

農委會林業特刊第17號

COA Forestry Series No. 17

台灣赤腹松鼠之生態、爲害與防治 試驗研究彙編

Abstracts of Studies and Research Reports Published in Taiwan
on Ecology, Damage and Control of Taiwan Red-bellied Tree Squirrels



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台大森林學系編輯
行政院農業委員會印行
中華民國七十七年六月

序 言

台灣松鼠為害乃林業上之重要保護問題，對於造林成果與木材生產之影響殊大，林業界甚為重視。最近10年間，早期在國科會與後期在農委會大力支持推行研究之下，已有相當的研究結果，且已轉移到實際之防治技術上，而使松鼠為害林木之情況顯著減少。本書乃就10餘年來台灣赤腹松鼠（包括飛鼠）有關生態、為害與防治之研究文獻共60餘篇加以摘錄，以期供研究與實務人士之參考。本研究彙編之印刷乃由農委會所支助，特致謝意。

在過去10年間，台灣松鼠問題之研究成果如何？茲引用本省植物保護前輩歐世瑛博士在其“台灣森林病蟲害研究發展之評估”（1984）中所提到的看法。歐氏大意說台灣有關松鼠之研究，有關單位確盡了相當大的力量，此包括國科會與農委會之經費補助，及台灣大學、東海大學、林業試驗所與林務局等單位之組成研究小組分工合作，著有成效。在目前台灣森林病蟲害研究人員不足之情形下，松鼠合作研究之模式頗有參考之處。回憶在1978年松鼠研究推行之初期，所彙集之研究人士多非松鼠問題專家，惟均有不同程度野生動物之知識背景，由於研究松鼠之興趣，以及解決松鼠問題之熱誠與願望，想不到一做就是10年，大家合作無間甚感愉快。連本人在日本九州大學之博士論文亦屬於松鼠為害之造林學的研究（1985）問題，若非大家之協助如何完成？同時在這10年之間，也訓練了台大研究生包括碩士班近20位及到國外進修博士4位，獲得學位後相繼參加與野生動物有關或自然保育之工作，此為松鼠研究計劃之另一成就，也值得稱贊。由於舉辦兩次松鼠防治研討會，也使動物界與森林界方面人士加強對野生動物知識之交流機會，並藉著動物生態之研究基礎，提升了松鼠防治之效果。歐氏又提及有關今後之台灣松鼠問題：多年來均以毒餌作短程之防治為主，長期方面應對森林經營及生物防治之治本工作予以加強。為因應台灣自然資源保育之要求，森林與松鼠兩者如何能達成共存，將為解決松鼠問題之最終目標，仍有待作深入之研究，願森林界與保育界共勉之。

國立台灣大學森林學系 郭寶章 謹識

中華民國七十七年六月

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臺灣產松鼠之生物學的考察

朱耀沂 易希陶

臺灣產五種松鼠中，屬於 *Callosciurus* 屬之三種松鼠為森林害獸，此三種松鼠皆生棲於本省平地及山地之造林地，對森林之加害重要性幾乎相等。松鼠對樹木之為害狀況有二：一為啃啮樹木果實，種子；二為咬剝樹皮，而後者為害遠甚於前者，即在本省柳杉，檜木，松樹等十種樹木，已列為被害樹種，其中柳杉之受害為最甚。此等被害樹木其樹皮被剝後，一面影響其生長及樹形，一面誘致木材腐敗菌之侵入，使材質部黑化後變質，大為減低木材之利用價值。

松鼠之樹皮加害，可能有兩種原因，即一為嗜食形成層另一為舐食傷口溢出之樹液。但真正為害目的，未能確定。

一般被害劇烈地為林內撫育差，而接近闊葉林或原始林之柳杉造林地。

松鼠之巢，普通造於喬木上，離地面 3~10 公尺之數條枝條輪生分叉之處。其造巢材料為附近容易得到之小樹枝，植物纖維等。惟從未發見把樹皮用為材料之巢。

松鼠本為雜食性動物，但主要為植物性食料，而在其胃中，往往可見各種小昆蟲之屍體，惟其量不多。關於植物性食物，因咀嚼力及胃部消化力極強，未能判斷其食料種類。

在三~五月之間曾發現四個懷孕的事例，其胎兒數為 1~3，由此可知，春季為松鼠懷胎之一時期。

松鼠防治方法，除利用藥劑，天敵之外，林地內之清理最為主要。此外造林地的選擇亦屬重要，如柳杉造林地，應設置於離原始林或闊葉林一百公尺以上之處，才可避免松鼠之為害。又鎗殺、陷阱法對減少松鼠數目亦有極大幫助，惟此法從保護自然資源起見，不可濫用。

除松鼠外，鼯鼠對森林之為害不亞於松鼠，本文中亦簡單說明臺灣產之鼯鼠。

SOME BIOLOGICAL NOTES ON THE TAIWAN SQUIRREL

Yau-I Chu Shi-Tao Yie

Among five species of Taiwan squirrels, three *Callosciurus* species cause a lot of damage to the forests. They are *C. erythraeus thaiwanensis* (Bonhote), *C. erythraeus roberti* (Bonhote) and *C. erythraeus centralis* (Bonhote). Those squirrels occur both on the mountainous and plain districts. No interspecific territory exists among them. Therefore, the hybrids of those species were often observed. Another subspecies, *C. erythraeus nigridorsalis* (Kuroda) seemed to be wrongly identified for old individual of the above mentioned subspecies.

The squirrels attack the trees with following two types. One is to gnaw fruits and seeds. The other is to peel the barks off trees. The later type causes much more serious injury to the trees. According to the authors' investigation, more than ten species of trees are listed as injured ones. Among them some acerose trees, such as *Cryptomeris japonica*, *Chae-*

maecypanis formosensis and some kinds of pines are severely attacked. Especially the damage on *C. japonica* is sometimes fatal. The results of the squirrels' injury, namely the bark peeling, induce the deformation and retardation of growth. In addition, the wounded parts become good entrances for the wood decaying fungi, then the xylem is denaturalized and blackened in color and become fragile in its quality. The infested area of fungi becomes enlarged afterwards, and therefore, the economic value of the damaged woods is largely diminished. In the worst case, the whole tree may decay and die when the bark has been peeled off circularly around the trunk.

As for the bark peeling habit, two reasons are considered: one is to gnaw and eat the cambium; the other is to lap the wood sap exuded from the wound. Anyway, the barks are scarcely used as the material to construct their nests.

Generally, the damage from these animals is serious in badly managed forests or acerose forests situated adjacent to the latifoliated or virgin forests.

The squirrels build globular nests in diameter of more than 30 cm. on the tall trees where the forks of branches hold radically. The altitude of nests generally ranged from 3 to 10 meter. A nest is constructed with twigs, plant fibers, leaves or grass etc. Barks are scarcely used.

Squirrels are originally omnivorous animals, while the results of inspection of stomach contents show that the plant materials are its chief food. Besides, a few amounts of insect body fractions are observed. The latter are considered as an appetizer or secondary important food. Due to its gnawing capacity and strong digestion, the identification of plant substance in the stomach is nearly impossible.

From March to May in 1965, 4 pregnancy cases have been observed. The numbers of embryo count from 1 to 3. From this fact, it is apparent that spring is one of the pregnancy seasons for the squirrels.

As for the control measures of the squirrels, besides the application of some rodenticides and natural enemies, the cleaning of forest is a very important factor to prevent the squirrels' damage.

The choice of the forest situation is also an unnegligible factor. For instance, the sensible trees, as *C. japonica*, should be afforested at the place separated from the latifoliated or virgin forest for at least 30 meters. Shooting and trapping are very efficient to decrease the squirrel's population in the restricted area, while unnecessary slaughter must be strictly forbidden for the purpose of natural resource preservation.

The flying squirrel, *Petaurista* spp. is also a very harmful animal to the acerose trees. The damage of *Petaurista* spp. frequently exceeds that of *Callosciurus* spp. Some data on *Petaurista* spp. are introduced in the present paper.

台灣赤腹松鼠爲害林木之生態研究

張 萬 福

1 帶狀調查乃探測林內被害頻率，被害部位，林內坡度，方位，地上主要生長植物種類，密度等對爲害林木相互間之關係，同時亦可藉此評價松鼠爲害林木後，對經濟效益之影響。根據所得資料可供分析或比較原始林、人工林及混淆林中之柳杉與潤葉木三者間之受害相關性。

192 號造林地帶狀調查發現，灌木叢生與蔓藤類植物繁茂之地區，柳杉林生長率甚差，受害率也比一般撫育良好之林地爲高，但茂密叢生之潤葉林，灌木，並無受害情形發生，因此，林內撫育程度之差異及雜生植物之多寡決定松鼠族群數量及受害輕重之關鍵所在。159 號造林地撫育情形遠優於 192 號造林地，無潤葉木，灌木群落混生之地域。地上植物生長密度較稀疏，林木受害程度較輕，受害部位且僅在樹梢，對林木之經濟價值並無多大影響。

192 號與 159 號造林地就其林木被害部位而言既有明顯之差異。192 號柳杉造林地樹齡爲 22 年，以樹幹部位受害最爲嚴重。159 號柳杉造林地樹齡爲 35 年，受害部位以樹梢爲主。根據「松鼠爲害林木研究問卷表」顯示出樹齡較年幼者，以樹幹部位受害最爲嚴重。樹齡較長者，受害部位以樹梢爲主。因此林木之受害部位是否與樹齡有關仍尙待進一步及廣範的探討研究。至於林內不同坡度及方位對林木爲害之頻率並沒有顯著之影響。

2 架設籠子捕捉，釋放，再捕捉松鼠之標放法乃探測松鼠族群數量，活動範圍及誘餌試用至爲可行之辦法。但標放法的成敗得失得視所使用之誘餌是否爲松鼠所喜好。誘餌之能否誘惑松鼠上鉤乃決定或然率高低的關鍵所在，若捕獲與再捕獲之數量形成懸殊之差距就難以測定該地區之族群數量，活動範圍等，故選擇較適用之誘餌乃首要工作。在捕捉的過程中曾試用過四季菓、香蕉、桃子、李子、地瓜（生與熟），楊桃、蕃茄、花生醬、棗子、白飯共十種。試用各種誘餌之天數皆相同唯獨四季菓爲其所食其他皆無效用。192 號造林地共捕獲 39 隻松鼠，3 隻爲再捕獲過之松鼠，此地所以能捕捉到松鼠乃是利用適時成熟之四季菓爲餌所致，而在 159 號造林地捕捉時因無四季菓可用，雖曾試用上述誘餌但無結果，在 20 個捕捉工作天裡僅獲一隻松鼠。溪頭地區捕捉松鼠時可用四季菓爲餌必有所收穫，若用他種食物爲餌就難有所得。但自清水溝營林區一位職業性獵戶捕捉松鼠之經驗得知，他所用之誘餌一年四季皆採用香蕉爲餌，或然率甚高。50 個籠子每月在十個捕捉工作天裡，平均可獲得 45 隻，但在溪頭地區香蕉就無用武之地了。生存於不同棲息環境之松鼠，是否因其天然食物供給量及種類之不同，而改變或選擇對某種食物的嗜好性，此種嗜好性食物種類之差異有深入探討之必要。

3 松鼠週期性活動調查，以沿線計數調查方法可瞭解松鼠每日活動頻率，亦可瞭解松鼠在各不同季節裡之活動情形，同時可做松鼠行爲之研究。松鼠每日出沒活動時間始自日出前 2 小時，早上七點前後爲活動之高峰，12 點以後至 16 點甚少活動，直至日沒後再行大量活動。松鼠行爲之研究較難從事，因松鼠常出沒於林木較密之處不易視察到，平常只聞其聲而不見其身。因此松鼠行爲之探討可依二種形式進行。(1) 繼續野外直接觀察，收集點點滴滴之片斷記錄。(2) 實驗室之行爲研究，既活捉松鼠飼養於實驗室以利觀察。因野外觀察動輒不免流爲粗雜，無法施行更加精密完整之監察注視。故二者須並進實行較爲妥當。雖然生存於自然環境與實驗室之松鼠行爲必有所差異，但可將實驗室所得行爲

資料與野外直接觀察所得片斷記錄相互印證，不難得知松鼠行爲。松鼠族群分佈之調查並沒有發現特殊群落，依聲音出沒之頻率各定點觀察站大致相似，不因定點觀察站爲嶺線，涯谷地，邊界而有所差異。平常觀察所得數量大致單獨行動爲最多，沒有群聚出沒之行爲記錄。

4. 食性之探討乃藉着射殺之方法獲取必須樣本之有效辦法。食性——乃研究松鼠習性中最重要之一環，藉着食性分析以便瞭解松鼠覓取食物種類，同時在不同環境與不同季節裡從事天然食物供給量之調查，以瞭解二者相互間之關係，以期透過天然食物供給量之控制而控制松鼠之族群數量，以仰制或減低松鼠對林木之爲害。

此次調查尚未得着一系列之松鼠食性資料，因獵人難雇，無法每月獲得固定之樣本數。故此項研究尙未完成仍須繼續從事。此次調查證實松鼠爲害林木之剝皮行爲，確實與其食物供需量充足與否有關。三月及四月可能因食物供需失調或缺乏而啃食樹皮，胃中內容物清析可見形如麻絲狀之樹皮形成層，幾乎佔有內容物之三分之二，唯有此二個月中才發現胃部內容物中有樹皮形成層之記錄。其他月份均無發現。此次調查因捕獲之樣本數量不足，未完成系統性之食性分析及探討松鼠覓取天然食物種類與需求量之季節性變化之調查。

5. 計數棲息於某一地區之松鼠族群數量及欲瞭解松鼠築巢材料，營巢位置，造巢分佈等情形，數巢法乃爲可行之辦法。但在高大茂密的樹林中就難以肯定指出松鼠築巢之確實位置及族群數量，除非在每木調查中逐一爬上樹梢一一清點，單以昂首尋視是難以獲得正確資料。所幸此次數巢時配合了砍伐工作，使得數巢工作得以順利進行。

此次調查發現松鼠築巢之分佈情形，大致以混淆林中之柳杉與潤叶木地區爲分佈密度最高，其次是築巢於造林地邊緣地帶與其他樹種接壤邊界處。邊緣地帶的分佈密度大於造林地之中央地帶，但邊緣地帶之分佈密度並不味着全爲分佈密度稠密之處，得視邊緣地區有否溪谷水流。192號造林地西面有溪谷且有水流，此處之松鼠巢密度就大於東南北面之乾燥地帶。築巢之位置大致在靠近樹梢約1至3公尺之間之分叉處。築巢所需材料與其築巢位置之樹種而異，皆各自取材於築巢位置樹種之枝條或葉子。松鼠喜好營巢於樹葉茂密且有蔓藤類植物盤繞的樹梢部位上。在尋獲的336個巢中未曾發現使用啃剝後之樹皮爲築巢材料。因此可斷然言之：溪頭地區松鼠爲害林木之剝皮行爲決不是因爲需要築巢材料而啃剝樹皮，而是因季節性天然食物供給量之失調或不足而產生季節性之爲害。

6. 台灣松鼠生態研究現階段首推松鼠生殖週期研究最爲完整。調查結果與宇田川龍男君（1954）對台灣產松鼠在日本伊豆大島繁殖期之視察完全相似。既松鼠懷孕率以12月底及5月初爲最高，9月到11月沒有懷孕之例爲松鼠生殖止期。

此次松鼠生態調查，首重於收集及探討松鼠之生態基本資料，基本資料之全備有助於日後控制松鼠數量及減低松鼠對林木爲害不可或缺之有力依據。此基本工作乃探討防治松鼠爲害之根本起點，由此起點而後步向對松鼠，植物及環境三者相互間關聯之認識。因問題之產生大致導因於各種複雜而廣範之因素，而松鼠生態研究僅是探討整體一系列因果之一小部份。因此控制松鼠爲害之有效辦法需要整體及長時間的研究發展，不僅探討松鼠消長之限制因子，了解族群變化及變化幅度之因素對於林業經營技術之探討，如林內撫育年限試驗等在在都需要並行配合才能求得一套可行之辦法。

THE ECOLOGICAL RESEARCH OF THE RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS ROBERTI*) DAMAGE TO FOREST IN TAIWAN

James Wan-Fu Chang

Artificial forests are being seriously damaged by tree squirrels. The effect of damage is a serious problem in Taiwan. The extent and degree of damaged continue to increase year by year, so control measures for squirrel damage to plantation are urgently needed. However, so far no effective measures have been found. We hope through studies of basic squirrel ecology arrive at more effective measures in the future.

There were six study methods used in the present study namely: Transect line survey, Time area count, Nest counting, Marking and release, Hunting success and Reproductive cycle survey. All methods gave reasonable results, but the latter was given the most extensive use.

A transect-line survey showed 65% of the *Cryptomeria japonica* trees have been damaged in compartment #192.2 Chitou Experimental Forest in June 1975. Most of the damaged at the middle or low part of the main trunk of the tree (Fig. 2). Another transect survey taken during March 1976 found 56% of the *Cryptomeria japonica* in compartment #159.2 had been injured. In this case, damage occurred at the highest part of the trees, (Fig. 1). A second transect line survey of compartment #192.2 in February 1976 found that 96% of the *Cryptomeria japonica* had been damage in a shorter period of time. According to Questionnaire responses from different forestry working stations, four to twelve years old trees had serious damage at the middle or low part of the tree, but over twelve years old trees tended to be damaged in their upper parts, (Fig. 3).

Time-area-count method showed that squirrels are most active around 7 A.M. Substantial decrease in activity occurs after 9 A.M, but increases again after 4 P.M, (Fig. 4). They prefer to act individually rather than in a pair or a group.

Thirty-nine squirrels were captured, marked and released during sixteen working days in compartment #192.2. Approximately equal numbers of male and female squirrels were captured. Three of the thirty-nine captured squirrels were recaptured at the same places as their original capture.

Twenty-one tree squirrels and four flyingsquirrels the stomach content of were analysed. Those sample was obtained in both plantations and virgin forests. Squirrels are omnivorous but mainly herbivorous. The proportion of plant materials to animal materials was 90:10 in March and April sample; 100% plant materials in July and August; and 70:30 in October and November. Only samples taken in March and April found cambium of the *Cryptomeria japonica* in the stomachs of the squirrels.

Nest counting found three hundred and thirty-six nests in 11.82 hectares of the compartment #192.2. Among them were six nests with young squirrels. As for the distribution of nesting, there were two type of environment with the highest densities: 1. Mixed forest of broadleaf and *Cryptomeria japonica*; and 2. Edges of the plantation forests which are along streams. Nest were located at a height of 10 meters in the upper part of the trees. Nests were shaded by dense branches covered with vines and ferns, especially passion fruit vines. The nests were oval shaped, 75 x 50 x 35 cm in size, with a side opening. Twigs or leaves of broad leaf and *C. japonica* were chosen as nesting materials. No stripped bark was found as nesting materials even in the most seriously damaged areas. Nests were constructed in two or three days.

There are two peak birth periods in a year, that is, May and December, (Fig. 7, 8, 9). The results of this study of tree squirrel ecology agree with the general conclusions of Udagawa (1954) in that breeding occurred in both winter and

summer.

There is a periodicity to tree damage during the year. Peak damage frequency occurred in late February to early April. Approximately two weeks after the peak, damage substantially declined to rise again in August.

東海大學校園中松鼠族群調查與 行爲觀察初步報告

鄭 先 祐

24隻(13♂; 11♀)由南投縣秀峰鄉捉回來的臺灣赤腹松鼠(*Callosciurus erythraeus taiwanensis* Bonhote), 耳朵標上記號後, 於去年八月一日在相思林中一定點(R)釋放。在八月六日到十八日之間, 以Bailey(1951, 1952)的公式算出其松鼠族群的總數是 13.3隻。其後因捕捉松鼠的籠子在野外丟掉太多, 而無法加以討論。據野外溪頭和校園中的觀察與簡單的試驗, 松鼠可能有四種以上的社會行爲(根據Scott, 1956年的分類法)。①Contactual behavior; ②Sexual behavior; ③Et-epimeletic behavior; ④Agonistic behavior。松鼠的活動範圍, 據朱耀沂與易希陶, 1970年的報告: 松鼠活動半徑約為 40 ~ 50 公尺。據本實驗間接指出其活動半徑約有 100 公尺左右。因其松鼠到新環境, 活動範圍的擴大是很可能的。

台灣赤腹松鼠的生殖週期

唐 代 駒

從民國六十四年六月到六十五年五月，工作人員按月自台灣中部山區捕集赤腹松鼠，檢驗生殖器官，雌雄合計，共 318 隻。結果顯示，雌鼠妊娠率以十二月底及五月初為最高，從九月到十一月，沒有妊娠例。

在沒有妊娠例的三個月中，卵巢與睪丸的平均重量減輕。切片證明，卵巢與睪丸有組織萎縮的現象，雖然萎縮並不十分完全，但足已顯示松鼠的生殖在秋季有休止的傾向。

一隻長成的雌松鼠可以年產多胎，每胎產一至二隻幼鼠。在一年之中，四十隻孕鼠平均每胎懷 1.68 隻胎兒。

THE REPRODUCTIVE CYCLE OF THE RED-BELLIED TREE SQUIRREL (*Callosciurus erythraeus*) IN CENTRAL TAIWAN

De-Chu Tang

From June 1975 to May 1976 monthly samples of the red-bellied tree squirrel (*Callosciurus erythraeus*) were examined. Reproductive parameters were obtained for a total of 318 squirrels trapped in Nantou Country, Central Taiwan; included were autopsies of 147 males and 171 females. The results show that the reproductive activities of both sexes were coordinately repressed in the autumn, based on findings that pregnant females were absent in September-November, coincided with the reduction in both testis and ovarian weights. The histological regression of both male and female gonads during this period, though incomplete, provides additional evidence of decreasing reproduction.

The adult female squirrel can produce more than one litter a year. An average litter size of 1.68 was determined from forty pregnant females at laparotomy, ranged from one to two.

台灣赤腹松鼠的生殖週期

唐代駒 歐保羅

赤腹松鼠 (*Callosciurus erythraeus*) 有剝樹皮之習性，對針葉林造成嚴重損害，故學者多積極從事其生態研究。本文係在臺灣中部誘捕赤腹松鼠，研究其生殖變數。由 1975 年 6 月至 1976 年 5 月計捕得 318 尾，作生殖腺之組織分析，發現該松鼠在全年中均進行生殖。惟由懷孕率以及生殖腺之退縮狀況來看，在 8 月為生殖減退期，12 月 (61%) 與 5 月 (71%) 為兩個懷孕率最高期，顯示為相繼之懷孕時期。由每孕限於兩個胎兒，顯示其生殖受到高族群密度的影響。

THE REPRODUCTIVE CYCLE OF THE RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*) IN TAIWAN

De-Chu Tang Paul S. Alexander

Reproductive parameters were obtained for a total of 318 *Callosciurus erythraeus* trapped in Central Taiwan where the bark-stripping activity of this species was causing severe damage to conifer forests. Monthly collections of squirrels were made from June, 1975 to May, 1976. Histological analysis of gonads suggests that this squirrel has the potential to breed throughout the year. A low ebb in autumnal breeding, however, is indicated by the data on pregnancy rate and gonadal regression. Two peaks in pregnancy rate are reported for December (61%) and May (71%), indicating successive pregnancies. The limit of two embryos or fetuses observed per pregnancy may reflect the influence of a high population density.

溪頭地區赤腹松鼠之族群研究

尤 少 彬

本研究自民國六十七年八月至六十八年五月調查溪頭林地內松鼠族群之大小，月變化，活動範圍，並探討影響松鼠捕獲率之因素。相對族群密度係採用定時定點觀察法。松鼠族群變化及活動範圍之研究則以標放法進行之。

七月份由定時定點法得知鳳凰山原始林及 168,159 人工造林地內每站數到的松鼠數目並無顯著差異。而鳳凰山之族群秋冬較夏天為高。168 人造林地之松鼠捕獲率以十一月最高，每百個鼠籠可捕捉 3.93 隻，隨後漸降至四月為 0.23 隻。以標放法發現在 168 林地（共 10.76 公頃）成體雄鼠比未成熟雄鼠，成體雌鼠及未成熟雌鼠之族群為大，其平均族群大小分別為 11.68, 6.3 和 7。雄鼠之活動範圍恆大於雌鼠，但活動範圍與成熟度無關。

松鼠之捕獲概率，受性別、成熟度、鼠籠安置地形影響。未成熟之雄鼠進籠頻率較其他松鼠為高。鼠籠擺設於稜線上比山坡地之捕獲率為高；但與鼠籠附近遮蔽度無關。

赤腹松鼠爲害與木材化學 組成份相關性之研究 (I)

高 清 方國運

赤腹松鼠爲害香杉，但不爲害臺灣杉。茲以赤腹松鼠爲生物檢定之工具，藉以明瞭臺灣杉中何種抽出物具有松鼠忌避劑之效能。

將香杉與臺灣杉之枝條以化學方法逐步除去其抽出物，枝條仍保持原狀，以供赤腹松鼠剝食，並比較其剝食量。供實驗枝條可以分爲下列幾種(1)新鮮枝條；(2)由 $45 \pm 2^\circ\text{C}$ 減壓乾燥除去精油之枝條；(3)以二氯甲烷爲溶劑除去粗樹脂之枝條；(4)以丙酮、水 (1 : 1 v/v) 爲溶劑除去粗丹寧之枝條。

實驗結果如次：

香杉枝條各種處理後，赤腹松鼠剝食量之差異不顯著。

臺灣杉枝條除去粗樹脂後，赤腹松鼠之剝食量顯著增加。換句話說，赤腹松鼠忌食未處理之臺灣杉，但剝食除去粗脂之臺灣杉枝條。

又將臺灣杉粗樹脂浸入糙米中，松鼠忌食此類糙米。易言之，即臺灣杉粗樹脂中含有赤腹松鼠忌食之成份。

本研究室擬繼續研究臺灣杉樹脂所含此種松鼠忌避劑之確實名稱及構造式。

RELATIONSHIP BETWEEN THE DAMAGE OF SQUIRREL AND WOOD CHEMICAL COMPOSITIONS (1)

Ching Kao Kuo-Yun Fang

This study is on the relationship between squirrel damage and the wood extracts in Taiwania (*Taiwania cryptomerioides* Hay.) and Konishi-fir (*Cunninghamia konishii* Hay.).

On the assumption that the resistance or susceptibility of conifers is due to squirrels' preference for some chemical compounds, we conducted the following experiments.

Without destroying the original form, essential oil, essential oil and resin, or essential oil, resin and tannin, were extracted respectively from the wood of both species. The specimens of wood thus treated were used separately in the biting test by Formosan redbellied tree squirrels (*Callosciurus erythraeus roberti* Bonhote) separately.

Process of extraction was as follows: 1. Essential oil in the raw wood was taken off at a temperature of $45 \pm 2^\circ\text{C}$ under reduced atmospheric pressure; 2. further resin was removed by dichloromethane solvent; and 3. there after, tannin was extracted by 1:1V/V acetowater solvent. The raw wood and three kinds of wood, from which some chemical compounds had been removed, were used in biting test by squirrels.

Results showed; 1. The Konishi-fir wood showed no significant difference between the raw wood or any of the treated wood specimens. 2. The squirrels preferred wood from which resin had been removed more than the untreated ones in Taiwania. This difference showed significantly in 1% level.

To confirm our discovery, we carried out another experiments show consistently that some chemical repellents exist in the Taiwania resin.

赤腹松鼠爲害與林木化學組成分相關性之研究

方 國 運

本實驗目的主在研究赤腹松鼠爲害林木之差異性，是否由林木所含化學組成分所促成。

赤腹松鼠殊爲害香杉，僅略爲害台灣杉或不爲害，遂以赤腹松鼠爲生物檢定 (bioassays) 之對象，藉供研究香杉與台灣杉之抗松鼠爲害之差異性，或由林木化學組成分之影響所致。

迨香杉與台灣杉枝條去除化學組成分，枝條仍保持原狀，以供赤腹松鼠剝食，並比較其剝食量。實驗枝條要區別爲次列數類：1 新鮮枝條；2 由 $45 \pm 2^\circ\text{C}$ 減壓乾燥除去揮發性精油之枝條；3 以二氯甲烷爲溶劑除去粗樹脂之枝條；4 以丙酮—水 (1 : 1 V / V) 爲溶劑除去粗單寧之枝條。香杉枝條各處理後，赤腹松鼠剝食量之差異不顯著；台灣杉枝條除去粗樹脂後，赤腹松鼠之剝食量極增。赤腹松鼠忌食未處理之台灣杉，但剝食除去粗樹脂後之台灣杉枝條。又將台灣杉粗樹脂浸入糙米中，赤腹松鼠則忌食此類糙米，亦即台灣杉粗樹脂含赤腹松鼠之忌食成分，致台灣杉亟具抗松鼠剝食性。

RELATIONSHIP BETWEEN THE DAMAGE OF FORMOSAN RED-BELLIED TREE SQUIRREL AND WOOD CHEMICAL COMPOSITIONS

Kuo-Yun Fang

This study is on the relationship between squirrel damage and the wood extracts in *Taiwania* (*Taiwania cryptomerioides* Hay.) and Konishi-fir (*Cunninghamia konishii* Hay.).

On the assumption that the resistance or susceptibility of conifers is due to squirrels' preference for some chemical compounds, I conducted the following experiments.

Without destroying the original form, essential oil, essential oil and resin, or essential oil, resin and tannin, were extracted respectively from the wood of both species. The specimens of wood thus treated were used separately in the biting test by Formosan red-bellied tree squirrels (*Callosciurus erythraeus roberti* Bonhote) separately.

Process of extraction was as follows: 1. Essential oil in the raw wood was taken off at a temperature of $45 \pm 2^\circ\text{C}$ under reduced atmospheric pressure; 2. further resin was removed by a dichloromethane solvent; and 3. there after, tannin was extracted by 1:1V/V acetone-water solvent. The raw wood and three kinds of wood, from which some chemical compounds had been removed, were used in a biting test by squirrels.

Results showed; 1. The Konishi-fir wood showed no significant difference between the raw wood or any of the treated wood specimens. 2. The squirrels preferred wood from which resin had been removed more than the untreated ones in *Taiwania*. This difference showed significantly in 1% level. To confirm my discovery, I carried out another experiment. Rice was immersed in resin removed from *Taiwania*. Squirrels were afraid to eat it. These two experiments show consistently that some chemical repellents exist in the *Taiwania* resin.

**POPULATION DYNAMICS OF THE RED-BELLIED TREE
SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)**

Yao-Sung Lin Shao-Pin Yo

This study was conducted in Chitou to investigate the population density, home range size and dispersal pattern of the red-bellied tree squirrel, factors that might affect trap response were also discussed. In July 1978 time-area counts were conducted at the Mt. Phoenix plot and in Plantations 168 and 159. Further intensive research employing the mark-recapturing methods was conducted at Plantation 168 from August 1978 to March 1980 to gather informations on monthly change in population density of the squirrels and their home range size.

Based on data obtained by time-area count, the density of squirrels in Plantation 168 was higher than that in Plantation 159. In Plantation 168 the average number of squirrels captured per 100 trap night (CPUE) was 2.34 from August 1978 to February 1979, and the estimated population density was 2.5 squirrels per hectare. The CPUE declined to a mean of only 0.81 from March to the following year. This significant decline in capture of squirrels coincided with the use of warfarin in neighboring Plantations.

The average number of months each squirrel was known to have lived in Plantation 168 was 4.5 months. Adult male exhibited the largest home range size. But no significant difference was observed among the home range size of adult female, immature male and immature female squirrels.

The male to female sex ratio for adult and immature squirrels was 15:10 and 15:15, respectively. Warfarin baiting had no differential effect on either sex.

The frequency that squirrels were trapped did not vary with sex or maturity. The obscuring cover density of the habitat had no effect on capture rate of squirrels, but the topography of the capture site definitely exhibited some effect on capture rate as more squirrels were captured per site on the ridge than the slope in Plantation 168.

赤腹松鼠爲害與林木抽出物相關性之研究

黃 豐 漢

本實驗之目的在：(一)研究赤腹松鼠忌食台灣杉化學組成分之分析；(二)測定香杉、台灣杉之全糖量及其含糖種類。庶尋出松鼠對台灣杉忌食之化學成分，及證實松鼠喜食含糖量較高之樹種。

將台灣杉非極性粗樹脂，用圓柱色層分析法 (Column Chromatography) 分離之；分別以次列數種溶劑沖洗：(1)正己烷 (N-hexane)；(2)75%苯—25%乙酸乙酯 (benzene-ethylacetate)；(3)50%苯—50%乙酸乙酯；(4)乙醇 (alcohol)。

得其沖洗溶液後，遂藉赤腹松鼠以行生物檢定 (bioassays)，即以下列三種處理之粗碎片玉米餵養松鼠：(a)對照組；(b)浸漬於不同溶劑之粗碎片玉米；(c)浸漬於不同沖洗溶液之粗碎片玉米。實驗結果，唯75%苯—25%乙酸乙酯之沖洗溶液，松鼠忌食之。

將香杉及台灣杉皮部磨成粉末，用甲醇抽出，經濾紙色層分析 (paper chromatography) 及糖定量分析結果：香杉皮部所含蔗糖爲台灣杉之1.23倍，又香杉含棉實糖，而台灣杉無之；即松鼠對香杉之爲害，與其含糖量及糖分種類亦具關係。

RELATIONSHIP BETWEEN THE DAMAGE OF FORMOSAN RED-BELLIED TREE SQUIRREL AND WOOD EXTRACTION

Feng-Dann Hwang

Formosan red-bellied tree squirrels, (*Callosciurus erythraeus roberti* Bonthote) rarely damage *Taiwania* (*Taiwania cryptomerioides*). We would study the mechanism of the squirrel resistant characters of this tree.

We study sugars in bark and sap wood qualitatively in *Taiwania*. As a comparison, we study sugars in konishii-fir (*Cunninghamia konishii*) bark & sapwood contained more sucrose than *Taiwania*'s. Besides, konishii-fir contained raffinose which was not detectable in *Taiwania*.

It trying to find a toxic secondary compound in *Taiwania*, we used column chromatography to separate non-polar resin. We used the following washing solvents; (1) n-hexane; (2) 75% benzene-25% ethyl acetate; (3) 50% benzene-50% ethyl acetate; (4) alcohol. After getting their washing solution, we, then, used Formosan Red-bellied tree squirrels to proceed bioassays. That means we fed the squirrels with three treatments soaked corn respectively. (a) control; (b) corns saturated into various solvents; (c) corns saturated into different washing solution. The results have shown that Formosan Red-bellied tree squirrels are only afraid to eat the corn soaked in the washing solution of 75% benzene-25% ethyl acetate.

松鼠爲害不同程度杉木基因型樹皮 過氧化同位酵素電泳分析之初步研究

黃堂厚 黃松根 許博行 鍾永立

採取 23 年生杉木被松鼠爲害最嚴重、輕微及未受害者各一株之樹枝，以硼酸系緩衝溶液萃取，用澱粉膠體電泳分析鑑定，其過氧化同位酵素帶，初步所得結果：受害嚴重者未顯出第二條帶（P₂）亦即與被害輕微及未被害者相比較，受害嚴重者不具有第二條對應基因，由遺傳上言；表示受害嚴重與受害輕微及未受害者具有不相同的基因型，因被害嚴重者缺乏第二條對應基因，以致不能把 Phenol 變成氧化狀態，致使松鼠較喜啃食，又未受害及受害輕微者之杉木樹皮，似可能具有某一種過氧化同位酵素，使 Phenolic compound 氧化而產生某一種具有毒性或特殊氣味之化合物，而使松鼠不喜啃食。

A PRELIMINARY STUDY BY PEROXIDASE ANALYSIS OF TWO GENOTYPES OF CHINA-FIR (*CUNNINGHAMIA LANCEOLATA*) DIFFERING IN THEIR SUSCEPTIBILITY TO SQUIRREL DAMAGE

Feng-Hou Huang Song-Gen Huang Po-Han Hsu Yen-Li Chung

We take one piece of bark from each of 3 *Cunninghamia lanceolata* trees grown up for 23 years in which one bark had been seriously damaged by the squirrel, the other bark was slightly damaged and the third bark was no harm, we determine them by analysis of starch gel electrophoresis with dense boric acid solution in order to reveal the enzyme bands of peroxidase, we got the primary result as following: the most harm bark did not appear P₂, which we made a comparison with slightly harm bark and no harm bark and we found the most harm bark did not appear the opposited basis of P₂, there are different natures of opposited basis among the serious harm bark, slightly harm bark and no harm bark according to the statement of heredity, because the serious bark is lack of opposited basis of P₂, so it can not make Phenol to become oxidized condition which make the squirrel like to eat the bark, however, the barks of *Cunninghamia lanceolata* without damage and the bark with slightly damage seem to have a certain peroxidase which made phenolic compound oxide to produce a certain poison nature or specialized odor containing compounds that make the squirrels do not like to eat them.

臺北縣坪林地區赤腹松鼠之生殖生物學

崔文慧 林芳郁 黃仲嘉

本文為就外部形態和生殖腺及副性腺組織學，研究台北縣坪林地區赤腹松鼠之生殖生物學 1978 年 12 月至 1980 年 2 月間，逐月採購，共得 100 隻雌性及 146 隻雄性赤腹松鼠。由分析 15 隻懷孕雌鼠，得知其排卵數為 2.07 ± 0.26 ，著床前與著床後死亡率分別為 6.5% 及 6.9%，每胎個體數 1.8 ± 0.56 。雌松鼠一年中有兩個生殖旺季，為初春及夏季兩季，其懷孕率分別為 50% 及 26%。69 隻成熟雌鼠中，單產者佔 71%，可能部份雌鼠一生或僅參與一次生殖。不成熟和成熟的雄鼠各佔 31% 及 69%，和雌鼠相仿。睪丸指數分佈曲線呈雙峯型，兩峯距寬 (0.6—8.0) 且頻度極低，意味轉變迅速，為轉變型，兩峯值分別為 0.4 及 10.0，前者屬幼鼠型，後者為功能型。睪丸指數 1~8 月維持在 8.0 以上，3 及 6 月居巔峯，4、5 月稍降，至 11 月急降至下限，12 月旋回升。四種副性腺指數的月變化，與睪丸指數的變化相符。

由前述雌、雄生殖週期及不成熟松鼠出現頻度顯示，坪林地區赤腹松鼠，一年可能有兩次性成熟的轉換，初春出生松鼠於夏—秋季發育至成熟前期，冬末春初成熟，另一次夏季出生者，於隔年春天進入成熟前期，夏季成熟。

THE REPRODUCTIVE BIOLOGY OF THE RED-BELLIED TREE SQUIRREL, *Callosciurus erythraeus*, AT PING-LIN, TAIPEI HSIEN

W. H. T'sui F. Y. Lin C. C. Huang

The reproductive biology of the red-bellied tree squirrel, *Callosciurus erythraeus*, was studied morphometrically and histologically. Conclusions were drawn based on 246 squirrels (100 ♀♀, 146 ♂♂) collected at Ping-Lin, Taipei Hsien, from December, 1978 through February, 1980. The female had two active reproductive periods, January to March and June to August. The pregnancy rate in spring (50%) was much higher than that in summer (26%). The ovulation rate, preimplantation loss, postimplantation mortality and litter size were analyzed from 15 pregnant females. The spring breeders produced more young than the summer breeders. The gonadosomatic index (GSI) was a reliable indicator for the reproductive state of the male. Cyclic changes in GSI were observed in the mature male but not in the immature. The mature male squirrels had two peaks of GSI values in March and June, respectively. Cyclic changes in the weights of the epididymis, seminal vesicle, prostate gland, and Cowper's gland were comparable to those in the testes. The adult male was sexually quiescent from September through November. The red-bellied tree squirrel reached its sexual maturity at the age of about one year. The spring litters grew faster and larger than the summer ones.

赤腹松鼠爲害與木材化學組成相關性之研究(Ⅲ)

——樹皮內之含糖量

郭寶章 高 清 劉啓福 黃豐淡

自溪頭採取柳杉、杉木、臺灣杉樹幹的內皮，以利剪將之剪碎，用甲醇抽出後，在真空下蒸發乾燥，再加少量之蒸餾水，然後用沸水沖洗。

收集上述之沖洗液，作糖之定性分析與定量分析，獲得柳杉、杉木與臺灣杉之含糖量結果顯示：上述樹皮內所含之醣類，皆以蔗糖爲主，柳杉與杉木樹皮受松鼠爲害的程度與樹皮含糖量極具顯著之正相關性；即當樹皮含糖量增加時，則樹皮受害量亦隨之增加。

但臺灣杉樹皮之受害與樹皮含糖量不呈相關性。

又松鼠爲害月份，柳杉、杉木樹皮中含糖量約爲臺灣杉之一倍。

CORRELATION OF THE DAMAGE BY FORMOSAN RED-BELLIED SQUIRREL WITH CHEMICAL COMPOSITION OF WOOD: PART III SUGAR CONTENT OF BARK

Pao-Chang Kuo Ching Kao Chii-Fuw Liu Feng-Dann Hwang

The objective of this research is to analyze the relationship between the amount of debarking by Formosan red-bellied squirrel (*Callosciurus erythraeus*) and the sugar content in bark of *Cryptomeria* (*Cryptomeria japonica*), China-fir (*Cunninghamia lanceolata*), and Taiwania (*Taiwania cryptomerioides*). Through this research, it is hoped to ascertain the reason of squirrel debarking damage of the three species.

The data on the amount of peeled bark by squirrel was collected from plantations of the species. The sugar in the inner bark (phloem plus cambium) was purified through a chromatographic column and analyzed by paper chromatography. Based on data collected through entire year, regressive equations were developed for each species to correlate the amount of debarking and the bark sugar content.

Several important results obtained in this study are cited as follows:

1. Sucrose is a major component of the sugar contained in the bark for three species examined. However, small amounts of raffinose were found in the bark of *Cryptomeria* and China-fir from January to March. On the other hand such sugar was not found in Taiwania's bark through the whole year. This presence of raffinose could be one reason for debarking however, a further confirmation is needed.

2. The sugar content and amount of the bark damage in of *Cryptomeria* and China-fir are significantly higher than in Taiwania. In other words, the sugar content of bark could be an important factor which controls the susceptibility of the three species to the debarking of squirrels.

3. The sugar content and amount of damage is not significantly correlated for Taiwania. The less incidence of squirrel debarking in Taiwania during the observed period is probably due to a low bark sugar content.

赤腹松鼠爲害與台灣杉枝條粗樹脂抽出物關連性之研究

徐 志 彥

台灣赤腹松鼠 (*Callosciurus erythraeus roberti* Bonhote) 對人工林造成嚴重的爲害，尤以香杉 (*Cunninghamia konishii* Hay.)、杉木 (*Cunninghamia lanceolata* Lamb.) 爲嚴重；而台灣杉 (*Taiwania cryptomerioides* Hay.) 則爲害輕微或不發生爲害。乃因台灣杉松脂中含有一種化合物，對赤腹松鼠有忌食作用。所以本實驗之目的在分析研究赤腹松鼠忌食之台灣杉化學組成分。

將台灣杉非極性粗樹脂，用圓柱色層分析法 (Column Chromatograph) 分離之。首先用 100 % 正己烷 200cc 沖洗溶劑沖洗，以上部份予以棄置；再分別以下列不同沖洗溶劑沖洗：(1) 100 % 苯 (benzene)，75 % 苯…… 25 % 乙酸乙酯 (ethyl acetate)；(2) 50 % 正己烷 (n-hexane) …… 50 % 苯，100 % 苯；(3) 25 % 正己烷…… 75 % 苯，100 % 苯；(4) 90 % 苯…… 10 % 乙酸乙酯，75 % 苯…… 25 % 乙酸乙酯。收集以上之沖洗溶液，藉赤腹松鼠以行生物檢定 (bioassays)，即以下列三種處理之粗碎片玉米餵養松鼠：(a) 對照組；(b) 浸漬於不同溶劑之粗碎片玉米；(c) 浸漬於不同沖洗溶液之粗碎片玉米。實驗結果發現：台灣杉粗樹脂中對赤腹松鼠具有忌食作用的部分，存在於 25 % 正己烷…… 75 % 苯至 75 % 苯…… 25 % 乙酸乙酯之沖洗溶液中。

A CONTINGENCY STUDY ON THE DAMAGE BY FORMOSAN RED-BELLIED TREE SQUIRREL AND GROSS RESIN EXTRACTIVES OF TAIWANIA SHOOT

Tyh-Yann Shyn

Formosan red-bellied tree squirrels (*Callosciurus erythraeus roberti* Bonhote) damage luan-tai fir (*Cunninghamia konishii*), China fir (*Cunninghamia lanceolata*). They damage china fir much more than Taiwanian (*Taiwania cryptomerioides*). According to my fellow students preceding works, the repellent compounds of Taiwanian exist in its resin. I used the column chromatography to separate non-polar resin. I used the following washing solvents; (1) 100% benzene; 75% benzene - 25% ethyl acetate; (2) 50% n-hexane - 50% benzene; 100% benzene; (3) 25% n-hexane - 75% benzene; 100% benzene; (4) 90% benzene - 10% ethyl acetate; 75% benzene - 25% ethyl acetate.

After collecting the washing solutions, corn would be soaked in these solutions respectively.

Then I worked on bioassay. I fed the squirrels with corn under the following treatments respectively (a) control (b) corn soaked in the different solvents. (c) corn soak in the different washing solutions.

The results have shown that the repellent compounds exists in the following part: the washing solutions of 25% n-hexane - 75% benzene to 75% benzene - 25% ethyl acetate.

赤腹松鼠爲害與木材化學組成相關性之研究(II)

——臺灣杉松鼠忌避物質之分離

高 清 徐志彥 黃豐漢

把台灣杉的二氯甲烷抽出物(相當於粗松脂部份),在真空狀態下濃縮。然後,倒入50公分高之矽膠(silica gel)圓柱中。

圓柱分別用200公分的下列溶劑沖洗(1)正己烷(2)50%正己烷與50%苯(3)25%正己烷與75%苯(4)100%苯(5)75%苯與25%乙酸乙脂(6)50%苯與50%苯酸乙脂(7)100%乙醇。

上述的沖洗溶液分別收集並濃縮至20立方公分。

把25克玉米碎片分作三種處理:(a)對照組(b)玉米碎片分別浸漬於上述某一種沖洗溶劑中(c)玉米碎片分別浸漬於上述某一種沖洗溶液中。把這些浸漬過的玉米放在室溫下,蒸發二天,然後把這三種不同處理的玉米供一隻赤腹松鼠食用。餵食時間是48小時,二天後求取被食用量,實驗重複十次。

上述圓柱色層分析所用的沖洗溶劑是按照溶劑極性大小來做沖洗洗後的順序。結果發現:用正己烷或且用50%正己烷與50%苯做沖洗溶劑,所得的沖洗溶液不具松鼠忌避物質。色層分析分圓柱經用200立方公分50%正己烷與50%苯沖洗後(上述部份倒掉),再分別用(1)25%正己烷與75%苯(2)100%苯(3)75%苯及25%乙酸乙脂沖洗,經證明這三部份都具有松鼠忌避的物質。

經200立方公分75%苯及25%乙酸乙脂沖洗後(含有台灣杉松脂)的色層分析用圓柱再分別用(1)50%苯與50%乙酸乙脂(2)乙醇沖洗,這二部份也都不含有松鼠忌避的物質。

RELATIONSHIP BETWEEN THE DAMAGE OF SQUIRREL AND WOOD CHEMICAL COMPOSITION (II)

Ching Kao. Tyh-Yann Shyn Feng-Dann Hwang

In our preceeding paper, we found that the squirrel repellents in Taiwania were in the crude resin.

Wood of Taiwania was extracted in dichloromethane, then, evaporated in a vacuum evaporator. The concentrated extract was pour into a silica column. Two hundred ml. of one of the following washing solvents was used to wash the column in sequence (1) n-hexane (2) 50% n-hexane and 50% benzene (3) 25% n-hexane and 75% benzene, (4) 100% benzene (5) 75% benzene and 25% ethyl acetate (6) 50% benzene and 50% ethyl acetate (7) 100% ethanol.

The described washed solutions were collected respectively.

Twenty five grams of crushed corn were divided into three parts (1) check (2) soaked in one of the described solvents (3) soaked in one of the described solutions respectively.

After soaking, these corn were dry in room temperature for 48 hr., then, were used for feeding one squirrel. After two feeding days, the residue corn were collected and weighed.

The replicates were used in these experiments.

We found that there was no squirrel repellent in (1) n-hexane (2) 50% n-hexane and 50% benzene, neither in (1) 75%

benzene and 25% ethyl acetate, and (2) ethanol parts.

The squirrel repellents were isolated in (1) 25% n-hexane and 75% benzene (2) 100% benzene and (3) 75% benzene and 25% ethyl acetate parts.

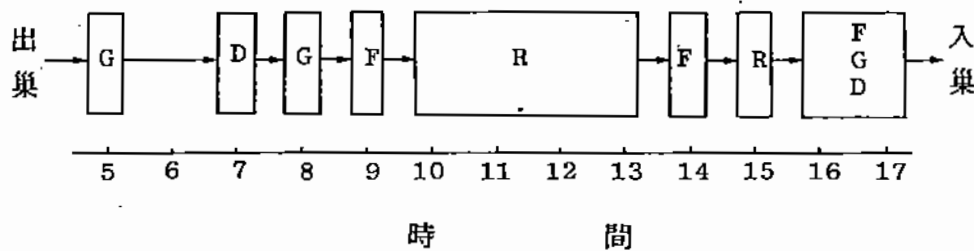
台北植物園赤腹松鼠(*Callosciurus erythraeus*)之行爲研究

周 蓮 香

自 1981 年 7 月至 1983 年 3 月於台北植物園中設立實驗區以觀察赤腹松鼠 (*Callosciurus erythraeus*) 之行爲。經二十一個月約 700 小時的觀察後，就松鼠的位移、攝食、啃剝樹皮、貯食、自我修飾、休息、築巢、敵對、友好、配對等行爲分別描述與分析。

赤腹松鼠在春秋二季較爲活躍；而夏冬較不活躍，且表現休息行爲的機會較多，夏季所採休息臥姿其軀體之伸展較冬季爲長。秋冬二季攝食活動的時間頻率較多，至地上覓食的機率也增加。啃食 (Peeling-feeding) 樹皮之活動在春季 3 月徒增，可能是因此時樹皮對松鼠之吸引力增加。硬殼類之果實或種子在秋季落果時會引發赤腹松鼠之貯食行爲。

由松鼠常見之攝食(F)、啃剝樹皮(D)、自我修飾(G)、及休息(R)行爲之日活動分析，綜合其高峯時段，可推出下列之日活動流程圖：



赤腹松鼠是無領域性的，但有固定之活動範圍，此活動範圍中各成員可能有穩定的階級。成鼠之敵意較幼鼠爲強，而雌性成體又有較雄性成體強的趨勢。雌鼠之追逐活動主要爲育幼及生殖之競爭；而雄鼠之追逐活動目的則爲求偶及驅逐幼鼠。

有關松鼠築巢之樹種、高度、巢之結構及巢口之方向等，亦有探討。

林試所研究報告 (Taiwan Forestry Research Institute)
419, 5 pp. (1984) 林試所
松鼠為害林木防治研討會論文集 (Proceedings Seminar on the
Control Squirrel Damage to Forest Trees) p. 81-85
(1985) 農委會特刊第二號

抗松鼠為害杉木品系之選育 (I) 樹皮含樹脂量與松鼠為害之關係

黃松根 謝瑞忠 康佐榮 傅昭憲

本省杉木造林松鼠為害甚為嚴重，為減低松鼠為害，以選拔抗松鼠之品系，當屬一種可行途徑。本研究旨在測定樹皮含樹脂量高低與松鼠為害之關係，以供造林選種之指標，試驗結果顯示受害嚴重之杉木其皮部含樹脂量比未受害者為低，在一年四季中，冬季為最少受松鼠為害之季節，蓋因冬天含樹脂量比其他三個季節者為高，又依據動物試驗結果，亦證實松鼠不喜愛吃含樹脂之食物，由此當知杉木樹皮之受害程度與其樹脂含量之高低，有密切關係。

BREEDING OF SQUIRREL-RESISTANT STRAINS OF *CUNNINGHAMIA LANCEOLATA*-(1) RELATIONSHIP BETWEEN BARK RESIN CONTENT AND SQUIRREL RESISTANCE

Song-Gen Huang Jui-Chung Shieh Zou-Yung Kung Chao-Hsien Fu

Cunninghamia lanceolata is heavily damaged by squirrels in Taiwan. Usually, the squirrels are poisoned by using pills to prevent or reduce the trees damage. However, there are difficulties in using this methods for a large scale protection. Hence, breeding of squirrel-resistant *Cunninghamia lanceolata* has received considerable attention in recent years.

It is suggested that any tree with higher resin content in the bark may increase its resistance against squirrels attack. Therefore, this study is to investigate whether the high-resin content theory does apply to breeding of squirrel-resistant strains of *Cunninghamia lanceolata*.

Results of this study revealed that the damaged trees had significant lower bark resin content than those of the undamaged trees. The test data indicated that the average content of the bark resin in the winter season was higher than the rest of the seasons. Hence, the degree of the squirrel damaged was very limited in the winter time.

A feeding test was also carried out and the results showed that the squirrels did not eat those foods with high resin content. We therefore concluded that the resistance of *Cunninghamia lanceolata* to squirrels damage is related to high resin content in the bark.

RADIO-TRACKING OF A RED-BELLIED TREE SQUIRREL AT TUNGHAI UNIVERSITY

Paul S. Alexander

INTRODUCTION

In August 1975, 13 female and 11 male squirrels (*Callosciurus erythraeus*) from Nantou Country were released in the campus woods of Tunghai University (Cheng, 1976). It was intended to study the reproductive ecology and habits of these squirrels in the convenient campus area for comparison with other studies of this species begun in 1974 (Chang 1976 and 1982; Tang and Alexander, 1979).

Although many notes have been recorded for the campus squirrels by the author and his students during the past nine years, no systematic study of the whole campus population of squirrels has been carried out. This paper is a brief note reporting the movements of an adult female squirrel for two weeks in April 1979.

METHODS

On April 9, 1979 a mature female Red-bellied Tree Squirrel was trapped in an Acacia tree within 10m distance from the author's home. A tiny radio-transmitter attached to a fitted collar (Wild-life Materials, Inc., U.S.A.) was placed on the squirrel's neck before release in the same place. With the use of a radio-receiver from the same company, the squirrel's movements were followed from April 11-24 with the exception of one day on April 21 when the author was absent from campus. After April 24 no subsequent signal could be recorded. On May 22 the squirrel was sighted about 100m from the site of trapping, and no signal was obtained at close range, indicating that the radio-transmitter battery was dead. The squirrel was trapped on September 11, 1979 about 50m from the site of trapping and was autopsied to examine its reproductive condition.

RESULTS AND DISCUSSION

Figure 1 shows the location of the female squirrel from the date of first trapping on April 9, during the period of radio-tracking April 11-24, on May 22 after the failure of the radio-transmitter battery, and on September 11 when it was finally trapped and autopsied. The densely wooded area covered by the squirrel was approximately two hectares, 200m long and 100m wide, between a rocky gully and four residential buildings. A total of 35 positions was recorded for the period April 11-24. The greatest distance between recorded positions in one day was about 150m on April 15, ending with an over-night rest in a nest in a bamboo 10m behind the author's home. The squirrel also spent the night of April 23 in the same nest. The overnigt position of the squirrel was located additionally only for the night of April 12 at the upper limit of its range near the student dormitories. On other nights a weak signal received at the author's home suggested the position to be in the upper half of the squirrel's home-territory.

During the period of these daily observations only one additional squirrel was seen or heard in this territory at the

same time that the position of the marked squirrel was known. Therefore, it was a great surprise to find that traps set in this area in early September and again in early October caught a total of 10 squirrels. Among these squirrels were three nearly full-grown, sexually immature squirrels and three small squirrels. The female squirrel with the "dead" radio-transmitter was captured on September 11 and found to be lactating. Three thick uterine scars suggest that this squirrel was the mother of the three small squirrels.

It is quite possible that she was also the mother of the three larger, immature squirrels captured. There are two breeding peaks for this species in winter and late spring (Tang and Alexander, 1979).

The home range of this female squirrel in the Tunghai campus, estimated to be approximately two hectares, is much larger than the home ranges estimated by Lin and Yo (1981) and Chang (1982) for squirrels trapped at Chitou (Nantou Country).

赤腹松鼠爲害與木材化學組成相關性之研究(IV)

台灣杉松鼠忌避物質之分離(2)

高 清 李載鳴

台灣針葉樹人工林遭受赤腹松鼠 (*Callosciurus erythraeus roberti* Bonthote) 爲害日趨嚴重，尤以柳杉 (*Cryptomeria japonica*)、香杉 (*Cunninghamia konishii*)、杉木 (*Cunninghamia lanceolata*) 等受害爲甚，惟台灣杉 (*Taiwania cryptomerioides*) 受害輕微，甚或不發生爲害。以往初步研究之結果，係認爲台灣杉之粗樹脂含有松鼠忌食之物質，而本實驗之主要目的爲探討粗樹脂內所含可能爲松鼠所忌食之化學組成分。

將台灣杉木粉以二氯甲烷 (Dichloromethane) 萃取其粗樹脂，再以管柱色層分析法 (Column chromatography) 分離其中成分。溶劑系統爲 100% 正己烷、50% 正己烷 + 50% 苯、10% 正己烷 + 90% 苯、100% 苯、80% 苯 + 20% 乙酸乙酯、75% 苯 + 25% 乙酸乙酯，依序沖洗後收集各部分沖出溶液，以赤腹松鼠做生物檢定，實驗結果爲以 100% 苯至 80% 苯 + 20% 乙酸乙酯爲溶劑之沖出液部份對松鼠有忌食之效應。

THE SQUIRREL-RESISTANT MECHANISM IN TAIWANIA (IV) THE ISOLATION OF THE SQUIRREL REPELLENTS FROM TAIWANIA BY COLUMN CHROMATOGRAPHY

Ching Kao Tsai-Ming Lee

The conifer plantation in Taiwan is damaged by formosan red-bellied tree squirrels (*Callosciurus erythraeus roberti* Bonthote). Luanta fir (*Cunninghamia konishii*), Cryptomeria (*Cryptomeria japonica*) and China fir (*Cunninghamia lanceolata*) were damaged severely, but there is less or even no harm in Taiwania (*Taiwania cryptomerioides*).

There is a serial research in finding the reason why the squirrels distaste Taiwania. According to previous experiments, we found there is related with resin.

In this experiment, we use column chromatography to separate the dichloromethane extract from the wood of Taiwania, the solvent system of elution is (1) 100% n-Hexane (2) 50% n-Hexane+50% Benzene (3) 10% n-Hexane+90% Benzene (4) 100% Benzene (5) 90% Benzene+10% Ethyl acetate (6) 80% Benzene+20% Ethyl acetate (7) 75% Benzene+25% Ethyl acetate (8) 50% Benzene+50% Ethyl acetate and collect those effluent respectively.

The squirrels are used to test each of these fractions and choose the fractions which the squirrel are more deterrent.

The fractions in using 100% benzene, 90% benzene+10% ethyl acetate and 80% benzene+20% ethyl acetate, as the running solvents, have shown the significant deterrent effect.

赤腹松鼠之行爲研究

周蓮香 林曜松 莫顯蒼

自 1981 年 7 月至 1983 年 3 月於台北植物園設立實驗區以觀察赤腹松鼠 (*Callosciurus erythraeus*) 之行爲。經 21 個月約 700 小時之觀察後，就松鼠的位移、警戒、探測、攝食、啃剝樹皮、貯食、自我修飾、休息、築巢、敵對、友好及配對等行爲分別描述與分析。

赤腹松鼠之個體行爲模式較近似於樹松鼠，而與地松鼠相去較遠，此可能因樹上或地上不同之棲息方式所致。攝食及休息的月變化可能與能量調節有關。啃食樹皮之行爲可能導源於樹皮中之化學物吸引。貯食行爲在秋季表現較頻繁，可能爲某些硬果及落果期所引發。

成鼠表現敵對行爲之頻率遠較幼鼠爲高，其中雌鼠又較雄鼠爲高。雄鼠之追逐活動主爲求偶及驅逐幼鼠。友好行爲多發生於母子、幼鼠及同窩成鼠之間，由月變化中可推知一年中應有兩次母子疏遠期，分別於 8 月及 12 月。通常雌、雄成鼠間具有一些敵意，生殖求偶開始時，數隻雄鼠同時追逐雌鼠，然後依序淘汰，最後剩一隻雄鼠被雌鼠接納。

BEHAVIORAL STUDY OF THE RED-BELLIED TREE SQUIRREL, *CALLOSCIURUS EYRTHRAEUS*

Lien-Siang Chou Yao-Sung Lin Hin-Kiu Mok

The behavior of the red-bellied tree squirrel, *Callosciurus erythraeus* was studied from July 1981 through March 1983 at the Taipei Botanical Garden. The patterns of locomotive, alert, exploratory, feeding, debarking, caching, auto-grooming, resting, nest-building, aggressive, amicable and mating behavior were described and their monthly activities were analyzed.

The behavioral patterns are more similar to those of other tree squirrels than those of other ground squirrels. This may be due to the difference in arboreal and terrestrial life styles. Monthly change in feeding and resting activities may be related to energy adjustment. The initiation of the peeling-feeding in debarking behavior may be due to the attraction of some chemical contents in the bark. Caching behavior appears frequently in autumn, and is elicited by certain kinds of drupes and their falling periods.

The adult is more aggressive than the juvenile and the female is more aggressive than the male. The chasing activities of males may be due to pursuing mates or getting rid of juveniles. The appearance of amicable behavior is frequently conducted by mother-children, siblings and nestmates. The separation of mother and children probably occurs in August and December. Usually, some aggression exists between male and female. When the courtship begins, several males will chase one female in the same time, and the males will compell each other away for competition. Finally, the last persistent one is accepted by the female.

赤腹松鼠爲害與木材化學組成相關性之研究 (V)

—台灣杉松鼠忌避成份之化學分析

鄭玉瑕 高 清 李載鳴

台灣針葉樹人工林遭受赤腹松鼠 (*Callosciurus erythraeus roberti* Bonthote) 爲害日趨嚴重，尤以柳杉 (*Cryptomeria japonica*)、香杉 (*Cunninghamia konoishii*)、杉木 (*Cunninghamia lanceolata*) 等受害爲甚，惟台灣杉 (*Taiwania cryptomerioides*) 受害輕微，甚或不發生爲害。以往初步研究之結果，係認爲台灣杉之粗樹脂含有松鼠忌食之物質，而本實驗之主要目的爲探討粗樹脂內所含可能爲松鼠所忌食之化學組成成分。

將台灣杉木粉以二氯甲烷 (Dichloromethane) 萃取其粗樹脂，再以管柱色層分析法 (Column chromatography) 分離其中成份。溶劑系統爲 100 % 正己烷、50 % 正己烷 + 50 % 苯、10 % 正己烷 + 90 % 苯、100 % 苯、80 % 苯 + 20 % 乙酸乙酯、75 % 苯 + 25 % 乙酸乙酯，依序沖洗後收集各部分沖出溶液，以赤腹松鼠做生物檢定，實驗結果爲以 100 % 苯至 80 % + 20 % 乙酸乙酯爲溶劑之沖出液部分對松鼠有忌食之效應。

以氣相色層分析法 (Gas chromatography) 分析該有效範圍所含物質，其中以滯留時間 (Retention time) 29.95 分時出現之物質佔全量之 11.4 %，30.37 分時出現之物質佔全量之 12.18 %，31.52 分出現之物質佔全量之 17.35 % 及 57.15 分出現之物質佔全量之 13.59 %，爲含量較多之四種物質。再經氣相色層分析共同注射 (Coinjection)、紅外線光譜 (Infrared Spectroscopy)、核磁共振光譜 (Nuclear Magnetic Resonance Spectroscopy) 分析，而得到該四種主要物質依其在氣相層析之滯留時間先後爲 T-Cadinol、T-Murrolol、 α -Cadinol，但由於比對樣品之缺乏，最後一種物質尙無法得知。

將所得之 T-Cadinol、T-Murrolol 餵飼松鼠做生物檢定，發現僅 T-Cadinol 存在時松鼠忌食效應並不顯著，而 T-Cadinol 與 T-Murrolol 混合時對松鼠有極顯著之忌食效應。

STUDIES ON THE SQUIRREL-RESISTANT MECHANISM IN TAIWANIA (V) — THE CHEMICAL ANALYSIS OF THE NATURAL REPELLENT FACTORS IN THE RESIN OF TAIWANIA

Yu-Sha Cheng Ching Kao Tsai-Ming Lee

The conifer plantation in Taiwan is damaged by formosan red-bellied tree squirrels (*Callosciurus erythraeus roberti* Bonthote). Luanta fir (*Cunninghamia konoishii*), Cryptomeria (*Cryptomeria japonica*) and China fir (*Cunninghamia lanceolata*) were damaged severely, but there is less or even no harm in Taiwania (*Taiwania cryptomerioides*).

There is a serial research in finding the reason why the squirrels distaste Taiwania. According to previous experi-

ments, we found there is related with resin.

In this experiment, we use column chromatography to separate the dichloromethane extract from the wood of Taiwan, the solvent system of elution is (1) 100% n-Hexane (2) 50% n-Hexane + 50% Benzene (3) 10% n-Hexane + 90% Benzene (4) 100% Benzene (5) 90% Benzene + 10% Ethyl acetate (6) 80% Benzene + 20% Ethyl acetate (7) 75% Benzene + 25% Ethyl acetate (8) 50% Benzene + 50% Ethyl acetate.

The squirrel are used to test each of these fractions and choose the fractions which the squirrels are more deterrent.

The fractions in using 100% benzene, 90% benzene + 10% ethyl acetate and 80% benzene + 20% ethyl acetate as the running solvents, have shown the significant effect.

Analyzing these fractions by gas chromatography, we found that there are four main materials. After reanalyzing in column chromatography and detecting in GC coinjection, infrared spectrometry and nuclear magnetic resonance spectroscopy, we consider these four compounds are, according their retention time, (1) in 29.95 min is T-Cadinol (2) in 30.37 min is T-Murrolol (3) in 31.52 min is α -Cadinol (4) in 57.15 min is unknown yet.

Using the purified compounds of T-Cadinol, T-Murrolol and α -Cadinol in bioassay, we find out that there isn't deterrent effect to formosana red-bellied tree squirrel in T-Cadinol only but is significant in T-Cadinol and T-Murrolol mixture.

METHODS OF SAFEGUARDING NONTARGET WILDLIFE WHEN CONTROLLING RODENTS

Rex E. Marsh

There are many techniques that can be used in Taiwan to safeguard nontarget wildlife when controlling rodents, in addition to wildlife-pesticide education. They include the appropriate selection of rodenticide, bait type and formulation, the rate and distribution of the bait, restricting accessibility of nontarget species to the bait, and timing of control. The importance of the type or kind of grain used for bait, the concentration of toxicant in the bait, artificially colored baits, conditioned aversion, and emetics is also detailed. Innovative baits and bait stations are discussed as they relate to protecting wildlife from exposure. Several examples are given of future directions for continuing efforts to provide new safeguards to nontarget wildlife.

防除齧齒類動物時保護非目標 野生動物的方法

Rex E. Marsh

劉一新 譯

在臺灣，當防除齧齒類動物時，除了要探討野生動物與農藥之教育外，尚有許多可行之技術可以顧到非目標野生動物 (non-target wildlife) 的安全性。這些技術包括：選擇適宜之殺鼠劑 (rodenticide)、毒餌類型及適當的合成、毒餌施放時的配佈情況與用量，以及防止非目標動物接近毒餌，防除工作施行之時間等等。

本文對於製作毒餌的穀類，其種類與形狀等重要性，毒餌內毒劑之濃度、毒餌之人工染色、條件嫌惡性 (conditioned aversion)、催吐劑等，也將逐項列舉說明。

其次，運用新式毒餌及餌站對於防止非目標動物發現餌料之效果，亦提出討論之。最後，對於保護非目標動物的新方法之提供上，舉例說明未來工作之方向及趨勢。

溪頭赤腹松鼠(*Callosciurus erythraeus*) 行爲之初步研究

林曜松 李玲玲

自民國 68 年 7 月起至民國 69 年 12 月，在溪頭營林區鳳凰山天然林及緊鄰其下方之 60-5 柳杉人工林內，進行野外觀察，以研究赤腹松鼠 (*Callosciurus erythraeus*) 之行爲活動，並期對防治松鼠危害有所裨益。

經由 710 小時之野外觀察，共計看到 850 隻次松鼠，其中大部份松鼠爲單獨活動 (88.6%)，有些則成對出現 (10.3%)，三隻或以上同時出現之機會較少 (1.1%)。松鼠在樹上活動之時間有兩段高峯，分別在清晨 (日出~上午 8:00) 及傍晚 (下午 4:00~日落)，而午間在草叢中出現機會較多。

民國 69 年 5 月以前在 60-5 林地內設有地瓜餌站 90 個，每站每日供應地瓜 300 公克，吸引大量松鼠至該地活動，平均每小時可見 1.21 隻次之松鼠，69 年 5 月起地瓜餌量漸減，至同年 7 月起停止供應，此時松鼠出現頻率亦下降，平均每小時僅見 0.26 隻次。

野外觀察松鼠行爲極爲不易，850 隻次松鼠中有 498 隻次僅匆匆經過，其餘 352 隻次松鼠所表現之行爲，則可分爲(1)攝食(2)修飾(3)遊戲(4)築巢(5)育幼(6)休息(7)對抗(8)跟隨(9)發聲等，本論文分別加以描述、分析及討論。

THE BEHAVIORAL STUDY OF THE RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)

Yao-Sung Lin · Ling-Ling Lee

This study was conducted at the natural forest and neighboring 60-5 plantation forest (*Cryptomeria japonica*) at Chitou from July, 1979 to December, 1980 to study the behavior and activity of the red-bellied tree squirrel (*Callosciurus erythraeus*).

Through 710 hours of field observation, a total of 850 times of squirrels were observed. They were solitary most of the time (88.6%), in pairs some times (10.3%), and occasionally in group of three or more (1.1%). The daily activity of the squirrels on trees showed a binomial pattern. They were more active at dawn (Sunrise-8:00 am) and dusk (4:00 pm-sunset), and less active at midday during which time they appeared in the underbrush.

Ninety bait stations were set in 60-5 plantation forest before May, 1980. Three hundred grams of sweet potatoes were distributed to each station daily, and this attracted many squirrels to that area. An average of 1.21 individual squirrels can be sighted per hour during that time period. Beginning in May, 1980, the amount of bait was gradually reduced and baiting was completely stopped in July, 1980. The number of squirrels sighted dropped to only 0.26 individual per hour

in average.

The field observation on the squirrel behavior was rather difficult. Out of the 850 times of squirrels sighted, 498 times of the squirrels were just passing by the viewer. The behavior of the remaining 352 times of individual squirrels can be divided into: (1) foraging behavior (2) grooming behavior (3) playing behavior (4) nesting behavior (5) parental care behavior (6) resting behavior (7) agonistic behavior (8) following behavior (9) vocalization. All these behaviors were described, analyzed and discussed.

飼養籠中赤腹松鼠之一些異常行爲： 殺食同類與颱風預感

郭 寶 章

作者為研究赤腹松鼠之食性，一般係向獵戶購入野生林間之松鼠，先將其放進大、中型鐵籠中數隻集中飼育，使其適應然後再進行正式試驗，從未發生互相咬殺之情形，此次亦將松鼠以 4—5 隻，少數為 6—7 隻集中飼育在一鐵籠中半年左右，在供應充足之飼料與飲水情況下，所飼養 100 餘隻松鼠當中，前後計有 65 隻被同籠中松鼠咬死，殘忍之程度令人震驚。赤腹松鼠乃與生俱來具有強烈羞怯性之動物，惟於民國 71 年安迪強烈颱風來襲的晝間，晴空萬里，平靜無風，但各籠內松鼠一反往日的靜寂與躲藏，在籠內跳躍尖叫，且將尾巴高高翹起，表現異常的緊張與警戒狀，此是否意味松鼠對颱風來臨前之預感？頗富研究之意義。

CANNIBAL BEHAVIOR OF CAGE-RAISED ANIMAL OF THE RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)

Pao-Chang Kuo

It has been a common practice for the author to conduct a study concerning food preference of squirrel. After squirrels were brought in by hunters, they were raised in the middle (60x50x45cm) or large (120x50x45cm) cages which normally contained four to seven animals for several weeks or month to become habituated before regular study is undertaken. Such arrangement has never caused any killing between squirrels raised in the same cage. Observation made in 1982 were based on four to seven squirrels raised for about half an year. The total number of test squirrels was about 100. Sixty five squirrels were killed when they were raised in the same cages. Such fact was cruel and unbelievable. The red-bellied tree squirrels are very shy and are always hidden in the cage when people working near them. One culm morning during the summer of 1982, before Andy typhoon hit Taipei, we observed squirrel jumped and yelled in the cages indicating that the typhoon was coming soon. In that evening, Andy typhoon came, seriously broke the roof and five squirrels dead.

赤腹松鼠(*Callosciurus erythraeus*) 個體行爲之研究

周蓮香 林曜松 莫顯蕃

自1981年11月至1982年10月在臺北植物園進行赤腹松鼠(*Callosciurus erythraeus*)個體行爲之研究。本文分別描述赤腹松鼠之位移、警戒、探測、攝食、啃樹皮、貯藏、自我修飾及休息等行爲模式，並分析後5種行爲活動的月變化。赤腹松鼠的行爲模式與其他樹松鼠較爲相近，而與地松鼠相差較遠，這可能是因牠們採用樹棲或地棲生活型態之不同所致。攝食與休息活動之月變化可能與能量調整有關。樹皮內某些化學成分可能是引發剝食(peeling-feeding)樹皮行爲的因素之一。貯藏行爲在秋季表現最頻繁，可能爲某些樹種的核果及熟落所引發。

STUDY OF THE MAINTENANCE BEHAVIOR OF THE RED-BELLIED TREE SQUIRREL, *CALLOSCIURUS ERYTHRAEUS*

Lien-Siang Chou Yao-Sung Lin Hin-Kiu Mok

The maintenance behaviors of the red-bellied tree squirrel, *Callosciurus erythraeus*, were studied from November 1981 through October 1982 at the Taipei Botanical Garden. The patterns of locomotive, alert, exploratory, feeding, debarking, caching, autogrooming and resting behaviors are described and the monthly change in the latter 5 behavioral activities are analysed. The behavioral patterns are more similar to those of other tree squirrels than those of other ground squirrels. This may be due to the difference in arboreal and terrestrial life styles. Monthly change in feeding and resting activities may be related to energy adjustment. The initiation of the peeling-feeding in debarking behavior may be due to the attraction of some chemical contents in the bark. Caching behavior appears frequently in autumn, and is elicited by certain kinds of drupes and their falling periods.

美國加州大學戴維斯分校博士論文 (Doctor Thesis of Philosophy
in Ecology in the Graduate Division of the University of
California Davis) 122.pp (1986)

POPULATION ECOLOGY OF THE RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*) IN JAPANESE FIR PLANTATION IN TAIWAN

Shao-Pin Yo

The population ecology of red-bellied tree squirrels (*Callosciurus erythraeus*) was studied at Chitou, an experimental forest station of National Taiwan University, by using mark-recapture method from August 1978 to May 1983. Multiple recapture data were used to analyze the life history, home range dynamics and population dynamics of red-bellied tree squirrels.

Subadult squirrels grow rapidly after weaning in summer or fall and reach adult body mass in winter. The body mass growth pattern was fitted better by the logistic model than either the Von Bertalanffy or the Gompertz model. One year is required for the subadult to reach reproductive maturity. Adult females produce one litter per year. Summer and fall are the main breeding seasons and the mean body weight of lactating females was heavier than the mean body weight of non-lactating females.

Home range of resident squirrels was measured with a non-parametric method. The mean home range of squirrels in summer was smaller than the mean home range of squirrels in other seasons. Adult female squirrels occupied stable home ranges, while adult males and subadults shifted their home ranges with food fluctuation in the habitat and reproductive seasons. Subadult squirrels shifted their home range apparently so as not to compete with their mothers in winter. Food supply is more important than population density in regulating home range sizes of the squirrels.

Three population estimation methods, MNA, Jolly-Seber and Otis et al., were compared by using the same multiple recapture data. MNA was the best estimation method for red-bellied tree squirrels. Otis et al. method underestimated population sizes in 24 out of 31 months, while Jolly-Seber method was not reliable when the sample size was small.

Population dynamics of red-bellied tree squirrels was analyzed to determine the impact of applying Klerat baits, warfarin baits and habitat manipulation on the squirrel populations. Treatment with Klerat baits reduced 50% of squirrel population in one year, but there were no significant changes in estimated seasonal survival rates after applying Klerat baits. The survival rate of subadults was higher than adults after applying warfaring baits.

Habitat manipulation, especially weeding, reduced the survival of squirrels, but the squirrels inhabiting the surrounding areas used the unoccupied space in the treated area as transients.

Red-bellied tree squirrel recruitment patterns were studied in plantation number 168 and 51-5. These sites differed in habitat quality. New squirrels replaced old squirrels more rapidly in 168 than in 51-5. Subadults were likely to stay longer in a poorer habitat like 168, while adults occupied the better quality habitats like 51-5. Adult females survived better than adult females.

Sex ratio (male/female) was not significantly different from 1:1 based on the yearly pooled data. However, the courtship behavior with groups of males chasing one female caused a male biased sex ratio in spring. The male biased subadult sex ratio suggested that subadult males have a greater tendency to disperse away from their nesting home after weaning.

Home ranges of 148 red-bellied tree squirrels were analyzed with univariate, bivariate and non-parametric statistical models. The non-parametric model is more precise and realistic than univariate and bivariate models.

A seasonal fluctuation of home range size was found in the red-bellied tree squirrel population. The mean home range of squirrels in summer was smaller than the mean home range of squirrels in other seasons. Most adult females hold stable home range areas. Adult males and subadults of both sexes shifted their home range more frequently than adult females. Home range shifts by adult males were related to changes in seasonal food supply, while subadults shifted their home ranges after weaning to avoid the competition with their mothers for food in winter.

A significant correlation was found between the number of red-bellied tree squirrels with overlapping home ranges and the population size. Food distribution and abundance are more important than population density in regulating the home range sizes of red-bellied tree squirrels.

溪頭與杉林溪赤腹松鼠分佈差異 原因之初步研究

陳 仲 賢

自民國 74 年 2 月至民國 75 年 2 月，在溪頭與杉林溪的柳杉造林地內，分二期依標放法估測松鼠族群。由捕獲率顯示，溪頭的松鼠族群密度大於杉林溪。從受害率與各期剝皮量的調查亦顯示，溪頭的受害亦較杉林溪為嚴重。

松鼠族群密度分佈差異的原因，可能有下列三點：溫度的高低、林地的土壤與地位差異、食餌植物的多寡。一般言之，溪頭的氣溫適度，林地土壤性質良好，地位指數較大，且食餌植物的種類與株數皆較多，較有利於松鼠的棲息；反之，杉林溪的低溫，林地土壤不佳，地位較差，且食餌植物的量較少，遂構成不利於松鼠的生存條件。

依本文之研究結果推測，土壤對松鼠食餌植物之分佈與生長，較具有關鍵的決定性，其他因子較為次要，惟仍有待進一步之研究證實。

PRELIMINARY STUDY ON THE DIFFERENCES OF DISTRIBUTION OF RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*) IN CHITOU AND SANLINCHI CRYPTOMERIA PLANTATIONS

Chung-Hsien Chen

From February 1985 to February 1986. This study was conducted at Cryptomeria plantations located in Chitou and Sanlinchi. Squirrel population was estimated during two periods by mark recapture method. Number of squirrels captured showed that squirrel population in Chitou is higher than that in Sanlinchi. It also reveals that squirrel damage is severer in Chitou than that in Sanlinchi.

The differences of distribution of squirrel population may be due to variations in temperature, soil and availability of food plants. Plantations in Chitou has warmer temperature, good soil and higher site index and more food plants than that in Sanlinchi. Sanlinchi plantations seems not very suitable for squirrel habitat, because of low temperature, poor soil and less distribution of food plants.

Availability of food plants to squirrel can be a key factor which results in the differences of squirrel distribution in Chitou and Sanlinchi. However, soil and site quality to some extent affect the growth of cover plants, but low temperature may be a minor factor in the distribution of both squirrel and cover plants. This requires a further study.

台灣杉、柳杉和杉木內皮化學成分 與松鼠危害之相關性

朱 紀 實

臺灣杉、柳杉和杉木受松鼠為害程度不同，僅臺灣杉木材成份中具有松鼠忌避成分，是否還有其他化學成分影響松鼠取食，於是在臺大實驗林溪頭林區採取臺灣杉、柳杉和杉木樹幹內皮作化學和構造成分分析。

木粉 I 以甲醇抽出，依美國皮革化學家協會方法除去單寧類後，測定全糖量、還原糖量和可溶性糖類種類，並以濾紙色層分析及氨基酸分析儀測定氨基酸質量。II 其他成分測定。

內皮全糖量、還原糖量、氨基酸量、絕乾重和含水量呈季節性變化。全糖量在七月最低，而臺灣杉在九月，柳杉和杉木在十二月最高；還原糖量臺灣杉和柳杉以三月最高，七月最低，杉木則以二月最高，九月最低。氨基酸量都在十二月最低，而臺灣杉在二月，柳杉在四月及杉木在七月含量最高。

臺灣杉、柳杉和杉木有七種游離糖類；臺灣杉和杉木有 12 種氨基酸，而組氨酸、蘇氨酸、纈氨酸、異百氨酸、白氨酸和苯丙氨酸等 6 種可能是松鼠基本氨基酸，柳杉有 11 種氨基酸，而基本氨基酸除苯丙氨酸外，和臺灣杉及杉木相同。

松鼠為害與內皮化學成分如可溶性糖類的質量、游離氨基酸質量、灰分量等營養成分無關。而與非極性粗樹脂與單寧類可能有關。

CHEMICAL CHARACTERISTICS OF THREE CONIFEROUS INNERBARKS AND THEIR INFLUENCE ON THE SUSCEPTIBILITY TO SQUIRREL DAMAGE

Chi-Shih Chu

Red-bellied tree squirrel fed on the bark of Taiwania, Cryptomeria, and China-fir at the different rate. Whether nutritional compounds and others in these trees affected the squirrel feeding. We collected the experimental materials in Chi-Tou District of Experimental Forest of National Taiwan University.

After extracting them with methanol and cleaning tannins out by ACLA method, the quantity of total sugars and reducing sugars were determined; the quality and quantity of free amino acids were determined by paper chromatography and auto-amino acid analyser. Other innerbark compositions such as moisture, oven-dry wood, nonpolar crude resins, starch, benzene-ethanol extracts, lignin, pentosans, cellulose, soluble tannins, and ash were determined.

Seasonal changes of the quantity of total sugars and reducing sugars and the quality and quantity of free amino acids were determined. The quantity of total sugars were all lowest in July but Taiwania was highest in September and Cryptomeria and China-fir were highest in December. The quantity of reducing sugars were all highest in March.

The innerbark of Taiwania and China-fir had 12 kinds of free amino acids. Six of them might be essential amino

acids of squirrel, these were histidine, threonine, valine, isoleucine, leucine, and phenylalanine. The innerbark of *Cryptomeria* had 11 kinds of free amino acids. It might have the same essential amino acids of squirrel in Taiwan and China-fir except phenylalanine. The quantity of free amino acids were all lowest in December but Taiwan was highest in February, *Cryptomeria* was highest in April, and China-fir was highest in July.

The chemical compositions of innerbark except tannins and nonpolar crude resins which may be the deterrents for Taiwan were no relation to tree damage by red-bellied tree squirrel.

臺灣松鼠爲害林木之初步調查

郭 寶 章

民國 45 年 2 月，曾擇臺灣大學實驗林溪頭營林區之柳杉、杉木、榿大杉、日本扁柏及銀杏等造林地，從事調查松鼠爲害之情形，俾明其實況。

松鼠爲害林木之程度，視各樹種而異：其被害較烈者均屬外來種；而本省固有種之榿大杉，則受害較輕。

柳杉各品種之被害率，以薩摩種爲最高。今後臺灣各地之造林，宜勿選用薩摩種。

松鼠爲害林木之部位，以爲害一處者爲最多；爲害二處者次之；爲害三處者又次之。其爲害之部位，以樹幹受害最烈，樹梢被害者次之；枝條被害者則較輕。

柳杉品種各部位之被害情形，亦同於各林木。

林木遭松鼠爲害以後，殊影響其發育，多使淪爲畸形或衰弱，然促使腐朽、瀕死或枯死者則較少。

A PRELIMINARY SURVEY OF SQUIRREL DAMAGE TO FOREST TREES IN TAIWAN

Pao-Chang Kuo

A good many important trees in the mountains of central Taiwan have been injured by various species of squirrels. The two species of squirrels, namely *Callosciurus erythraeus centralis* (Bonhote) and *Tamias swinhoi formosanus* (Bonhote), were found at Chi-tou District of the Experimental Forest of National Taiwan University. The effect of their injuries becomes a very serious problem in forest protection. Not only is the wood quality of the damaged tree greatly reduced, but, also the rate of growth of the tree is retarded. In one instance an entire plantation of the exotic Japanese cypress (*Chamaecyparis obtusa* S. & Z.) turned out to be a failure due to the excessive injury by squirrels.

Observations of squirrel damage were carried out in compartments 2, 3, 5 and 6 of the Chi-tou District in 1956. On 45 circular plots of 0.01 ha each, a total of 740 trees of 5 species, namely *Cryptomeria* (*Cryptomeria japonica* D. Don.), China fir (*Cunninghamia lanceolata* Hook.), Luanta fir (*Cunninghamia konishii* Hay.), Japanese cypress (*Chamaecyparis obtusa* S. & Z.), and maidenhair tree (*Ginkgo biloba* L.), ranging from 12 to 37 years old, was examined. During the observation, special attention was paid to the three races of *Cryptomeria* (Yoshino, Satsuma and Kumano). Over a period of two years in the forest, the author had learned the cause of the scars and trunk deformities in the various species. They were caused by the removal of strips of bark by squirrels. This cause was proved by the presence of teeth marks of squirrels on all the damaged trees. It is believed that the objective of the squirrels in stripping up the bark is to eat the gelatinous cambium which lies just inside the bark of the trees.

INVESTIGATION OF SQUIRREL DAMAGE TO FOREST TREES IN TAIWAN

Yau-Teh Fan

SUMMARY

A good many important tree-species in the mountains of Taiwan have been injured by squirrels. The effect of their injuries becomes a very serious problem in forest protection in Taiwan. Not only is the wood quality of the damaged tree greatly reduced but also the rate of growth of the tree is retarded.

EXTENT OF INJURY

Extent of injury to tree species & stands, at pure stands of softwood, the exotic treespecies, is the highest, except those with horizontal dehiscent barks, like Hookpine, & with barks of resinous or special taste & aromatic, thus as pine species of Loblolly-pine & Slash-pine. Japanese cypress. Cryptomeria. China-fir & Taiwan incense cedar, their fibrous, & longitudinally dehiscent barks are to strip off from the boles. So that their extent of injury is higher than pines & Hook-pine. But the native species of Taiwan incense cedar, suffered little damage pure stands of hardwood, such as Golden shower senna. Honduras mahogany. Mahogany & tanniferous bark of Taiwan acacia was not injuries by squirrels; but exotic tree species of Malaco albizzia Bombay black senna, Teak, Burmeses rose wood is higher than other tree species. Exotic tree species forests at low altitudes, are with higher damage than those of medium altitudes. As to softwoods, the squirrel damage of mixed stands are lighter than those of pure stands. The squirrel damage of hardwood pure & mixed stands are different in tree species, as shown in Table III, IV & VIII.

Observations of squirrel damage in 20 tree species, serious injuries was found on the Cryptomeria, China fir, Malaca albizzia, Bombay black senna, Teak, Burmese rose wood, Taiwan incense cedar, Palimara alstonia, Chinese cork oak, Woodoil tree, Silk tree, Para rubber tree, Honduras mahogany, Mahogany, Slash pine, Loblolly pine, Hook-pine, & Taiwan acacia. Golden shower senna were no found.

FREQUENCY & POSITION OF INJURIES

No matter what tree species is the frequencies of squirrel injury position to each injured tree are all the same. Injury at one place is the highest, two injuries was higher & three injuries was not found. Injuries occurred (as shown in Table V.) mostly on the bole, less than top, the least damage at branches.

INFLUENCE OF SQUIRREL DAMAGE ON TREE GROWTH

Estimates of the effect of squirrel damage upon growth of the 20 tree species were made by observation of weakness & death among injured trees as compared to normal trees in vigor & growth. In all stands investigated, dying trees are the least, weakened trees are the highest.

松鼠對於主要造林木之爲害 及其影響木材物理與機械性質之研究

高 大 成

柳杉及杉木爲目前台灣廣爲栽植之樹種，分佈既廣，數量亦多，然因部份幼齡林分，時遭松鼠爲害，致陷損失，甚爲可惜。本論文之研究目的，主在觀察其爲害狀況及對受害木材之物理及機械性質加以研究。

台灣所產松鼠，當以台灣松鼠屬之台灣松鼠，赤腹松鼠及條腹松鼠三亞種生棲數爲最多，分佈亦廣，致對林木構成嚴重之威脅。

不論爲固有種或引進種，均遭松鼠爲害，主隨其生育環境而異。柳杉及杉木樹皮經松鼠撕剝後，林木輒發生生長延遲，畸形發育，材部腐敗以及全株枯死等現象。

柳杉及杉木遭受松鼠齧食二至三年後，木材之各種物理及機械性質與健康木間則呈顯著差異，柳杉尤較杉木爲著。

作者認爲松鼠受害木不應視爲腐朽材，因其強度之減弱，不若腐朽材爲著，故二者有別。

林木遭受松鼠爲害後，利用率劇減，致經濟收益大爲減少，實爲今日台灣森林界亟需解決之問題。

A RESEARCH ON DAMAGED CONDITIONS OF TREES SQUIRRELS AND THEIR EFFECTS ON PHYSICAL AND MECHANICAL PROPERTIES OF MAJOR PLANTED SPECIES IN TAIWAN

Ta-Cheng Kao

Cryptomeria japonica and *Cunninghamia lanceolata* are the most extensively planted species in Taiwan. However, in view of their extensiveness and quantities they have been subjected to wildlife problems. Young stands were reportedly damaged by the gnawing of tree squirrels. The loss was tremendous. This thesis deals with the damaged conditions and the effects of tree squirrels on physical and mechanical properties of major planted species.

Among the seven species of Taiwan tree squirrels, three *Callosciurus* species caused serious damages to forest. They are *C. erythraeus taiwanensis* (Bonhote), *C. erythraeus roberti* (Bonhote) and *C. erythraeus oentralis* (Bonhote). No matter whether they were native or exotic species, suffering of damages by tree squirrels was just the same. But the difference of damage was affected by the habitat. As a result of tree squirrel injury caused by bark peeling, it induces the delay of growth, deformation of bole, decay of xylem and death.

After two to three years, the differences in physical and mechanical properties between normal and damaged woods of *Cryptomeria japonica* were more significant than those of *Cunninghamia lanceolata*.

台灣赤腹松鼠爲害溪頭柳杉之研究

袁 強

本論文之研究目的，主在蒐集溪頭松鼠之各種基本資料，藉供各林分自行“生態控制”之依據。由溪頭營林區之赤腹松鼠之生態習性，以探究松鼠爲害柳杉之原因。

本研究另尚探討柳杉之爲害部位與各齡級之關係，有關松鼠季節性爲害之變異，亦予探究。

A STUDY ON DAMAGED CRYPTOMERIA (*CRYPTOMERIA JAPONICA* D. DON.) AT CHI-TOU DISTRICT BY NORTH FORMOSAN RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS ROBERTI* BONHOTE)

John Jung Yuan

This study is aimed at determining basic information which can be used to design 'ecological controls' which can be applied through manipulation of the forest stand itself.

North-formosan red-bellied tree squirrel (*Callosciurus erythraeus roberti* BONHOTE) dominant species of tree squirrel in Chi-Tou district, whose ecological habitat can be used to trace the origin of tree squirrel peeling *Cryptomeria* (*Cryptomeria japonica* D. DON.)

The research will also aim at discovering the interrelation between damaged parts of tree and different age classes. And finding the relation between seasonal alternation and squirrel injuries will be considered too.

松鼠對臺灣經濟林木之爲害 ——松鼠爲害與樹種及樹齡之關係——

王子定 郭寶章

凡欲控制松鼠對林木之爲害，須自基本上及實際上研究松鼠之種類、習性、食性、生態及防治方法。本研究即爲此一綜合性研究之一部份。

本研究之目的有三：(一)松鼠種類之鑑定；(二)松鼠對樹種之爲害；(三)松鼠爲害與樹齡之關係。

據本研究之結果顯示：爲害林木之松鼠種類中，當推赤腹松鼠爲著。帶紋松鼠、荷士東松鼠雖具爲害，然不若赤腹松鼠爲甚。故本研究主以赤腹松鼠爲對象。赤腹松鼠之分佈遍及全省各地，自平地以至山區，惟以海拔 800~1,500 公尺爲其適生區域。松鼠之日間活動有兩個高峰，一在黎明（6~8 時），一在黃昏（16~18 時），惟以黎明出現機會較多。松鼠之出沒以單獨行動爲最多。松鼠極喜食果實類，尤嗜食含糖份或汁液較多之果實；松鼠之爲害林木呈季節性之變化，冬季由於潤葉樹果實成熟，林木少遭爲害，夏、秋兩季因盛產百香果，爲害亦較少，春季因天然食物短缺，且林木含樹液較多，松鼠爲吮食樹液，遂予蓄食，致形成較大之爲害。赤腹松鼠每年門齒之生長速度爲 0.248 公分，藉樹皮類之硬物予以磨擦，以阻止生長，而利取食。故松鼠磨損門齒亦爲樹皮遭撕剝之另一重要原因。

赤腹松鼠對樹種之爲害頗具選擇性，針葉樹之爲害大於潤葉樹；引進樹種如柳杉、杉木、琉球松、濕地松等，遠較臺灣固有之臺灣杉、紅檜、臺灣二葉松及臺灣五葉松等爲害嚴重。然亦有例外，如本地種之臺灣肖楠、香杉，殊遭嚴重爲害。

松鼠爲害林木之部位不同，遂影響林木之發育及木材之性質，潤葉樹種以果實、花芽受害爲多；針葉樹種則以樹皮受害爲大。

赤腹松鼠爲害與樹齡間具相關性。柳杉各齡級之爲害率呈極顯著之差異；以幼齡木爲害較輕，壯齡木爲害嚴重，老齡木又趨輕微，然較幼齡木爲著。幼齡木之受害部位以樹幹下段爲主，隨樹齡之增加，受害部位則漸移向上部或樹冠層。

SQUIRREL DAMAGE TO ECONOMIC FORESTS IN TAIWAN — RELATION BETWEEN SQUIRREL DAMAGE AND THE SPECIES AND AGE OF FOREST PLANTATIONS —

Tze-Ting Wang Pao-Chang Kuo

It is essential in the control of squirrel damage to forest plantations in Taiwan that a careful study be made of the squirrels that exist in the forest. This involves a study of the species, habitat, food habits and ecology of the squirrels. The damage caused by squirrels in this study refers to the bark-peeling by squirrels which usually retards the growth of trees and reduces the wood quality of the timber. Squirrel damage to forest plantations has been a critical problem in Taiwan in its reforestation program due to lack of knowledge of the squirrels and their habits and of control measures.

The objectives of the study are:

1. To identify the species of squirrel that damage the forest plantations.
2. To find out the species of trees which are damaged by squirrels.
3. To find out the relationship between squirrel damage and the age of forest plantations.

The area of study covers many forest districts under the control of the Taiwan Forestry Bureau. Most of the results obtained were from the Chitou District of the Experimental Forest of the National Taiwan University located in the middle part of Taiwan.

It was found from this study that the main squirrel damage to Taiwan forest plantations was caused by the red-bellied tree squirrel (*Callosciurus erythraeus*). Two other species of squirrels: Formosan striped squirrel (*Tamias maritimus*) and Perny's long-nosed squirrel (*Dremomys pernyi*) have caused less damage to forest plantations as compared to the red-bellied tree squirrel. Therefore, the results reported in this study are mostly about those damages caused by red-bellied squirrel.

Red-bellied tree squirrels are distributed all over this island from the lowlands to the high mountains. However, an elevation of 800 to 1,500 meter provides the best condition for their habitat. Squirrels start their intensive activity in the forest twice a day: in the early morning and early evening. It is believed that more squirrels come out in the morning than in the evening. Squirrels like to eat tree fruits, especially the kinds with high sugar and juice content.

There are seasonal differences in the squirrel damage to forest plantations. Less damage occurs during the winter due to the plentiful production of hardwood fruits from the natural forests. The summer and autumn seasons also have less damage because of a good supply of passion fruit. Spring presents the most serious damage because of the short supply of natural food. There are two other reasons that may explain the occurrence of serious damage: tree sap running in the spring may attract squirrel to lick the juice and the gnawing behavior of squirrels permits necessary wear of incisors.

Squirrel damage to forest plantations varies greatly with the species of trees. As a rule, conifers are more heavily damaged than the hardwoods. Introduced tree species, such as Cryptomeria (*Cryptomeria japonica*), China fir (*Cunninghamia lanceolata*), Luchu pine (*Pinus luchuensis*) and slash pine (*Pinus elliottii*) are easily damaged by squirrels. Native tree species such as Taiwania (*Taiwania cryptomerioides*), Taiwan red pine (*Pinus taiwanensis*), Taiwan red cypress (*Chamaecyparis formosensis*) and Taiwan white pine (*Pinus morrisonicola*) are less susceptible to their damage. However, some locally distributed trees such as Taiwan incense cedar (*Calocedrus formosana*) and Luanta fir (*Cunninghamia konishii*) are liable to be heavily damaged by squirrels.

In the hardwoods, the fruits and flower buds are the main food of the squirrels, while in coniferous forests the bark is peeled by squirrels.

There is a significant correlation between the age of Cryptomeria trees and the squirrel damage to trees as observed in this study. Young and old plantations appear less damaged than the moderate-aged stands. In the sapling stage, the lower part of the trunk is more heavily damaged. However, the damage will proceed upward to the crown of tree as tree grows older.

SQUIRREL DAMAGE TO FOREST TREES IN TAIWAN

Pao-Chang Kuo

Squirrel damage to conifer plantations has been a critical problem in Taiwan forest protection. One which called red-bellied tree squirrel is causing the most damage to forest trees. Squirrel strongly selects conifer for debarking. Introduced trees present heavier damage than that of indigenous. Less damage on hardwood species observed. Wounds caused by squirrel is seldom healed second damage by subsequent fungus infection is very common resulted in a decay of wood. It reduces the growth of tree and deform of the trunk or causes the failure of plantation establishment. Sapling trees are more susceptible to squirrel damage than that of young or old trees. The damage proceeds upward to the crown as the tree grows older.

A rice-paraffin bait block of warfarin has been used dominantly for poisoning squirrel with some success. Silvicultural treatments including weeding, pruning and thinning seem effective in the manipulation of squirrel habitat to reduce the population density of squirrel. Selection of reforestation tree species that have been highly resistance is a key step to control squirrel damage.

松鼠爲害臺灣杉與木荷之考察

——兼論中興大學惠蓀實驗林場之松鼠爲害概況——

郭寶章 林文鎮 方榮坤

中興大學實驗林惠蓀實驗林場，尙存有相當完整之天然林分布，以其特有之自然景觀及大面積之人工美林，不論在推進學術研究及發展森林遊樂上，均具有甚大之潛力。然原本輕微之松鼠爲害問題，已有日趨嚴重之勢，尤其一向少受爲害之台灣杉與木荷造林木，遭受爲害之情況，不容忽視。本文除報導兩樹種之受害實況外，並略述該林場之一般松鼠爲害情形，藉供參考。對於日益加重之松鼠爲害，必謀防範與控制之道，以維持及提高育林成果。

OBSERVATION ON SQUIRREL DAMAGE TO PLANTATIONS OF TAIWANIA AND CHINESE GUGER TREE —WITH SPECIAL REFERENCE TO SQUIRREL PROBLEMS IN THE HUESUN EXPERIMENTAL FOREST, NATIONAL CHUNGHSING UNIVERSITY—

Pao-Chang Kuo Un-Ching Lin Yung-Kuen Fang

Huesun Experimental Forest of National Chungsing University has still reserved quite area of natural forest together with its unique feature of terrain and scenery, there is a good potential in the development of forest research and recreation implementation. Due to its large area of forestation program under taken mainly with conifers, plantations established have encountered with varied extends of squirrel damage. Especially plantations of Taiwania and Chinese guger tree which show light to moderate squirrel debarking that have never been observed in this Station or other Forest Districts of Taiwan. There are squirrel problems of other tree species in this Station. Such problem has been increasing as the establishment of conifer plantation increases. Planting of tree species that are highly susceptible to squirrel damage should incorporate with an intensive forest care and control measures. Forestation effort can hardly be achieved if squirrel problem is not under control.

溪頭營林區松鼠爲害造林木實況之分析 ——兼論台大實驗林之松鼠爲害概況——

郭寶章 姜家華

台大實驗林五個營林區中以溪頭營林區開發最早，隨著天然闊葉林之伐採，而進行針葉樹造林之面積較廣，故松鼠爲害之問題亦較其他營林區爲嚴重，影響育林成果及經濟之收益甚著。溪頭因交通方便，地點適中，向爲研究松鼠生態及防治之中心地區。經研究觀察，溪頭遭受爲害嚴重之造林地，多屬於撫育不良。毗鄰天然闊葉林，溪側、蔭閉之壯齡林。目前每公頃施放 2 kg 可滅鼠臘米餌加以防治，似已顯著減少松鼠之新爲害發生。

ANALYSIS OF SQUIRREL DAMAGE TO FOREST PLANTATIONS IN CHITOU WITH REFERENCE TO GENERAL CONDITION OF SQUIRREL DAMAGE IN THE EXPERIMENTAL FOREST, NATIONAL TAIWAN UNIVERSITY

Pao-Chang Kuo Chia-Hwa Chiang

Chitou, one of five tracts of the Experimental Forest of National Taiwan University, was developed much earlier than other four tracts in term of forestation and management. Extensive planting of conifer trees has been undertaken following clear-cutting of natural hardwood stands. Such intensive management may be the major reason for squirrel damages to the conifer plantations. It caused a great economical loss as well as diminished our forestation efforts. Because of wide range of damage distribution and good accommodation facility, Chitou has become a center of research for ecological studies of squirrel and prevention measures of this pest animal. Findings from the past studies showed that poorly managed plantations are more susceptible to squirrel damage. Plantations adjacent to the natural hardwoods had higher damages. Pole-sized stands are easier to become damaged than the young or old stands. The application of 2 kg klerat per hectare seems very effective to reduce the new damage caused by the squirrels.

針葉樹栽植林之林分組成對松鼠為害之影響

郭寶章 王子定 陳栢蒼 李惠蘭

生育地因子殊影響松鼠之活動，不同林分組成適足改變森林之微環境因子。本文為欲瞭解森林微環境因子之改變對松鼠族群之影響，以及松鼠對林木為害之消長情形。

本研究主要以溪頭地區之針葉樹栽植林（柳杉、杉木與台灣杉）為對象，探討林分組成如樹種之混合形成及栽植密度對松鼠活動與為害林木之影響。

據本文之研究結果：台灣杉乃唯一未遭為害之樹種。柳杉與杉木之為害較嚴重，呈極顯著性之差異。惟柳杉與杉木混合林之為害率則低於柳杉或杉木之單純林。柳杉與杉木混合林內之杉木為害率又高於柳杉，呈顯著性之差異。

柳杉之栽植距離愈大，林木之為害率愈低，其中以疏植區 4×4 m 及 5×5 m 為最低，其與密植區（ 1×1 m、 2×2 m 及 3×3 m）之差異顯著，惟兩區內之各栽植距離不呈顯著性差異。隨栽植距離之增加，為害率有自幹部移向冠部之趨勢。直徑較大之優勢木易遭松鼠為害，故直徑級與栽植距離同為影響松鼠為害林木之主要因子，唯以栽植距離較直徑級為顯著。杉木之密植林分之為害率亦顯著地高於疏植林分。

EFFECTS OF FOREST COMPOSITION ON THE SQUIRREL DAMAGE IN CONIFEROUS PLANTATIONS

Pao-Chang Kuo Tze-Ting Wang Bor-Tsang Chen Wai-Lan Li

Condition of forest plantation is considered to be important factors to determine the preference of the habitat for the squirrels. In this study it is intended to find out the effects of forest composition on the squirrel damage to coniferous plantations.

The investigated areas were chosen including plantations of *Cryptomeria*, China-fir and *Taiwania* established in the Experimental Forest of National Taiwan University located in the central part of Taiwan. The effects of tree species, their composition and planting spacing on *Cryptomeria* plantation were investigated.

The following results are obtained through the present works: *Taiwania* is the only undamaged species by squirrels. Pure stand of either *Cryptomeria* or China-fir are more severely damaged. Squirrel damage in mixed stand of *Cryptomeria* and China-fir is lower than in the pure stands of either tree species. In mixed stand, squirrel damage on China-fir is significantly higher than that on *Cryptomeria* in the same stand.

Squirrel damage is low when planting space is large. For example, in *Cryptomeria* plantation, planting space of 4×4 m and 5×5 m showed a lower damage than that of 1×1 m, 2×2 m, and 3×3 m spacings. The damaged part by squirrel tends to go up from trunk to crown as planting space increases. Dominant trees seem more susceptible to squirrel damage than the suppressed trees. However, planting space shows highly significant on the squirrel damage when tree growth is vigor. Dense stand of China-fir also shows higher damage than sparse stand of the same species.

Due to wood decay caused by squirrel barking, the stem utilization percentage of Cryptomeria and China-fir has decreased to 0.53 and 0.55 respectively when the stem utilization percentage of healthy wood is 0.7. This figure shows about 20 percent decrease. A form factor of tree stem was decreased to 0.40 and 0.38 for Cryptomeria and China-fir respectively. On both species it corresponds 10 percent less than the form factor of 0.45 for healthy trees. In fact both form factor and utilization percentage of stem are key factors for the calculation of stem volume in forestry. Squirrel damage seriously reduced the growth of both species of tree especially on volume growth which was decreased remarkably as the degree of damage increases. The effects of squirrel barking on the growth of diameter and height was significantly different among the various class of damage. The tendency is more remarkable in the plantation of Cryptomeria, China-fir showed irregular trend on the growth pattern as related to squirrel damage.

松鼠害對造林木生長及木材損害之影響

郭 寶 章

松鼠為害造林木所造成之經濟損失及造林成果之減低已引起林業界之嚴重關切。本文欲瞭解林木遭受松鼠為害後對林木之生長、幹材利用率與形數之影響及為害樹齡、傷口數、傷口位置等之關係，以供為松鼠為害林木所受損失之評估資料及林業經營方面之參考。

自溪頭 20 年生之柳杉與杉木之伐倒木各逢機取樣 106 株、調查受害木之傷口位置、傷口數，並計算其立木材積、利用率與各樹種不同為害等級之形數差異。由不同為害等級中各逢機選取 4 株樣木進行樹幹解析 (tree stem analysis)，以調查林木之生長量及決定其對林木之樹高、胸徑及材積生長量之影響；並由圓盤之判釋決定為害年齡、傷口數、傷口位置與腐朽面積之關係。

松鼠為害所造成之木材腐朽使柳杉與杉木之幹材利用率分別減低為 0.53 與 0.55，較一般所訂之 0.7 者約低 20% 強。柳杉與杉木受害木之平均形數分別為 0.40 與 0.38，約低於一般所訂之形數 (0.45) 10%。幹材利用率及形數可供松鼠為害林木材積計算之依據。松鼠之為害，顯著地降低林木之生長量，此在材積生長方面尤為顯著，均因為害程度之增加而降低。胸徑與樹高生長方面之差異，柳杉較為顯著，而杉木較不規則。

自樹幹圓盤上之判釋，柳杉之受害樹齡始於 6 年生，以 13~14 年生為最嚴重，杉木則始於 5 年生，最多為 14~15 年生，在受害嚴重時期之後，傷口數顯著減少。柳杉與杉木之傷口數以樹幹下側之位置 (分別為 3.3~4.3m, 0.3~1.3m) 較多，樹幹下側之木材為幹材之主要部份，遭受松鼠為害後，將嚴重地減低材積及木材之價值。

THE EFFECTS OF SQUIRREL DAMAGE ON TREE GROWTH AND WOOD LOSS

Pao-Chang Kuo

The economical losses and reduction of reforestation effort due to squirrel barking has become a big problem in Taiwan forestry. This study intends to estimate the influences of squirrel damage on the growth of trees, stem utilization percentage and form factor. The relationship between wood loss and age of tree damaged, number of wounds, location of wounds were also studied. The result of the study will serve an information for evaluation of trees lost by squirrel barking and propose baseline for forest management after damaged.

The present work was conducted with 106 felled trees of 20-year Cryptomeria and China-fir. Location and number of wounds of trees damaged by squirrel were recorded. The volume and utilization percentage of trees and their form factor of various damaged trees were calculated. Four trees from each damaged class were sampled for tree stem analysis. It was used to determine the growth of height, diameter and volume of trees of various classes of squirrel damage. The relationship between age damaged, number and location of wounds were investigated from the trunk disk.

為害造林木松鼠類動物之鑑定

——依樹皮屑片為基準——

郭寶章 何鴻育

台灣有關松鼠為害及防治情況，主以赤腹松鼠為研究對象，惟多年來已發現飛鼠類亦參與為害林木，不容忽視。故近年已積極研究飛鼠之生態與習性，並確定其為害之情況，實屬嚴重。赤腹松鼠與飛鼠類兩者多棲息於相同之環境區內，兩類動物有其不同之生活習性，為害林木之情形亦不盡相同。如何鑑定為害林木之動物種類，對於為害之評估與研究，亟為重要。本文乃擇台灣大學實驗林及林務局玉山林區與巒大林區小部分造林地加以調查，依受害木之樹皮被剝食情況區分為二類，以分析受害木傷口之位置、剝落樹皮重量、樹皮上遺留齒痕之角度、齒痕間之距離等特性，而確定各類樹皮之剝害動物種類，以供鑑定上之參考。因研究時間短促，僅屬於初步之結果，有待日後加強研究，以使資料更為充實而可靠。

IDENTIFICATION OF DAMAGE-CAUSING ANIMALS OF SCIURIDAE TO FOREST PLANTATIONS — BASED ON THE PIECES OF DAMAGED BARK —

Pao-Chang Kuo Hung-Yu Ho

In Taiwan for many years the study and control of squirrel damages to forest plantations has been concentrated on red-bellied tree squirrels. Because it is believed to be the main culprit of damage-causing animal. However, there is a definite evidence shown that flying squirrels have been involved in the debarking problems. These two kinds of animals belonging to Sciuridae basically inhabit in the same habitat and depending on forests for living. It is important to identify the damage-causing animal for a better control implementation. This study selected small portion of infested plantations in the Forestry Districts of Yushan and Luanta, Taiwan Forestry Bureau and the Experimental Forest of National Taiwan University located in Central Taiwan where squirrel damages have been mostly a serious problem. Three types of bark damaged by pest animals were classified according to the characteristics of bark pieces damaged. The classification of bark types was based on the location of wound from the ground, clear length of the damaged tree and weight of bark damaged for a single tree and tooth markings which included the angle and distance between the marks. From the criteria for the classification of bark pieces three damage-causing animals were identified in accordance with the major peculiarities observed. They were red-bellied tree squirrel (*Callosclurus erythraeus*), Formosan giant flying squirrel (*Petaurista petuarista grandis*), and white-faced flying squirrel (*Petaurista aldorus lena*).

台大森林學研究所碩士論文 (Master Thesis of Division of
Silviculture, Graduate Inst. Forestry, N.T.U.) 57 pp.
(1987)
中華林學季刊 (Q. Jour. Chin. For.) 20(3):29-43
(1987)

松鼠剝皮後杉木癒傷組織之形成與解剖的研究

林錫鑫 郭寶章

自民國75年3月至民國76年3月，在南投縣之和社與蓮華池的杉木造林地，觀察松鼠剝皮傷口癒傷組織之形成與發育。松鼠剝皮之時間，因地區不同而略有差異，傷口之形狀，位置亦極不一致；和社地區傷口之高度約為蓮華池之二倍，可能與林齡、枝下高及人為干擾有關。

杉木之癒傷組織其來源有三：(1)韌皮部，(2)形成層，(3)幼嫩之木質部組織（早材），它們相會合後再逐漸封閉傷口。影響癒傷組織發育之環境因子，主要的有氣溫與降雨量；蓮華池之平均氣溫較和社高3℃，且溫差小，降雨量較高，較有利於癒傷組織之發育。本研究顯示，6月至9月為杉木癒傷組織發育之旺盛期，在適溫狀態，降雨量對癒傷組織之發育殊具決定性。在適宜的生育環境，剝皮傷口寬度未達0.8 cm時，將可在一年內癒合。

溫度對松鼠剝皮傷口癒傷組織發育之影響並不顯著；同時，高溫多濕易導致暴露之木質部變色，由本研究結果推測，幼齡杉木（10年生以下），不論傷口大小，只要木質部暴露期間超過6個月。木質部都會變色，甚至有微生物侵入。

CALLUS FORMATION AND ANATOMICAL STUDIES ON TREE WOUNDS OF CHINA-FIR DEBARKED BY FORMOSAN RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)

Shi-Shin Lin Pao-Chang Kuo

This study, callus formation and anatomical studies on tree wounds of China-fir (*Cunninghamia lanceolata*) debarked by Formosan red-bellied tree squirrels, was conducted in Hoshe and Lienhwachi China-fir plantations from March 1986 to March 1987.

Study results revealed that shape of wounds and their locations on the trunk varied with the study site and time of debarking. Debarked wounds located were two times higher in Hoshe than Lienhwachi, this possibly was due to the difference in age of the trees and clear-length of trunk or human disturbance near the study site would probably cause squirrel debarking in the higher locations of the trunk.

Callus formation was originated from three sources: phloem, cambium and young exlem or spring wood. Wounds were healed when these three tissues developed together. Major environmental factors involved in callus formation were temperature and rainfall. Temperature in Lienhwachi was 3°C higher than Hoshe and the range of temperature was also smaller and with its high rainfall so that climate in Lienhwachi greatly favored the growth of callus tissue than that

in Hoshe. In both study sites, the development of callus was most luxuriant from June to September of the year.

Under an optimum temperature condition, rainfall became an important factor to determine the development of callus tissue. Size of wounds less than 0.8 cm could be healed within one year.

Humidity showed insignificant effect on the development of callus formation. Besides, high humidity would result in a discoloration of wood in the wounds. Young trees of China-fir below ten-year old, disregarding the size of wounds, wood discoloration might result and microorganism infection would appear, when wounds were exposed in the air over six months after debarking by the squirrels.

美國之西部灰松鼠啃剝針葉樹樹皮之觀察

郭寶章 陳仲賢 譯

不同種類之樹松鼠 (Tree squirrel) 啃剝針葉樹之樹皮，主在取食韌皮部與形成層之組織，有時是爲了採集築巢所需的材料。本文作者之一鮑德溫 (Baldwin) 於 1977 年在美國南奧勒岡州 (Southern Oregon) 傑克森郡 (Jackson County) 內近菩提瀑布 (Butte Falls) 之森林，首先發現西部灰松鼠 (Western gray squirrel, *Sciurus griseus*) 啃剝美國西部黃松 (*Pinus ponderosa*) 與花旗松 (*Pseudotsuga menziesii*) 的樹皮，爲害情況相當嚴重。啃剝樹皮係在某一特定的部位，受害木一般是 0.8m 的直徑居多，受害部位的高度可達 21m 之樹幹，受害木遠看有如理髮店招牌螺旋狀的桿柱。灰松鼠用前門齒啃剝樹皮，成細長條狀，啃剝的速度很快，在很短的時間內，林地上便堆滿了樹皮屑，剝皮的時期是 2 月中旬至 4 月，但這一特殊族群灰松鼠啃剝樹皮之真正動機，尙欠明瞭。

SQUIRREL DEBARKING AND DAMAGE TO FOREST PLANTATIONS

P. C. Kuo T. Y. Ku

Studies conducted over the past five years have shown that the red-bellied tree squirrel (*Callosciurus erythraeus*) is closely involved in the debarking problem affecting Taiwan's forest plantations. Debarking by this pest animal means the stripping or peeling of bark from the trunk of a tree. Variation in debarking susceptibility among different tree species is considerable. Conifers are generally more susceptible to debarking than hardwoods. Conifers with a high sugar content in the bark appear to be very susceptible to debarking. Data show that more damage occurs in the spring when the sugar content is high. Tooth marks observed on the inner bark suggest that debarking is for food. Trees reaching the sapling stage show more damage than young or old stands. However, trees with dead tops caused by squirrel girdling in the upper trunk are also common in old stands. Squirrel damage was considered to be a local problem but in recent years many larger areas of plantations have also been involved. This is due mainly to the conversion of natural hardwood stands into monocultured conifer plantations. Heavy debarking and subsequent fungal infection of *Cryptomeria* and China fir have greatly reduced the diameter growth and volume yield of these trees. Squirrel damage can also reduce tree survival in the early stages of plantations. Trunk deformation and wood decay resulting from debarking reduce wood quality and the sale prices of timber.

不同殺鼠劑對松鼠之毒殺效果研究

姜家華 施能毅 蔡輝 陳茂雄
呂正吉 江桓冲 鄧偉雄 簡文村
顏秉貞 王亞男 劉筱馨

近年來因林相變更與改良的結果，天然林逐漸減少，取而代之的為大面積之人工林；由於生態環境改變，松鼠賴以維生之多種闊葉樹果實大量減少，遂導致松鼠遷移至人工林，啃嚙樹皮、樹梢，為害造林木。又因松鼠之天敵老鷹、山貓等幾已絕跡，以致松鼠族群急速增加，為害林木情形日益嚴重，因而松鼠防治之研究為林業界當前刻不容緩之急務。

防治松鼠之方法很多，欲使松鼠族群急速下降，在本省目前最有效最快速之方法即是毒殺。本研究在實驗室內使用遲效性殺鼠劑Warfarin及Diphacin與速效性殺鼠劑Zinc phosphide及Sodium monofluoroacetate配成各種濃度之蠟米毒餌進行毒殺試驗。試驗結果，各種殺鼠劑之適宜濃度如下：①Warfarin 0.025% ②Diphacin 0.005% ③Zinc phosphide 2% ④Sodium monofluoroacetate 0.25%。

據試驗結果所得的Warfarin最佳濃度0.025%之蠟米毒餌在野外林間進行毒殺試驗，結果施放毒餌後造林地之林木均未再受害，對照區之林木仍有2%之新受害，由此可見使用Warfarin毒餌毒殺松鼠之效果頗佳。除Sodium monofluoroacetate有二次中毒現象且無解藥因此停止試驗外，現正同時進行另外三種藥劑之野外毒殺試驗，期能找出毒殺松鼠之最佳毒餌。

STUDY ON THE EFFECT OF DIFFERENT RODENTICIDES TO SQUIRREL

Chia-Hwa Chiang Neng-Yih Shih Whei Tsai
Mao-Hsiung Chen Cheng-Chi Lii Hwan-Chong Giang
Wei-Hsiung Tang Wen-Tsuen Chien Bing-Jen Yen
Ya-Nan Wang Hsiao-Hsing Liu

The recent forest improvement operation has induced a large scale of the artificial forest to replace the original natural forest. In the matter of course, it brought a remarkable shortage of hardwood fruits and nuts in the habitat of Formosan squirrel. Then, the squirrels are compelled to immigrate to the artificial forest to attack the bark of some coniferous trees. In addition, the extinguishment of the natural enemies, such as carnivorous mammal hawks enhanced the virulence of squirrel damage in the artificial forest. Therefore, the squirrels are recognized as one of the most destructive animals to forest for the last ten years. And the establishment of the squirrel control methods are urgently demanded on the point of forest protection view.

In the present situation, the application of the poison bait is considered as the most rapid and advisable control method against the squirrel. To set this aim, the present work is conducted for the purpose of designing the preferable use of poison bait for the squirrel control. The work was done with following 4 rodenticides. They are: Warfarin, Diphacin, Zinc phosphide and Sodium monofluoroacetate. Among them, the first two are acute chemicals and the others are known as chronic ones.

The result of the laboratory test reveals the fact that, the optimum concentrations for the preparation of a poison bait are 0.025, 0.005, 2 and 0.25% for Warfarin, Diphacin, Zinc phosphide and Sodium monofluoroacetate respectively.

The field test was carried out with the poison bait which contains 0.025% Warfarin. Then, no new squirrel damage was observed in the bait-treated area. However 2% of newly damaged tree are estimated in the untreated area.

Sodium monofluoroacetate is recognized as an unfavorable rodenticide for the squirrel control because of its high toxicity to the manking and lacking of an effective antidote.

The further field test is still on proceeding with the other three rodenticides.

赤腹松鼠對誘引物之接受性試驗

郭寶章 呂理昌

本研究係就赤腹松鼠對於兩種餌料誘引物 (bait attractants): 糖鹽類 (糖精、食鹽及香蕉油等, 分爲高低兩種用量) 及食油類 (豬油、花生油、玉米油、沙拉油、食用醋調味品等, 均爲一種用量) 之嗜食性試驗。將上項誘引物添加在餌料中餵食松鼠, 以調查對於松鼠之取食效應。

結果顯示赤腹松鼠在糖鹽類誘引物中對 0.1 % 香蕉油之添加達到最高之取食率, 添加 0.1 % 及 0.2 % 糖精次之, 兩種添加物與其他添加物間之差異均達顯著水準, 添加 0.1 % 及 0.2 % 食鹽對於松鼠不具誘引之效應, 而於餌料中添加 0.2 % 香蕉油, 反有減低松鼠取食之影響, 值得注意 (圖 1)。在食油類誘引物中以添加調味品 5 % 食用醋對松鼠呈現極高之誘引效應, 並較其餘各種食用油之添加的取食差異超過甚多, 而達極顯著水準。

TESTING ON THE ACCEPTANCE OF SOME ATTRACTANTS BY RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)

Pao-Chang Kuo Lii-Chang Leu

The objectives of this study was to test two groups of attractants on the consumption by red-bellied tree squirrel. Attractants tested included a group of sugar and salt: saccharin, salt, and banana oil, all had two concentrations and a group of vegetable oils: lard, peanut oil, corn oil, salada oil, sesame oil and vinegar, all had single concentration.

It was found from this study that 0.1% of banana oil added to the bait showed the highest consumption by the squirrel than that of saccharin and salt. Saccharin was secondary good. A 5% of vinegar added to the bait showed the highest consumption by the squirrel than the four vegetable oils tested. Four vegetable oils showed no effect on the consumption by the squirrel. The findings mentioned above all indicated statistically differences. It is concluded that 0.1% of banana oil and 5% of vinegar were highly accepted by the squirrel in term of food consumption. Saccharin either 0.1% or 0.2% indicated moderate high acceptance by the squirrel.

可滅鼠毒殺赤腹松鼠之機制與效應

郭寶章 應之璘 呂理昌 林季櫻

赤腹松鼠之為害林木，已嚴重的減低台灣之造林成果，多年來迄以採用毒殺法為主，著有成效。本文之內容包括作者等之試驗結果及引用若干本省有關文獻，作綜合性的討論與敘述，其目的在提供今後松鼠毒殺上之基本資料。具體之資料有主要殺鼠劑之介紹，特別為本省近年引進之可滅鼠之毒殺松鼠機制與效應，並與殺鼠靈做一比較，亦包括 1080 化合物與磷化鋅之毒殺松鼠效果。此外，尚有作者等近年實施之室內試驗結果，如可滅鼠毒殺松鼠之半致死量，不同濃度之死亡率與死亡天數；及取食不同濃度可滅鼠臘米餌之影響與最低之致死量等，此外尚包括可滅鼠之林內試驗結果。最後，並有可滅鼠應用上基本原則之建議要點。

MECHANISM AND EFFICACY OF KLERAT IN THE CONTROL OF FORMOSAN RED-BELLIED TREE SQUIRREL

Pao-Chang Kuo Sze-Ling Ying Lii-Chang Leu Chi-Ying Lin

In Taiwan, reforestation has been greatly hindered due to the extensive damage of forest plantations caused by squirrel debarking. For many years, poisoning has been the main measure and fairly effective means in the control of squirrel damage. This report consists of results obtained from studies conducted by the authors and local experts of similar field to draw an integrated conclusion of some rodenticides especially klerat and others in their mechanism and efficacy over Formosan red-bellied tree squirrels. Detailed results include LD_{50} of klerat, minimum amount of rice-paraffin block of klerat that will kill the animal, etc. Together with the results of klerat applied in the forest plantation, this report can serve as basic information in the klerat application for squirrel control in Taiwan forestry.

不同殺鼠劑毒殺效果之研究

姜家華 施能毅 蔡輝 陳茂雄
呂正吉 江桓冲 鄧偉雄 簡文村
王亞男 劉筱馨 鍾年鈞 顏來貞

近年來天然林逐漸減少，人工林取而代之，由於生態環境改變，松鼠維生之果實銳減；又因松鼠天敵老鷹、山貓等幾已絕跡，松鼠族群因而急速增加，並導致松鼠遷移至人工林後，造林木之鼠害日趨嚴重，故松鼠防治之研究為林業界當前刻不容緩之急務。

防治松鼠方法很多，本省目前最有效而快速方法之一即毒殺。本研究先在實驗室內使用遲效性殺鼠劑殺鼠靈 (Warfarin)、得伐鼠 (Diphacin)、可滅鼠 (Klerat) 及撲滅鼠 (Bromadiolone) 與速效性殺鼠劑磷化鋅 (Zinc phosphide) 及 Sodium monofluoroacetate 配成各種不同濃度之臘米毒餌進行毒殺試驗。經試驗結果，各種殺鼠劑之適宜濃度如下：①殺鼠靈 0.025 %，②得伐鼠 0.005 %，③可滅鼠 0.005 %，④撲滅鼠 0.005 %，⑤磷化鋅 2 %，⑥ Sodium monofluoroacetate 0.25 %。

據室內試驗結果，以殺鼠靈最佳濃度 0.025 %、可滅鼠 0.005 % 及撲滅鼠 0.005 % 之蜡米毒餌置於造林地進行毒殺試驗，結果已施放毒餌後之造林地均少見受害，反之，對照區尚有 2 % 林木新受害，可見使用殺鼠靈、撲滅鼠及可滅鼠毒餌之效果均佳，故可滅鼠及撲滅鼠更具使用量少且不需連續多次施放之特性，故大面積施放較為經濟。

STUDY ON THE EFFECT OF DIFFERENT RODENTICIDES

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Wei-Hsiung Tang Wen-Tsuen Chien Ya-Nan Wang
Hsiao-Hsing Liu Lain-Chun Chung Bing-Jen Yen

Due to the recent forest improvement operations, large scale of the artificial forests have been converted from natural forests. In the meantime, remarkable shortage of hardwood fruits and nuts of Formosan squirrels in the habitat happens. Then, the squirrels are forced to immigrate to attack the coniferous trees in the plantations. In addition, the decrease of the natural enemies of squirrels, such as carnivorous mammal hawks enhanced the virulence of squirrel damage in the man-made forest. The squirrels are generally recognized as one of the most destructive animals to man-made forest for the last ten years. Therefore the squirrel control is urgent.

At the present time, poisoning is considered as the most effective and recommended for its control. The purpose of this paper is to test and choose suitable poison baits for the squirrel control. The work is done with following six rodenticides; Warfarin, Diphacin, Klerat, Bromadiolone, Zinc phosphide and Sodium monofluoroacetate. Among them, the first four are acute effect and the rest are chronic.

The result in laboratory test reveals that, the optimum concentrations for the poison are 0.025, 0.005, 0.005, 0.005, 2 and 0.25% for Warfarin, Diphacin, Klerat, Bromadiolone, Zinc phosphide and Sodium monofluoroacetate respectively.

In the field tests, the treatments are 0.025% Warfarin, 0.005% Klerat and 0.005% Bromadiolone respectively. So far, no new damage was found in the all-treated plots, but 2% of newly damaged trees are calculated in the check.

造林地松鼠毒殺效果評估之芻議

郭寶章 李惠蘭 劉一新

台灣之林務機構爲防止松鼠之爲害林木，在全省各林區正廣泛的施用可滅鼠以進行毒殺松鼠，在施用之後新被害木之株數已少有發現，顯已呈現良好防治效果，然究竟成效如何，尚缺乏數量化之可靠資料加以印證。因之，發展一套合理的松鼠毒殺效果之評估方法，乃松鼠防治上亟重要之措施。本文首先總括的舉示影響松鼠毒殺效果之各項因子，並依可滅鼠之施用爲原則，就兩年來擇台大實驗林、台灣省林務局玉山、文山兩林區計三處造林地，進行之評估調查，以列述餌料之施放重點與毒殺效果評估之結果，以提供評估松鼠毒殺效果之初步模式，惟仍有待進一步之深入求證，以臻完善。

GENERAL APPROACH TO AN EFFECTIVE EVALUATION OF SQUIRREL CONTROL WITH KLERAT IN FOREST PLANTATIONS

Pao-Chang Kuo Wai-Lan Li I-Hsien Liu

In Taiwan forestry, an extensive program of squirrel control with klerat has been carried out in many Forest Districts during past few years. Good result shown by the reduction of newly damaged trees after control indicates that klerat has been a promising rodenticide in use. However, there is a lacking of quantitative information on the actual result of squirrel controlled. It is essential to develop a model for damage assessment and control evaluation of the klerat application for a better implementation. This report concludes factors that will affect the efficacy of the application of rodenticides in forestry. A field observation was done on three infested forest plantations selected from the Experimental Forest of National Taiwan University and Taiwan Forestry Bureau. In the past two years both considerations for bait placement and techniques of efficacy evaluation of squirrel control were observed. Results derived from the investigation can serve as a primary information in the development of a model to evaluate effort accomplished in squirrel control with klerat. Detailed studies undertaken by the authors hopefully would supply additional information on the construction of a better model.

台灣森林鼠害之防除與研究

應之璘 蘇學波

1 解決防除經費困難：

森林鼠害為害林木，早自日據時期即已發現，惟至台灣光復以後，情況更趨嚴重，尤以民國五十四年以後，大量伐除天然闊葉樹林，改植單純之針葉樹種，松鼠的棲息環境被破壞，天然果實等食物短缺，遂剝食樹皮。松鼠以外尚有飛鼠、野鼠，近年來高山地區（海拔 2,000 公尺左右）紅檜新植造林亦常遭受台灣森鼠為害，影響造林成果至鉅。而飛鼠、森鼠之生態習性尚乏研究，故森林鼠害防除之困難可以概見。何況近年來林務局財務情況不佳，自民國七十二年度以來皆賴行政院農委會農糧處（前農發會）之補助，惟林區面積廣大，經費有限，應用毒殺法亦僅就為害嚴重地區作重點防除，每年防除面積僅佔全省林地面積之 1 / 400，微乎其微，未能全面有效的防除，必須大量寬增經費從事防除，否則杯水車薪，無濟於事。

2 改善林業經營：

鼠害防除今後除請行政院農委會繼續補助，作全面性、持續性與有計劃執行外，並應自鼠類生態學的觀點來改善林業經營，例如溪頭台大實驗林之森林帶主屬暖帶林（海拔 700 ~ 1,500 公尺），高溫多濕而雨量又特多，林內林床植物繁茂，為赤腹松鼠棲息適生之良好環境，其受松鼠為害亦最烈。反之，本局檮大林區轄內杉林溪與溪頭林區鄰接，同樣種植柳杉造林地，而松鼠之為害率僅在 10% 以下，甚為輕微。此可能由於(1)杉林溪海拔 1,500 ~ 1,800 公尺，較之溪頭略高，(2)杉林溪之地形較具開放性，日光量多，濕度低，一日之氣溫變化亦較大，林內林床植物之生育未如溪頭之繁茂（郭寶章，1985）。Shaw (1925) 稱陽光、坡向與水分每影響哥倫比亞地松鼠 (Columbian ground squirrel) 之活動。由於溪頭為一谷形盆地，屬陽光較少之坡向，故林木之受害率自較杉林溪為高。此外期由樹種之選定與森林經營方法之應用，以造成不適松鼠棲息之生育地，降低族群密度而達控制松鼠為害之目的。

3 改進育林技術

近年來本局推行複層林之育林技術，或稍可彌補過去大面積單純林造林之缺點，因不施皆伐，有維持地力，保持水土之功效且生物相複雜，生態作用強，有利於松鼠及其天敵之棲息，易於保持自然界的生態平衡。

三者有效配合運用，將可有效控制森林鼠害，否則難望有成。

赤腹松鼠毒殺防治技術與效果評估方法 之初步研究

劉 一 新

自民國70年以來，臺灣省林務局與台大實驗林先後採用可滅鼠以毒殺赤腹松鼠，施用後顯已呈現良好之效果，新被害木的株數亦有減少之趨勢，然而確切成效究竟如何，尚缺乏數量化之可靠資料加以印證，因之，發展一套合理可行的松鼠毒殺效果評估方法乃松鼠防治上極重要之措施。

本試驗以食物消耗調查為主，以標放法調查為輔，於民國74年2月至75年4月間，分別在臺灣省林務局玉山林區及台大實驗林內茅埔營林區二地進行評估調查，所得之結果可以做為毒殺評估及改良現行毒殺方法之依據，唯細節部分，尚待進一步之研究。

試驗中發現：

- 1 食物消耗法可以簡單而經濟的評估赤腹松鼠之毒殺效果。
- 2 以塑膠袋裝餌毒殺赤腹松鼠時，每包毒餌量不宜超過 10 gr。
- 3 單位面積之毒餌施放量可以低至 0.3 kg/ha，然可達於 98 % 之毒殺效果。

PRELIMINARY STUDY ON THE CONTROL TECHNIQUES AND EFFICACY EVALUATION OF POISONING RED-BELLIED TREE SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*)

I-Hsien Liu

A study on the improvement and evaluation of squirrel control with Klerat has been carried out in plantations established by Taiwan Forest Brueau and the Experimental Forest of N.T.U. The objective of this study is to develop a reasonable model for the evaluation of squirrel control and its control techniques.

Food Consumption Index (FCI) and Marking and Release Method have been used to evaluate the efficacy of the Klerat application in two squirrel infested forest plantations were selected and studied from Feb. 1985 to Mar. 1986. Results derived from the investigation can serve as a primary information to improve the evaluation effort and control practices of squirrel damages in forest plantations.

Food Consumption Index can be used to evaluate the efficacy of squirrel control just as good as means of Marking and Release and more simple and economy.

When plastic bag of bait is used as a means of settling bait, the amount of a bag should not exceed 10 gr., and the application of the bait should be less than 0.3 kg/ha.

赤腹松鼠毒殺技術與效果評估之研究

郭寶章 劉一新 應之璘

台灣赤腹松鼠對造林木所造成之為害，已嚴重的降低育林成果。過去十餘年之研究顯示，松鼠之為害與人工林內之自然食物缺乏供應不足，以致啃食樹皮有關。故防治之道首在減低松鼠之族群密度，而毒殺因較其他捕殺法更有效果，故為目前普遍應用之方法。本文乃以近 5 年間連續研究松鼠毒殺之有關技術所獲基本資料為基礎，再配合室內與野外試驗之各項評估結果，而擬定赤腹松鼠毒殺防治之規範，包括佈餌時期（季節），施放地點（造林地內位置）與毒劑用量（單位面積之施用量）等，與舉示最經濟及符合生態之防治原則。並就毒殺松鼠後所發生之效果，加以評估一點，亦發展一套可行之模式，而使赤腹松鼠毒殺技術與效果評估兩點，做綜合性的歸納，以利林業上松鼠防治之參考。同時，本文所示結果反應若干問題需要作深入研究與求證，以為今後松鼠防治之技術，與效果評估上改進之依據。

CONTROL TECHNIQUES AND EFFICACY EVALUATION OF POISONING FORMOSAN RED-BELLIED TREE SQUIRREL (*Callosciurus erythraeus*)

Pao-Chang Kuo I-Hsien Liu Sze-Ling Ying

Formosan red-bellied tree squirrel (*Callosciurus erythraeus*) has been a squirrel in Taiwan that caused a major damage to forest plantations. Thereby, reforestation effort was seriously reduced. It was believed that short supply of natural food to the squirrels in the monoculture plantation would be the main reason for trunk debarking. Reduction of squirrel population by poisoning has been effective and considered as a major practice in the control of squirrel damage to forests. This study, summarize technical aspects of squirrel control based on results of research conducted in last five years by the authors to provide information for a success prevention of squirrel damage. Details of guideline on time, location and dosage of poisoning squirrel to be applied in the infested plantation were concluded. In addition, efficacy evaluation model was developed which serves as a baseline in assessing how a control program of poisoning squirrel can be effectively conducted.

食物消耗與標放調查在赤腹松鼠防治上的應用 ——受害造林地內赤腹松鼠之活動與分布估測——

郭寶章 劉一新

自民國70年以來，臺灣省林務局與臺大實驗林，先後採用可滅鼠 (Klerat) 毒餌以毒殺赤腹松鼠，施用後新被害木有減少的趨勢，顯已呈現良好的防治效果。然而確切成效如何，尚缺乏數量化的可靠資料加以印證。因此，發展一套合理可行的松鼠毒殺效果評估方法，乃松鼠防治工作上之重要措施。

本文乃第二作者自民國74年2月至75年4月間，於臺大實驗林內茅埔營林區所做調查之結果，並為其碩士論文之一部分。調查以食物消耗法為主，標放法為輔，並進行棲息地重要因子之解析，以明瞭松鼠在造林地內之活動與分布情況，所得之結果可供為松鼠毒殺效果評估及改進毒殺技術之依據。

根據調查之結果，發現以下論點：

- 1 食物消耗法可以簡單而經濟地估測赤腹松鼠之活動與相對密度及掌握其分布之概況。
- 2 造林地內赤腹松鼠之活動與分布情況頗受棲息地因子之影響，其中尤以食餌植物之數量及林分鬱閉度二項最為重要。
- 3 以塑膠袋裝餌毒殺赤腹松鼠時，每包毒餌量不宜超過10公克，單位面積之毒餌施放量降低至每公頃300公克時，仍可獲98%的毒殺效果。
- 4 應用食物消耗法調查松鼠之相對密度及活動分布與標放法所獲結果相當一致，依研究者之目的，可酌予選用。
- 5 本研究結果中之部分資料曾在台大實驗林研究報告1(3):1-16, 1987 "赤腹松鼠毒殺技術與效果評估之研究"一文中引用，閱讀時請參考。

APPLICATION OF FOOD CONSUMPTION AND MARK-RECAPTURE IN THE CONTROL OF FORMOSAN RED-BELLIED TREE SQUIRREL — AN ESTIMATION OF THE ACTIVITY AND DISTRIBUTION OF THE SQUIRREL IN AN INFESTED PLANTATION OF CHINA - FIR—

Pao-Chang Kuo I-Hsien Liu

Since 1980 the damage of squirrel to trees has been greatly reduced by the application of poison bait of klerat in the forest plantations in Taiwan Forestry Bureau and the Experimental Forest of National Taiwan University. However, the actual efficiency of squirrel damage reduced still need a quantitative verification. Therefore, to develop an optional and feasible model for evaluating the efficacy of squirrel control by poisoning has been an essential measure in the forest protection of squirrel damage in Taiwan forestry.

This paper was a major part of a MS thesis for the co-author and a study conducted in Naimopu tract of the Experimental Forest of National Taiwan University from 1985 to 1986. The objective of this study was to estimate the activity and distribution pattern of the pest squirrel in an infested plantation of China-fir by testing two methods: Food consumption and mark-recapture of the animal together with the analysis of some forest and cover plant factors. It was hoped to provide information for an effective control of the squirrel when poisoning measure is applied.

The following findings are obtained from the study:

1. The activity and relative density of squirrel population in the infested plantation can easily and economically be detected through the application of food consumption.
2. The major factors that control the activity and distribution of squirrels in the forest plantation are the availability of food plants and density of canopy closure of the stand inhabited.
3. When vinyl bag of poison bait is used for controlling the squirrel in the plantation, rate of rice-paraffin poison cake of klerat should not exceed 10 gr. per bag and 0.3 kg of the cake per hectare. The research reveals that 98 percent of efficacy of control was obtained with the above rate applied.
4. Very similar result can be obtained in the estimation of the activity and relative density of the squirrel population by the application of food consumption just as good as by mark-recapture method. Either method can be used to achieve the goal depending on the objective of study and economical adjustment of research.
5. Readers may get useful reference from an article: Control techniques and efficacy evaluation of poisoning Formosan red-bellied tree squirrel (*Callosciurus erythraeus*) by the authors published in the previous issue 1(3): 1-16, 1987, of the same technical report (Q. J. Expt. Forest NTU), because part of this study's result has been quoted in that paper for information used to develop a model for evaluating squirrel control efficacy by poisoning in Taiwan forestry.

松鼠爲害六龜試驗林之調查及防治研究

黃松根 康佐榮 蔡達金

本所六龜試驗林內松鼠種類經調查結果，有赤腹松鼠、臺灣松鼠及白胸鼯鼠等三種，對林木均有嚙食之爲害，而以香杉被害最爲嚴重，通常於栽植後第三年開始受害，至第五年受害率達 32.70%，枯死率爲 5.01%，12 年生之壯齡木受害率高達 89.90%。松鼠分佈：以海拔 1,200~1,600 公尺處爲最多，在此海拔高度內之人工造林木被害亦最嚴重，被害部位均在樹幹。每株立木被害處數有達 11 處者，平均每株被害爲 4~5 處。松鼠喜啃食纖維質縱列長條狀樹皮，其啃咬樹皮主要動機在嚙食內皮以充飢、惟磨牙、戲耍及營巢等三者亦兼而有之。據初步觀察結果，土法以稻草人豎立於林地，具有嚇阻松鼠侵入林地爲害幼齡林木之效果，市上出售之殺鼠藥磷化鋅 1% 及最新出品之 vacor 2% 與樹薯簽混合調配之毒餌，松鼠食後 4.1~5.4 小時內可導致死亡。

INVESTIGATION AND CONTROLLING STUDY OF SQUIRREL DAMAGE TO THE EXPERIMENTAL PLANTATION AT LU-KUEI BRANCH

Song-Gen Huang Zou-Yung Kung Da-Chuan Tsai

The Lu-Kuei Experimental Forest of Taiwan Forestry Research Institute covers the area of 9952.8 hectares. To meet the needs of economical construction and experiments, the over-age natural stands were gradually cut-off since 1970, and regenerated high-value tree species. However, the trees always suffer from squirrel's injury. Therefore, an investigation and protecting study against such damage was initiated in 1975. The three-year data were analyzed and preliminary results are shown as follows:

1. Investigation on the kinds of squirrel

As the result shows, there are three kinds of squirrel existing in Lu-Kuei area:

(1) *Callosciurus crythraeus roberti*

(2) *Callosciurus caniceps taiwanensis*

(3) *Petaurista pectoralis*. Woodfibers were found to be one of the component of nest-building materials, indicating that the three kinds of squirrel are all able to injure trees.

2. Investigation on the extent of damage

(1) The extent of damage of young trees: one or two year-old trees usually were not injured, but the trees were started to suffer the damage from the third year. The damage percentage of five-year-old stands of Luanta-fir is 32.7% (mortality 5.01%) the four-year-old *Cryptomeria* stands is 1.67%, but stands of Taiwan red cypress and *Taiwania* have not been damaged yet.

(2) The extent of damage of trees with more than ten years of age: Stands of broad-leaf trees were found not to be injured, but damage on coniferous stands were common and the extents differ between tree species. Luanta-fir stands suffered most seriously, the rate up to 89.90%, China-fir 82.08%, Formosan Douglas-fir 72.63%, *Cryptomeria*

55.10%, Taiwan incense cedar 47.53%, Pines 31.08%, Taiwan red cypress 18.18% and Taiwania 11.49%.

(3) The extent of damage at different elevations: The average percentage of damage of China-fir, Taiwan red cypress, Cryptomeria and Taiwan incense cedar at various elevations are as follows: 60.78% at 1400m, 50.61% at 1200m, 44.33% at 1600m, 29.83% at 1000m, 0.03% at 600m, indicating that the appropriate habitable areas for squirrels are at elevations from 1200m to 1400m.

(4) Investigation of damage portions on trees: As the results showed, the damage portion of four coniferous species is trunk, not branch. About 14-15% of trees have 4-5 damaged spots, 12% trees have 3 or 6 spots, 11.26% trees have 2 spots and 3% trees have 8 to 11 spots.

3. Study on browsing habit of squirrels

(1) Favorite food: squirrels are the wild animal with multiple browsing habits. Besides fruit and seed of tree, they also favor papaya, sweet potato, peanut, and chicken feed. About 40-100 ounces of feed are usually taken by one squirrel per day. This amount is approximately 10-12 times of its body weight.

(2) Reasons of browsing tree bark: Squirrels usually browse bark along the trunk longitudinally, but not transversely or in small scale-like pieces. The bark they take is for feed, tooth-friction, playing or nest-building.

4. Controlling study

(1) Study on the control of squirrel damage to forest trees: The present experiment contains three treatments; coating tree bark with repellents, setting straw-man and contrast. From July of 1976 to June of 1977, we found only two trees were injured at plot of repellent-coating. However, two months later, when the straw-men were all blown down by typhoon in July of 1977, we found the number of damaged trees is 8 at straw-man plot and repellent coating plot, 5 at contrast plot. This result indicates that setting straw-men on plantation have the frightful effect against squirrels.

(2) Study on toxic effect: 1% Zinc phosphate and 2% Vacor all showed significant toxic effect to squirrels. The lethal dosage are 1.2g and 5.6g respectively. Squirrels will be dead within 4.1-5.4 hours after they took Zinc phosphate or Vacor, 1% Vacor, 0.025%, 1%, 2%, 3%, Warfavin and 0.5% Warfavin powder supplying continuously for 24 hours, may only make squirrels have stomach ache or stolidity, but not be lethal to squirrels in short time.

SOLVING TREE SQUIRREL DEBARKING PROBLEMS IN TAIWAN-A REVIEW

Pao-Chang Kuo

Extensive forest conversion of the low-valued natural hardwood forest into coniferous plantations is the possible cause of the critical problem of squirrel debarking. The tree squirrel that causes the major damage is the red-bellied tree squirrel (*Callosciurus erythraeus*). Conifers are more susceptible to the damage than are hardwood species, especially the exotics. Intermediate-aged plantations appear to have the highest debarking. More damage occurs in the spring than the other seasons. The lower part of the trunk is more heavily debarked than the upper. Debarking is progressively upward to the crown as the tree grows older. Home range, food habit and behavior of the red-bellied tree squirrel are under intensive study and some preliminary results have been obtained.

Selection of tree species less susceptible to squirrel debarking has been a main step to control the damage. Intensive weeding and thinning may reduce much of the squirrel preferred habitat and therefore reduce damage. Leaving any natural hardwood forest within or adjacent to the coniferous plantations may provide squirrels with a more attractive cover and food supply. A rice-paraffin bait block of warfarin has been used to poison them with some success. But laboratory studies show klerat (brodifacoum) has a faster lethal efficacy than warfarin. Application of baits and other trapping method to control squirrel populations need more study and evaluation.

台灣赤腹松鼠對於森林為害及其防除之造林學的研究

郭 寶 章

台灣三分之二森林面積為闊葉樹林，原來動植物相亟為豐富，惜因山地土著民傳統式的亂獵及掠奪式燒墾，使大面積之森林化為草生地，在森林中棲息之大型獸，殆為捕殺絕滅。同時林業之經營過去及近年所實施之林相變更，曾大面積皆伐天然闊葉林而建造單純針葉林之人工林，及降低野生動物之捕食區，而促進松鼠族群之增殖，在食物缺乏季節，遂造成局部之森林為害。本研究之目的在分析赤腹松鼠為害之實況及其為害之防治法，尤以討論對松鼠為害之造林學的林業防治法為重點。

1 森林害獸——赤腹松鼠之習性

台灣分佈之樹松鼠 (tree squirrel) 共有 3 種，而其中僅一種：赤腹松鼠 (*Callosciurus erythraeus*) 構成為害，有關松鼠為害林木之事實，早在第二次世界大戰期間即有記載，惟以 1960 年代天然闊葉林木大面積遭受皆伐後才開始嚴重。

本松鼠主依造林地之林林植生 (蔓類、灌木類及草類) 而生存。赤腹松鼠之巢多築於受害林地林木茂密樹冠上。其日間活動以黎明與黃昏之時刻較為頻繁。本動物門齒銳利，生長速度月平均為 2.5 mm。喜攝取食物以含糖分較高且多汁之水果類，對於百香菓之嗜食性為最高。在赤腹松鼠之食餌中添加 0.1% 之香蕉油可提高其取食率，食餌中若添加 0.1 及 0.2% 之糖精亦喜取食，又對食餌中加入 5% 食用醋時亦顯示甚高之嗜好效果。因之，松鼠為害對樹種頗具選擇性，一般且以食物缺乏之早春剝皮較盛。

2 松鼠為害對林木之影響

赤腹松鼠為害對於森林之影響，可列為下列三種形質：造成林木之枯死，生長量之減低及木材利用上之損失。受害木除非年齡幼小，多不枯死。

松鼠剝皮足以妨礙林木之直徑及材積生長，因材部腐朽亦嚴重的影響木材之物理的與機械的性質。被害木木部木材之收縮率，木材徑向彈性率 (modulus of elasticity in static bending)，縱向引強 (tensile strength in longitudinal direction)，衝擊彎曲吸引能 (absorption energy of impact bending) 等機械的性質均較健全木為低。因之，受害木多不能達到用材之目的。

3 松鼠為害與森林之條件

一般，幼齡林之松鼠為害較為輕微，且剝皮部位多位於幹部，被害隨樹齡而增加，且向樹冠部上升。每株造林木受害之傷口數多為一處，少有 10 處者。剝皮傷口多不癒合，故易為腐朽菌侵入而造成二次為害。

松鼠為害與樹種間具有關係，以柏科之日本扁柏及台灣肖楠受害最多，惟同科之紅檜受害情況並不嚴重。杉科之柳杉、杉木、香杉亦為受害相當嚴重之樹種，然杉科之台灣杉卻為受害較輕微之樹種，同時柳杉之品種不同，受害亦異。一般闊葉樹種之受害情形微不足道。林木遭受松鼠為害與其木材

樹皮內糖分含量有關，受害較多之柳杉與杉木，其糖分之含量則較受害輕微之台灣杉為多，且亟顯著，而為害最多之 12 月～4 月間，亦為年中樹皮內含糖量最多之時期。

就柳杉與杉木之調查結果而言，混合林之松鼠受害率較之單純林者為低，尤以與不易遭受松鼠為害之台灣杉混植之際，其受害度尤為降低。疏植之柳杉林較之密植者被害率為低，密林分之松鼠為害部位且以樹幹為主，而疏植林木之被害部位有向樹冠移動之趨勢。且一般松鼠多擇大徑木而加以為害。林林植物之存否與繁茂程度亦顯著的影響松鼠對於林木為害，凡造林地接壤天然闊葉樹林地區，因分布之植生種類較多，適於松鼠棲息所發生之邊緣效應而增高松鼠為害。

乾燥及土質低劣之造林地，松鼠之為害較少，此乃因生育地條件所提供之環境收容力較低。高海拔地區氣溫較低，松鼠棲息密度可能較低，故林木之被害較少。因發展森林遊樂設施，人車通行較繁，松鼠為害應該減少，然在道路兩側，仍見有相當的松鼠為害，此或因在松鼠活動期間車輛通行較少之故。松鼠對於果實、竹筍有高嗜好性，因之，鄰近果園及竹林之造林地松鼠之為害較少。同時高度集約經營之林業地區松鼠害亦屬輕微，概以除草較勤、林林植生較為貧弱之故。

4. 松鼠為害之防除對策

防治松鼠為害，有控制族群密度及調節棲息地之兩大原則。在台灣，因松鼠族群密度偏高，故首應考慮第一原則。在清早之際，使用獵槍射殺 (shooting) 松鼠，命中率甚高，利用美製捕鼠夾子或鐵絲捕鼠籠亦可獲較高之捕獲率。台灣林務局獎勵捕殺之收購松鼠辦法實施多年 (1965 年迄今)，對於松鼠為害之防治收效尚佳。最近，毒劑可滅鼠 (klerat) 之應用，毒殺效果尚稱良好，然在大面積造林地普遍進行毒殺，其效果之判定與評估，仍多有待研究。

在松鼠棲息地之調節上，曾施行各種造林學的研究，結果顯示：造林木實施修枝，每促使松鼠為害集中在樹冠部，然松鼠為害並不因修枝而獲減少。除草及疏伐可減少松鼠在林內出現之活動機會及為害林木之株數與剝皮量，強度疏伐較之弱度者有效。在綜合性松鼠防治體系上，應依據生態的原則即恒久的為害防治措施，亦即林業方法之應用，此包括選擇不易遭受松鼠為害之樹種造林，並推行混合造林及實施複層林業經營，勵行集約的育林撫育等。在松鼠族群偏高之林地，仍應併用毒殺以獲整體的防治效果。

SILVICULTURAL STUDIES ON DAMAGE TO FOREST PLANTATIONS BY THE FORMOSAN RED-BELLIED TREE SQUIRREL AND ITS CONTROL PROCEDURES

Pao-Chang Kuo

In Taiwan the natural hardwood forest that occupies two-thirds of the total forest land used to be very rich in flora and fauna. It was a habitat for squirrels and other forms of wildlife. However, large areas of natural hardwood forest were burned and changed to grasslands due to hunting and practice of shifting cultivation by aborigines in the mountain area. Because of the low commercial value of natural hardwood, accessible forest has been cleared and converted to plantations of coniferous trees for better timber production. As a result, both habitat area and food source for the squirrel have been greatly reduced, forcing the squirrels to live in conifer plantations. Those could not support a sufficient

number of potential predators and population growth of the squirrels has been greatly encouraged. These are the main reasons for the squirrel damage in plantations of the island.

The objective of this paper is to assess the forest damage caused by squirrels and possible silvicultural control measures. Japanese studies on the red-bellied squirrel have been cited, as have other US and Japanese publications concerning pest animal damage to the forest.

About the Pest Squirrel

There are three species of tree squirrels in Taiwan only one of which is causing forest damage. It is called red-bellied tree squirrel (*Callosciurus erythraeus*), the largest of the squirrel. In Taiwan, squirrel damage was recorded in the 1940's. However, serious damage did not occur until the 1960's when there was a big program for cutting and reforestation progressively undertaken as part of the efforts for forestry development.

Two species of flying squirrels also debark trees. The toothmark of the red-bellied tree squirrel is different from that of the flying squirrel (Fig. 3). The incisor of red-bellied tree squirrels is narrower in width and more closely arranged than that of flying squirrels. The monthly growth rate of incisor for this squirrel is 2.3mm.

The red-bellied tree squirrel is diurnal. It moves mostly in the early morning and less in the late evening. This squirrel is inactive during continuous rainy weather.

This squirrel used to nest in the dense crowns of large trees. The squirrel preferred fruit, particularly passion fruit (*Passiflora edulis*), a vine grown in the plantations. This fruit is juicy and a little sour. There is no damage on trees during the ripening season of this climber. Bait having 0.1% banana oil is highly attractive to this squirrel. So is bait with 0.1%-0.2% saccharin and 5% vinegar.

The Effect of Squirrel Damage

Forest damage varied with tree age. Young plantations are damaged least. Damage becomes progressively more serious as trees grow older. Squirrel barkwounds do not heal. Secondary infections of wood decay fungus two years after bark damage is common. The damage results in a significant decrease in rate of growth and in stem deformation. Log grades are reduced by the deformation and wood decay. Stem analyses of a 20-year old heavily damaged plantation of *Cryptomeria* in Chitou Experimental Forest, showed that number of wounds and amount of wood decay are the highest at age 13-14, and in the lower parts of the trunk.

The physical and mechanical properties of *Cryptomeria* are greatly affected by wood decay. Testing of an 8-year old *Cryptomeria* showed a lowering of the following wood properties: radial shrinkage, modulus of elasticity in static bending, longitudinal tensile strength and impact bending.

Squirrel Damage and Forest Condition

The total squirrel damaged area in Taiwan is 7,239 hectares (Table 16), mostly at mid-elevation mountains in central Taiwan. Plantations in northern Taiwan have less damage. Damage has been greatest in national forest land. There are larger areas and greater concentrations of *Cryptomeria* and China-fir plantations of national forest land than on other land.

In conifer plantations, there is more damage to the trunk than to the crown. Trunk damage is found in juvenile to mid-aged plantations and crown damage is in old plantations. Most damaged trees have a single debarked area, but some as high as ten.

Squirrel barking of trees affects only certain species of conifers. *Chamaecyparis obtusa* (Hinoki-cypress) and *Calo-*

cedrus formosana (Taiwan incense cedar) are very susceptible to squirrel damage, but *Chamaecyparis formosensis* (Taiwan red cypress) sustains a relatively little damage. *Cryptomeria japonica* (Cryptomeria) and *Cunninghamia lanceolata* (China-fir) and *Cunninghamia konishii* (Luanta-fir) are heavily damaged but the closely related *Taiwania cryptomerioides* (Taiwania) sustains little damage. Different strains of *Cryptomeria* have different amounts of damage. Squirrel damage may be related to amount of sugar content in the cambium as damage is greatest in species with high sugar content i.e., *Cryptomeria* and China-fir, and in the period December to April sugar content is high. It is revealed that plantations of hardwood species sustain little damage. Squirrel damage is less in mixed than in pure stands, and in sparse than in dense plantations. Within a stand it is greatest on the most vigorous trees.

In Taiwan, squirrels inhabit mainly mid-elevations with warm temperature and high humidity. This type of area was occupied by hardwood forest, which was the squirrel's original habitat. As a result of clearcutting and planting of conifers, the natural habitable areas for squirrel have greatly diminished. Squirrels have been forced to move into plantations and cause damage during periods of food shortage. As plantation areas grow, squirrels are forced to rely on planted trees. Within a plantation, damage to conifers is least in open areas having alternating food supplies.

Suitable sites for planting *Cryptomeria* and China-fir preferred habitat coincide with the squirrels! A few *Cryptomeria* and China-fir plantations have shown two species having little squirrel damage, possibly because of adverse site condition. Sanlinchi plantations (elevation 1,700m) of *Cryptomeria* near Chitou have a dry climate. They have little undergrowth and show very low squirrel damage. Plantations at high elevations also show little squirrel damage possibly due to the cold weather. In forest recreation areas, plantations close to camping sites have a low squirrel damage rate. That is possibly due to visitor's disturbance as red-bellied tree squirrels are shy. However, Plantations along roads which are not used intensively in early morning or late evening may have considerable damage. There is little damage on trees adjacent to good food supplies such as fruit orchards or bamboo groves. Intensively managed stands are often lightly attacked.

Squirrel Damage Control

There are two basic principles of squirrel damage control: reduction of squirrel population and habitat manipulation. With high population densities, the first principle should be applied. Shooting in the early morning and trapping have produced high capture rates since Government bounties were started in 1965, but have not been effective in reducing forest damage. Chemical control with an anti-coagulant toxicant such as Klerat has met with some success. However, poisons pose some difficulties in application and evaluation.

Habitat manipulation has obtained good results in both the control of squirrel appearance and the barking damage. Pruning of trees forces squirrels to go up and damage crowns rather than stems. That results in less damage to wood quality. Clearing of underbrush shows excellent control over squirrel damage. Heavy thinning is effective. However, neither measure completely eliminates squirrel damage. For total control, population reduction is also necessary. In further plantations, *Taiwania* and hardwoods may be substituted for squirrel-susceptible species. Consideration should be given to the mix-culture approach incorporated with intensive tending care.

整合性有害動物經營與松鼠害防治

尤少彬 林曜松

INTEGRATED PEST MANAGEMENT CONCEPTS AND TREE SQUIRREL CONTROL

Shao-Pin Yo Yao-Sung Lin Rox E. Marsh Walter E. Howard

The concepts of Integrated Pest Management (IPM) in vertebrate control of crop ecosystems can be applied to forest ecosystems. However, the parameters used in crop ecosystems are not realistic for forest ecosystems due to the different life history patterns of the pests. Researches on ecological and economic models of forest ecosystems will be needed before IPM concepts become a reality. The multiple control methods including habitat modification, control with toxic baits, biological control and the use of chemosterilants were discussed as potential IPM tools for tree squirrel control in Taiwan.

撫育對柳杉造林地內松鼠活動與爲害之影響

郭寶章 廖宇康

爲明瞭森林撫育作業：除草切蔓及疏伐對於柳杉造林地內赤腹松鼠之活動與爲害林木之影響，於民國 69 年 9 月至 74 年 2 月約 4 年半之時間，擇台灣大學實驗林溪頭營林區內 8 年生、20 年生及 18 年生柳杉造林地三處，分別施行除草（包括切蔓），弱度及強度疏伐後，裝設鼠籠依標識再捕捉法觀察松鼠在處理區與對照區內之活動，並調查爲害林木之情形，經 4 年來之調查結果顯示，各種撫育方法因已使林內環境發生變化不適松鼠之棲息活動，故處理區之松鼠出現機會顯爲減少，尤以強度疏伐作業區爲然，足證明撫育措施已發生抑制松鼠活動之效應。惟對於其爲害林木而言，僅在氣候異常之冬雨連續年度，呈顯著性至極顯著性之差異，氣候正常之年度，未顯現減低爲害林木之效應。

ACTIVITY OF FORMOSAN RED-BELLIED TREE SQUIRRELS AND THEIR DAMAGES TO TREES IN CRYPTOMERIA PLANTATIONS FOLLOWING WEEDING AND THINNING OPERATIONS

Pao-Chang Kuo Yue-Ken Liao

The objective of this study were to learn the effects of forest tending care or habitat manipulation on the activity of squirrels and their damages to trees. From September 1980 to February 1985, three Cryptomeria plantations of 8, 20, and 18 years old in Chitou Tract of the Experimental Forest, National Taiwan University were selected for study sites. Weeding and light and heavy thinnings were applied in the study sites respectively. Findings from mark-recapture on squirrel's activity in four study years reveals that tending would definitely reduce the activity of squirrel in the treated plots. However light thinning could reduce the tree damage only during abnormal weather in the winter of 1982 when there was a continued rainstorm occurred for about three months.

松鼠爲害林木防治研討會論文集 (Proceedings Seminar on the
Control of Squirrel Damage to Forest Trees) p.157—
166 (1985) 農委會特刊第二號

ECOLOGY AND CONTROL OF DEBARKING BY TREE SQUIRRELS

Walter E. Howard

The different types of tree squirrel debarking damage to conifers in Taiwan and the United States are compared. Suggestions as to how the tree squirrel problem in Taiwan might be resolved are discussed, using as examples habitat manipulation, neck snares, traps, toxic baits, shooting, and other miscellaneous methods. A great variety of control methods is actually needed because of the diversity in environmental conditions in the different conifer plantations.

自然文化景觀保育論文集(白) 野生動物保育專輯 (Memoir of
Nature, Endangered and Rare Plant/Animal Species and
Landscape Conservation(白) p.173--177 (1986) 農委
會林業特刊第十號

松鼠啃剝樹皮行爲之生態與防治

Walter E. Howard

張淑美 譯

比較臺灣及美國的松鼠剝樹行爲危害針葉林之不同型態，並討論防治臺灣松鼠問題之可能解決建議，如使用棲息地的控制、頸部套索、捕鼠器、毒餌、射殺和其他之方法。由於在不同的針葉林地內，其環境狀況亦有變異，因此需要有各式各樣的防治方法，以因應所需。

台大森林學研究所碩士論文 (Master Thesis of Division of
Silviculture, Graduate Inst. Forestry, N.T.U.) 50pp.
(1985)

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廖 宇 康

爲明瞭森林撫育作業：除草切蔓及疏伐對於柳杉造林地內赤腹松鼠之活動與爲害林木之影響，於民國 69 年 9 月至 74 年 2 月約 4 年半之時間，擇台灣大學實驗林溪頭營林區內 8 年生、20 年生及 18 年生柳杉造林地三處，分別施行除草（包括切蔓）、弱度及強度疏伐後，裝設鼠籠依標識再捕捉法觀察松鼠在處理區與對照區內之活動，並調查爲害林木之情形，經 4 年來之調查結果顯示，各種撫育方法因已使林內環境發生變化，不適松鼠之棲息活動，故處理區之松鼠出現機會顯爲減少，尤以強度疏伐作業區爲然，足證明撫育措施已發生抑制松鼠活動之效應。惟對於其爲害林木而言，僅在氣候異常之冬雨連綿年度，疏伐減少了爲害的發生，而氣候正常時，撫育作業未顯現減低爲害之效應。

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DAMAGE AND CONTROL OF SQUIRREL DEBARKING IN FORESTS OF TAIWAN

Pao-Chang Kuo Chia-Hwa Chiang

One species of tree squirrel (*Callosciurus erythraeus*) is the main culprit responsible for the debarking problem in Taiwan forests. Consequent tree damage from secondary infection by fungus in the barkwounds results in a reduction of wood quality and may cause death of young trees. The main reason for debarking could be due to seasonal shortage of natural food supply in the plantations, as evidenced by the large amount of cambium layer found in squirrel stomachs at the time of debarking. Drastic harvesting of squirrel predators in the past has encouraged rapid growth of squirrel populations. Squirrel debarking varies with tree species. Conifers are more susceptible to damage than hardwoods. This animal prefers tree species with high sugar content in the bark.

In squirrel control, shooting has not proved to be very effective. Poisoning with klerat has provided some good results in reducing new damages. However, the population density of squirrels soon builds up in one to two years after poisoning. Application of poison baits accidentally kills non-target animals living in the plantations. An approach using permanent bait stations is under study. It is hoped that an improved squirrel control method with high security to wildlife will be developed. Choice of tree species with high resistance to squirrel debarking should be a basic preventive measure for damage control. Habitat manipulation through application of weeding or thinning of infested plantations is very effective in reducing squirrel activity but is not very effective in preventing new damages.

英國地區灰松鼠(*Sciurus carolinensis*) 之爲害及防治概況

郭寶章 劉一新

本文簡單的介紹了英國地區灰松鼠的爲害及防治之概況，論及灰松鼠撕剝樹皮之成因，英國地區防治灰松鼠之方法、規定與一些觀念，乃致於因灰松鼠所引發的一些生態與野生動物保育的問題。

首先就爲害之成因而言，Kenward (1983) 認爲：在遭灰松鼠爲害之區域內，某些與之有關的數據可以支持一個或一個以上的假說。一般而言，爲害較多之區域，當歲幼鼠 (spring-young) 的族群密度亦有較高的傾向，這有可能造成擱抗行爲之發生，然而，松鼠爲害有時出現在幼鼠發生之前，而有時在爲害率高的地方，幼鼠之陷阱捕獲率並未呈現相對增高之傾向。食物短缺導因於族群密度過高，以之解釋剝皮現象，確爲一有力之佐證。高生殖率、人工供餌的誘集作用及所引發之擱抗行爲等亦可解釋之。不過無論如何，族群密度確與爲害有着直接與相當的關聯。此點在防治觀念上，當甚爲基本且易爲接受。

英國到目前爲止，企圖減低灰松鼠族群之努力並未成功，這或許是因爲，森林中生物負荷力 (carrying capacity) 未變更的狀態之下，具有高生殖力、高侵略性的灰松鼠極易補足被消滅的部分族群，而且不要很久的時間，這種情況，與台灣地區赤腹松鼠之防治工作所面臨的困擾是一樣的，不過就目前而言，英國地區的防治方法，其溫和有體系及尊重自然，維護自然的態度，的確值得台灣的松鼠防治工作者深思及參考的。

在可預見的未來，造林地整治 (Plantation management) 在松鼠爲害防治上所扮演的角色當愈形重要，證之於英國及臺灣地區當有某種程度的立場與理論根據。

生育地整治用在有害生物經營 (Pest management) 上由來已久，在現今整合性有害生物經營 (IPM, Integrated Pest Management) 的觀念中，森林有害生物經營的方法當以此法爲主 (Marsh 1985)，生育地整治即利用人爲方法使林地變爲更適宜或不適宜動物之棲息，亦即以各種森林撫育的方法來達成調整其負荷力之目的，這較諸毒殺、陷阱等防治法，有其自然性及安全性自不言而喻，且可能是一種治本的方法，唯在(1)動物本身之資料：生態及族群動態 (population dynamics)。(2)森林本身之資料：林型、地被植群、生物承載量。(3)動物與森林，動物與動物間的交互關係 (interaction) 未明瞭之前，其施行仍有甚大的困難。

造林地除草對赤腹松鼠活動及爲害之影響

謝 學 源

本研究旨在瞭解造林地除草對赤腹松鼠活動與爲害之影響，以提供森林經營與松鼠爲害防治之參考。自民國74年10月至民國76年3月間，擇台北縣烏來鄉內一處8年生柳杉造林地調查除草前、後赤腹松鼠的活動、爲害及地被植物之種類、覆蓋度。另自民國75年4月至民國76年3月間在鄰接之天然潤葉樹林內調查赤腹松鼠的活動與分佈。調查結果顯示，天然潤葉樹林之松鼠族群密度及活動較柳杉造林地者爲高。造林地之除草不僅具有抑制松鼠活動之效果，且具有減輕松鼠爲害之效應。除草之後，在處理區所發生的爲害，多由棲息於鄰接樣區或林地之松鼠所造成，因此配合除草作業而在林緣地區增設陷阱或佈放毒餌，不僅合乎經濟原則且能兼顧環境安全。本研究之試驗方法係採取併對樣區之雙重對照設計，並將樣區面積擴大且設置緩衝區，藉以消除林緣效應等，凡此均可正確反應處理對松鼠之影響，此一試驗方法可供爾後松鼠研究之參考。

EFFECTS OF WEEDING ON THE ACTIVITY AND DAMAGE OF RED-BELLIED TREE SQUIRREL IN A CRYPTOMERIA PLANTATION

Hsueh-Yuan Shieh

The purpose of this study was to find out the effects of weeding in forest plantation on the activities and damage of red-bellied squirrels to trees of Cryptomeria. The result of the study can be used as reference in the planning of forest management and squirrel control program. The study was conducted in an 8-years old plantation of Cryptomeria and a natural hardwood stand in adjoining area. Activity and damage of squirrel to trees, changes in cover plants were observed before and after treatment of weeding during October 1985 to March 1987.

The results showed that population density and activity frequency of squirrels were higher in the natural stand than that in plantation. Weeding had significantly affected the activities and damage of squirrel in study plantation. New damages occurred in weeded plots caused by squirrels immigrated from adjacent check plots. For a better control of squirrel damage in the forest, it is suggested to operate weeding intensively together with trapping and/or poisoning in the edged area between plantation and natural hardwood stand. Because there was where the high frequency of squirrel activities occurred.

The experimental design applied in this study had some advantages for a similar study of squirrel problem. A wider-sized plot e.g. one hectare in double-check paired plots gave good results of observation. A buffer set along the plots had eliminated the error of weeding on the activities of squirrels in the study plots. It seemed that this study had greatly improved a previous study of similar objective conducted in Chitou in 1981-1986 by Kuo and Liao.

飛鼠爲害林木問題之探討 ——兼論日本飛鼠對林木之爲害——

郭 寶 章

台灣一部分針葉樹之育林成果，因遭受松鼠之爲害而深受影響。近年於積極謀求防治松鼠爲害之際，而飛鼠之爲害林木也已被證實，如此，更加深問題之嚴重性，實不容忽視。本文就學術界對於台灣飛鼠及其爲害之初步瞭解，加以探討。並記述日本飛鼠之生態及其爲害林木情形與防治方法，以供本省今後研究及防治此一問題之參考。

SIGNIFICANT DAMAGE OF FLYING SQUIRRELS TO FOREST PLANTATIONS

Pao-Chang Kuo

In Taiwan, due to the damage caused by tree squirrels, reforestation effort of conifers has been greatly reduced. While measures were taken to control the problem of squirrel debarking, flying squirrels (*Petaurista* spp.) have been identified as a secondary culprit involved in debarking mammals to forest plantations. This makes the damage caused by squirrels even more serious which should not be neglected. This paper is intended to bring the general understanding of flying squirrel debarking in some of Taiwan's conifer plantations, and to outline the ecology and damage of flying squirrels to Japanese plantations as needed information for research and control of flying squirrels in Taiwan.

大赤鼯鼠之生殖與生態研究

李 培 芬

自 1981 年 10 月至 1983 年 2 月在南投縣溪頭進行 50 個晚上，156.7 小時的野外實地觀察，並於 1981 年 12 月至 1982 年 11 月間在高雄縣三民鄉購買大赤鼯鼠 (*Petaurista petaurista grandis*) 的標本，以瞭解其生殖與生態習性，作為經營大赤鼯鼠族群之參考。

研究期間共得 279 隻大赤鼯鼠，其中成熟個體 216 隻 (雌 100，雄 116) 未成熟個體 63 隻 (雌 41，雄 22)。成熟雄鼠之成對睪丸重量、長度和精細管直徑之月變化，均顯示在 4—5 月和 10—11 月為高峯，是雄鼠之主要性成熟期，在 6—8 月和 12—2 月時為低峯，此時飛鼠進入性休止狀況。成熟雌鼠卵巢重之月變化，亦呈雙峯，在 1 月和 8 月達到最高。懷孕雌鼠共 24 隻，集中出現在 12—2 月和 6—8 月。懷孕雌鼠之平均排卵數為 1.13，平均每胎生產隻數為 1.04，著床前死亡率為 7.4%，著床後死亡率甚低，接近 0。大赤鼯鼠之族群每年 12—1 月和 6—7 月為性成熟期，成熟個體於此時加入成熟族群。幼鼠自出生後，約需 11—12 個月的時間方始達到成熟。

在溪頭共發現 159 隻次大赤鼯鼠，單獨活動者有 85.5%，成對活動者 8.8%，3 隻同時出現者最少佔 5.7%，其觀察相對數量和叫聲數均以春季 (3—5 月) 最高，其它三季差異較小。

大赤鼯鼠除了以樹洞作為休息場所外，亦會營樹葉巢，此種巢內均曾發現幼鼠。大赤鼯鼠之食性為葉食性 (Folivorous)，以血藤 (*Mucuna macrocarpa*) 和大葉校栗 (*Pasania kawakamii*) 為主食，四季均有攝食，其餘之食物呈季節變化。大赤鼯鼠亦會啃咬柳杉樹皮，由 1982 年 11 月間得到之胃含物，其內含有 70—80% 之樹皮內層組織。

大赤鼯鼠和白面鼯鼠有生態隔離之現象，兩種飛鼠在棲息地之選擇，棲息樹種以及棲息高度，均有區別。

飛鼠之生態與行爲研究

林曜松 李培芬 蒲唐納 王立言 侯平君 謝寶森

飛鼠又名鼯鼠，屬松鼠科。台灣產三種；分別是大赤鼯鼠 (*Petaurista petaurista grandis*)，白面鼯鼠 (*Petaurista alborufus lena*) 和台灣小鼯鼠 (*Belomys pearsoni kaleensis*) (Jones et al, 1971)。早在 1954 年，Udagawa 即報導日本之飛鼠 (*Petarista leucogenys*) 會啃咬柳杉樹皮。Chu and Yie (1970) 曾推測台灣之飛鼠可能會危害林木。筆者等於 1981 年 7 月至 1985 年 3 月間進行飛鼠之生態與行爲的研究，有關初步結論分述如下：(1)活動，(2)行爲，(3)食性，(4)棲息，(5)生殖與生長。

台灣中部飛鼠生態之研究

張 萬 福

民國 70 年 7 月至 73 年 6 月底止，於台灣中部之中橫古道沿線，海拔 700~3997 公尺之間，從事夜行樹棲性之飛鼠種類、分布及習性等調查。

飛鼠種類經調查結果，有台灣小鼯鼠、大赤鼯鼠與白面鼯鼠，各自分布於海拔 400~2000 公尺，700~2600 公尺與 1200~3750 公尺。觀察並捕獲之大赤與白面鼯鼠中，大部份喜單獨活動 (85%)。(台灣小鼯鼠因觀察及捕獲之隻數太少，不在本文討論範圍內)，求偶期與撫育期間方能發現成對及携眷之情形。兩種飛鼠活動時刻，因季節性日出與日落的時間差異而略顯不同。但都會在日落後 30~50 分鐘之間陸續出巢，於日出前 1~2 小時之間回巢。每晚活動之時間，其頻率高峯呈雙峯型，分別在晚上 9 時與清晨 2~3 小時之間。

兩種飛鼠為葉食性，主要以樹葉為生。但在不同的季節裡亦會攝取嫩芽、花蕾、種子、菓實及樹皮為食。胃含物解析顯示，白面鼯鼠攝取 8 種植物，2 種動物性食餌。大赤鼯鼠共攝取 12 種植物。每晚攝取之食物種類僅 1~2 種，均具有很高的專一性。

每年之 4~7 月與 11~1 月為兩種飛鼠之求偶期。7~9 月與 12~3 月為懷孕期。2~4 月與 8~10 月為生產期。每胎一隻。兩種飛鼠以洞穴為巢，亦會築巢於枝幹間。主要以針葉樹種的外層樹皮為營巢材料。同樹上不同樹洞中，可居住著不同個體的飛鼠。兩種飛鼠選定之巢穴位置，並沒有一定的嗜好性高度，在 6~35 公尺之洞穴均可發現，但大多選擇較粗大的樟科、殼斗科、杉科、松科及柏科的主幹或古木的洞穴中為巢，洞口直徑約 10~25 公分之間。

原始林裡之飛鼠為害呈零星狀態。為害方式以啃剝樹皮及嚙咬樹皮發生於 2~3 月及 8~10 月間，春季所獲之兩種飛鼠，其胃含物中均可發現少許的樹皮形成層，秋季曾目睹啃剝行為，僅剝取主幹外層樹皮，而不深入材質部。剝離的樹皮，搬運至樹洞，供作營巢用材料。本調查均在原始林裡進行，有關人造林地之飛鼠生態及為害狀況，有待進一步之探討與研究。

ECOLOGICAL STUDY OF THE FLYING SQUIRREL IN CENTRAL TAIWAN

James Wan-Fu Chang

This project was initiate from July 1981 to June 1984 in central Taiwan along a Cross-island Route leading from Tungpo via Patungkuan to Yusan.

There are three species of flying squirrel has been recorded. There are *Petaurista alborufus lena* Thomas, *Petaurista petaurista grandis* Swinhoe and *Belomys pearsoni kaleensis* Swinhoe. Distribution from 1200-3750m, 700-2600m and 400-2000m.

They prefer to act individually rather than in a pair or a group. They usually leaving from the tree hollow at 30-50 minutes after sun set and returned at one or two hours before sunrise. There are two peaks of activity period through the night. The most intense active occurs 8:30-9:30 PM and the second peak from 2:00-3:00 AM.

126 and 149 of *P. petaurista* and *P. alborufus* was collected for food habits analysis. Field observed and stomachs content analysed shows that both flying squirrel are folivores. Diet was chiefly of leaves and small parts of seeds nuts but fruits and some time takes animal foods. Stomach content analysis and field observation were found 7 species of plants materials and 2 species of animal materials from *P. alborufus*, and 12 species of plant of materials from *P. petaurista*. Only samples taken in spring season found cambium for several trees in the stomachs of both flying squirrels. The quantity, quality and availability of flying squirrel food are various in different season but also affect carry capacity of the habitats.

Breeding occurred in February to April and August to October. As for the distribution of nesting, they are preferred to build nest in the area of dense and huge tree of the conifers forest. Nest were located at a height of 6-35M of trees hollow, also build nest at the dense branches. Twigs, leaves and tree barks were chosen as nesting materials.

There is a periodicity to tree damage during the year, bark stripping occurred, in February and March.

BIBLIOGRAPHY OF PETAURISTINAE (RODENTIA, SCIURIDAE)

Yao-Sung Lin Donald R. Progulské

Pei-Fen Lee Yeong-Tyi Day

Flying squirrels (Petauristinae) are found in America, Asia, and Europe, including 33 species grouped into 11 genera (Honacki et al., 1982). An unusually rich Petauristine fauna occurs in east and southeast Asia. Flying squirrels are nocturnal gliders and hide in the holes or leaf dreys during daytime (Walker, 1964). Most of them are confined to forested regions. The degree of herbivory of species is dependent on their body size; the smaller size species tend to be less herbivorous and the largest are the most herbivorous (Muul and Lim, 1978). There are only five other mammalian families that share the same niche as the Petauristine species (Thorington and Heaney, 1981). These are the scaly-tailed flying squirrels (Anomaluridae, Rodentia), the gliding possum (*Acrobates*, *Petaurus*, and *Schoinobates*, Marsupial) and flying lemurs (Cynocephalidae, Dermoptera).

Petauristinae suffer from habitat loss by clear cutting of primary forests, especially in southeast Asia (Muul and Lim, 1978). In a series of studies on the biology of the giant flying squirrels in Taiwan we collected all the possible literature on flying squirrels which is compiled herein as a benefit to researchers interested in these animals.

METHODS

We utilized "BIOSIS PREVIEWS" database (1969-1981) provided by the Science and Technology Information Center of the National Science Council, ROC to search for articles pertaining to flying squirrels. Other titles were found in current journals. Most original papers on the descriptions of the new species were not included, but, those of Taiwan, including *Petaurista petaurista grandis*, *P. alborufus lena*, and *Belomys pearsoni kaleensis*, were listed (Swinhoe, 1862; Thomas, 1907; 1908). Bibliography of original papers pertaining to the other species can be obtained from Walker's (1964) Mammals of the World (volume 3, pages 156-183).

RESULTS

Relatively few papers have been published on the flying squirrels. One hundred and sixty-six articles or books were found and categorized into 7 subjects under each species (Table 1). Among the Petauristinae, North American flying squirrel (*Glaucomys volans*) is studied most intensively. Nearly all of the papers were written in English; five were in Japanese and three in Chinese.

Table 1. Numbers of papers pertaining to flying squirrels according to subjects

Species	Beh. &	Disease	Dist.	General biology	Gen.	Par.	Tax.	Total
<i>Glaucomys volans</i>	29	9	6	14	2	7	1	68
<i>sabrinus</i>	15	1		1	2	1	1	21
<i>Petaurista</i>								
<i>Petaurista alborufus</i>	2	2			3	6	3	16
<i>leucogenys</i>	1	1		1		1	5	9
<i>magnificus</i>	8			1		1		10
<i>elegans</i>					1	6		7
						2		2
<i>Pteromys volans</i>	4		1	3	1		1	10
<i>Belomys pearsoni</i>		1		1			2	4
<i>Hylopetes alboniger</i>				1	1	1		3
<i>lepidus</i>	1							1
<i>Pteromyscus pulverulentus</i>	1			1				2
<i>Petinomys genibarbis</i>				2				2
<i>morris</i>							1	1
General (no specific)	2			1			8	11
Unknown*			1	3	1	1	2	8

*: Literature were not reviewed.

溪頭大赤鼯鼠(*Petaurista petaurista*) 爲害柳杉之研究

林曜松 李培芬

自1982年3月起至1984年5月，在溪頭營林區之柳杉人工林內，進行野外觀察飛鼠之行爲和樹皮收集工作，以研究大赤鼯鼠(*Petaurista petaurista*)爲害林木之狀況，並將此種爲害現象與赤腹松鼠(*Callosciurus erythraeus*)之情形相比較，期建立這兩種動物啃咬樹皮之判斷標準，作防治松鼠科動物爲害林木之參考。

DEBARKING ON CRYPTOMERIA TREES BY RED-GIANT FLYING SQUIRREL (*PETAURISTA PETAURISTA*) IN CHITOU

Yao-Sung Lin Pei-Fen Lee

This research, conducted at the *Cryptomeria* plantations in Chitou from March 1982 to June 1984, was to study the debarking problem of red-giant flying squirrel (*Petaurista petaurista*) by nightly behavioural observations in-field and barks analysis in laboratory. We compared the damage condition caused by *P. petaurista* and that by red-bellied tree squirrel (*Callosciurus erythraeus*) in order to establish the identification criteria of *Cryptomeria* damage by these two squirrel species in hope to provide a reference to the control of squirrel damage in Taiwan.

From our observations, we confirmed *P. petaurista* debarked *Cryptomeria* and this damage can last for 3 or more months. Thus, the stripped areas in tree were enlarged as time passed, which in turn caused death of tree top due to the circular girdling or rot of tree trunks due to fungi infection. The damaged areas were located within 1 to 4m from the trees' tops. A high correlation ($r=0.95$, $p < 0.001$) was found between the midpoint height of damaged areas in trees and tree height. The collected *Cryptomeria* barks were classified into 3 typical types (I, II, and III). Type II was debarked by *P. petaurista*, while type I and III were done by *C. erythraeus*. Other evidences, namely direct nightly observations, location of damage areas in trees, time of debarking, and relationships between the teeth mark widths in barks and squirrels' incisor widths, all partly supported our findings. The debarking period of *P. petaurista* lasted from September to next April, while that of *C. erythraeus* were in February to April and August to November.

ECOLOGICAL STUDIES ON TWO SYMPATRIC *PETAURISTA* SPECIES IN TAIWAN

Pei-Fen Lee Donald R. Progulské Yao-Sung Lin

The study, conducted at Chitou, was to describe the general ecology and behavior of the two species of giant flying squirrel (*Petaurista petaurista* and *P. alborufus*), to determine if they debark conifer plantations, and to compare their habitats and feeding. We made observations primarily at night during 1800-2400 hrs along established trails by spotlighting the tree canopy from October 1981 to May 1983.

The two species appeared tolerant to each other while out feeding or loafing. Although sighting of singles was the norm, pairs and triples were sometimes observed. Three types of behavior: mating, feeding and following, were recognized when two or more individuals of the same species were seen at the same time. Mating behavior was observed in December, January, and June for *P. petaurista*, and in June for *P. alborufus*.

Each species has unique vocalizations. Counts revealed that *P. petaurista* celled more frequently than *P. alborufus*. Most calls were from the tree canopy but individual squirrels sometimes called from a tree cavity.

Eighteen tree cavities used for nesting were located. Nearly all cavities were built in the trees of Lauraceae and Fagaceae. Two leaf nests used by *P. petaurista* were also found.

Both species of squirrels showed strong preference for the hardwood forest. *P. alborufus* were at higher altitudes than *P. petaurista* although the ranges overlapped. Both species utilized many of the same tree species for feeding and resting. *P. petaurista* usually used lower layers of vegetation for their daily activity, while *P. alborufus* used higher layers. Seasonal abundance of food in different tree layers influenced where the squirrels would be. Two *P. petaurista* were observed feeding on bark of *Cryptomeria japonica*, a plantation tree, and when they were collected, their stomachs were nearly full of bark.

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