無可避免地要向外推估。Severinghaus 在 1977 年首次估計了全台灣的黑長尾雉族群大小。他提到，“假如黑長尾雉的數量達到 5,000 至 10,000 隻之間，一點也不令人意外”。在該項研究之前，

一般對黑長尾雉的印象是其數量十分稀少，族群大小僅有幾百隻（Severinghaus 1977）。Severinghaus 的估計是來自郡大林道（長 5 km）上的 21 次黑長尾雉目擊記錄。第二次的黑長尾雉族群估算僅針對玉山國家公園（Severinghaus & Severinghaus 1987）。根據每單位距離目擊之黑長尾雉數量（隻/公里），該研究估計玉山國家公園內的黑長尾雉數量在 5,800 ~ 10,000 之間。本次研究所得到之估計值，則來自兩個經過徹底研究地區（圖 24）之族群密度、棲地資料（圖 5&25），以及傳統概念中的黑長尾雉海拔分佈（1,600 ~ 3,300 m；表 2）。

上述三個研究所做出的族群估算，都是基於不斷增加的探查、不斷增加的目擊資料以及對黑長尾雉不斷增加的瞭解，並有著不斷增加的條件限制。縱然如此，黑長尾雉的族群估計值仍然一次次的提高。這個傾向代表著從 1906 年發現黑長尾雉以來，牠們一直擁有合理且相當穩定的族群大小；不同之處只在於我們對黑長尾雉所增加的瞭解。

相對數量

雖然玉山國家公園仍擁有相當大之黑長尾雉族群，有些證據顯示這個族群正在衰退；至少在過去七年當中並沒有增加。1991 ~ 1992 年之間，郡大林道研究地的黑長尾雉族群估計值是 50；七年之後，其族群估計值為 53。若雌性黑長尾雉每年都能擁有一到五隻幼鳥（Severinghaus 1977, Bridgman 1994），其族群數量應會增加。然而正如我們所知，在過去三年之中，黑長尾雉的生殖力非常低落；在研究地目擊幼鳥以及未成年個體的次數都十分稀少（表 6）。

另一個黑長尾雉族群數量衰退的徵候，係檢視過去在郡大林道研究所獲得之目擊指標（Bridgman 1994），並與現行研究的結果互相比較（表 8）而來。目擊指標即相對數量指標；在某些族群數量無法估算的狀況下，相對數量指標具有很大的價值。以本研究而言，我們已經得到族群估計值，但仍值得與相對數量指標做一比較。

根據黑長尾雉的相對數量，牠們的族群在過去七年呈現衰退現象。以 1996 ~ 1999 年郡大林道而言，每觀察十個小時可以看見一到二隻黑長尾雉（表 8）；而在 1991 ~ 1992 年, 每十個小時可以看到九隻黑長尾雉（表 8；Bridgman 1994）。比較之下，1996 ~ 1999 年是一個很劇烈的衰退。將這些目擊指標資料同前人的研究（Severinghaus & Severinghaus 1987）做一比較，可以看到一些有趣的事。他們的研究所得到的目擊指標為：每十個小時看見將近三隻黑長尾雉（表 8）。如果我們以玉山國家公園從 1985 年成立至今的黑長尾雉相對數量來看，郡大研究地的黑長尾雉族群基本上是維持穩定、或輕微的衰減。也許 1991 ~ 1992 年對黑長尾雉而言是超乎尋常的一年，而 1986 的調查（Severinghaus & Severinghaus 1987）以及近三年研究（1996 ~ 1999 年）所獲得的模式才是典型的狀態。

以上所描述的郡大研究地黑長尾雉相對數量模式，在對關研究地也同樣適用。1991 ~ 1992 年對於對關研究地也是特別的一年，其目擊指標為：每十個小時看見九隻黑長尾雉（表 8；Bridgman，未發表）。如果將觀察黑長尾雉的總時數一併列入檢討的話，這個目擊率更是令人訝異。該年僅花費了 36 小時於對關地區，主要目標亦不在於觀察黑長尾雉；只是在由東埔前往郡大研究地時必須經過對關地區，而由對關步行到觀高需耗時一至

二個鐘頭。在 1996 ~ 1999 年之研究期間，我們才開始常態性的在對關研究地觀察黑長尾雉並收集無線電遙測資料。估且不論觀察黑長尾雉的總時數為何，1991 ~ 1992 年目擊黑長尾雉的總次數仍遠高於 1996 ~ 1999 年的研究（表 8）。若以目擊率來看，這三年研究期間從未達到每十個小時目擊兩隻以上黑長尾雉的紀錄。再次強調的是，顯然 1991 ~ 1992 年對黑長尾雉是極佳的一年。在 Severinghaus and Severinghaus（1987）的研究報告中，此地區的黑長尾雉目擊指標為：每十個小時可以見到一隻黑長尾雉。

在 1991 年秋季以及 1992 年春季當中，有許多目擊記錄是雌性黑長尾雉伴隨著未成年個體；這代表牠們擁有很高的生殖力（表 6）。然而 1996 年以後的情況就大不相同。我們幾次在整個月當中沒有看見任何黑長尾雉。從 1996 ~ 1999 年，不但年度目擊指標以及目擊次數總和都很低落，其生殖力亦不佳。雌性黑長尾雉帶領幼年個體的目擊次數幾乎闕如（表 6）。

或許黑長尾雉擁有一個循環性的生殖力模式：在某些年份具有很高的相對數量以及生殖力，大部分時期則反之。以目前而言，重要的是觀察其相對數量以及生殖力的差異。我們必須從事進一步的研究才能確定黑長尾雉的生殖力模式（如果這個模式存在的話）。有趣的是黑長尾雉在 1991 ~ 1992 年的高生殖力以及相對數量並沒有增加牠們整體的族群大小；若其族群增大，應該可以在 1996 ~ 1999 年之間觀察出來。可能性之一，是黑長尾雉的族群大小一向相當穩定；而黑長尾雉在成年之後必須等待諸如 1991 ~ 1992 這樣的「好年」才有能力繁殖下一代。

建議事項

研究計劃的時程安排

在研究鳥類之繁殖行為及其生殖力時，5 ~ 8 月是很重要的月份。然而在本研究期間，我們必須在這些月份之中為玉山國家公園撰寫報告而無法蒐集資料。國家公園或者是其他機構也許可以稍有彈性地安排研究計劃之行事曆，以免錯失在這些重要季節收集資料的機會。

狩獵

令人感到不安的是，自 1989 年以來狩獵活動倍增的事實。狩獵的主要影響在於人類使用的狩獵技術是沒有篩選性的：無論黑長尾雉是否成年、無論其健康與否，狩獵活動將牠們從族群當中一律移除。狩獵所使用的繩圈特別具有危險性；因為在獵人離去很久之後，這種陷阱仍然可以繼續捕獲動物。

因此我們建議國家公園應該調查區內的狩獵活動，包括狩獵者類型（其經濟及教育狀況、工作及居住地）、狩獵之原因、對象以及方法。要控制公園區內的狩獵活動，社會學研究所透露的訊息可能比單純地增加警力來的有效。

生殖力的監測

生殖力是黑長尾雉維持或增加其族群大小的重要因素。本研究曾指出黑長尾雉在玉山國家公園區內的族群數量相當大；就黑長尾雉的族群大小（Severinghaus & Severinghaus 1987、Garson（私人通訊）以及目前之研究）以及台灣受保護之棲地範圍（Bridgman et al. 1998）來看，我們可以宣佈黑長尾雉仍然是安全的，並沒有滅絕的立即威脅。

本次研究同時認為黑長尾雉的族群並未增長，實際上可能是衰退的；主要原因是在這三年裡，幾乎沒有未成年個體加入族群之中。以壽命可達六到十年的動物（如本研究的某些黑長尾雉）而言，若三年之間沒有任何新成員的加入，可能會危害族群的健康。職是之故，長期的、每年監測黑長尾雉的生殖力是非常重要的。

我們建議玉山國家公園以一個簡單的方法來進行黑長尾雉生殖力之長程監測計劃：

1) 每年七月及九月派員前往郡大及對關研究地進行一週的調查。兩個研究地的調查時間長度必須相等。

2) 每日 06:00 ~ 10:00 以及 14:00 ~ 18:00 兩個時段裡，在郡大林道（67.5 ~ 66.0 km）以及八通關古道（14.3 ~ 0.2 km）緩慢的走動，並小心記錄觀察的時間以及行進距離（記錄表 1）。

3) 看見黑長尾雉時，記錄發生時間、地點，並特別註明雌性個體攜幼之狀況、幼年個體數量等。我們必須知道在一段觀察時間內所目擊的

未成年個體數量，以計算黑長尾雉之年度生殖力指標。

4) **記錄調查期間的步道狀況（例如雜草長度、能見度）、以及氣候狀態。這些因子可能會影響黑長尾雉的目擊率。**

我們必須以這個簡易的方法每年蒐集資料，以評估黑長尾雉的族群是否健康、穩定，並持續調查 10 ~ 20 **年以上。**

ABSTRACT

While the distribution and some notes on behavior have been recorded, very little is known of the biology of the Mikado Pheasant (*Syrmaticus mikado*). It was the objectives of this study to use trapping, observation, and radio-telemetry techniques to improve our understanding of Mikado Pheasants. Of particular interest were: 1) the reproductive potential and pattern, 2) sources of mortality, 3) longevity, 4) habitat use, 5) distribution and interaction of radio-tagged pheasants, and 6) population size of pheasants within the two study sites and within the Yushan National Park.

Research was concentrated in two study areas inside Yushan National Park. The Chun Ta study site was near Kwan Kao on the Chun Ta Logging Road. The Dwei Kwan study site was on the Patungkwan Trail between Kwan Kao Gap and Dwei Kwan. All the data presented here are from these two study sites.

While Mikado Pheasants have high reproductive potential (one to five chicks per female; Severinghaus 1977, Bridgman 1994), productivity from 1996-1999 was very low (productivity index: <0.09 chicks per hour). Avian predators and small carnivores are now known to be predators of Mikado Pheasants. There is also an ongoing human threat. Hunting was found to double from 1992 to 1999. In spite of the mortality, Mikado Pheasants are now known to live as long as 10 years, possibly longer.

The habitat used by radio-tagged pheasants was predominantly mixed forest habitat; either logged or pristine. Radio-tagged pheasants had overlapping

ranges, suggesting lack of territorial behavior. Generally, ranges were very small, or elliptical following the topography. This indicates that there is no elevational migration in this species. It also suggests that individual Mikado Pheasants have their preferred range and do not wander very much.

For the Chun Ta study site, 53 pheasants were estimated to use the logging road. Population density was estimated to be 59 pheasants per km^2. The number of pheasants estimated to use the Patungkwan Trail within the Dwei Kwan study site was 101. This study site had an estimated population density of 69 pheasants per km^2. Inside Yushan National Park, there is about 320 km^2 of habitat similar to that found in the two study sites. Assuming that the density of Mikado Pheasants is constant in these habitats, that they do not occur in other habitats, and that they are found only between 1,600-3,300 m in elevation, there are at least 11,000 Mikado Pheasants inside Yushan National Park. Based on comparisons of relative abundance (Encounter Index) this large population is either stable or declining. Yushan National Park has a large population of Mikado Pheasants. Even so, Mikado Pheasants should still be monitored to examine the patterns of productivity and the effects of hunting.

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INTRODUCTION

The Mikado Pheasant, *Syrmaticus mikado* (Hume), is endemic to the high elevations of Taiwan (Delacour 1951). Until recently, it has been classified as an endangered species (International Union for Conservation of Nature and Natural Resources 1966), primarily because of poaching and habitat destruction (Severinghaus 1977). Since 1993, however, it has been considered safe from the threats of extinction (McGowan & Garson 1995). Regardless, there is much yet to be learned about the bird's life cycle in its natural habitat.

Systematic study of the Mikado Pheasant began in 1975 (Severinghaus 1977). This survey of the island concluded that the pheasant lives at high elevations in primary and secondary growth forests. Shortly after its creation, Yushan National Park was surveyed for Mikado Pheasants in a follow up study by Severinghaus and Severinghaus (1986). Research resumed again in 1989 (Alexander et al. 1990). In this study, research effort was concentrated in the secondary growth habitat of the Chun Ta Logging Road at Kwan Kao. It was in this study, that individual pheasants were trapped and banded. Radio-telemetry study did not begin until 1991 (Bridgman 1994). These studies, especially the last one, thoroughly documented that Mikado Pheasants can and do use secondary growth habitats. Beginning in 1992, Yao Cheng-te of the Taiwan Endemic Species Research Institute began observation and telemetry research of Mikado Pheasants in the broadleaf and mixed forest habitats of the Zueyenshi Nature Reserve. This was the first time research of Mikado Pheasants was concentrated in primary growth habitats.

In 1996, Yushan National Park agreed to support their fourth research project on

Mikado Pheasants. This study is the basis for comparisons of the Mikado Pheasants in two habitat types: the secondary growth habitats of the Chun Ta Logging Road near Kwan Kao; and the primary habitats of the Patungkwan Trail between Dwei Kwan and Kwan Kao. Our objectives were to use trapping, observation, and radio-telemetry techniques to improve our understanding of Mikado Pheasants. Of particular interest was: 1) reproductive potential and pattern, 2) sources of mortality, 3) longevity, 4) habitat use, 5) distribution and interaction of radio-tagged pheasants, and 6) Pheasants population number within the two study sites and within the Yushan National Park.

STUDY SITE DESCRIPTION

The two study sites (Figure 4: 23° 30' N, 121° 00' E) were selected for ease of access and because Mikado Pheasants had been frequently observed there in past studies (Severinghaus 1977, Severinghaus and Severinghaus 1987, Alexander et al. 1990). Both study sites are between 2,000 and 2,700 m in elevation. The Chun Ta study site (Figure 5) aptly fits Severinghaus' (1977) description of mixed disturbed forests. This site is located near the northern edge of Yushan National Park between 65.7 km and 68.1 km along the Chun Ta Logging Road. The Dwei Kwan study site (Figure 4) is on the Patungkwan Trail between Dwei Kwan (10.16 km from the town of Tungpu) and Kwan Kao Gap (14.3 km from the town of Tungpu). The Dwei Kwan study site aptly fits Severinghaus' (1977) description of a primary forest (Figure 5).

The Chun Ta study site (Figure 5) has essentially an eastern exposure. It is extremely steep with slopes measuring from 30° to 80°. The area surrounding the road had been logged of its original *Chamaecyparis formosana* (Taiwan red cypress) forest and has, in the past 20 years, undergone a reforestation program in which red cypress and *Alnus japonica* were planted.

The Dwei Kwan study site is quite different from the Chun Ta study site. It has a western exposure, but probably receives less direct sunlight than the Chun Ta study site because of afternoon cloud and fog cover. This study site is a climax community forest within 1 km of the Chun Ta site (Figure 5). Here, too, the hillsides are very steep with slopes ranging from 30° to 80°. Forest types are the mixed communities of Chamaecyparis, Tsuga, and Pinus that mark the transition zone between the temperate humid forest (1,500 – 2,500 m in elevation) and the subalpine zone (2,500 – 3,000 m in elevation). These forests vary in age class due to naturally occurring landslides and fires. Many trees, especially the Chamaecyparis, may be 1,000 – 3,000 years old (Wang 1968). Because of the steepness of the terrain, there are many naturally occurring landslides. There are also many pockets of secondary growth similar to that of the Chun Ta site.

METHODS

Mapping

Chun Ta Logging Road, between 65.5 km and 67.5 km from the town of Sini, was surveyed using a plane table and alidade to produce a detailed map of the study area. Kwan Kao, a former logging settlement is located at 67.5 km. The Patungkwan Trail from Kwan Kao Gap (14.3 km) to Dwei Kwan (10.16 km) was mapped using a logging tape and Brunton compass. The trail from Kwan Kao Gap to the Chun Ta Logging Road at Kwan Kao was also mapped. Both the logging road and the Patungkwan Trail were marked every 20 meters. The locations of these markers were also mapped. The coordinates of road and trail markers were determined for Taiwan Grid (similar to UTM) and integrated into GIS (Figure 5).

Study Site Maintenance

The Chun Ta Logging Road was trimmed by the project once or three times a year (Figure 1A). This trimming was necessary to allow movement along the road, and to allow for observations of pheasants. The road was usually trimmed to create a corridor 2-3 meters wide. This increased visibility by about 30 meters, greatly increasing the chance of observing pheasants.

The Patungkwan Trail from Kwan Kao Gap to Dwei Kwan was trimmed by park employees twice from July 1996 through May 1999. After trimming, a corridor was created that was about one meter wide. Visibility was limited by the convolutions of the trail, usually between 5 and 20 meters.

Trapping

Between 10 and 30 foot snares (described by Severinghaus, 1977; Figure 1B) were placed most months in each study site. Snares were placed on or adjacent to the road or trail. They were completely destroyed at the end of each trip. Snares were checked hourly during the day (05:30 to 19:00).

Captured pheasants were sexed and classed as adult or juvenile based on coloration and size. Any pheasant 600 g or greater that was also in adult plumage was considered to be an adult. Body mass was determined using a spring scale. Measurements of bill (gape), forewing, tail (longest tail feather), body, and spur were recorded, as were tibiotarsus length, width and diameter (Figure 1C). The dates, time, and trap location were also recorded (Data sheet 4). Birds were photographed and banded with two to four plastic colored leg rings and one numbered aluminum ring. The mean and range of the physical measurements of all pheasants captured from 1990 -1999 were calculated.

Daily Log

Trips to the study site were made monthly from from July 1996 through May 1999. Each trip lasted about 15 days. About half the time was spent at each study site: the Chun Ta Logging Road and the Patungkwan Trail.

A written log of activities, weather, distance traveled and miscellaneous items were kept for each day in the field (Data sheet 1). Weather data, including temperature, degree of cloud cover, precipitation, and wind, were recorded three to six times daily (generally: morning, noon and night). A rain gauge was used for the 1996 -1999 study period, and rainfall was measured twice a day. Survey route information, i.e. distance covered, time expended and number of pheasants (if any) observed, was recorded (Data sheet 2). Miscellaneous items included sightings of hikers, large mammals, other galliform species, locations of nests of small birds, discoveries of traps or snares, and anything else that was of interest.

Observations

The study sites were monitored for Mikado Pheasant activity. For each direct observation of a pheasant, the time, date, location, identification marks such as sex, age, and leg rings, and a description of observed behavior were recorded (Data sheet 2 & 3). All observations were made from the logging road or the trail. Pheasants were followed for as long as they remained on the road or trail.

Nest Survey

During the breeding season, time was spent searching for nests of radio-tagged females thought to be nesting (Figures 1D&2A). Attempts were made to follow radio-tagged females to their nests.

Productivity

Productivity was determined from the number of chicks or sub adults seen during the months of July and September 1991, 1996, 1997, and 1998. The productivity index was calculated as the number of chicks or sub-adults encountered for each hour spent looking for pheasants. The months of July and September were selected because sub-adults were large enough to be easily seen, and because the study sites were visited during these months for each of these years.

Longevity

Longevity was determined by the recaptures of pheasants first trapped in the 1991-1992 study period. Age of recaptured pheasants was estimated based on their estimated age when first captured in 1991-1992.

Mortality

Mortality causes and identification of predators were determined by homing in on pheasants whose radio-transmitter had a mortality signal. In those cases where it was possible to conclude the pheasant was dead, photographs were made, and the cause of mortality determined.

Hunting Index

Hunting intensity was determined by counting the number of snares, gunshots, remains, etc, found or heard during each year from 1989 to 1992, and from 1996 through 1999 (Table 1, Figure 3). This number was divided by the number of days spent in the field during each year (thereby adjusting for differences in observer effort) to create a Hunting Index. Stashes of snares or traps were counted as one unit.

Radio-telemetry System Error

Telemetry system error was estimated by placing transmitters 20 to 150 meters below or above the road and trail. Ten test transmitters were placed in the Chun Ta study site, and eight test transmitters were placed in the Dwei Kwan study site. Bearings were recorded for each test transmitter from the stations most frequently used to radio-locate pheasants in the region of the test transmitter. This data will later be analysed (White & Garrott 1990, Lee et al. 1985) to test the accuracy of the radio-telemetry locations.

Telemetry

Seasonal and yearly ranges for July 1996 though May 1999 were made by following radio-tagged pheasants trapped during this period. Transmitters used were Model WL300 backpack transmitters with a mortality switch (Hi-Tech Services). The mortality signal switched on if the transmitter remained motionless for 11 hours. Transmitters weighed 20 grams, including harness material (about 3% body weight of a 600g pheasant). During this time, all pheasants which weighed more than 600g were radio tagged. Birds were located using LA12-Q portable telemetry receivers (AVM), and 3-element collapsible hand-held Yagi antennas (AVM) or Model RA-14 antennas (Telonics). Transmitter frequencies ranged between 150 and 151 MHz. Three methods of attaching transmitters to the pheasants were used: necklace, duck harness (Dwyer 1972), and backpack.

Radio-tagged Mikado Pheasants were located via triangulation (Kenward 1987, White & Garrott 1990, Data sheet 5) from road and trail markers established at 20 m intervals. Radio locations were made at four hour intervals for a maximum of 4 locations per day. Usually, two or three locations were made per day. In general, ten locations were determined for each bird each month.

Triangulation was made by taking at least three bearings from three different stations (road or trail markers) within a 30-minute period. Bearing angles had to be at least 30 degrees different to be acceptable. Within the study sites, however, differences of 30 degrees were often not adequate to determine the general location of the pheasant. Hence, the need for at least three bearings. Because of problems with bounce, telemetry stations were often several hundred meters apart, and three to 10 bearings were made for each location. While most triangulations could be made within 500 meters, to have telemetry stations 1000 meters apart was not unusual.

To recover transmitters, the radio-telemetry technique of homing was used: the signal was followed as the signal volume increased until the transmitter was found. Homing took as long as eight hours depending on the location of the transmitter and the difficulty of the terrain (Figure 1D). Attempts were made to home in on all transmitters emitting a mortality signal. This mortality signal indicated that either the transmitter had fallen off the pheasant, or the pheasant was dead.

The 95% minimum convex polygon (MCP) range of each pheasant was estimated using triangulation telemetry data. The computer program, TELEM (Coleman 1987), was used to determine the coordinates of telemetry locations. Coordinate data were plotted using ArcView (1994). The program CALHOME (Kie 1994) was used to calculate 95% MCP ranges. The 95% MCP was used because most studies have used this method, allowing for comparisons between studies and between species. A 95% MCP range was calculated for every pheasant having at least 6 locations in a three-month period (season). Each year was divided into four seasons: Winter (December 1 of the previous year through February 28), Spring (March 1 through May 31), Summer (June 1 through August 31), and Fall (September 1 through November 30). These seasons correspond roughly with seasonal changes in the weather and with the yearly cycles in pheasant activity and behavior.

Habitat Analysis

Habitat analysis was done using Geographic Information Systems (GIS). The GIS data of land use type and elevation was collected by the Taiwan Forest Bureau (1995). Maps of the road and trail made during this project were overlaid onto the GIS data (Figure 5). Study site outlines (100% MCP) were determined using the seasonal radio-telemetry ranges of any pheasant with more than six locations (Figure 6). The elevation distribution of Mikado Pheasants was determined from a review of four field guides to Taiwan birds (Severinghaus & Blackshaw 1976, Wang et al. 1991, Chang 1995, and Jan et al. 1996) and the Handbook of the Birds of the World (del Hoyo et al. 1994). These sources generally agreed that the Mikado Pheasant occurs between the elevations of 1,600-3,300 m (Table 2).

A map of Mikado Pheasant habitat inside Yushan National Park was made by highlighting the habitat types found in the two study sites that were between 1,600 and 3,300 meters in elevation. From this GIS model, the area Mikado Pheasant habitat was determined. This data was used to estimate the population of Mikado Pheasants inside Yushan National Park. This model assumes that pheasants only occur between the elevations of 1,600 to 3,300 m, and that pheasants were only found in those land use categories occurring within the two study sites.

Population Estimation

A population estimate was made for the Chun Ta study site for July 1991 through June 1992, and for July 1996 through May 1999. It was also made for the Dwei Kwan study site for July 1996 through May 1999. The population estimate was calculated using mark-resighting data and the Bowden's Model Estimation in the program NOREMARK (White 1996). This estimator was selected because it estimates the population using the study area. It does not estimate population density. In this case, the study area is 2 km of the Chun Ta Logging Road (66.0-68.1 km) or 3 km of the Patungkwan Trail (11.3-14.3 km); all sightings and trapped pheasants were on the road or the trail. Only those encounters on the road & trail within the area's outlines in Figure 6 were used. Bowden's Model estimates population number using the following data: number of pheasants captured, number of resightings for each tagged pheasant, and number of untagged pheasants sighted. Pheasants that were recaptured were considered to be resightings. Bowden's model produces an estimate and a 95% confidence interval (suggested maximum and minimum population number). To calculate population density, the Bowden's population estimate for a study site was divided by radio-telemetry 100% MCP study site area.

The population estimate for the entire Yushan National Park was calculated using the maximum & minimum 1996-1999 estimates of population density (Figure 24) and the land use types within the study sites (Figure 5). Four assumptions were made: 1) that the density of pheasants was constant for all land-use types found in each study area; 2) that pheasants were found in all areas inside the park with the same land-use categories found in the study sites; 3) that no pheasants occurred in any land-use type not found in the study sites, and 4) Mikado only occur between 1,600 and 3,300 in elevation (Table 2). Separate population estimates were calculated for land-use types similar to the Chun Ta study site and for land-use types similar to the Dwei Kwan study site. These two estimates were added together to generate a total estimate for the park. The population estimate for the park is presented as a range: minimum estimate and maximum estimate. The GIS data from the Taiwan Forest Bureau (1995) was used to identify land-use categories and to calculate the area of each land-use category.

Relative Abundance

Relative abundance was determined from the encounter index. This index was calculated to eliminate observer bias. The encounter index was the number of pheasants observed per hour spent looking for pheasants. This index was calculated for each study site for each year from July 1996 through May 1999, and for the year July 1991-July 1992. Estimates from the 1996-1999 study were compared to estimates from the 1991-1992 study to examine the population trends of the Mikado Pheasant.

RESULTS and DISCUSSION

Trapping

Traps were set almost every month. Twenty-one pheasants were captured in the Chun Ta study site. This includes the four pheasants first caught in 1991 or 1992 (Table 3). Seventeen pheasants were captured in the Dwei Kwan study site (Table 4).

Average size and weight of pheasants trapped inside Yushan National Park since 1990 are listed in Table 5. Pheasants in these two study sites weighed less than those trapped in the Zueyenshi Nature Reserve (Yao et al. 1998). Comparisons of the other measurements suggest that Mikado Pheasants inside Yushan National Park are, in general, smaller than those in the Zueyenshi Nature reserve. Some of the differences, however, are due to differences in technique.

Sex Ratio

The sex ratio of pheasants trapped on the Chun Ta Logging Road was 1:1 (Table 3). Most of these pheasants were adult. Of the trapped males, three were juveniles. In the Dwei Kwan study site, the sex ratio was 0.89 males for each female (Table 4). Only one juvenile male was trapped in that study site. It was not possible to determine with any confidence the age of any of the trapped females. This is because by late summer, chicks can be as large and as heavy as adult females (Bridgman 1994), and because juvenile females have the same plumage coloration as adult females. Aging the males is easier, because juvenile males, until they are about a year old, will retain some feathers of female coloration.

Reproduction

A total of 19 female pheasants were radio-tagged during this study (Tables 3&4). No nests were found. Nesting behaviour was deduced from radio-telemetry. A nesting female should have most of her radio-locations in the same place (Bridgman 1994). Only one female exhibited nesting behaviour. Two attempts were made to locate her and her nest. Both failed because she began moving around during the search. While no nests were found, this does not mean that the radio-tagged females were not nesting. Three radio-tagged females were seen with chicks, and five radio-tagged females had brood patches on their abdomens (Figure 2A).

Productivity

The encounter rate of juvenile pheasants is shown in Table 6 as a Productivity Index. For both study sites, the productivity index for the years 1996-1998 are negligible compared to 1991. At this time, it is not possible to say what productivity in the average year is like. Productivity in 1991 was very good. Two of those juveniles (Table 3) survived to be radio-tagged in 1997 and 1998. Productivity for the duration of this study was very poor. Very few juveniles were observed (Table 6), and only four to six (if the trapped females were, in fact, juveniles) were trapped.

A possible hypothesis for the poor productivity of 1996-1998 is the weather. For these three years, there were frequent, very heavy, rains in the study areas during the breeding season (personal observation). In the summer of 1996, two major typhoons visited Nantou County. The study areas are within Nantou County. In the spring of 1997 and 1998, rain appeared in the form of thunderstorms and cloudbursts. It is possible that these heavy rains caused mortality in Mikado chicks due to exposure and hypothermia. The spring and summer of 1991 was very dry. When it did rain, the rains were light (personal observation). Further study is needed to determine the pattern of productivity in Mikado Pheasants. Study is also needed to see if productivity is correlated with yearly weather patterns.

Longevity

Of the 24 pheasants trapped 1991-1992 (Bridgman 1994), four (17%) were recaptured during this study (Table 3). Two of the males were juveniles when captured in 1991 or 1992. They probably hatched in spring or summer of 1991. One of these males was lost in 1997 due to predation by a small carnivore (Table 3). He was probably six years old. The rest of these pheasants were still alive at the end of the study, making one male eight years old and the other male and the female at least 9 years old. These last two individuals cannot be aged, because they were full adults when first captured in 1992 or 1991. They were born no later than 1990.

Mortality

During the first six months of the project, mortality was high. The deaths of at least two of the pheasants that died during this time can be directly attributed to the transmitters (Bridgman et al. 1997). Transmitters probably had an effect on some of the other deaths. The main result of the first six-month's experience was an evaluation of transmitter attachment methods (Bridgman & Lin 1997). After this, transmitters were attached to the pheasant using either the Dwyer method (Dwyer 1972) or the backpack method. During the last 2.5 years of the project, four radio-tagged pheasants died. Causes of mortality were poaching, small carnivores, and avian predators (Tables 3&4). While the method of attaching the transmitter to the pheasant is important, none of the mortalities after December 1996 can be attributed to the transmitter. Eight pheasants carried transmitters for a year or longer. One male was followed for almost two years.

Discovery of dead non-tagged pheasants was entirely serendipitous. Regardless, the remains of three pheasants were found on the Chun Ta Logging Road (1989-1999, personal observation). Between 1996 and 1999, the remains of two pheasants (one a Swinhoe's Pheasant, Figure 3C) were found near fire-rings within the Dwei Kwan study site. Cause of death for these two pheasants was assumed to be poaching.

Clearing the Chun Ta Logging Road may have had a negative effect by making that region accessible to hunters. Trimming the road was necessary for research activities: observing pheasants and doing radio-telemetry. A wellcleared road or trail also attracts Mikado Pheasants (Bridgman 1994). The aspects that make the road and trail attractive to pheasants (ease of movement) also make them attractive to humans. Almost all the hunting activities recorded during this study were on, or immediately adjacent to, the road or trail.

Hunting does still occur within Yushan National Park boundaries. In fact, since 1989, the incidence of hunting inside the Chun Ta and Dwei Kwan study sites has doubled (Table 7). It is a great pity that there is no Hunting Index from the study sites before the existence of the park. As it is, all that can be concluded is that in the past ten years, hunting inside the study area has doubled. For the three-year period (1989-1992) the Hunting Index was 10% or less (Table 7). For the three years of this study (1996-1999), the Hunting Index is 19% or greater. The data used to determine the Hunting Index is listed in Table 1.

The main methods of hunting were snares or guns. Of these two methods, use of snares should cause the greatest concern. Snares continue hunting long after the hunter has left the areas. Snares were found throughout both study sites. Most were on or adjacent to the road or trail. A few, however, were found more than 500 meters distant from the Chun Ta Logging Road in places where there was no trail or other signs of human activity. It appears that snares are placed wherever people may go, regardless of accessibility.

Activity patterns

For the 1991-1992 study period, 1,499 hours were spent looking for pheasants in the Chun Ta study site (Table 8; Bridgman 1994). These hours were spread over 12 months and 152 days (Bridgman 1994). Because the Chun Ta study site was reached only by hiking the Patungkwan Trail, the Dwei Kwan study site of 1996-1999 was also visited, and observations of pheasants were made. During 1991-1992, a total of 36 hours were spent looking for pheasants in this study site (Table F, Bridgman 1994). From 1996-1999, research effort was split between the two study sites, with slightly more time spent in the Chun Ta study site. For each year during this period, between 216 and 423 hours were spend in the Dwei Kwan study site (Table 8). Between 343 and 396 hours were spent looking for pheasants in the Chun Ta study site (Table 8). None of these estimates of hours expended include time spent off the road or trail doing habitat analysis or searching for transmitters emitting a mortality signal. For the three years from July 1996 through May 1999, 100, 69, and 113 days, respectively, were spent in the two study sites (Table 7).

The high number of hours expended in the 1991-1992 study period is due to the fact there were four people patrolling the Chun Ta Logging Road. All four people recorded the data needed to create an Encounter Index: time spent on the road or trail and number of pheasants observed. During the 1996-1999 period, only one person (the primary author) kept track of hours spent as well as pheasants observed. Other people helping with the study only recorded encounters with pheasants. Their observations were not used in the calculations of the Encounter Index or Productivity Index for this period.

Not all hours of the day, or months of the year, were equally surveyed by the people doing the research. Time was taken for meals or for other aspects of the project. Some months were not surveyed (i.e. August 1996) because of weather or other reasons. Therefore, all the observation data has been presented as an Encounter Index: the number of pheasants encountered for each hour expended by the researchers.

Summary of daily activity patterns of Mikado Pheasants, as determined by the Encounter Index, can be seen in Figures 7&8. These activity patterns are different from those observed in Bridgman (1994): a peak in the early morning, with a low rate of activity for the rest of the day. For the Chun Ta Logging Road (Figure 7), pheasant activity showed an early morning peak, a mid-morning lull, and three peaks in the afternoon. Activity patterns on the Patungkwan Trail were different than on the Chun Ta Logging Road. Pheasant activity was much more evenly distributed throughout the day (Figure 8). There were three peaks: a gradual increase until about 09:00, a short peak around noon, and an afternoon peak from 15:00 to 17:00 (Figure 8). Overall, the Encounter Index was low: less than 0.3.

The monthly Encounter Index on the Chun Ta Logging Road shows a pattern similar to that of the 1991-1992 study (Bridgman 1994). In Figure 9, one can see that pheasants are active on the road throughout the year, except in the winter months. Pheasant activity on the Patungkwan Trail inside the Dwei Kwan study site does not show the same pattern. Except for a peak in June, the Encounter Index was similar for most months (Figure 10). This June peak is entirely based on encounters in June 1998. This suggests that surveys during the month of June are important. Neither study site was visited June 1997 or 1999, because of the logistics of writing and presenting final reports to Yushan National Park Headquarters. Neither study site was visited in August 1996 or 1997 because of the weather and logistical reasons. The typhoons that devastated Nantou County in 1996, prevented access to the study site that year, especially. Spending time in the field during the summer months of May, June, July, and August is very important for understanding the breeding behaviour and productivity of most birds.

Two other studies have recorded Mikado Pheasant daily and yearly patterns of activity on roads and trails. These studies did not present their data as an Encounter Index. Data was presented as number of pheasants observed (Alexander et al. 1990, Yao 1996). These two studies show two peaks of daily activity: early morning and late afternoon. Bridgman (1994) presents patterns of activity using both pheasant number and the Encounter Index. Data using pheasant number indicated an early morning and late afternoon peaks of activity (Bridgman 1994). When this data was adjusted for survey effort, the afternoon peak disappeared, suggesting that pheasants were mainly active in open areas like roads and trails in the early morning (Bridgman 1994).

All studies, including this study from 1996-1999, indicate that most pheasant activity on roads and trails is in the warmer months (May through September). This pattern emerges regardless of whether the encounter data is adjusted for survey effort. It is only the Dwei Kwan study site that show a different pattern – one that suggests pheasants use the trail throughout the year. This pattern may also suggest that the existence of the trail does not affect Mikado Pheasant activity.

Adjusting encounter data for survey effort is important. In our study, we presented all pheasant activity relative to our own activity. Doing this should help us to determine the true pattern of activity in the Mikado Pheasant. This adjustment is necessary, because not all hours of the day or months of the year were surveyed equally. This must certainly be the case for other studies. In fact, the mid-day low in daily activity shown in Alexander et al. (1990) is most likely due to the fact that survey effort during mid-day was reduced (Bridgman, personal observation). For this same study, survey effort during the winter months was also reduced (Bridgman, personal observation). Alexander et al. (1990) used the Encounter Index in addition to pheasant number to describe Mikado Pheasant yearly activity patterns. Because they did so, they were able to conclude that pheasant activity on roads and trails is greatly reduced during winter months. For the Chun ta Logging Road, this conclusion is supported by later studies (Bridgman 1994, present study).

Telemetry ranges

The 95% MCP telemetry ranges were calculated for each radio tagged pheasant for each season. Range size and seasons for each pheasant are presented in Tables 9&10. Range maps and locations are displayed for each season in Figures 11-22.

For the fall 1996 season (Figure 11), five pheasants were radio tracked in the Dwei Kwan site and one was followed in the Chun Ta site. Except for the one male (#272), all the ranges were small. The distribution of the female ranges on the Dwei Kwan site is interesting: non-overlapping. By no means were all the females in this area trapped or radio-tagged.

For winter 1997 (Figure 12), the range of male #272 decreased slightly. All three pheasants radio-tracked on the Dwei Kwan study site were male, and their ranges all overlapped. For the Chun Ta study site, the female followed in this season had a larger range than the female followed fall 1996.

In the spring of 1997 (Figure 13), six pheasants were followed. Male #272 greatly expanded his range. During this time, his range also overlapped another male's (#369). In the Chun Ta study site, neither the range of the males nor the females overlapped. This does not indicate defended territories, however, as there were non-tagged pheasants of both sexes observed throughout the study area. Ranges were all much smaller than in the Dwei Kwan study site.

Ranges during the summer 1997 (Figure 14) were all very small (less than 1 ha). One reason for these small sizes may be an artifact of radio-telemetry sampling. Basically, the more locations the larger the range. In general, the number of radio-locations per pheasant during this season were much smaller than for any other season (Tables 9&10). Female #1189 managed to lose her transmitter during this season. A year after this, she was sighted on the logging road. She was finally recaptured in spring 1999 (Table 3).

During fall 1997 (Figure 15) there was only one pheasant carrying a functional transmitter (male #949). His range increased from its summer time size, but the location remained about the same. There is no telemetry data for winter 1998. By this time, even the transmitter on male #949 had fallen off.

During spring 1998, more than seven pheasants were trapped, or recaptured, and radio-tagged. These pheasants included male #949, who was given a new transmitter. Because all these pheasants were trapped during this season, the number of radio-locations per pheasant is low (Table 9&10), affecting range size. The two pheasants in the Dwei Kwan study site had disjunct ranges (Figure 16). In the Chun Ta study site, however, three of the pheasants had overlapping ranges. Male #949 shared parts of his range with two females (Figure 16). As for the other two pheasants, male #1209 and female #869, their ranges were not exclusive, as non-tagged birds were observed.

Twelve pheasants were followed during the summer of 1998. Four of these pheasants were in the Dwei Kwan study site (Figure 17). The three males all shared parts of their range. In the Chun Ta study site, three males also had ranges with considerable overlap (Figure 18). These ranges also overlapped with four females (Figure 19).

Range size increased in fall 1998 (Figure 20). In the Chun Ta study site, especially, all the pheasants appeared to be using the same area. Female #869 shifted, and greatly expanded, her range. There was close overlap in range size and location for male #949 and female #707, and for male #833 and females #869 and #288. In the Dwei Kwan study site, female #187 expanded her range, which happened to overlap male #487. Female #228 was trapped during this time, and her range also overlapped with male #487. Female #187 died during this season, predated by a small carnivore. A few days later, we were fortunate enough to capture female #228, keeping the number of radio-tagged pheasants in this study site stable.

For winter 1999, the same seven pheasants were radio-located. Range size was similar to that in the fall, and in similar locations (Figure 21). In the Chun Ta study site, all the pheasants had some area in common. In the Dwei Kwan study site, male #487 reduced his area of activity somewhat. One effect of this was a reduction in overlap with female #228.

During spring 1999, we continued following the pheasants of the previous fall and winter. It was in this spring, that we lost track of male #949, after following him for almost two years. He had also been frequently observed on the logging road. During spring 1999, we did not see him on the road, and we could not pick up a signal from his transmitter. During this spring, we did find snares on the road in the region where we had often observed this male. It is possible that the transmitter battery expired. It is also possible that he was trapped by hunters visiting the study site. Female #707 managed to lose her transmitter. This transmitter was recovered, and the female, herself, was resighted. Female #1169 was recaptured during this season. Radio-telemetry data for the remaining five pheasants are in Figure 22. Range size in the Chun Ta study site decreased. Ranges also shifted away from the logging road. In the Dwei Kwan study site, range sizes were similar, but their location also shifted somewhat.

Bridgman (1994) found that Mikado Pheasants avoided the Chun Ta Logging Road during winter months. For the current study, this pattern continues. In the Dwei Kwan study site, ranges seem to include the Patungkwan Trail, regardless of the season.

While Bridgman (1994) found that winter 95% MCP ranges were considerably smaller than during other seasons, this pattern was not observed for either study site from 1996-1999. Restriction of activity in the winter has been observed in Cabot's Tragopan, *Tragopan caboti* (Young et al. 1991), and in the Ring-necked Pheasant (Hill & Robertson 1988).

Examination of these ranges shows that there is a high degree of overlap. Those pheasants showing ranges that appear exclusive still share the area with non-radio-tagged pheasants (personal observation). There is no indication that

Mikado Pheasants are territorial. Also, examination of the spring and summer ranges (the breeding season), do not help clarify the breeding system of Mikado Pheasants. Bridgman (1994) demonstrated that one female could share the range of two radio-tagged males. Here, too, males share ranges with multiple females and females share ranges with multiple males.

Several of the pheasants captured in the Chun Ta study site were never seen again. Their ranges show their activity to be below the road. Some radio-locations were quite close to the road, but there is no indication of these birds using the forest on both sides of the road. This is particularly true for the last year of the study. For the Dwei Kwan study site, radio-tagged pheasants appeared to be active on both sides of the Patungkwan Trail.

In general, Mikado Pheasant 95% MCP ranges were either small and round, or elliptical, paralleling the topography. This suggests that the Mikado make only limited altitudinal movements. These observations are consistent with the findings of Young et al. (1991) in their study of the pheasant Cabot's Tragopan, *Tragopan caboti*, of southeastern China.

Habitat Use

According to the inventory data of the Taiwan Forest Bureau (1995), the Chun Ta study site is predominantly Mixed Plantation Forest, with patches of *Chamaecyparis formosensis* Plantation and *Tsuga* Forest (Figure 5). The Dwei Kwan study site is predominantly Mixed Forest with patches of Broadleaf Forest and *Chamaecyparis* Forest (圖 5). Almost all of the 95% MCP ranges of radio-tagged pheasants are in Mixed Plantation (the Chun Ta study site) or Mixed Forest (the Dwei Kwan study site).

Bridgman (1994) clearly documented that Mikado Pheasants can use disturbed habitats. During the study period 1996-1999, research effort was divided between the Chun Ta study site (disturbed habitat) and the Dwei Kwan study site (pristine habitat) to examine differences and similarities in use, population number, and activity patterns of the pheasant. While it is not yet possible to say that one habitat type is better or more suitable than another, one can say that Mikado Pheasants use a variety of habitats and are capable in surviving in habitats that are pristine or disturbed.

Population Estimate

A separate population estimate was made for each study site. Data of captures and resightings were compiled for the entire three-year period: 1996-1999. A third population estimate was made for the Chun Ta study site for the year 1991-1992. Estimates and 95% confidence intervals are presented in Figure 23.

Fifty pheasants were estimated to frequent the Chun Ta Logging Road from July 1991 through June 1992. Seven years later, the estimate is about the same: 53 pheasants using the logging road from September 1996 through May 1999. For both time periods, the same 2 km section of road was surveyed. For the Dwei Kwan study site, about 101 pheasants were estimated to frequent the trail. Three kilometers of trail were surveyed for this estimate (14.3 km to 11.3 km).

From 1991-1992, in the Chun Ta study site, 26 pheasants were trapped, and there were 887 encounters. The resighting rate was 50% (Bridgman 1994). Because of this sample size and resighting rate, the 95% confidence interval is fairly narrow (Figure 23). This suggests that the population estimate of 50 pheasants frequenting the logging road is reasonably accurate. The confidence intervals for the years 1996-1999 are nowhere near as narrow (Figure 23). Sample sizes were small, and the resighting rate was low. For the Chun Ta study site, 179 pheasants were encountered on the logging road. The resighting rate of tagged pheasants was 15%. On the Patungkwan Trail, the resighting rate was 17%, and 101 pheasants were encountered. The number of pheasants trapped was similar for all three estimates: 17 to 26 pheasants.

Regardless, this is the first time a population estimate has been made for Mikado pheasants using tagged animals. In previous studies, all analyses were of unmarked pheasants. For this study, recapture rates were too low for standard capture-recapture techniques. With banded pheasants, however, it was possible to estimate population using the Bowden's Model Estimator. This estimator was appropriate to this study because it considers differences in resighting rates for different individuals. While most of the trapped pheasants were never resighted, some were seen multiple times. In particular, male #949 was resighted 27 times. This pattern holds for the study from 1991-1992, as well. During that year, one female, #16, was resighted 122 times (Bridgman 1994).

These population estimates are limited. According to these estimates, the population of Mikado Pheasants using the Chun Ta Logging Road in the past three years may be as few as 26 individuals or as many as 107. The population using the Patungkwan Trail may be as few as 55 or as many as 183. These 95% confidence intervals are used in the following efforts to determine population density for the study areas and for the Yushan National Park as a whole.

As outlined in the Method's section, the 95% MCP ranges of all radio-located pheasants within each study site were combined to determine the area of the study site (Figure 6). All of these radio-located pheasants were trapped on the Chun Ta Logging Road or the Patungkwan Trail. These pheasants were used in the calculation of the population estimate. They were considered to be representative of the pheasants in each study site. A review of their 95% MCP ranges reveals that many of the pheasants had ranges that did not include the road or trail (Figures 11-22).

The Chun Ta study site had an area of 0.674 km^2 (Figure 6). It was half the size of the Dwei Kwan study site, which had an area of 1.482 km^2 (Figure 6). It is possible that these estimates of area are conservative and that pheasants observed on the road and trail wandered further than is indicated in Figure 6. If these estimates of area are conservative, then the estimates of population density will be artificially high. While estimates of population density are presented as a range (Figure 24), the lowest estimate should be used for determining the health and conservation status of Mikado Pheasants.

Because of differences in area, the population densities in the two study sites are similar. The density for the Chun Ta study site is slightly lower (29-119 pheasants/ km^2) than for the Dwei Kwan study site (38-125 pheasants/ km^2). The minimum estimate for the Dwei Kwan study site is similar to that for the Chun Ta study site for 1991-1992 (37-86 pheasants/ km^2). In general, the densities are quite high. When one considers that these study areas were selected because of their reputation for having pheasants, these estimates may not be unreasonable.

The estimates of population density for this study period (1996-1999) were used to generate an estimate of population number for the entire Yushan National Park (Table 11). The locations of habitat types similar to those found within the study sites (Figure 5) are shown in Figure 25. There are probably between 11,000 and 39,000 Mikado Pheasants within Yushan National Park.

This model assumes that Mikado Pheasants are found only in those habitats described for the study areas and that they are found at the densities estimated for the study areas. It also assumes that Mikado Pheasants occur only between 1,600 m and 3,300 m in elevation. It is a fact that Mikado have been observed in areas outside that described in this model. It is also highly probable that densities of Mikado Pheasants vary. Some of the places shown in Figure 25 may not have any Mikado Pheasants at all. Some of the places left blank certainly do have populations of Mikado.

Once an estimate of population density has been determined, the tendency to extrapolate is irresistible. The first population estimate of Mikado Pheasants was made by Severinghaus in 1977 for the whole island. He said "I would not be surprised if [Mikado Pheasants] numbered between 5,000 and 10,000 individuals" (p. 198). Previous to this study, the general impression was that the Mikado was rare with a population size in the hundreds (Severinghaus 1977). Severinghaus's estimate is derived from the number of pheasants (21) encountered along 5 km of logging road. As the logging road switched back and forth, the road was used to estimate area. The second population estimate was made for Yushan National Park (Severinghaus & Severinghaus 1987), only. This estimate, 5,800-10,000, was determined using the rate at which pheasants were encountered (pheasants/km) at different elevations. The estimate of the current study used the densities of two thoroughly researched areas (Figure 24), the habitats of these areas (Figures 5&25) and the traditionally accepted elevation distribution of the pheasant (1,600-3,300 m; Table 2).

These three population estimates are based on a continually increasing understanding of the Mikado. Each estimate is also based on an increasing amount of effort on the part of the investigators, and on an increasing number of encounters with the pheasant. Each of these estimates is also based on increasingly limited assumptions. Regardless, the estimates of population have also increased in number. This trend in population estimation suggests that the Mikado Pheasant population has been reasonably large and reasonably stable ever since its discovery in 1906. The difference appears to be due to our increased understanding.

Relative Abundance

While there is a reasonably large population of Mikado Pheasants inside Yushan National Park, there is some evidence that the population has declined. At the very least, it has not increase in the past seven years. The population estimate for the Chun Ta Logging Road for 1991-1992 was 50 pheasants. Seven years later, the estimate for 1996-1999 is 53 pheasants. When one considers that female Mikado are capable of having one to five chicks each year (Severinghaus 1977, Bridgman 1994), the population should be increasing.

We know, however, that productivity has been very low these past three years. Encounters with chicks and juveniles have been rare at both study sites (Table 6).

Another indication of population decline is found by looking at the Encounter Index for the Chun Ta Logging Road from past studies (Bridgman 1994) and the current study (Table 8). This Encounter Index is an index of relative abundance. There are many instances where an estimate of population number cannot be calculated. In these cases, indices of relative abundance have great value. For this study, we have estimated the population of the two study sites. But, it is worthwhile comparing this estimate to the index of relative abundance.

Examination of Mikado relative abundance indicates a population decrease over the past seven years. For the Chun Ta Logging Road from 1996 to 1999, one or two pheasants were seen for every ten hours of survey (Table 8). This is a sharp decline from the 1991-1992 study, when nine pheasants were seen for 10 hours of investigation (Table 8; Bridgman 1994). What is interesting, however, is a comparison of these Encounter Indices with Severinghaus and Severinghaus (1987). In their study, they had an encounter index of almost three pheasants for every ten hours survey (Table 8). If one considers the relative abundance of Mikado Pheasants inside Yushan National Park since its creation in 1985, the population at the Chun Ta study site has basically remained stable or shown a slight decline. The year 1991-1992 appears as an extraordinarily good year for pheasants. It may be that the patterns observed in 1986 (Severinghaus & Severinghaus 1987) and over the past three years (1996-1999) are more typical.

The patterns of relative abundance described above for the Chun Ta study site also hold for the Dwei Kwan study site. Here, too, the 1991-1992 study period appears as an exceptionally good year for observing pheasants. The encounter index was nine pheasants for every ten hours of survey effort (Table 8; Bridgman, unpublished data). When one considers the quality of the survey effort, this encounter rate is even more surprising. Only 36 hours were spent in this study site during that year, and the focus of these 36 hours was not to look pheasants but to reach the Chun Ta study site. During this year, one to two hours were spent at a time between Dwei Kwan and Kwan Kao, during the hike from Tungpu to Kwan Kao. For the 1996-1999 study period, most of the hours spent in the Dwei Kwan study site were devoted to collecting radio-telemetry data and to looking for pheasants. Regardless of the differences in amount and quality of effort, Mikado were encountered much more frequently in 1991-1992, than from 1996-1999 (Table 8). For the three years of this study, the rate of encounter has never been over two pheasants per 10 hours of effort. Once again, it appears that 1991-1992 was an incredibly good year for pheasants. Severinghaus and Severinghaus (1987) report an encounter index for this study site of one pheasant per 10 hours effort.

The relative abundance of Mikado Pheasants has declined since 1991. In 1991-1992, pheasants were so abundant that encounters in both study sites were frequent and high. Many of the encounters in the Fall 1991 and Spring 1992 were of females with juveniles. This indicates high productivity as well (Table 6). During this year, pheasants were abundant and productive. Since 1996, however, the story has been quite different. There are whole months when not a single pheasant was encountered. The yearly and total encounter index for this period (1996-1999) is low. Encounters with pheasants were rare. Furthermore, productivity was also low. Encounters of females with juveniles were almost non-existent (Table 6).

It is possible that Mikado Pheasants show some cycling in their productivity: high productivity and high relative abundance in some years, low or no productivity and low relative abundance in most years. At current, just the observation of the differences in relative abundance and productivity is important. Further study should be made to determine the pattern, if any. It is interesting that the productivity and relative abundance of 1991-1992 did not result in an overall increase in population, which would have been observed for 1996-1999. It is possible that Mikado Pheasant population size is fairly stable. It may well be that the survival of Mikado Pheasants depends on the survival of its adult population. These adult pheasants may be needed to wait for a year like 1991-1992 to produce the next generation of pheasants.

RECOMMENDATIONS

Project Scheduling

To understand the breeding behaviour and productivity of most birds, it is very important that time be spent in the field during the months of May, June, July, and August. During this project, collecting data during these months was sacrificed to fulfill funding requirements of the Yushan National Park Headquarters: writing and presenting proposals, progress reports, and final reports. Organizations such as Yushan National Park might wish to consider flexible scheduling for projects or the presentation of reports to encourage data collection during the important spring and summer breeding season.

Hunting

It is disturbing that the incidence of hunting has doubled since 1989. The main effect of hunting is the removal of adult pheasants from the population. All the techniques used by humans are non-discriminatory: removing pheasants in good health as well as pheasants in poor condition. The use of snares is especially dangerous, because snares continue to trap animals long after the hunter has left the area.

Therefore, it is recommended that Yushan National Park investigate the incidence of hunting within its borders. The types of hunters (economic and educational status, place of employment and residence) should be examined. The motivation, targets, and methods of hunting should be determined. This sort of sociological study may reveal information much more useful to control hunting within the park than merely increasing the presence of police.

Productivity Monitoring

Productivity is very important for maintaining or increasing Mikado Pheasant populations. This study has documented that the population number of Mikado Pheasants inside Yushan National Park is quite large. The population size (Severinghaus & Severinghaus 1987, Garson (personal communication), current study) and the extent of protected habitat in Taiwan (Bridgman et al. 1998) is enough to declare this species safe from the immediate threats of extinction.

This study has also determined that the Mikado Pheasant population is not growing and may actually be declining. This is primarily due to lack of recruitment. For three years, almost no juveniles have been added to the population. For an animal that lives 6 to 10 years (as have some of the pheasants in this study), a period of three years without recruitment could damage the health of the population. It is important that productivity in Mikado Pheasants be monitored on a long-term, yearly, basis.

Therefore, it is recommended that Yushan National Park implement a long-term productivity survey. The methodology of this study is simple, and the amount of research effort is small.

1) The Dwei Kwan study site and the Chun Ta study site should be visited

by one or two people every year during July and September. Visits need only last one week, but both study areas should be surveyed equally.

2) The Chun Ta Logging Road (67.5 km to 66.0 km) and the Patungkwan Trail (14.3 km to 10.2 km) should be slowly walked each day from about 06:00 - 10:00 and from 14:00 - 18:00. Careful record should be kept of the time and distance surveyed (Data Sheet 1).

3) The time and location of all observed pheasants should be recorded. Special note should be made of groups of females with chicks, especially the number of chicks with each female. It is this data that is needed to calculate a yearly productivity index: number of juveniles encountered for the number of hours spent surveying.

4) Records of trail and road condition (e.g. herb height, visibility) and of the weather during the survey should also be recorded. These conditions may have an effect on pheasant encounter rate.

This simple survey should be made each year for 10 to 20 years (or even longer). The data gained from such a survey is necessary to make evaluations about the population health and population stability of Taiwan's Mikado Pheasants.

參考文獻 LITERATURE CITED

王嘉雄、吳森雄、黃光瀛、楊秀英、蔡仲晃、蔡牧起、蕭慶亮，1991・台灣野鳥圖鑑・亞舍圖書有限公司。

姚正得，1996・瑞岩溪自然保護區黑長尾雉之生物學初探・野生動物保育彙報及通訊 4 (2): 3-8。

姚正德、艾台霖、蔡銘源、黃秀珍、許富雄，1998・黑長尾雉在瑞岩溪自然保護區之繁殖與生態・第三屆海峽兩岸鳥類學術研討會論文集。

喬雅玲、林良恭，1997・台灣帝雉無線電追蹤之方法評析初探・野生動物保育彙報及通訊 5 (2): 2-5。

張萬福，1985・台灣鳥類彩色圖鑑增訂再版・禽影圖書有限公司。

詹照欽主編，1996・保育類野生動圖鑑・台灣省特有生物研究保育中心。

歐保羅、張萬福、喬雅玲，1990・特定鳥類族群及行為之研究——帝雉・內政部營建署玉山國家公園管理處。

謝孝同、劉小如，1987・玉山國家公園帝雉、藍腹鷴生態調查研究報告・內政部營建署玉山國家公園管理處。

Alexander, P.S., W.F. Chang, and C.L. Bridgman. 1990. Special research topics on bird communities and behavior: the Mikado Pheasant. Yushan National Park Administration Report No. 1034. Department of Construction, Ministry of Interior, Taiwan. 78pp. (in Chinese).

ArcView: The Geographic Information System for Everyone. 1994. Environmental Systems Research Institute, Inc. Redlands, CA. 98pp.

Bridgman, C.L. 1994. Mikado Pheasant use of disturbed habitats in Yushan National Park, Taiwan, with notes on its natural history. Unpublished Master's Thesis, Eastern Kentucky University, Richmond, KY. 96pp.

Bridgman, C.L. and L.K. Lin. 1997. Critique of methods used to radio-tag Mikado Pheasants in Taiwan. *Notes of Wildlifers and Newsletter of Wildlifers* 5(2):2-5. (in English with Chinese abstract).

Bridgman, C.L., L.K. Lin and L.S. Chen. 1997. Winter mortality of *Syrmaticus mikado* inside Yushan National Park. *Proceedings of Taiwan's First Bird Study Symposium*, 10 May 1997, Taipei, Taiwan.

Bridgman, C.L., F.L, Feng, and L.K. Lin. 1998. The range of Mikado Pheasants in the mountains of Taiwan. *Proceedings: IUFRO Inter-Divisional Seoul Conference*. 12-17 October 1998. Seoul, Korea.

Chang, W.F. 1985. *A Field Guide to the Birds of Taiwan.* 2nd Ed. Chin Ying Book Publishing Company. Taichung, Taiwan. 346pp. (in Chinese and English).

Coleman, J.S. 1987. *User's Guide to TELEM*. Dept. Fish and Wild. Sci., Virginia Polytechnic Inst. and State University, Blacksburg, VA. 46pp.

Delacour, J. 1951. *The Pheasants of the World*. Country Life, Ltd., London. 347p.

del Hoyo, J., A. Elliott, and J. Sargatal, eds. 1994. *Handbook of the Birds of the World*. Vol. 2. New world vultures to guinea fowl. Lynx Editions, Barcelona. 638pp.

Dwyer, T.S. 1972. An adjustable radio package for ducks. *Bird Banding* 43:282-284.

Hill, D. and P. Robertson. 1988. *The Pheasant: Ecology, Management, and Conservation*. BSP Professional Books, Oxford. 281pp.

International Union for Conservation of Nature and Natural Resources. 1966. *Red data book,* Aves. International Union for the Conservation of Nature and Natural Resources, Morges, Switzerland.

Jan, J.C., ed. 1996. *A Guide to Wildlife Conservation in Taiwan.* Taiwan Endemic Species Research Institute, Nantou County, Taiwan. 320pp (in Chinese).

Kenward, R.E. 1987. *Wildlife Radio-tagging: Equipment, Field Techniques and Data Analysis*. Academic Press, London. 222 pp.

Kie, J.G. 1994. *Program CALHOME: A Home Range Analysis Program*. MS-Dos Version 1.0.

Lee, J.E., G.C. White, R.A. Garrott, R.M. Bartmann, and A.W. Alldredge. 1985. Accessing accuracy of a radio telemetry system for estimating animal locations. *Journal of Wildlife Management* 49:658-663.

McGowan, P.J.K., and P.J. Garson. 1995. *Status Survey and Conservation Action Plan 1995-1999: Pheasants*. IUCN, Gland, Switzerland. 116pp.

Severinghaus, S.R. 1977. A study of the Swinhoe's and Mikado Pheasants in Taiwan with recommendations for their conservation. Ph.D. Diss., Cornell Univ., Ithaca, NY. 362pp.

Severinghaus, S.R. and K.T. Blackshaw. 1976. *A New Guide to the Birds of Taiwan*. Mei Ya Publications, Inc. Taipei, Taiwan. 222pp. (in Chinese and English).

Severinghaus, S.R., and L.S. Severinghaus. 1987. Ecological status report of the Mikado Pheasant and the Swinhoe's Pheasant. Yushan National Park Report. 102pp. (in Chinese).

Taiwan Forest Bureau. 1995. *The Third Forest Resources and Land Use Inventory in Taiwan.* Taiwan Forest Bureau Publications. Taipei, Taiwan. 258 pp. (in Chinese).

Wang, C.S., S.S. Wu,K.I. Huang, S.I. Yang, J.H. Tsan, M.C. Tsan, and C.L. Hsiao. 1991. *A Field Guide to the Birds of Taiwan.* Ya-Sir Publications, Inc. Taichung, Taiwan. 276pp. (in Chinese).

White, G.C. 1996. *Program NOREMARK Software Reference Manual.* Department of Fishery and Wildlife, Coloradio State University.

White, G.C., and R.A. Garrott. 1990. *Analysis of Wildlife RadioTracking Data*. Academic Press, Inc., San Diego, CA. 383pp.

Yao, C.T. 1996. Ecological study of Mikado Pheasants (*Syrmaticus mikado*) in Zueyenshi Nature Reserve. *Notes of Wildlifers and Newsletter of Wildlifers* 4(2):3-8. (in Chinese).

Yao, C.T., T.L. Ai, M.Y. Tsai, S.J.Huang, and F.S. Shu. 1998. Breeding ecology of Mikado Pheasants in the Zueyenshi Nature Reserve. *Proceedings: The Third Conference of China and Taiwan Birds.* 21-22 January 1998. (in Chinese).

Young, L., G.M. Zheng, and Z.W. Zhang. 1991. Winter movements and habitat use by Cabot's Tragopans Tragopan caboti in southeastern China. *Ibis* 133:121-126.