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Rodent species in mangosteen intercropped with coconuts and their bait preferences

(Spesies rodensia dan pemilihan umpannya dalam kebun manggis-kelapa)

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Key words: rodents, preferences, mangosteen, damage, symptoms

Abstrak

Kajian terhadap jenis spesies, jantina dan pemilihan umpan oleh haiwan perosak rodensia dalam kebun kelapa-manggis yang buah manggisnya rosak teruk telah dijalankan di Kluang. Tiga spesies rodensia iaitu tupai merah *(Callosciurus notatus)*, tikus belukar *(Rattus tiomanicus)* dan tupai naning *(Rhinosciurus laticaudatus)* telah diperangkap dan dikenal pasti. Spesies tupai merah paling banyak diperangkap dengan menggunakan umpan buah nangka diikuti oleh tikus belukar dan tupai naning. Bilangan tupai merah yang diperangkap berkurangan apabila pisang masak digunakan sebagai umpan. Bilangannya semakin berkurangan apabila menggunakan umpan ketulan isi kelapa. Tikus belukar pula, lebih banyak diperangkap dengan umpan ketulan isi kelapa berbanding dengan umpan buah nangka atau pisang masak. Spesies yang paling banyak diperangkap ialah tupai merah (56 ekor) diikuti dengan tikus belukar (35 ekor) dan tupai naning (13 ekor). Haiwan yang diperangkap, dikaji dari segi potensi kerosakan yang dilakukan, corak dan cara merosakkan buah. Kerosakan pada buah manggis terjadi apabila pokok mula berbuah. Buah yang masih hijau, muda dan yang sedang membesar hinggalah yang mula masak didapati rosak. Buah yang rosak didapati berlubang dengan bekas gigitan gigi pada kulit. Pulpa yang putih dalamnya telah dimakan dan terdapat serpihan kulit buah pada daun dan di kawasan bawah buah yang diserang. Di makmal, semua tanda kerosakan tersebut dikenal pasti sebagai serangan tupai merah. Tupai merah berupaya merosakkan sebiji buah manggis dalam masa dua hari (0.5 buah/tupai/hari), manakala tikus belukar dan tupai naning tidak berupaya merosakkan buah manggis yang diberi. Kedua-dua binatang tersebut merupakan perosak sekunder, iaitu akan memakan buah yang sebelumnya telah dirosakkan oleh tupai merah. Dalam masa dua minggu dipasang perangkap, tupai merah tidak lagi menjadi penghuni di kawasan tersebut dan tiada lagi buah yang rosak. Ternyata penggunaan perangkap ialah satu cara kawalan yang berkesan.

Abstract

A study on the rodent species composition, sex and bait preferences was undertaken in a coconut-mangosteen plot in Kluang that had relatively severe mangosteen fruit damage. Three rodent species namely the red-bellied squirrel *(Callosciurus notatus)*, the wood rat *(Rattus tiomanicus)* and the ground squirrel *(Rhinosciurus laticaudatus)* were trapped and identified present in the field plot.

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A high number of red-bellied squirrels was trapped with jackfruit baits with a lesser number caught using ripe bananas and the least trapped with fresh coconut pieces. In contrast more wood rats were trapped using fresh coconut pieces and a lesser number caught with ripe bananas and jackfruit baits. The dominant species was the red-bellied squirrel with 56 animals trapped, followed by 35 wood rats and 13 ground squirrels. The animals caught were studied on their damage potential and their pattern and mode of damage. Mangosteen fruits that were light greenish, unripe and developing to matured purplish, almost ripe fruits were attacked. Damaged fruits in the field were found to have holes bored, with striation teeth marks on the fruit husk, the white succulent pulp inside fed upon and small size husk chippings below the fruit. Such damage symptoms in the laboratory were noted to be caused by the red-bellied squirrel which had a damage potential of 0.5 mangosteen fruit/animal/day. The wood rat and the ground squirrel were noted not able to gnaw through any mangosteen fruit provided and thus are not likely to cause any fruit damage in the field. These two animal species would likely feed upon mangosteen fruits already damaged by the red-bellied squirrel and are thus secondary feeders. At the end of the two weeks trapping period there was no more fresh mangosteen fruit damage and it was apparent trapping can be an effective means of squirrel control.

Introduction

Mangosteen (*Garcinia mangostana* L.) has been identified as one of the fresh fruits with export potential for the Malaysian fruit industry (Anon. 1993). It has been an important fruit crop of Thailand which is exported fresh (3 117 mt, with a monetary value of 65.7 Mbaht; 25baht = US$1) (Sethpakdee 1996) and frozen (704 mt, 46.1 Mbaht). It is mainly grown in Southern Thailand and exported as fresh fruits (fruit size and weight requirement of 80 g) to Hong Kong and Taiwan and as frozen fruit to Japan (Poonachit et al. 1996). In Malaysia the crop can potentially be grown throughout the peninsular. It is a tropical fruit crop that has very little pest and disease problems. There has only been three insect pests (leaf miner, leaf defoliator and a fruit borer) and stem canker, thread blight and gamosis noted in the crop (Mohd. Shamsudin 1990). This paper describes the damage and symptoms caused by rodents (especially squirrels) associated to the crop and an appraisal on their damage potential and bait preferences.

Materials and methods

Field studies

A 2-ha plot of Mawa coconut was intercropped with mangosteen at MARDI, Kluang. The coconuts were planted in 1980 and spaced at 9.1 m equilateral triangular. In 1991 within the inter-rows of the coconut, mangosteen plantings were established at 7.6 m apart in a single row. Fruiting of mangosteen was noted in some trees in 1997. The initial number of fruits was low and rodent damage was noted. By the second fruiting season in 1998, out of about 100 mangosteen plants in the field plot, 60 trees were fruiting and there were severe fruit damage that were suspected to be due to rodents. Fruit damage symptoms in the field were characterised and described. The number of fruits in the field and those damaged were assessed to determine the loss noted.

Live-traps (25 cm x 18 cm x 13 cm) were placed in a square grid system of 6 x 10 co-ordinates spaced at a tree interval with fresh coconut meat (2 cm x 2 cm), ripe bananas and jackfruit (nangka) as baits at random. Two traps were placed at each co-ordinate; one on a branch within the

mangosteen tree canopy and the other at ground level within the tree base. The traps were left in position, undisturbed until the next morning and inspected daily. Trapping was undertaken until no new animals were caught for two consecutive nights.

Animals caught were weighed to the nearest gram using a Pesola scale, sexed and identified to the species level according to the characteristics described by Harrison (1965). Trap location and position of the trap animals (ground or tree top) and the baits taken were recorded.

Laboratory studies

All animal species caught were immediately subjected to mangosteen fruit depredation studies without conditioning. Ten animals of each species caught in abundance were used to study the fruit depredation potential. For those less abundant, five or less animals were used. In a choice-test, animals were individually caged in cages (45 cm x 45 cm x 30 cm) and provided with a ripe mangosteen, an unripe matured mangosteen, a ripe banana, a ripe jackfruit and fresh coconut meat. Daily inspection was undertaken and the baits consumed were recorded and replaced. Similarly, another batch of animals were provided with ripe and unripe mangosteens in a no-choice test. When no fruit consumption was noted over a 2-day exposure, animals were given ripe bananas, jackfruit and coconut meat to feed upon to prevent starvation and subsequent weakening and death of the animals.

Results and discussion

Characteristics and symptoms of fruit damage

In the field, mangosteens which were greenish and unripe to the purplish dark matured stage were found to be damaged *(Plate 1)*. The fruit had holes gnawed with striation marks of the teeth on the outer husk layer. There were also small chips of the husk still attached to the damaged fruit which still hangs from the branch of the mangosteen tree. On the leaves below the damaged fruit were chip pieces of the outer husk layer. Once the fruit was broken into, feeding was upon the sweet succulent whitish pulp. The damaged fruit still has more than half of the remaining pulp and are predispose to disease infection and feeding by other secondary pests; thus the fruit is a total loss. Such symptoms and characteristic of damage are typical of rodents especially squirrels. The chipping sizes of the husk, teeth mark dimensions on the fruit and more than half of the fruit husk being chipped off were found to conform to that of squirrels noted in the laboratory. Similar findings have been reported on rodents damaging cocoa (Kamarudin and Lee 1981). It is apparent here that the position of the gnawed holes on the mangosteen fruit was at the point where the animal can have sufficient foot hold within the tree and easy access to feed upon the fruit. Another form of injury noted was bark removal of some of the mangosteen trees *(Plate 2).*

Damage was quite high as out of a total of 530 fruits present in the field, 182 were gnawed and fed upon, i.e. 34.3% crop loss. This level of fruit loss is considered severe since young developing and unripe fruits have been attacked. Furthermore crop losses began at the beginning of fruiting.

Animal species

A total of 104 animals of three different species were trapped from the field plot over 840 trapping nights *(Table 1)*. Overall, equal similar number of baits were consumed although more jackfruits were taken with lesser amounts of ripe bananas and fresh coconut meat. All three species were caught within the tree canopy as well as on the ground suggesting arboreal activity and had the potential of inflicting damage on the mangosteen fruit. In terms of species, the highest number of animals caught was 56, and they were squirrels (*Callosciurus notatus* Boeddaert), ranging from adolescent to lactating female adults *(Plate 3)*. This tend to support the squirrel as the dominant residing population within the area and is

a

b

c

Plate 1. Damaged mangosteen fruits a) unripe and developing, b) matured and fully developed, and c) matured and exposed to red-bellied squirrels, noted in the field and laboratory respectively

Table 1. Summary of species, bait preferences, animal weight, sexes and location caught

Species	Baits			Animal wt.	Sexes		Trap location		Total
	(1)	(2)	(3)	(g)	M	F	T	G	
Cn	14	16	26	86–325	24	32	42	14	56
Rt	17	12	6	42–132	19	16	15	20	35
Rl	2	7	4	120–230	6	7	7	6	13
Total	33	35	36	49	55	64	40	104	

Cn = *Callosciurus notatus*, Rt = *Rattus tiomanicus*, Rl = *Rhinosciurus laticaudatus*
(1) = Fresh coconut pieces, (2) = Ripe bananas, (3) = Jackfruit
M = Male, F = Female, T = Tree top/canopy, G = Ground

probably the main pests causing damage to the mangosteen fruits. More females were caught ($p < 0.05$), indicating a higher intrinsic population growth rate and with squirrels mainly caught within the mangosteen tree canopy further substantiates that they are damaging and feeding upon the fruit. A higher number of squirrels caught with jackfruit in contrast to ripe bananas and fresh coconut baits is probably attributable to the fragrance and fruity scent of the ripe jackfruit over the other two baits.

Plate 2. Mangosteen tree branch exposed due to bark removal and injury by red-bellied squirrels

There were 35 rats caught belonging to the species *Rattus tiomanicus* (Miller), with almost similar number of males and females, with their body weights indicating foraging youngs to adults. Although rats were noted present in the field, the extent of damage to coconuts was very minimal and were of no economical importance in view of low coconut prices. More rats were caught with fresh coconut and a lesser number with ripe bananas and the least with jackfruit baits. In contrast to squirrels, the rats were found not to prefer jackfruit or fruits. The least caught were the ground squirrel, *Rhinosciurus laticaudatus* Muller and almost similar numbers were caught within the tree canopy and on the ground. More of this species were caught with ripe bananas and they were mostly foraging adults.

Mode of depredation and damage potential

In the Hobson's choice feeding test, mangosteen fruit exposed to squirrels in the laboratory had damage symptoms similar to that noted on fruits in the field *(Plate 1c)*.

Plate 3. Trapped red-bellied squirrels of adolescence and lactating stage (swollen, enlarged teats)

Table 2. Summary of damage potential upon mangosteen of rodent species caught

Treatment	Species	No. of animals	Total fruit exposed	Number of fruit damage	Mean exposure time (days)	Mean fruit damage per animal per day
No-choice	Cn	10	20m	10	2	0.5
feeding	Rt	10	20m	0	5	0
test	Rl	5	10m	0	5	0
Choice	Cn	10	10m, 10fc, 10b,10jf	2m,10fc, 2jf,10b	2	0.1m, 0.1jf, 0.5fc, 0.5b
feeding	Rt	10	—do—	10fc, 10b	2	0.5fc, 0.5b
test	Rl	5	—do—	10b, 5jf	2	1b, 0.5jf

m = mangosteen, fc = fresh coconut, jf = jackfruit, b = bananas

There were bored holes with striation teeth marks on the fruit husk and feeding was upon the whitish succulent sweet pulp inside. Mangosteen husk chips were similar in size to that in the field showing a similar mode of depredation and gaining access to feeding upon the fruit. In contrast, the rats and the ground squirrels were noted not to damage and feed upon any of the mangosteen fruits offered *(Table 2)*. Squirrels were noted to damage and feed upon the mangosteen fruit over a 2-day exposure, whereas no rats and ground squirrel fed upon the mangosteen despite a 5-day exposure period (3rd day fed ripe bananas/coconut meat to prevent possible starvation and weakening of animal). However, the wood rats and ground squirrels were noted to feed when offered damaged mangosteen fruits. This suggests that rats and ground squirrels are relatively harmless and at best would be secondary feeders, i.e. feeding upon the remnants and fruits already damaged by squirrels. However, when provided with damaged mangosteen fruits, these animals were noted to feed upon the white succulent sweet pulp.

In a choice-feeding test, jackfruit, ripe bananas and coconut meat were all nibbled upon by all the species caught in the area and only occasional feeding upon the mangosteen fruit by the squirrel was noted. The damage potential of the squirrel was about 0.1 fruit /animal/day. This indicated that squirrels were generally omnivorous feeders and were not specific. Squirrel *C. notatus* from cocoa fields in Pahang, Perak and Trengganu have similar feeding behaviour in the laboratory (Lee 1995).

Fragrance and scent may have a vital role in the depredation of the fruit. Squirrels and rats would gnaw through cocoa pods and feed upon the inner succulent mucilage (Kamarudin and Lee 1981). Similarly damage upon durians by squirrels were very quick despite the fruit had not ripen (Lee 1999) and in the field durian damage due to squirrels were severe in contrast to light damage by rats upon fruit that had fallen to the ground and in most cases dehisce fruits (Ithnin 1992). With whole jackfruit, rats were noted not to gnaw through and this was probably due to the sticky sap. In contrast it took two and more days for the squirrels to gnaw through the fruit to feed upon the aromatic succulent fleshy pulp *(Plate 4)*. Only a few fleshy succulent pulp close to the outer skin layer were fed upon, with the rest as remnants of the damaged fruit. The unattractive sticky sap is probably a hindrance to the squirrel gnawing and feeding upon the fruit. This probably accounts for the high squirrel capture in contrast to other baits because the succulent fleshy pulp of the jackfruit was used. This is further substantiated by trees of jackfruit in an adjacent field within roaming range of the plot which were not damaged nor infested by the squirrels. Similarly, the outer pericarp and the sap of the mangosteen are probably a hindrance and thus not eaten by the rats which have smaller teeth size and structure as compared to squirrels.

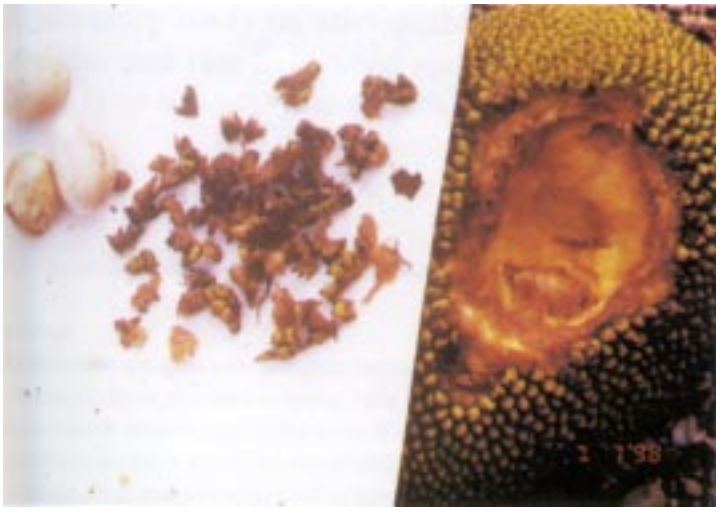

Plate 4. Jackfruit damage and skin chippings caused by red-bellied squirrels

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References

Anon, (1993). The fruit industry in Malaysia. *Proc. Fruit industry in Malaysia* (Mohamad, M. S., Ahmad Tarmizi, S. and Pauziah, M. ed.) p. 1–2. Serdang: MARDI

Harrison, J. L. (1965). *Key to the mammals of the Malay Peninsular South of the Thailand-Malaysian border* 34 p. Singapore: Univ. of Singapore Publ.

Ithnin, B. (1992). A comparison of species composition of rodents in the ecosystems of a monocropped durian versus an intercropped durian and cocoa. *Proc. Nat. IRPA Seminar* (Ho, Y. W., Vidyadaran, M. K., Norhani, A., Jainudeen, M. R. and Abd. Rani Bahaman, ed.) p.753–4. Serdang: UPM Serdang

Kamarudin, K. A. and Lee, C. H. (1981). Modes of cocoa pod depredation by three small mammals. *MARDI Res. Bull.* ***9:*** 42–8

Lee, C. H. (1995). Vertebrate pest species of cocoa with special reference to rodent management in Peninsular Malaysia. Ph. D. Thesis, Univ. of Malaya, Kuala Lumpur 229 p.

—— (1999). Fruit depredation and pest status of some mammals. Paper presented at the 5th Int. conf. on plt. protect. in the tropics, 15–18 Mac. 1999, Kuala Lumpur. Organiser: MAPPS

Mohd. Shamsudin, O. (1990). Pest and disease control. In *Guide to mangosteen cultivation* (M. Z. Mohd. Khalid and A. Rukayah ed.) p. 19–23. Kuala Lumpur: MARDI (in Bahasa Melayu)

Sethpakdee, R. (1996). Commercial production of tropical fruits in Thailand: problems and Prospects. *Proc. Int. conf. on tropical fruits* (Vijaysegaran, S., Pauziah, M., Mohamad M. S. and Ahmad Tarmizi S., ed.) p. 63–70. Serdang: MARDI

Poonachit, U., Alakpetch, S., Chandraparnik, S. and Hiranpradit, H. (1996). Phenological development and plant vigour affected mangosteen production. *Proc. int. conf. on tropical fruits* (Vijaysegaran, S., Pauziah, M., Mohamad M. S. and Ahmad Tarmizi S., ed.) p. 255–61. Serdang: MARDI

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