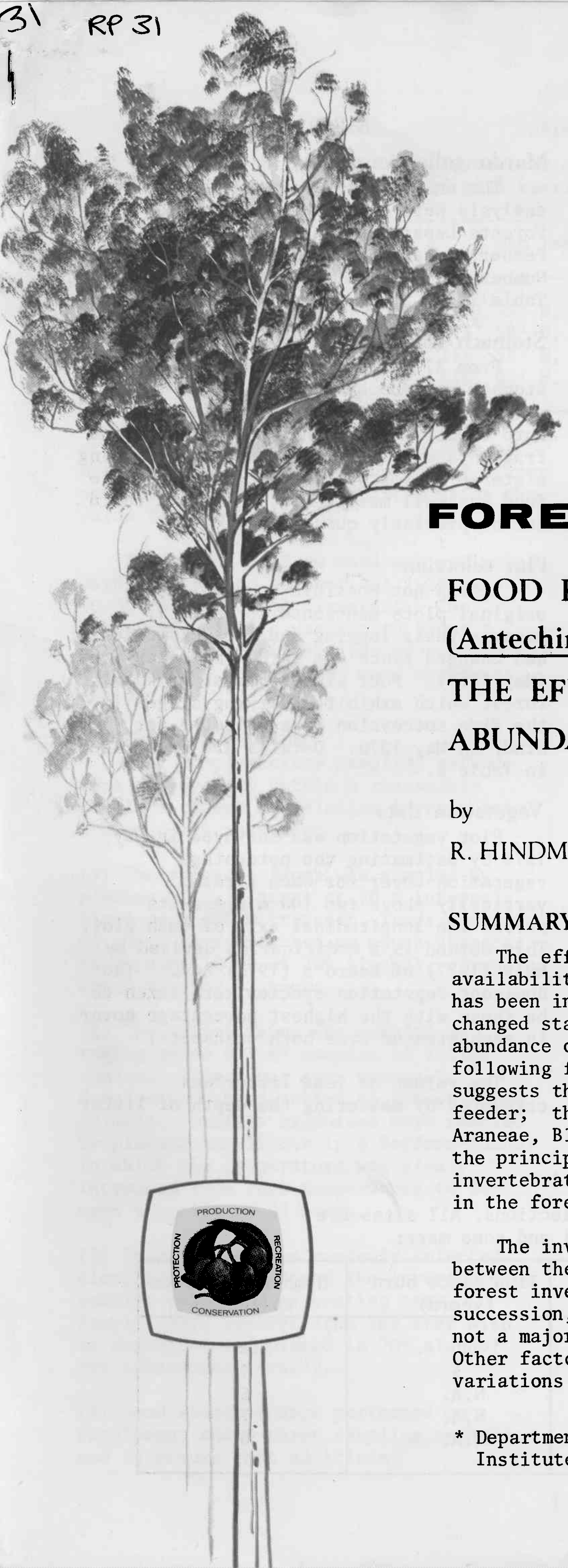

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OF WESTERN AUSTRALIA

FOOD REQUIREMENTS OF MARDO (Antechinus flavipes (Waterhouse)) AND THE EFFECT OF FIRE ON MARDO ABUNDANCE

by

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SUMMARY

The effect of prescribed burning on the availability and abundance of forest invertebrates has been investigated to determine whether the changed status of food supply influences the abundance of the mardo (Antechinus flavipes) following fire. Analysis of stomach contents suggests that the mardo is an opportunistic feeder; the numerically predominant invertebrates Araneae, Blattodea, Coleoptera and Hymenoptera are the principal food sources. The habitats of these invertebrates indicate that the mardo feeds mainly in the forest litter layer.

The investigation revealed no correlation between the abundance of the mardo and that of the forest invertebrates during the post-fire succession, suggesting that food availability is not a major factor in mardo population changes. Other factors which might cause the observed variations in mardo abundance are briefly considered.

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INTRODUCTION

The mardo (Antechinus flavipes (Waterhouse)) is prevalent in the forests of southwest Western Australia. It is predominantly insectivorous although carrion is also eaten (Marlow, 1961). Observation has revealed that mardo abundance is considerably reduced following wild or prescribed fires in the jarrah and karri forests. As the post-fire succession proceeds there is a delayed recovery in the numbers of mardo compared with that of other sympatric mammals. The abundance of mardos appears to be related to the time lapse since the last burn (Christensen & Kimber, 1975).

A similar phenomenon has been reported for A. swainsonii (Waterhouse) and A. stuartii Macleay where no recovery of numbers to pre-burn levels was observed in the two years following the 1972 Nadgee wildfire (Newsome et al., 1975).

This study examines the food preferences of the mardo in karri forests, and the possibility that food availability is the limiting factor in the post-fire recovery of the mardo population.

Food preferences have been elucidated by examining the gut contents of mardos trapped by the Forests Department in plots of varying fire histories in the Pemberton area. An attempt is made to correlate these data with data concerning the availability and abundance of invertebrates trapped from similar forest areas so that an understanding of the post-fire mardo population density may be gained.

METHOD

Mardo collections

The animals used for the gut content analysis were trapped by officers of the Forests Department in the Manjimup-Pemberton karri forests in May 1974. Number and site data are summarized in Table 1.

Stomach content analysis

From 37 formalin-preserved mardos the stomach and duodenum were removed then weighed, slit open and the contents washed into a petri dish with 70% alcohol. Food fragments were identified and scored using a stereo microscope, although because the food was well masticated, the items could not be precisely quantified.

Plot selection

It was not possible to sample the original plots mentioned in Table 1, because their logging and fire histories had changed since the mardos were captured, (May 1974). Four similar areas of karri forest which exhibited varying stages in the fire succession were selected for study in May 1976. Details are summarized in Table 2.

Vegetation data

Plot vegetation was surveyed in May 1976 by estimating the percentage vegetation cover for each stratum vertically above two 100 m transects across the longitudinal axis of each plot. This method is a modification devised by Muir (1977) of Beard's (1975) key. The dominant vegetation species were taken to be those with the highest percentage cover in each stratum over both transects.

The volume of leaf litter was estimated by measuring the depth of litter

TABLE 1

Site data for mardo collections. All sites are forested with karri and some marri

Location	Map reference	Time since burn (years)	Number of mardos collected
House Brook Road	115° 59' E, 34° 24' S	40	18
Pine Creek Road	115° 51' E, 34° 18' S	5	1
Curd Road	115° 58' E, 34° 31' S	N.A.	5
Henwood Road	115° 53' E, 34° 16' S	N.A.	7
Locality unknown		N.A.	6

N.A. - data not available

TABLE 2

Site data for invertebrate collections. All sites are forested with karri and some marri

Location	Map reference	Time since burn (years)
House Brook Road	115° 59' E, 34° 24' S	>40
Barker Road	115° 58' E, 34° 31' S	>20
Barker Road	115° 58' E, 34° 32' S	5
Crowea Road	116° 02' E, 34° 32' S	0.5

at 50 cm intervals along either side of each 100 m transect. The volume of litter per hectare was then calculated using the value for the mean depth.

The amount of dead wood was estimated using three size categories: 1-10 cm, 10-30 cm and >30 cm diameter. The occurrence of wood was scored along a 50 cm strip on either side of each 100 m transect and an index of wood abundance estimated.

Invertebrate sampling

Four complementary sampling methods were employed to obtain a reasonably complete census of relative invertebrate abundance in each plot.

(1) The epigaeic fauna was sampled by placing pitfall traps at 10 m intervals along each 100 m transect. Traps consisted of glass jars with a 4 cm mouth diameter containing 10 ml of 70% alcohol. Trapping continued for 72 hours.

(2) The litter fauna was sampled by taking three 0.1 m^2 samples of litter randomly from along each transect. Samples were hand-sorted to remove large animals. Smaller organisms were removed by placing the litter in a Berlese funnel in which the temperature was slowly increased from room temperature to 38°C over a period of 24 hours.

(3) Four shrubs were randomly selected along each transect and the invertebrates sampled using a 1 m^2 beating tray. Samples were removed from the tray with an aspirator and placed in 70% alcohol for subsequent sorting.

(4) Hand searches were performed to supplement these three sampling methods and to ensure that additional microhabitats, such as logs, were also sampled. Two persons collected all invertebrates along each transect for a period of 15 minutes.

RESULTS

The raw stomach content data of the mardo are summarised in Table 3. The items included a wide variety of invertebrates of which Araneae, Blattodea, Coleoptera and Hymenoptera (excluding ants) were the most abundant. One bird and one reptile limb were found, supporting Marlow's (1961) comment that carrion may be eaten. No plant material was found.

The vegetation data for the four plots surveyed are summarized in Table 4.

TABLE 4

Summary of vegetation data in study plots

Location	Time since burn (years)	Vegetation summary
House Brook Road	> 40	A1/C3/C4/C5/C6
Barker Road	> 20	B1/C3/C4/C5/C6
Barker Road	5	B1/C3/B4/C5/C6
Crowea Road	0.5	B1/B4/C5/C6

Legend

1. Trees
2. Mallee form
3. Shrubs
4. Grasses and herbs
5. Sedges
6. Ferns, mosses etc.

A. Dense (70-100% coverage)
B. Mid-dense (30- 70% ")
C. Sparse (0- 30% ")

TABLE 3

Stomach contents and biological data of mardos

	No.	Sex	Preserved weight (g)	Stomach weight (g)	Body length (cm)	Stomach contents
House Brook Rd.	118	F	29.70	1.4	10.00	Dermaptera, Blattodea, Coleoptera Hymenoptera (Wasp?)
	119	F	18.05	0.3	7.75	-
	120	M	26.90	0.8	9.50	Araneae
	121	F	22.60	1.4	9.25	Blattodea, Araneae, Coleoptera Hemiptera ?
	156	M	29.1	1.0	9.75	Blattodea, Hymenoptera (Bee?)
	157	M	28.91	0.8	9.50	-
	158	F	29.87	1.1	10.50	Homoptera (Fulgoroidea - 6 nymphs) Curculionidae
	159	F	23.90	1.0	9.00	Chilopoda
	186	M	34.70	1.7	10.00	-
	187	F	31.89	1.3	11.00	Araneae
	188	M	29.35	0.7	10.75	-
	189	M	50.00	1.0	12.00	Araneae, Curculionidae, Blattodea
	190	M	28.35	1.5	10.75	Araneae, Blattodea
	191	F	21.29	0.6	9.75	Araneae, Dermaptera, Coleoptera
	192	F	20.60	1.2	9.50	Blattodea
	193	F	23.22	0.8	9.50	Coleoptera, Araneae, Blattodea?
	128	M	37.50	0.6	10.25	Coleoptera, Araneae
	114	M	41.35	0.7	10.75	Homoptera, Coleoptera
Pine Creek Rd.	47	F	27.20	0.4	10.00	Araneae
Curd Road	151	F	22.75	0.6	7.75	Coleoptera (Nitidulidae - 4+), Symphyta larva
	152	M	43.05	1.4	10.00	raneae, Coleoptera (Nitidulidae) Other Coleoptera
	153	M	45.75	0.6	10.50	Birds foot and feathers, Coleoptera
	155	F	23.50	0.4	7.75	
	172	F	19.37	0.3	8.50	Coleoptera, (Nitidulidae)
Henwood Road	22	M	45.72	1.1	11.25	Blattodea
	23	F	23.71	0.3	9.25	Araneae
	59	F	28.90	0.7	10.25	Curculionidae, Heteroptera
	80	M	50.40	1.3	11.50	Dermaptera, Chilopoda, Blattodea, Araneae
	56	F	23.85	0.7	9.75	Blattodea
	57	F	21.65	0.4	10.00	Araneae, Blattodea, Diplopoda Hymenoptera (Ant or Wasp) Staphylinidae, Lizard leg (Skink)
	58	F	24.90	0.9	9.75	Araneae, Diptera (Mosquito?) Blattodea
Locality unknown	216					Myriapoda (Diplopoda or Chilopoda), Araneae
	219					Blattodea, Heteroptera?, Coleoptera? Blattodea
	217					Scarabaeidae, Araneae
	228					Coleoptera (Nitidulidae), Araneae, Other Coleoptera, Hymenoptera
	221					Blattodea, Araneae (2), Coleoptera
	220					Scorpionida?, Chilopoda? Heteroptera, Araneae, Larva (Lepidoptera?), Homoptera.

Marked inter-plot differences occurred in the understorey strata. The most recently burnt plot had no shrub layer, a herb and grass layer of medium density and sparsely distributed sedges and ferns. The plot burnt five years previously was characterised by a more dense herb and shrub layer of 'fireweed' such as <u>Crowea angustifolia</u> Sm. and <u>Acacia pulchella</u> R.Br. The 'fireweed' understorey was considerably less dense twenty years after burning but the lower tree stratum was more dense. This trend continued in the site burnt over forty years earlier.

The volume of leaf litter was directly related to the fire histories of the sites; a gradual accumulation of litter coincided with the recovery from burning on each site (Fig. 1). This trend was also found with the dead wood

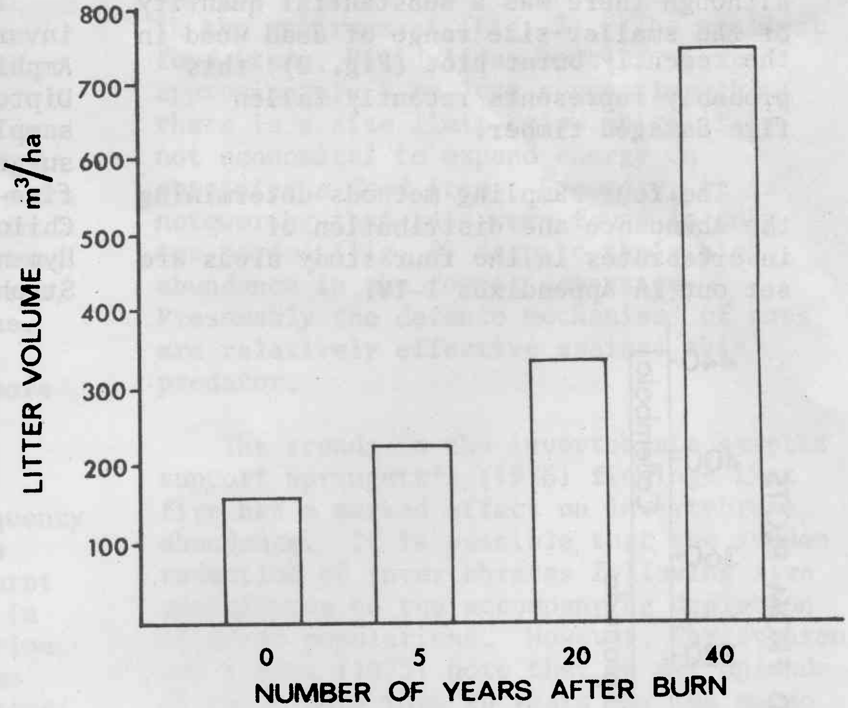

FIGURE 1: Estimation of leaf litter in the four study areas.

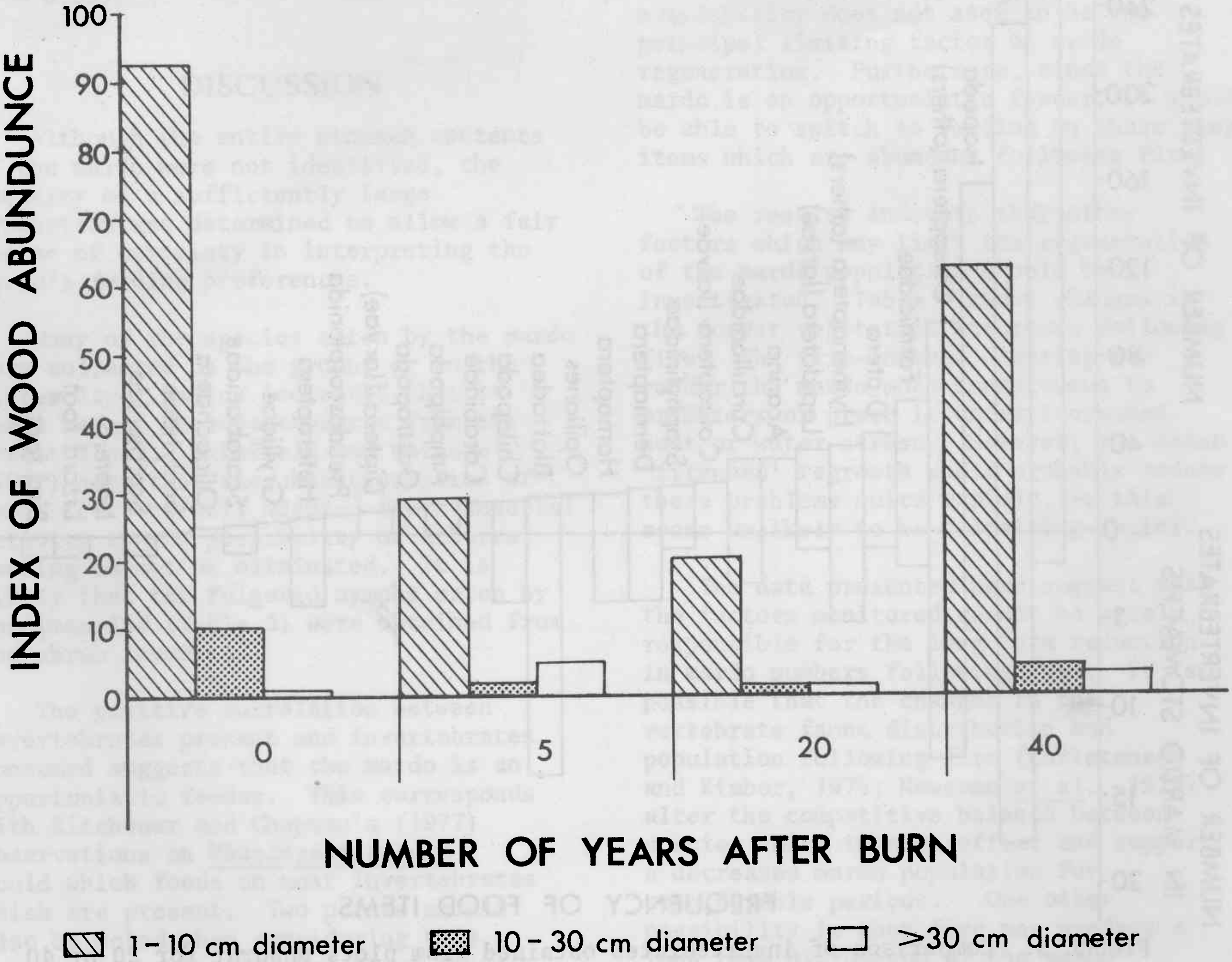

FIGURE 2: Estimation of dead wood in the four study areas.

although there was a substantial quantity of the smaller size range of dead wood in the recently burnt plot (Fig. 2): this probably represents recently fallen fire-damaged timber.

The four sampling methods determining the abundance and distribution of invertebrates in the four study areas are set out in Appendixes I-IV.

The results show no general trend of invertebrate abundance following fire. Amphipoda, Isoptera, Heteroptera and Diptera (larvae) were not found in the samples from the recently burnt area, suggesting that they are the most fire-sensitive. The Pseudoscorpionida, Chilopoda, Blattodea, Dermaptera, Hymenoptera (excluding ants), Staphylinidae and Curculionidae increased

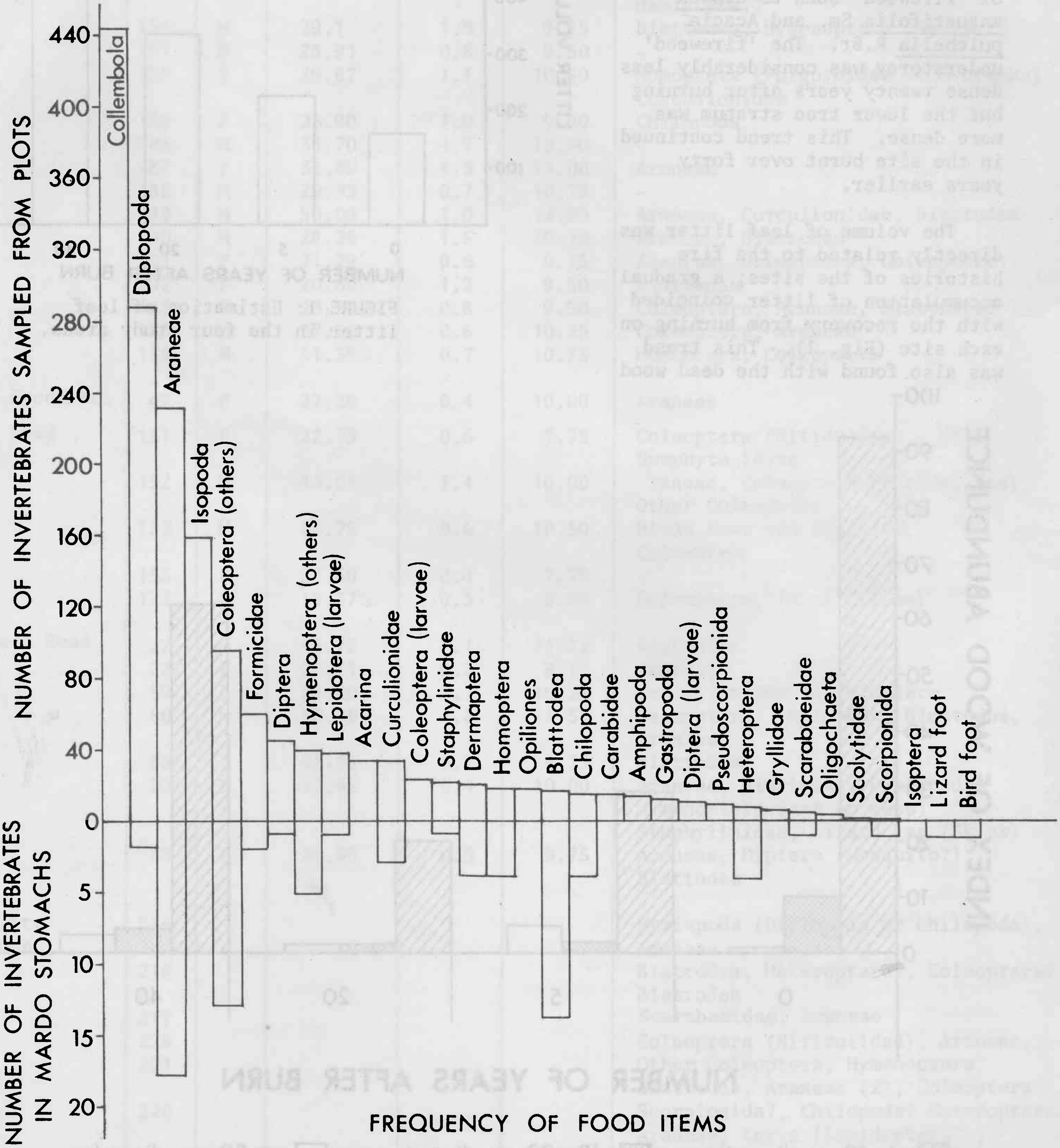

FIGURE 3: Comparison of invertebrates obtained from plots unburnt for 20 or 40 years (upper part of graph) with the frequency of food items in mardo stomachs (lower part of graph).

in abundance shortly after the burn. Other groups were reduced in abundance following the fire but increased again as the post-fire succession progressed. These included Opiliones, Isopoda, Diplopoda, Collembola and Lepidoptera (larvae). A final group showed a peak in the plot burnt five years previously and then declined in abundance; included in this group were the Scorpionida, Acarina, Araneae, Amphipoda, Gryllidae, Homoptera, Formicidae, Carabidae and Scarabaeidae. The significance of these interplot differences was tested by the chi-square method and the results are shown in Appendix V.

A comparison of invertebrate frequency in the mardo stomachs and that of the invertebrates collected from the unburnt (for 20 and 40 years) plots is shown in Figure 3. A Spearman's rank correlation coefficient was calculated for the two sets of ranked data. The obtained value of r_s was 0.338. By testing this value using Students t it may be concluded that these variables are positively correlated ($p = 0.05$).

DISCUSSION

Although the entire stomach contents of the mardo were not identified, the identity of a sufficiently large proportion was determined to allow a fair degree of certainty in interpreting the mardo's feeding preferences.

Many of the species eaten by the mardo were collected on the ground or in the litter layer, which indicates that it feeds mainly on invertebrates from the forest floor. Wakefield and Warneke (1967) note that the characteristics of mardo feet are well adapted for scansorial activity so the possibility of arboreal feeding cannot be eliminated. It is likely that the fulgorid nymphs eaten by specimen 158 (Table 3) were obtained from the shrub layer.

The positive correlation between invertebrates present and invertebrates consumed suggests that the mardo is an opportunistic feeder. This corresponds with Kitchener and Chapman's (1977) observations on *Phascogale calura* Gould which feeds on most invertebrates which are present. Two points should also be noted when considering this opportunism. One is that there appears to be a minimum size limit for food consumed. No Collembola were found in the gut despite their high abundance in the environment (Fig. 3). The smallest food items, Nitidulidae beetles, were approximately 3 mm long suggesting that there is a size limit below which it is not economical to expend energy on obtaining a food item. Secondly, it is noteworthy that ants were found in only two mardos (Fig. 3) despite their high abundance in the forest ecosystem. Presumably the defence mechanisms of ants are relatively effective against this predator.

The trends in the invertebrate samples support Springett's (1976) findings that fire has a marked effect on invertebrate abundance. It is possible that the sudden reduction of invertebrates following fire contributes to the accompanying depletion of mardo populations. However, Christensen and Kimber (1975) note that on dry uplands it takes more than 20 years for the mardo population to return to pre-fire levels. Since many of the invertebrate groups have returned to their former population levels within five years (Appendixes I-IV) food availability does not seem to be the principal limiting factor on mardo regeneration. Furthermore, since the mardo is an opportunistic feeder, it would be able to switch to feeding on those prey items which are abundant following fire.

The results indicate that other factors which may limit the regeneration of the mardo population should be investigated. Table 4 shows changes in the forest vegetation structure following fire. The fire-induced clearing may render the mardo more conspicuous to predators or place it under increased heat or water stress. However, the dense 'fireweed' regrowth would probably reduce these problems quite rapidly, so this seems unlikely to be a limiting factor.

The data presented here suggest that the factors monitored cannot be solely responsible for the long term reduction in mardo numbers following fire. It is possible that the changes in the vertebrate fauna distribution and population following fire (Christensen and Kimber, 1975; Newsome *et al.*, 1975) alter the competitive balance between species which in turn effect and support a decreased mardo population for considerable periods. One other possibility is that fire may produce a long term disruption of the mardo breeding pattern.

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APPENDIX 1

Total number of invertebrates trapped by the pitfall trap method

Class	Order	Family	Years after burn 0	5	20	40
Arachnida	Scorpionida		0	2	0	0
	Pseudoscorpionida		10	1	3	2
	Opiliones		4	2	2	5
	Acarina		5	24	2	1
	Araneae		10	20	16	18
Crustacea	Amphipoda		0	13	1	2
	Isopoda		0	11	1	6
Diplopoda			1	0	3	0
Chilopoda			1	1	0	0
Insecta	Collembola		117	61	49	103
	Orthoptera:	Gryllidae	2	4	3	0
	Blattodea		1	4	1	1
	Dermaptera		21	19	14	2
	Isoptera		0	0	0	0
	Homoptera		1	5	0	2
	Heteroptera		0	2	0	0
	Lepidoptera (Larvae)		0	0	2	3
	Diptera		10	8	6	13
	Diptera (Larvae)		0	0	2	3
	Hymenoptera:	Formicidae	13	35	25	7
		Others	1	8	6	4
	Coleoptera:	Staphylinidae	37	27	14	4
		Scolytidae	0	0	0	0
		Curculionidae	9	8	1	1
		Carabidae	11	19	11	3
		Scarabaeidae	15	21	0	1
		Others	44	0	14	9
		Larvae	3	0	3	1
Oligochaeta			0	0	1	0
Gastropoda			2	1	1	0

APPENDIX II

Total number of invertebrates collected from litter samples

Class	Order	Family	Years after burn 0	5	20	40
Arachnida	Scorpionida		0	2	0	0
	Pseudiscorpionida		0	0	1	0
	Opiliones		0	1	4	8
	Acarina		0	11	9	0
	Araneae		5	19	14	16
Crustacea	Amphipoda		0	2	9	2
	Isopoda		2	11	4	18
Diplopoda			0	44	21	41
Chilopoda			0	5	7	3
Insecta	Collembola		7	1	12	0
	Orthoptera:	Gryllidae	0	1	0	0
	Blattodea		0	6	3	3
	Dermaptera		0	0	5	0
	Isoptera		0	0	0	0
	Homoptera		0	0	1	2
	Heteroptera		0	2	5	1
	Lepidoptera (Larvae)		3	2	10	0
	Diptera		1	0	0	0
	Diptera (Larvae)		0	3	4	0
	Hymenoptera:	Formicidae	2	1	15	3
		Others	0	1	0	1
	Coleoptera:	Staphylinidae	0	2	2	0
		Scolytidae	0	0	0	0
		Curculionidae	0	2	1	0
		Carabidae	0	4	0	2
		Scarabaeidae	0	0	0	0
		Others	1	4	6	1
		Larvae	0	8	14	3
Oligochaeta			0	0	0	0
Gastropoda			0	0	1	0

APPENDIX III

Total number of invertebrates collected by beating shrubs

Class	Order	Family	Years after burn			
			0	5	20	40
Arachnida	Scorpionida		0	0	0	0
	Pseudoscorpionida		0	0	0	0
	Opiliones		0	0	0	0
	Acarina		1	3	17	5
	Araneae		27	102	82	62
Crustacea	Amphipoda		0	0	0	0
	Isopoda		0	25	0	112
Diplopoda			0	0	0	1
Chilopoda			0	0	0	0
Insecta	Collembola		35	12	111	128
	Orthoptera:	Gryllidae	0	0	1	0
	Blattodea		0	0	1	4
	Dermaptera		0	0	0	0
	Isoptera		0	0	0	0
	Homoptera		5	2	3	11
	Heteroptera		0	3	0	0
	Lepidoptera (Larvae)		2	5	11	13
	Diptera		10	4	14	10
	Diptera (Larvae)		0	0	0	0
	Hymenoptera:	Formicidae	0	3	1	3
		Others	37	9	15	14
	Coleoptera:	Staphylinidae	3	1	0	1
		Scolytidae	0	0	0	1
		Curculionidae	8	1	4	16
		Carabidae	0	0	0	0
		Scarabaeidae	0	0	0	0
		Others	27	4	63	2
		Larvae	0	0	0	0
Oligochaeta			0	0	0	0
Gastropoda			0	0	0	0

APPENDIX IV

Total number of invertebrates collected by the unit search method

Class	Order	Family	Years after burn			
			0	5	20	40
Arachnida	Scorpionida		1	1	1	0
	Pseudoscorpionida		1	0	0	1
	Opiliones		0	0	0	0
	Acarina		1	2	1	0
	Araneae		9	9	13	11
Crustacea	Amphipoda		0	0	0	1
	Isopoda		16	7	3	16
Diplopoda			94	36	61	163
Chilopoda			17	4	4	2
Insecta	Collembola		0	2	0	2
	Orthoptera:	Gryllidae	0	0	0	0
	Blattodea		23	6	4	1
	Dermaptera		2	0	0	0
	Isoptera		0	16	0	0
	Homoptera		1	15	0	0
	Heteroptera		0	0	0	0
	Lepidoptera (Larvae)		0	1	0	0
	Diptera		0	0	0	0
	Diptera (Larvae)		0	0	0	0
	Hymenoptera:	Formicidae	3	98	9	0
		Others	0	0	0	0
	Coleoptera:	Staphylinidae	0	0	1	0
		Scolytidae	0	0	0	0
		Curculionidae	2	3	11	0
		Carabidae	1	0	0	0
		Scarabaeidae	0	0	1	0
		Others	0	0	2	0
		Larvae	0	0	1	1
Oligochaeta			2	1	0	0
Gastropoda			0	0	9	0

APPENDIX V

Comparison of pooled, invertebrate collections from the four sample plots using the chi-square method

Class	Order	Family	X^2	
Arachnida	+Scorpionida		-	
	+Pseudoscorpionida		-	
	Opiliones		9.38	ns
	Acarina		41.22	**
	Araneae		48.00	**
Crustacea	Amphipoda		16.67	ns
	Isopoda		243.36	**
Diplopoda			212.12	**
Chilopoda			7.82	ns
Insecta	Collembola		78.31	**
	+Orthoptera:	Gryllidae	-	-
	Blattodea		16.552	ns
	Dermaptera		17.38	*
	+Isoptera		-	-
	Homoptera		16.50	ns
	+Heteroptera			
	Lepidoptera (Larvae)		15.23	ns
	Diptera		3.78	ns
	+Diptera Larvae		-	-
	Hymenoptera :	Formicidae	181.30	**
		Others	11.08	ns
	Coleoptera:	Staphylinidae	30.35	**
		+Scolytidae	-	-
		Curculionidae	5.80	ns
		Carabidae	13.23	ns
		Scarabaeidae	32.32	**
		Others	171.02	**
		+Larvae	-	
+Oligochaeta			-	-
+Gastropoda			-	-

X^2 (critical) for df=9 at 5% level = 16.92 *
1% level = 21.67 **

+ No test done since e >5 and T>20