BIOLOGY PROJECT 302

THE EFFECTS OF PRESCRIBED BURNING IN THE FORESTS OF SOUTH WEST WESTERN AUSTRALIA ON THE INVERTEBRATE FAUNA AND ITS POSSIBLE RELATION TO THE DELAYED RECOVERY IN THE POPULATION OF *ANTECHINUS FLAVIPES*

By

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ERRATA

Pteridium esquilentum should read *Pteridium esculentum*.
Crowea dentata should read *Crowea angustifolia*.
Leucopogon verticullatus should read *Leucopogon verticillatus*.

SUMMARY

The effect of prescribed burning and its effect on the availability and abundance of the invertebrate fauna was examined with the possibility that it may be a contributing factor to the delayed recovery in the abundance of the marsupial mouse, Antechinus flavipes. Although the marsupial mouse feeds predominantly on invertebrates the post fire trends suggest that they are not the limiting factor. Changes in habitat and vegetation structure were also assessed as a possible contributing factor. Analysis of the stomach contents and subsequent statistical analysis of the data shows that A. flavipes is an opportunistic feeder, however, there was insufficient data to suggest that it was aboreal in nature.

INTRODUCTION

The small predatory mouse, the mardo (*Antechinus flavipes*) common in the south west of Western Australia, is believed to be predominantly insectivorous, although carrion is also eaten (Marlow, 1961). When karri and jarrah forests are burnt to reduce fuel and thus minimise the likelyhood of wildfire, the abundance of mardos is much reduced. As the resulting post fire succession proceeds there is a delayed recolonisation of the area by the mardo when compared with other mammals with which it normally co-exists. There appears to be a definite relationship between the period since the last burn and the abundance of mardos (Christensen and Kimber, 1975).

A similar phenomena has been reported for *A. swainsonii* and *A. stuartii* where no increase in numbers to pre-fire levels was observed in the two years following the Nadgee wildfire in 1972, while the abundance of other small mammals greatly increased (Newsome, McIlroy and Catling, 1975).

This study set out to examine the possibility that food availability is the limiting factor in the recovery of the mardo population.

The stomach contents of A. *flavipes* trapped in the Pemberton area from forests at various stages of succession were examined to determine feeding preferences. An attempt was then made to correlate these findings with the availability and abundance of invertebrates trapped from similar areas. It was also hoped that this information may reveal whether or not *A. flavipes* is aboreal as is *A. stuartii* (Wood, 1970).

Changes in vegetation and habitat were also assessed since the period between burns can have a marked effect on the structure of the forest particularly the shrub layer (Christensen, 1972 , Peet and Van Didden, 1973) and the litter layer (Springett, 1976).

METHODS

STUDY AREAS

Area 1 was part of a karri/marri forest that had been logged but unburnt for more than forty years situated in House Brook Road in the Big Brook forest (Plate 1).

Area 2 was part of a karri/marri forest that had been unburnt for more than twenty years situated off Barker Road in the Warren forest (Plate 2).

Area 3 was part of a karri/jarrah forest that had been burnt five years previously in 1971 situated off Barker Road in the Warren forest (Plate 3).

Area 4 was part of a karri/marri forest that had been burnt in December, 1975, less than a year previously situated off Crowea Road in the Crowea forest (Plate 4).

FOREST STRUCTURE

Vegetation surveys were carried out by the plotless sampling method of estimating percentage canopy cover for each particular stratum along a 100 metre transect. This was based on a modification of Beard's key (Beard, 1975) devised by B. Muir of the W.A. Museum.

Two transects were laid out in each of the study areas and the percentage cover estimated by recording the distance along the tape that each stratum over shadowed. The dominant species were taken as those with the highest percentage cover in each stratum over both transects.

The volume of leaf litter was estimated by measuring the depth of the litter fifty centimetres either side of each ten metre interval along the transects. From these measurements an average depth over a one hundred square metre area was estimated and thus, volume per hectare calculated.

The amount of dead wood was also estimated by dividing it into three arbitary size categories, 1 - 10 cms, 10 - 30 cms and greater than 30 cms in diameter and recording the frequency of dead wood of each size that occurred in the same one hundred square metre area that the volume of litter had been estimated.

INVERTEBRATE SAMPLING

Four methods of sampling were carried out on each of the eight transects.

PIT FALL TRAPS: Eleven traps were placed along each transect at ten metre intervals. These consisted of 100 ml screw-topped jars of 40 mm mouth diameter containing a small quantity of 70% alcohol. These were placed in the soil with the lip of the jar level with the ground. Care was taken not to disturb the area surrounding the trap although in areas with thick litter cover some disturbance was inevitable. The traps were allowed to remain in the ground for 72 hours.

BEATING: Four shrubs were selected along each transect and the invertebrates dislodged by stiking the shrub sharply several times with a stick and collecting the fauna on a metre square tray held underneath. With the aid of an aspirator they were quickly gathered up and preserved in 70% alcohol.

LITTER COLLECTION: Three samples of litter were collected along each transect using a metal hoop to cut an area of 0.1 square metres. The litter was then sorted by hand to remove the larger animals, which were preserved, before combining the litter samples from the one area and placing them in a Berlese funnel. The areas with heavy litter cover may not have been sorted efficiently by the Berlese funnel method because such a large bulk of litter in the funnel may not have been sufficiently heated in the centre to cause the animals to move downward into the collecting jar.

The litter was left in the funnel for twenty four hours over which time the temperature was gradually increased from room temperature to between 34 and 38 degrees centigrade. The berlesates were collected and combined with the animals that had been hand sorted from the litter previously.

HAND SEARCH: Two people equiped with forceps and a collecting jar made hand searches along each transect for fifteen minutes. Since a certain amount of practice is involved in this technique the first attempt was repeated. Only the animals collected on the second attempt were included in the subsequent analysis.

All the invertebrates were later identified and counted and a selected few photographed (Appendix C).

The vegetation surveys and the invertebrate trapping had been carried out in May, 1976.

ANALYSIS OF STOMACH CONTENTS

The stomach and half the duodenum was removed from thirty seven preserved mardos (kindly supplied by the Forest Dept, Manjimup) that had been trapped in various forest areas of known fire history in May, 1974. The stomach was weighed and the contents removed and sorted for identifiable fragments. Due to the efficient mastication of the food items by the mardos the numbers of each item could not be estimated.

RESULTS

VEGETATION STRUCTURE

The vegetation keys for the areas studied and information of the forest structure has been summarized under Plates 1, 2, 3, and 4 and a species list is contained in Appendix A.

From this it can be seen that there is a succession of plant species in the lower strata from the period directly following the burn to the period some forty years following a burn. The area burnt less than a year previously had no shrub layer and only a sparse ground cover of herbs which progressed to a stage in the area five years after a burn where the shrub and herb layer had become more dense with the growth of such "fireweeds" as Crowea dentata and Acacia pulchella. However, in the area burnt twenty years previously, the lower tree stratum has become more dense and the herb and shrub layer less dense. The area unburnt for more than forty years shows that the understorey has collapsed leaving a mid-dense lower tree stratum of Casuarina decussata and Bossiaea laidlawiana over a sparse shrub layer and a herb layer of mainly creepers such as Clematis aristata. The bracken fern, Pteridium esquilentum was present in all the areas and the tall tree strata varied only slightly between the areas since the mild fires normally used in prescribed burning had little effect on the canopy.

The volume of litter on the ground appears to be directly related to the fire history of the areas (Figure 2) with gradual increase in the volume with increasing time since the last burn.

Although the estimation of dead wood was only arbitary it was sufficient for comparative purposes. Following a recent burn, the amount of dead wood on the groundis fairly substantial compared to the other areas, however, there appears to be an absence of large logs (Figure 3). The frequency of dead wood in the larger size categories may well be related to the logging history of the area, unfortunately, this information was not available for all the areas.

INVERTEBRATE TRAPPING

The abundance and distribution of invertebrates in the four study areas is shown in Table 1 which is a summary of the data contained in tables 1 to 4 of Appendix B.

Of all the species collected only those of the Amphipoda, Isoptera, Heteroptera and Diptera larvae were absent from the area most recently burnt and would appear to be the most fire sensitive. Those that showed an increase in numbers in the same area were species of Pseudoscorpionida, Chilopoda, Blattodea, Dermaptera, Hymenoptera, Staphylinidae and Curculionidae. Many other species tended to show reduced numbers directly after a burn with a general increase in numbers as the post fire succession progressed. These were species of Opiliones, Isopoda, Diplopoda, Collembola and Lepidoptera larvae. The trend in some species was a general increase in numbers in the area burnt five years ago followed by a general decline in numbers as further successional changes occurred. These belonged to the Scorpionida, Acarina, Araneae, Amphipoda, Gryllidae, Homoptera, Heteroptera, Formicidae, Carabidae and Scarabidae.

A chi squared test was carried out on the data which is graphically illustrated in Figures 1 to 24 in Appendix B, to find if the period since the last burn had any effect on the distribution or abundance of the invertebrates from a particular group. The test also revealed significant differences ($P < 0.01$) between the numbers trapped and the trapping method. Table 5 of Appendix B summarizes the results of the statistical test, which shows that in many cases there was no significant differences between the numbers caught and the area from which they were trapped. This suggests that the occurrence of fire does little to restrict their abundance.

A statistical analysis using Kendall's coefficient of concordance (Siegel, 1956) was carried out on the data contained in Table 1 to test for any significant differences between the abundance of invertebrates in general and the area from which they were trapped. The result of this analysis is presented in Table 6, Appendix B.

STOMACH CONTENTS ANALYSIS

Although the mardos were trapped at the same time of the year as the invertebrates, they were not trapped in the same year. However, some conclusions can be drawn from the data that was obtained.

Some examples of stomach contents are illustrated in Plates 5 and 6 and give some idea as to the difficulty in identifying the food items when it is considered that these examples were the more recognisable.

From Tables 1 to 5 in Appendix D, it can be seen that a wide variety of invertebrates had been eaten by the mardos and that it had also consumed carrion in the form of a bird's foot and a lizard's foot. No plant material of any description was found in the stomachs. This data has been summarized in Figure 4b and shows that the most frequently occurring invertebrates to be species of Araneae, Blattodea, Hymenoptera and Coleoptera (combined).

A statistical analysis using Spearman's rank correlation coefficient (Siegel, 1956) was carried out on the data contained in Figure 4 to test the significance between the frequency of invertebrates identified in the stomach contents and the gross abundance of invertebrates from all four study areas and thus conclude from this whether or not the mardo is an opportunistic feeder. The result of this test is set out in Table 7, Appendix B and indicates that the mardo would eat what was available.

PLATE 1: Area that was logged but unburnt for more than 40 years, situated in House Brook Road in the Big Brook area (see ★ on Figure 1).

Key to Vegetation Structure (Beard, 1975)

$e_1Td.e_1n_{13}Mc.n_{13}e_1LAc.n_{21}n_{33}LBi.$
$n_{27}Sr.n_{27}SAr.n_{39}SBr.n_{27}n_{21}SCr.n_{28}SDr.$
$n_{38}GLi.n_1n_{14}n_{39}Ji.n_{10}VLi.n_{12}Xi.$

(Refer to species list in Appendix A)

Dense overstorey of karri, mi-dense casuarina and netic, very sparse shrub layer of *Lasiopetalum floribundum*, *Tremandra stelligera* and *Pteridium esquilentum* also sparsely distributed.

PLATE 2 : Area that had been unburnt for more than 20 years, situated off Barker Road in the Warren area (see 2, Figure 1).

Key to the vegetation structure (Beard, 1975)

$e_1Ti.e_1e_2Mc.n_{13}e_2LAc.e_2n_{13}n_9LBi.$

$n_{27}Si.n_{28}SAr.n_{15}n_{28}SBi.n_{15}n_{28}SCr.n_{15}n_{28}SDr.$

$n_{39}n_{14}Ji.n_{29}n_{41}VLi.n_{12}Xi.$

(Refer to species list in Appendix A)

Sparse to middense overstorey of Karri and Marri with some casuarinas in the lower tree level over very sparse to sparse shrub layer of *Hibbertia cuneiformis* and *Macrozamia reidlei* over an understorey *Patersonia xanthina*, *Tremandra stelligera* and *P. esquilentum*.

PLATE 3 : Area that was burnt 5 years previously in 1971, situated off Barker Road In the Warren area (see 3 on Figure 1).

Key to the vegetation structure (Beard, 1975)

$e_2Ti.e_1e_2Md.n_{13}e_2LAc.n_{13}n_{21}LBc.$

$n_{25}Sr.n_{25}n_{27}SBr.n_{18}n_{25}SCr.n_{18}n_{25}SDr.$

$n_{38}GLr.n_{26}n_{39}Jc.n_2VTi.n_{29}n_{10}VLr.n_{12}Xr.$

(Refer to species list in Appendix A)

Mid-dense to dense overstorey of Marri and Karri with some casuarina over sparse growth of Acacia pulchella, Bossiaea linophylla and Lasiopetalum floribundum with a lower storey of Crowea dentata and P. esquilentum, which was mid-dense to sparse.

PLATE 4 : Area that was burnt in the December of the previous year, 1975, situated off Crowea Road in the Crowea area (see 4, Figure 1).

Key to the vegetation structure (Beard, 1975).

$e_1Ti.e_2Md.n_{13}LAi.n_{13}LBr.$

$n_{38}n_{29}GLi.n_{19}n_{32}Jc.n_{47}VLr.n_{12}Xi.$

(Refer to the species list in Appendix A).

Sparse to dense overstorey of Karri and Marri with some casuarinas in the lower tree layer . There is no shrub layer and only very sparse to mid-dense understorey of Leucopogon verticullatus , Hovea elliptica and P. esquilentum all of which were showing new growth.

FIGURE 1 : MAP of the trapping areas in the Pemberton district.

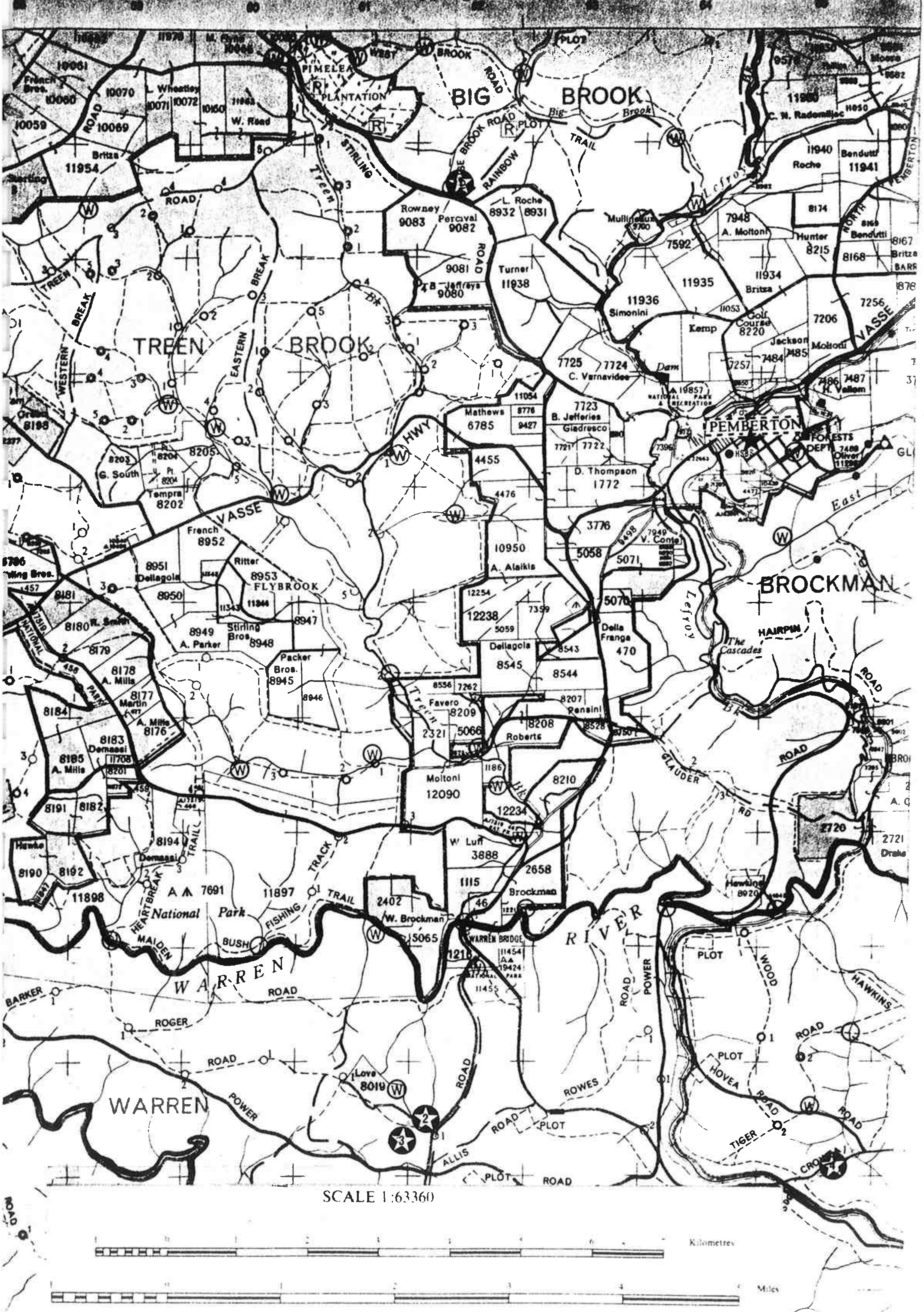

TABLE 1: Total numbers of individuals of each taxa trapped in the four study areas.

CLASS	ORDER	FAMILY	YEARS AFTER BURN			
			40	20	0	5
Arachnida	Scorpionida		0	1	1	5
	Pseudoscorpionida		3	4	11	1
	Opiliones		13	6	4	3
	Acarina		6	29	7	40
	Araneae		107	125	51	150
Crustacea	Amphipoda		5	10	0	15
	Isopoda		152	8	18	54
Diplopoda			205	85	95	80
Chilopoda			5	11	18	10
Insecta	Collembola		233	172	159	76
	Orthoptera:	Gryllidae	0	4	2	5
	Blattodea		9	9	24	16
	Dermaptera		2	19	23	19
	Isoptera		0	0	0	16
	Homoptera		15	4	7	22
	Heteroptera		1	5	0	7
	Lepidoptera (Larvae)		16	23	5	8
	Diptera		23	21	21	12
	Diptera (Larvae)		3	6	0	3
	Hymenoptera:	Formicidae	13	50	18	137
		Others	19	21	38	18
	Coleoptera:	Staphylinidae	5	17	40	30
		Scolytidae	1	0	0	0
		Curculionidae	17	17	19	14
		Carabidae	5	11	12	23
		Scarabidae	1	1	15	21
		Others	12	85	72	8
		Larvae	5	18	3	8
Oligochaeta			1	1	2	1
Gastropoda			0	11	2	1

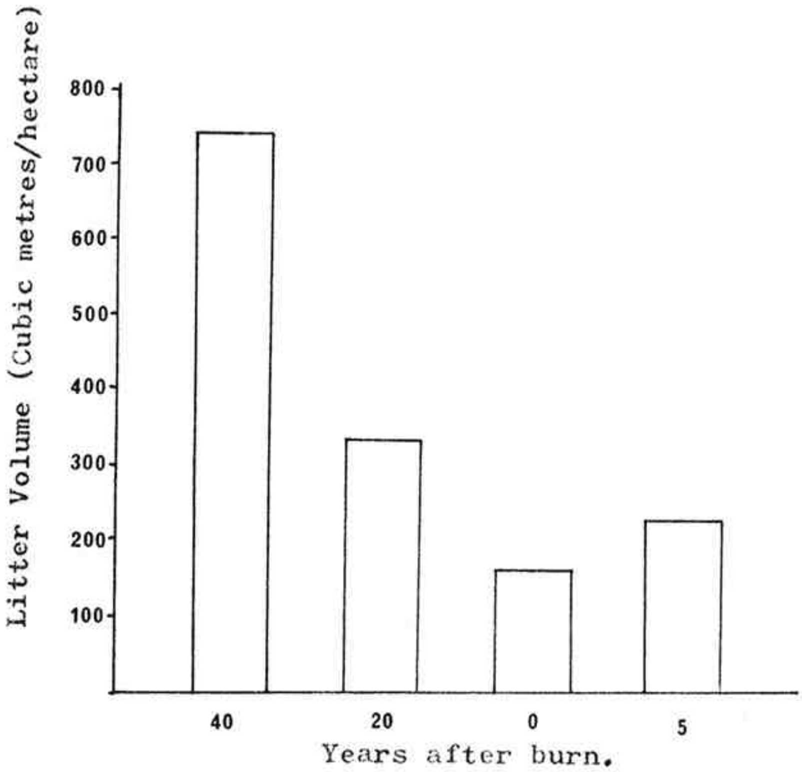

FIGURE 2 : Estimation of the leaf litter in the four study areas expressed in cubic metres per hectare.

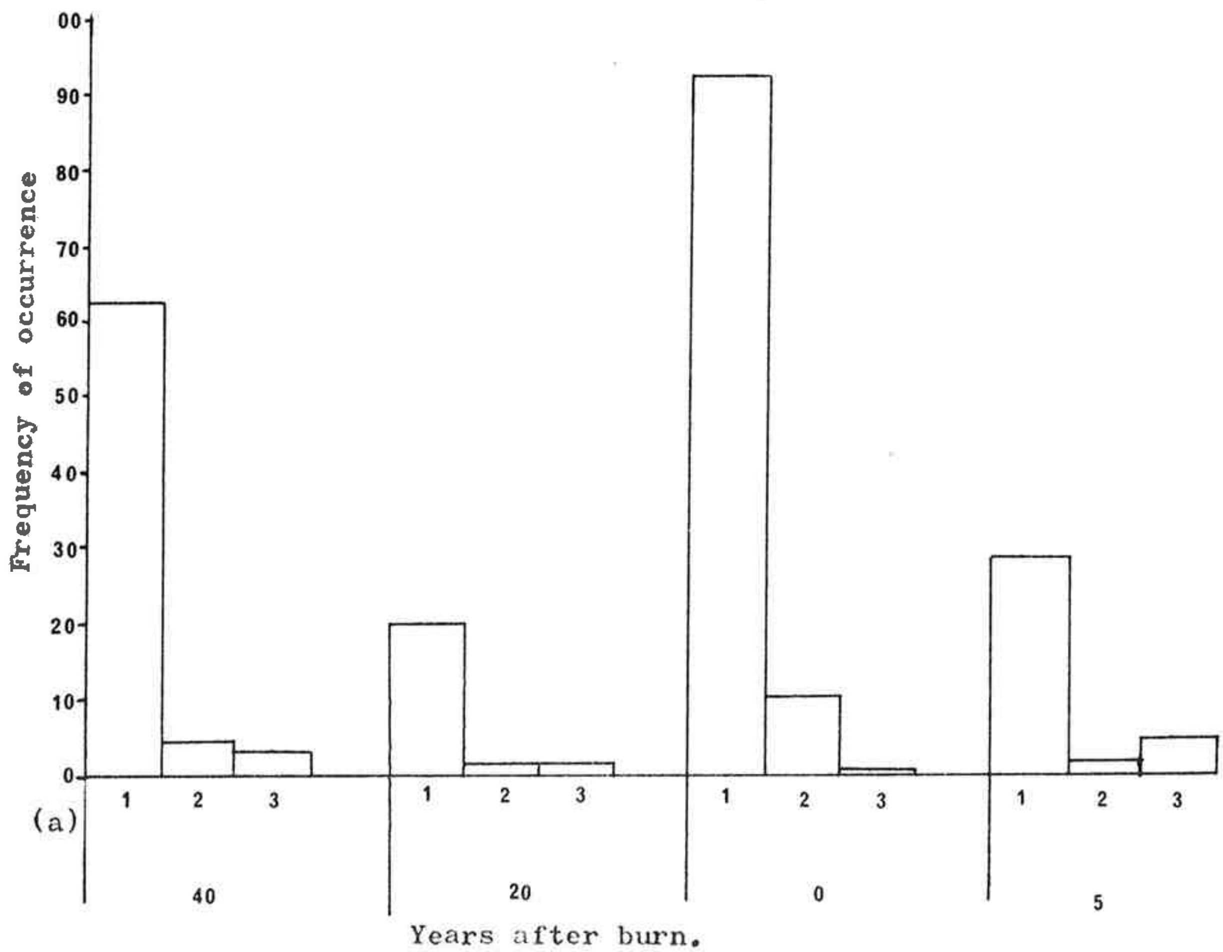

FIGURE 3 : Estimation of dead wood in the four study areas according to three size categories -
1. 1 - 10 cms in diameter ; 2. 10 - 30 cms; 3. greater than 30 cms in diameter.

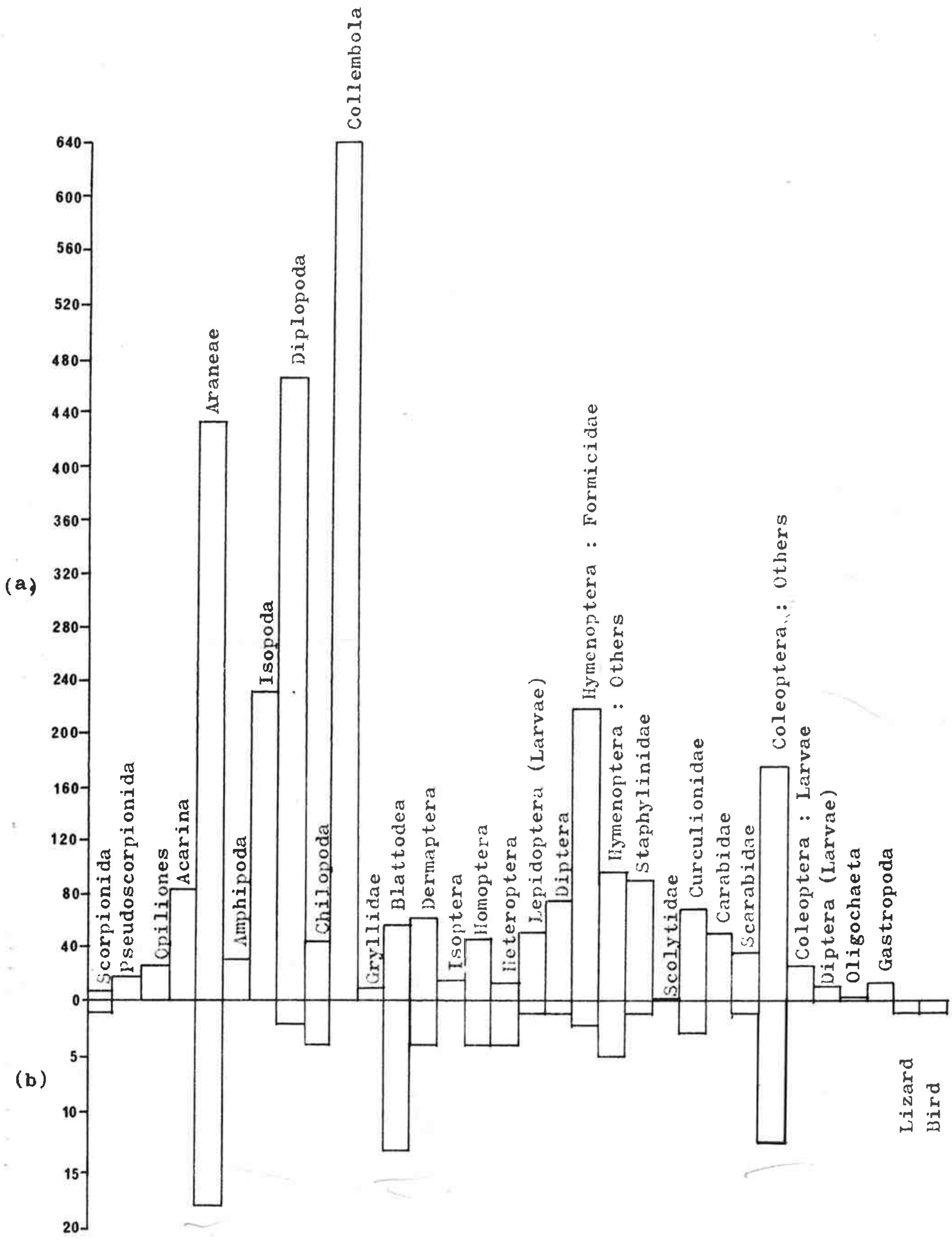

FIGURE 4 : (a) Total number of individuals in each taxa trapped in all four study areas.

(b) Frequency of food items identified in the stomach contents of Antechinus flavipes.

Refer to TABLE 7, APPENDIX B for the results Spearman's rank correlation coefficient using this data.

PLATE 5 : HOMOPTERA nymphs - Fulgoroideae found in the stomachs of several A. flavipes

PLATE 6 : COLEOPTERA - fragments of Nitidulidae found in the stomachs of several A. flavipes. See Plate 24, Appendix C for complete animal.

DISCUSSION

It is apparent from the results of this study that fire causes marked changes in the forest and invertebrate structure of an area. A similar result has been reported by Springett, 1976. However, it would be inadvisable to conclude that fire is the only factor which could cause such changes in the invertebrate structure. Statistically, there is no significant difference between the abundance of invertebrates and the area from which they were trapped (Table 6, Appendix B), although some individual groups show a significant difference between the areas (Table 5, Appendix B). Whether or not these changes can be correlated with the feeding preferences of the mardo and thus be a factor contributing to its delayed recovery may be difficult to ascertain in view of the many parameters which may affect such a recovery.

Variations in efficiency of the invertebrate trapping methods provides a very real limitation on the value of relative estimates even for comparative purposes (Southwood, 1966). These variations maybe due to many factors such as diurnal and seasonal activity, the physical conditions prevailing at the time of trapping and reproductive and general biology of the animal. The trapping methods used in this study are not without their inadequacies.

Interesting trends can be observed such as certain groups increased in numbers by the fifth year following the burn but later declined as the post fire succession progressed. This may be attributed to the degeneration of the shrub layer which may effect their habitat or food supply. Abundance changes in many of the invertebrates that were initially affected by the fire but showed a general increase in numbers with progressive successional changes may be due to the increase in the quantity of the ground litter which may provide a more suitable habitat conducive to its reproduction and survival.

Yet again, other species appeared to recolonise the burnt area almost immediately, particularly the species of Blattodea and Coleoptera. The fact that the amount of deadwood on the forest floor in this area was high may have contributed by providing suitable habitat and cover for these invertebrates.

There appears to be marked trends in habitat preferences of some of the invertebrates as illustrated by the methods of trapping and is possibly one of the main factors governing the invertebrate succession in the forest when considered in relation to the understorey changes that occur following prescribed burning.

Kendall's statistical analysis indicates that the abundance of invertebrates, on the whole, is independent of the area type from which they were collected and thus it can be stated that abundance is not affected to any great extent by prescribed burning of the forest.

Analysis of the stomach contents confirmed that the mardo is insectivorous and will eat carrion. Correlation between the frequency of food items identified in the stomach and gross numbers of invertebrates using Spearman's rank coefficient indicates that the mardo is also an opportunistic feeder.

There was a predominance of species of Araneae, Blattodea and Coleoptera in the stomach contents. Several of these invertebrates identified in the contents are illustrated in Plates 19, 20 and 24 in Appendix C. Both Araneae and Blattodea numbers decreased directly following fire (Figure 5 and 12, Appendix B). The high number of Blattodea trapped by the hand search method may have been entirely due to the fact that they were more conspicuous in the open understorey of the area burnt less than a year before. However, both groups increased to prefire levels five years after the fire. This could be a contributing factor to the delayed recovery of the mardos but is unlikely since the mardo is an opportunist and could change to eating some other type of prey that was more abundant. Another reason that makes it unlikely is that the invertebrates belonging to these two groups increased in numbers after five years and the mardo population takes much longer to recover.

The type of invertebrate most frequently preyed upon was either particularly abundant as was the Araneae and Coleoptera or of large size as was the Blattodea. Larger prey would be energetically more economic to the mardo and therefore it is not surprising that the larger invertebrates constitute a large proportion of the prey. Although the Collembola were the most abundant invertebrate trapped it is unlikely to be eaten by the mardo because of their small size.

Other factors may also affect the type of invertebrate that the mardo preys on such as where they are found, in the trees or on the ground or burrowed in the soil. The results show that most of the invertebrates in the stomach contents were trapped on the ground while some were trapped both on the ground and in the foliage. The abundance of prey items suggests that the mardo obtains the bulk of its food from the ground strata although some food may be obtained from the shrub layer or from tree trunks.

CONCLUSION

The recovery of the mardo population appears not to be related to availability or abundance of the invertebrates that constitute its diet. The delayed recovery may be related to a reduction of suitable habitat for breeding purposes or increased predation by other animals. However, this latter possibility is unlikely in view of the fact that the populations of *Mus musculus* tend to recover within five to six months following prescribed burning (Christensen and Kimber, 1975) and it would be presumed that the same predation pressure would occur for the mouse.

Not enough information was available to suggest that the mardo is aboreal, however, the characteristics of its feet suggests that it is well adapted to scansorial activity (Wakefield and Warneke, 1967).

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APPENDIX A.

Species list for use with the vegetation key in Plates 1, 2, 3, and 4.

e_1	Eucalyptus diversicolor (karri)
e_2	Eucalyptus calophylla (marri)
e_3	Eucalyptus marginata (jarrah)
n_1	Clematis aristata
n_2	Lepidosperma effusum
n_3	Podocarpus drouyniana
n_4	Logania vaginalis
n_5	Leucopogon capitellatus
n_6	Chorizema ilicifolium
n_7	Hibbertia amplexicaulis
n_8	Dodder sp.
n_9	Acacia urophylla
n_{10}	Lepidosperma schoenus
n_{11}	Acacia saligna
n_{12}	Pteridium esquilentum
n_{13}	Casuarina decussata
n_{14}	Opercularia hispidula
n_{15}	Hibbertia cuneiformis
n_{16}	Hardenbergia comptoniana
n_{17}	Persoonia longifolia
n_{18}	Bossiaea linophylla
n_{19}	Leucopogon verticullatus
n_{20}	Hibbertia montana
n_{21}	Bossiaea laidlawiana (netic)
n_{22}	Anigozanthus flavida

n_{23} Agonis flexuosa

n_{24} unknown

n_{25} Acacia pulchella

n_{26} Crowea dentata

n_{27} Lasiopetalum floribundum

n_{28} Macrozamia riedlei

n_{29} Patersonia xanthina

n_{30} Leucopogon revolutis

n_{31} Erodium sp.

n_{32} Hovea elliptica

n_{33} Trymalium spathulatum (hazel)

n_{35} Pimelea sp.

n_{36} Acacia decipiens

n_{37} Agonis parviceps

n_{38} Acanthocarpus ? sp.

n_{39} Tremandra stelligera

n_{40} Solanum nigrum

n_{41} Lepidospermum angistatum

n_{42} Erodium sp.

n_{43} Moss

n_{44} Lichen

n_{45} Liverwort

n_{46} Halorrhagis rotundiflora

n_{47} unknown

n_{48} unknown

n_{49} unknown

n_{50} Caladenia sp.

n_{51} Medicago

n_{52} Leucopogon sp.

All species listed were collected along the transects and specimens were entered in a field herbarium for later identification.

Vegetation Structure Key (used in Plates 1, 2, 3, and 4)

Life form:

T	Trees greater than 30 m
M	Trees 15 to 30 m
LA	Trees 5 to 15m
LB	Trees less than 5m
S	Shrubs greater than 2m
SA	Shrubs 1.5 to 2m
SB	Shrubs 1.0 to 1.5m
SC	Shrubs 0.5 to 1.0m
SD	Shrubs 0 to 0.5m
GT	Bunch grass greater than 0.5m
GL	Bunch grass less than 0.5m
J	Herbaceous spp.
VT	Sedges greater than 0.5m
VL	Sedges less than 0.5m
X	Ferns, Mosses, Liverworts.

Density class:

d	Dense 70-100%
c	Mid-dense 30-70%
i	Sparse 10-30%
r	Very sparse less than 10%

APPENDIX B

Invertebrate trapping data and statistical results.

TABLE 1: Total numbers of individuals trapped by the Hand Collection method.

CLASS	ORDER	FAMILY	YEARS AFTER BURN 40	20	0	5
Arachnida	Scorpionida		0	1	1	1
	Pseudoscorpionida		1	0	1	0
	Opiliones		0	0	0	0
	Acarina		0	1	1	2
	Araneae		11	13	9	9
Crustacea	Amphipoda		1	0	0	0
	Isopoda		16	3	16	7
Diplopoda			163	61	94	36
Chilopoda			2	4	17	4
Insecta	Collembola		2	0	0	2
	Orthoptera:	Gryllidae	0	0	0	0
	Blattodea		1	4	23	6
	Dermaptera		0	0	2	0
	* Isoptera		0	0	0	16
	Homoptera		0	0	1	15
	Heteroptera		0	0	0	0
	Lepidoptera (Larvae)		0	0	0	1
	Diptera		0	0	0	0
	* Diptera (Larvae)		0	0	0	0
	Hymenoptera:	Formicidae	0	9	3	98
		Others	0	0	0	0
	Coleoptera:	Staphylinidae	0	1	0	0
		*Scolytidae	0	0	0	0
		Curculionidae	0	11	2	3
		Carabidae	0	0	1	0
		Scarabidae	0	1	0	0
		Others	0	2	0	0
		*Larvae	1	1	0	0
*Oligochaeta			0	0	2	1
*Gastropoda			0	9	0	0

* Results not graphically illustrated.

TABLE 2: Total numbers of individuals trapped by the pit traps method in the study areas.

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

*Results not graphically illustrated.

TABLE 3; Total numbers of individuals trapped by the beating tray method

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

* Results not graphically illustrated.

TABLE 4: Total numbers of individuals sorted from litter collections.

CLASS	ORDER	FAMILY	YEARS AFTER BURN 40	20	0	5
Arachnida	Scorpionida		0	0	0	2
	Pseudiscorpionida		0	1	0	0
	Opiliones		8	4	0	1
	Acarina		0	9	0	11
	Araneae		16	14	5	19
Crustacea	Amphipoda		2	9	0	2
	Isopoda		18	4	2	11
Diplopoda			41	21	0	44
Chilopoda			3	7	0	5
Insecta	Collembola		0	12	7	1
	Orthoptera:	Gryllidae	0	0	0	1
	Blattodea		3	3	0	6
	Dermaptera		0	5	0	0
	*Isoptera		0	0	0	0
	Homoptera		2	1	0	0
	Heteroptera		1	5	0	2
	Lepidoptera (Larvae)		0	10	3	2
	Diptera		0	1	1	0
	*Diptera (Larvae)		0	4	0	3
	Hymenoptera:	Formicidae	3	15	2	1
		Others	1	0	0	1
	Coleoptera:	Staphylinidae	0	2	0	2
		*Scolytidae	0	0	0	0
		Curculionidae	0	1	0	2
		Carabidae	2	0	0	4
		Scarabidae	0	0	0	0
		Others	1	6	1	4
		*Larvae	3	14	0	8
*Oligochaeta			1	0	0	0
*Gastropoda			0	1	0	0

* Results not graphically illustrated.

TABLE 5: χ^2 test on each Taxa to test for any significance between the four areas and the four sampling methods.

CLASS	ORDER	FAMILY	χ^2 AREAS	SIGN.	χ^2 METHOD	SIGN.
Arachnida	+Scorpionida					
	+Pseudoscorpionida					
	Opiliones		9.38	ns	26.00	**
	Acarina		41.22	**	21.22	*
	Araneae		48.00	**	336	**
Crustacea	Amphipoda		16.67	ns	26.80	**
	Isopoda		243.36	**	148.72	**
Diplopoda			212.12	**	709.78	**
Chilopoda			7.82	ns	35.29	**
Insecta	Collembolla		78.31	**	554.45	**
	+Orthoptera:	Gryllidae	-	-	-	-
	Blattodea		16.552	ns	36.76	**
	Dermaptera		17.38	*	51.63	**
	+Isoptera		-	-	-	-
	Homoptera		16.50	ns	16.17	ns
	+Heteroptera					
	Lepidoptera (larvae)		15.23	ns	42.23	**
	Diptera		3.78	ns	69.34	**
	+Diptera Larvae		-	-	-	-
	Hymenoptera :	Formicidae	181.30	**	130.44	**
		Others	11.08	ns	153.58	**
	Coleoptera:	Staphylinidae	30.35	**	202.17	**
		+Scolytidae	-	-	-	-
		Curculionidae	5.80	ns	26.30	**
		Carabidae	13.23	ns	103.74	**
		Scarabidae	32.32	**	106.21	**
		Others	171.02	**	127.85	**
		+Larvae	-	-	-	-
+Oligochaeta			=	-	-	-
+Gastropoda			-	-	-	-

χ^2 (critical) for df=9 at 5% level = 16.92 *

1% level = 21.67 **

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

TABLE 6 : Results of Kendall's Coefficient of Concordance (W) to test the null hypothesis H_0: that the ranking of the total number of individuals in each area is not related and therefore distribution of invertebrates is independent of area type and not effected by the fire history.

W=0.036 χ^2(Calculated)= 3.240

χ^2(Critical) df= 3 at 1% level = 11.34

Therefore accept the null hypothesis.

TABLE 7 : Results of Spearman Rank Correlation Coefficient r_s, to test the null hypothesis H_0: that there is no association between the total number of individuals in each taxa trapped in all four study areas and the frequency of the food items identified in the stomach contents.

n=32 Therefore t test applied, where $t = r_s \sqrt{\frac{N-2}{1-r_s^2}}$

t (critical) at 5% level = 1.697

t (calculated) = 2.167

Therefore reject the null hypothesis and accept that there is an association between the two variables and therefore it can be concluded that A. flavipes is an opportunistic feeder.

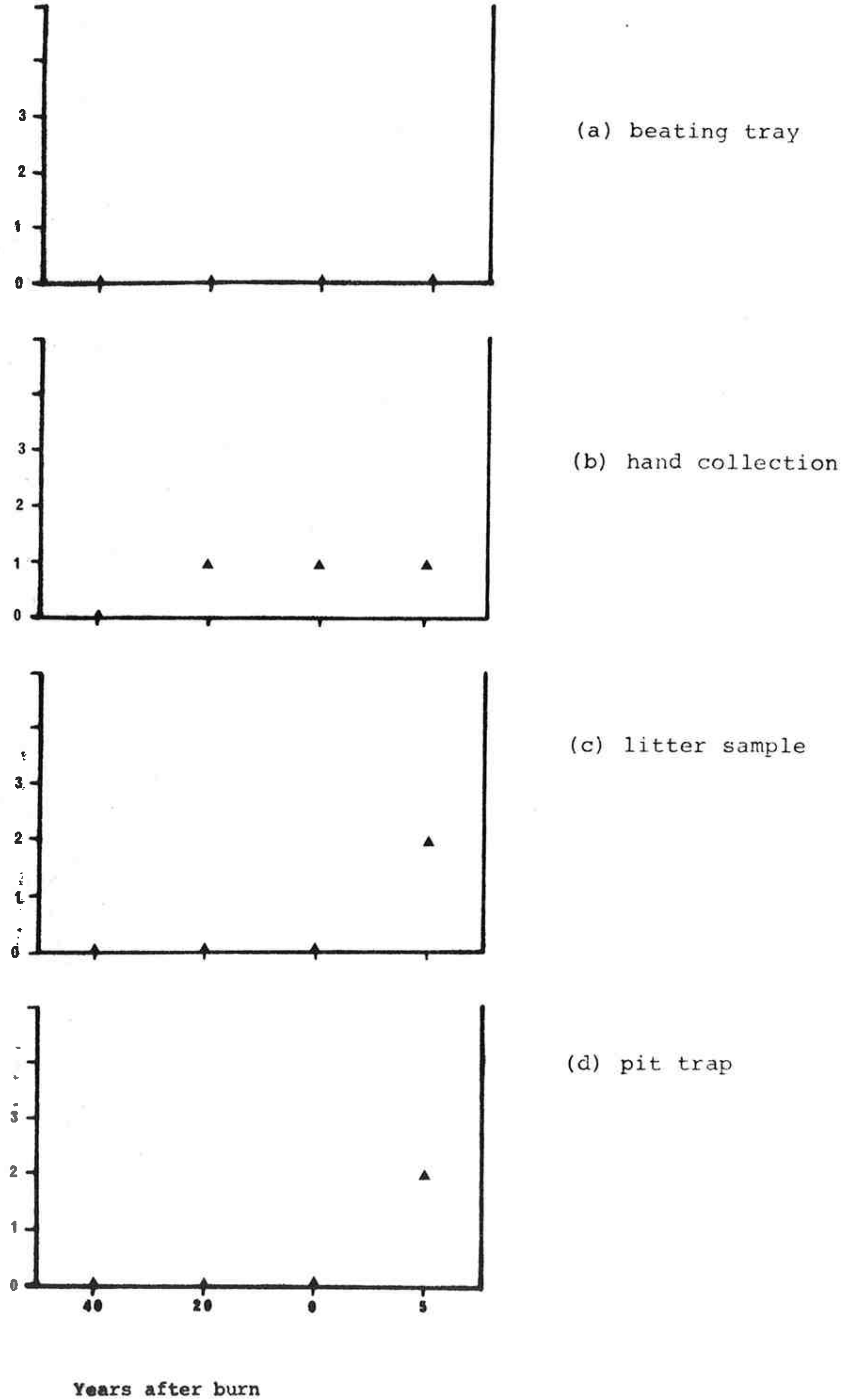
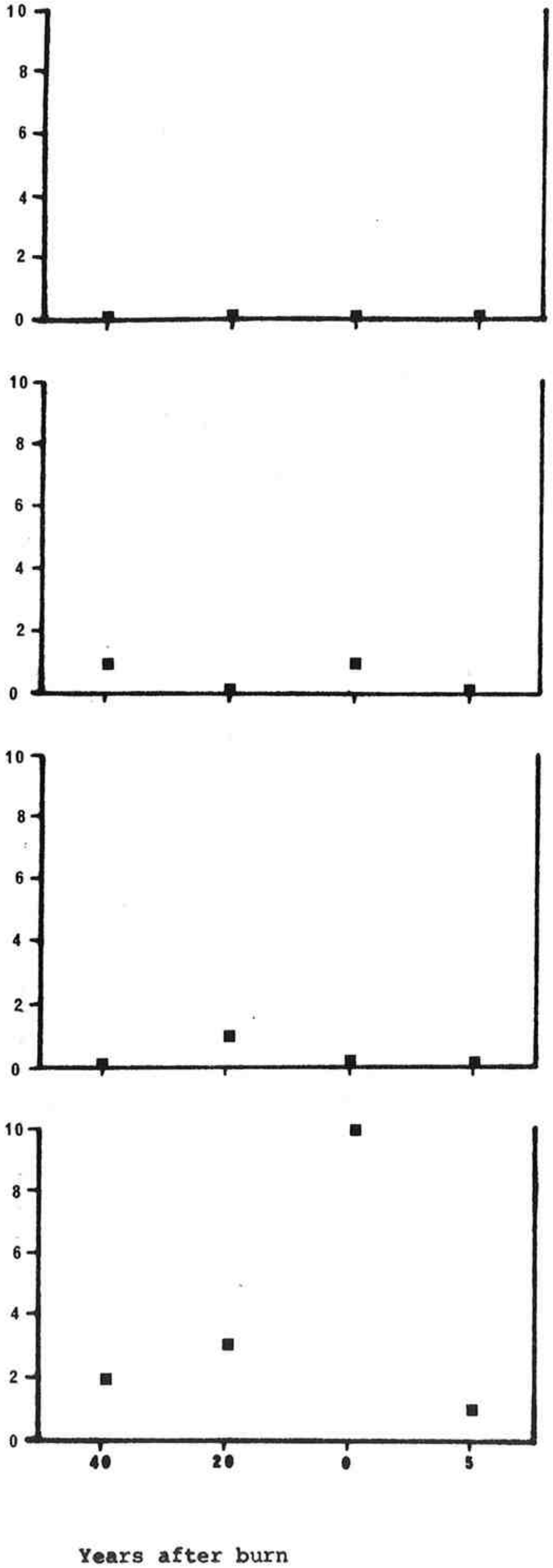


FIGURE 1 : Distribution of SCORPIONIDA in the study areas using four sampling methods.



(a) beating tray

(b) hand collection

(c) litter sample

(d) pit trap

FIGURE 2 : Distribution of PSEUDOSCORPIONIDA in the study areas using four sampling methods.

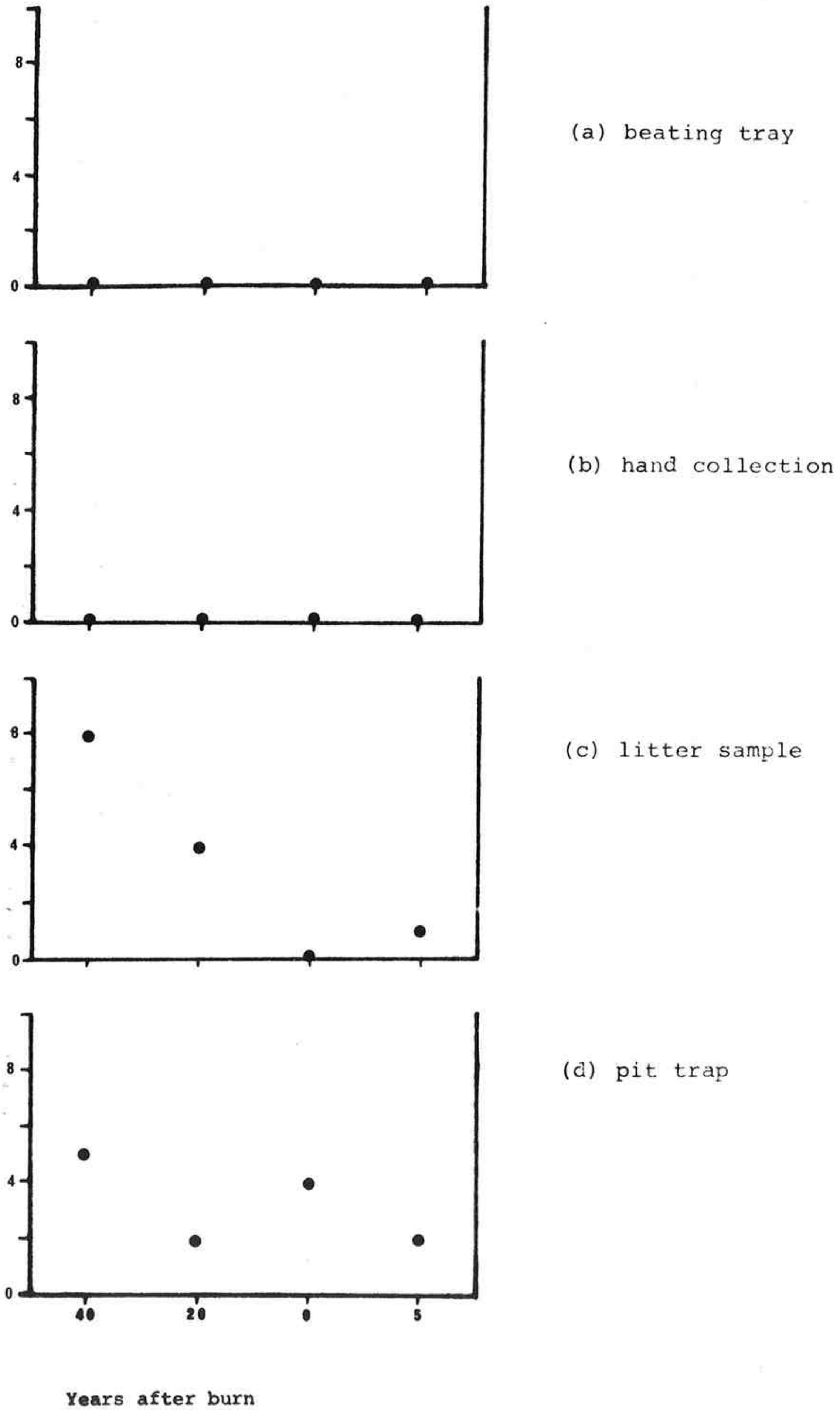


FIGURE 3 : Distribution of OPILIONES in the study areas using four sampling methods.

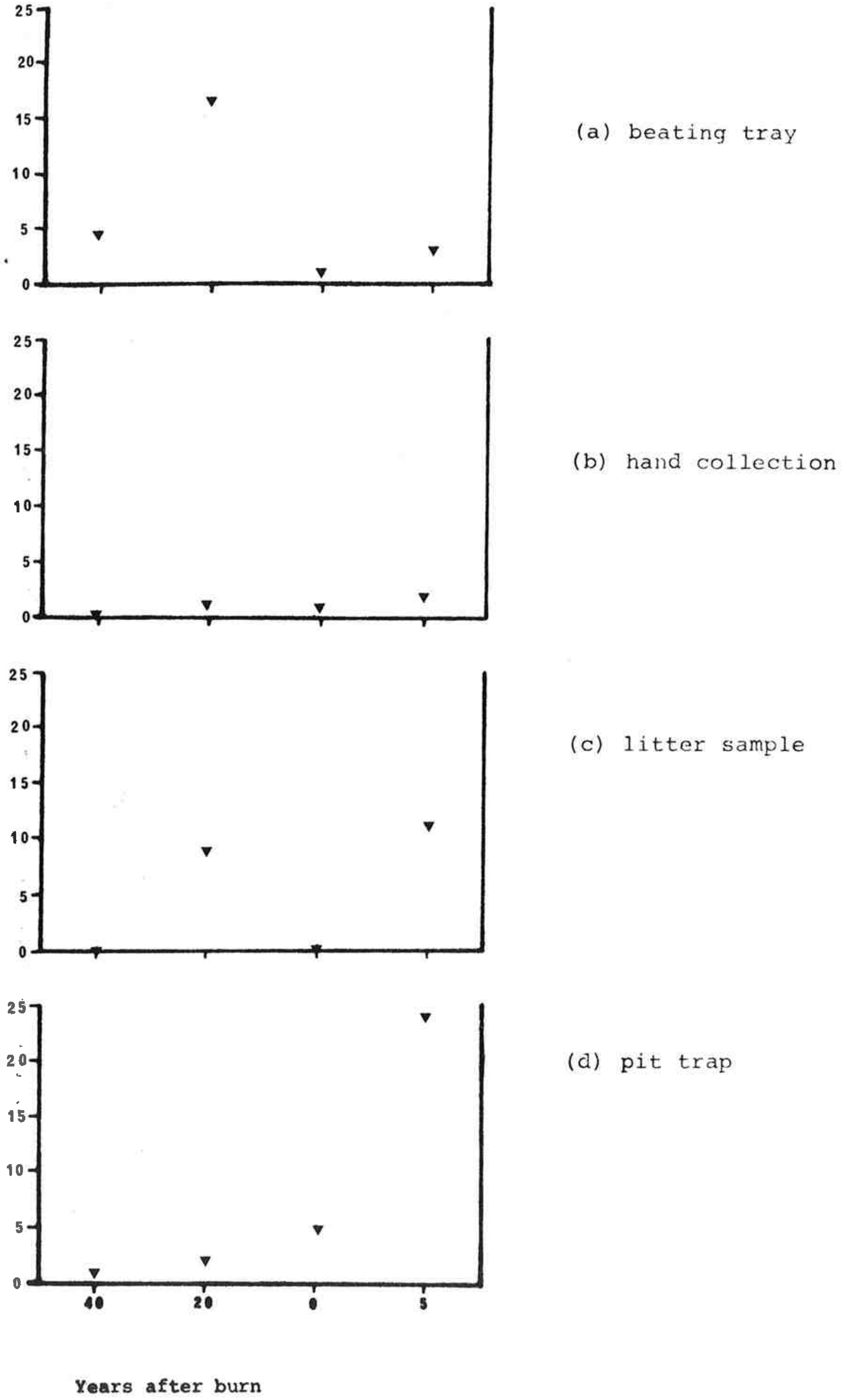


FIGURE 4 : Distribution of ACARINA in the study areas using four sampling methods.

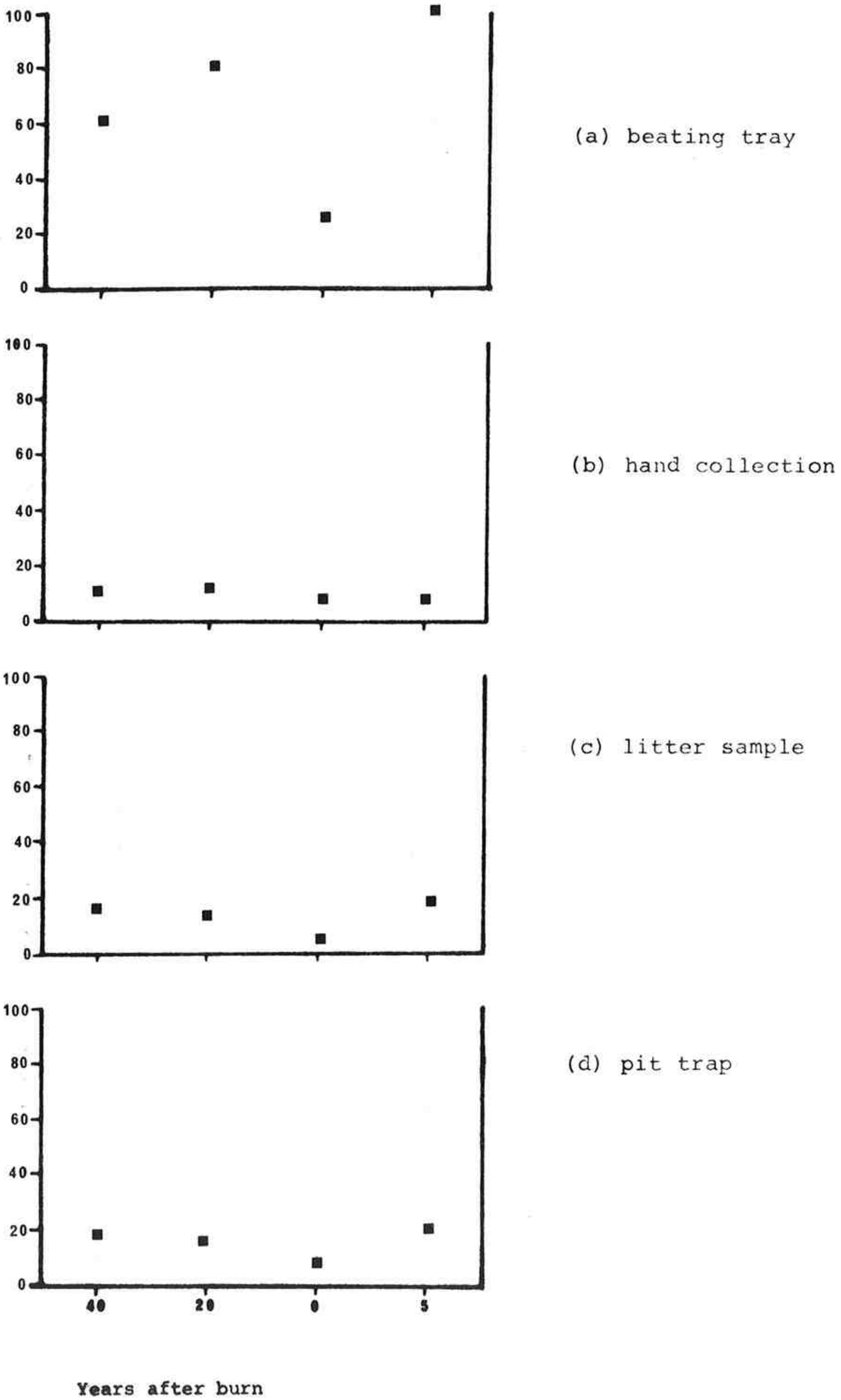


FIGURE 5 : Distribution of ARANEAE in the study areas using four sampling methods.

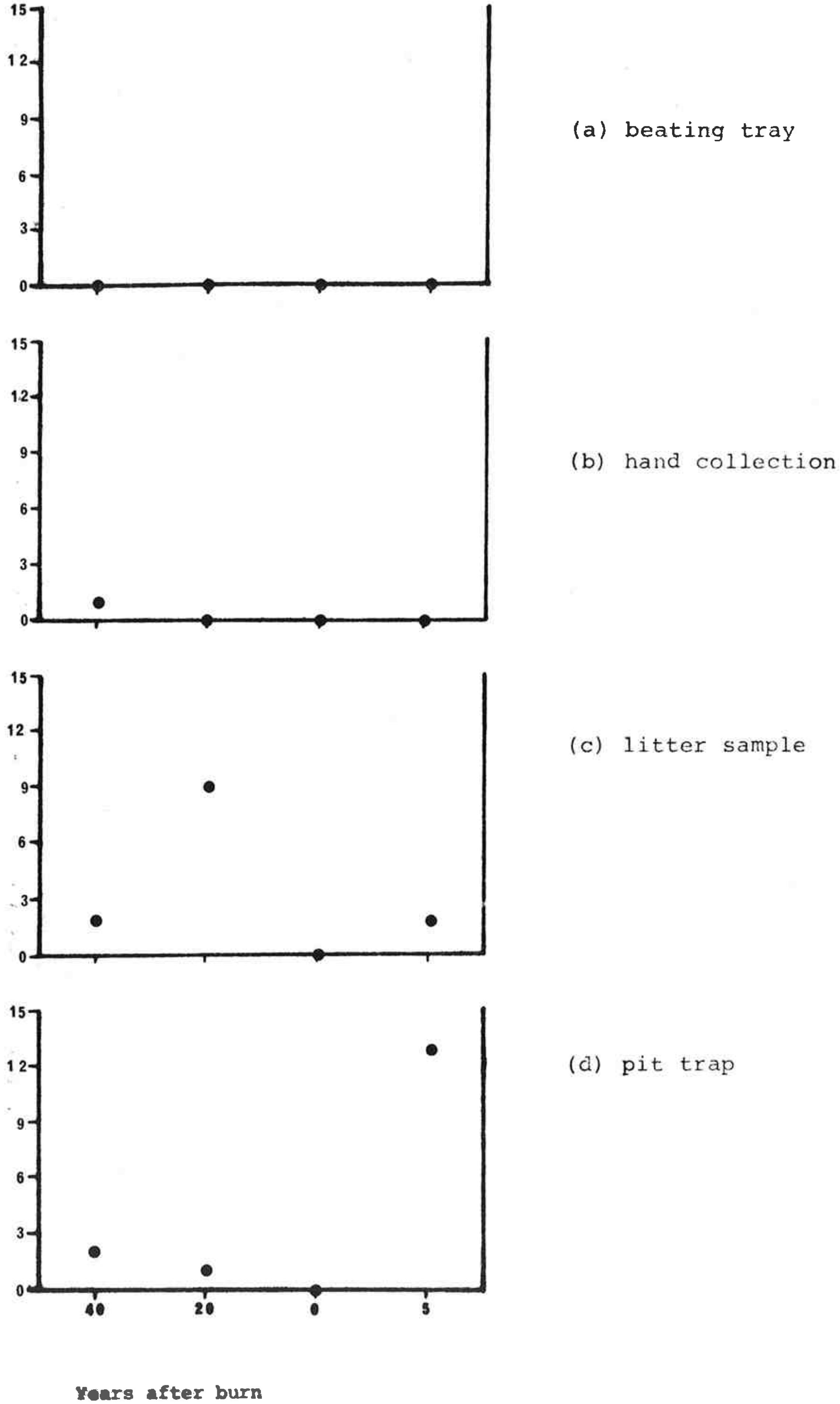


FIGURE 6 : Distribution of AMPHIPODA in the study areas using four sampling methods.

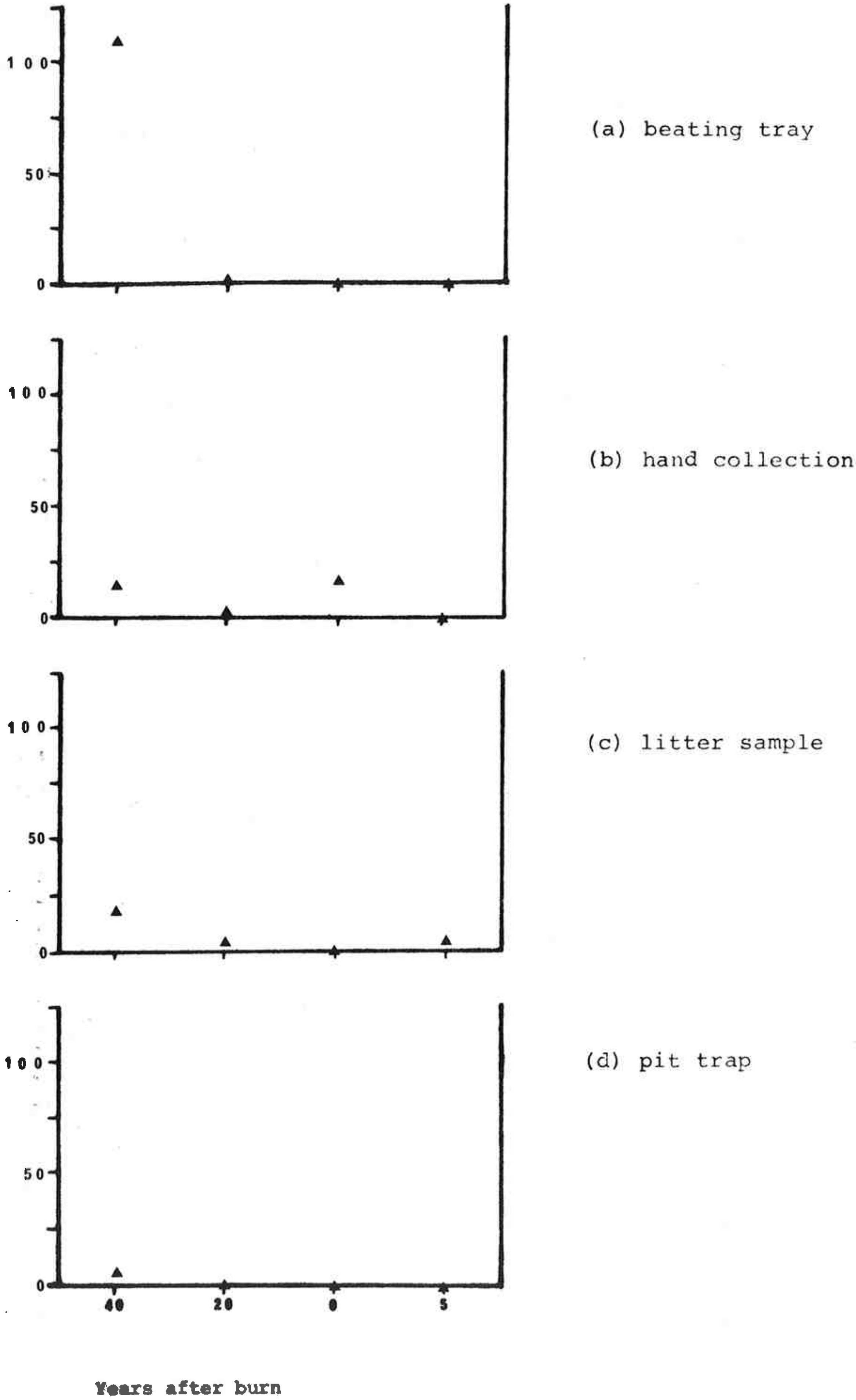


FIGURE 7 : Distribution of ISOPODA in the study areas using four sampling methods.

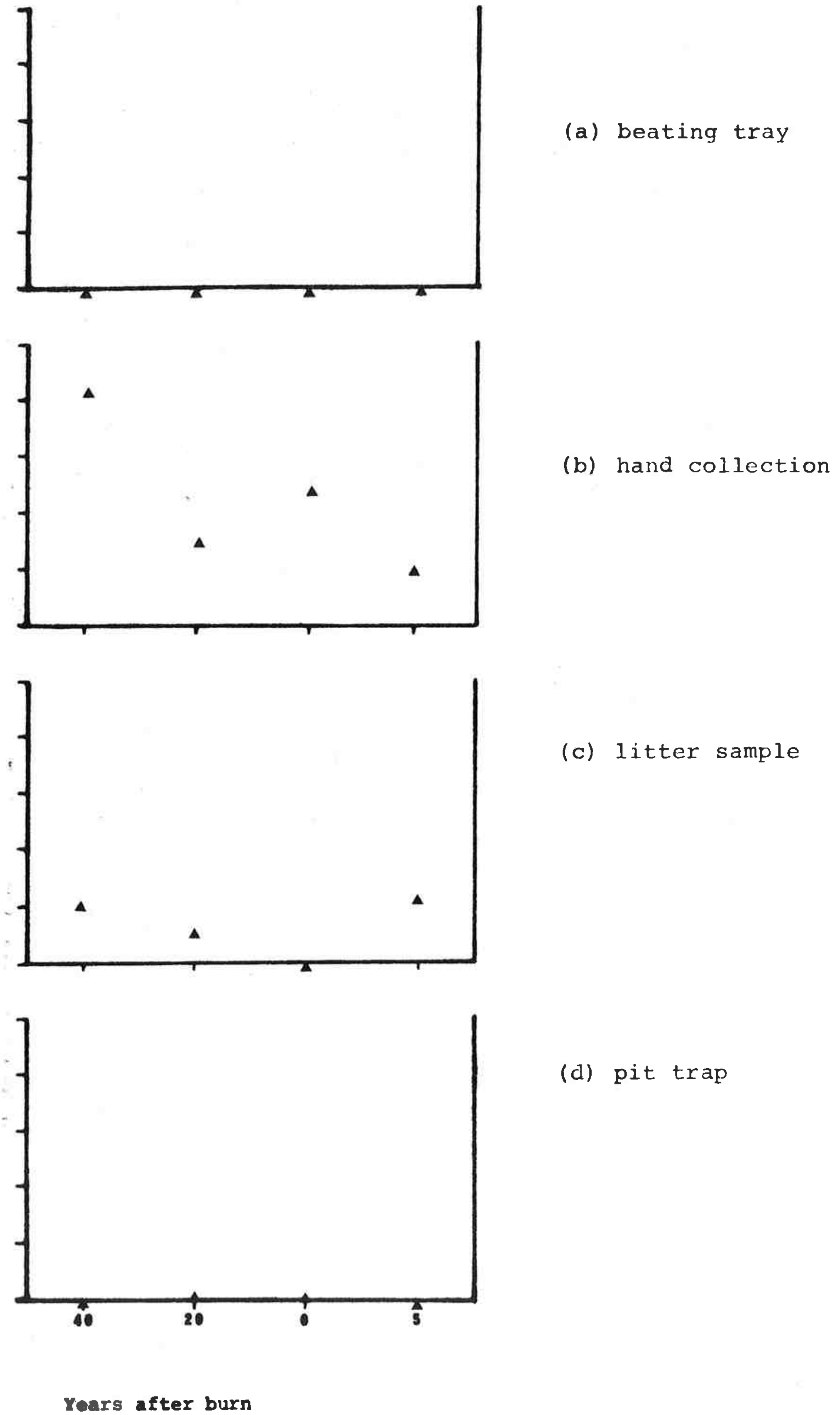


FIGURE 8 : Distribution of DIPLOPODA in the study areas using four sampling methods.

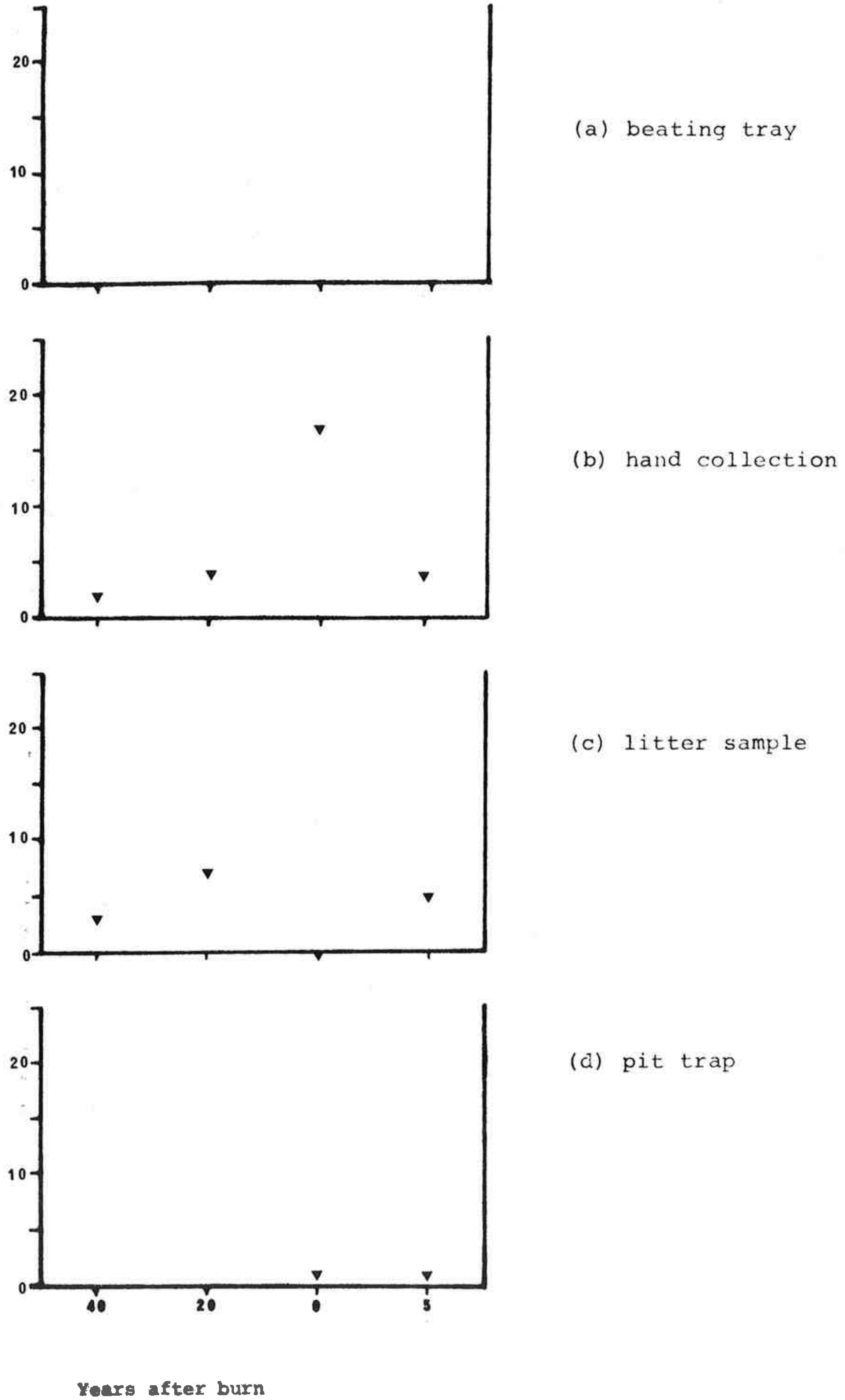


FIGURE 9 : Distribution of CHILOPODA in the study areas using four sampling methods.

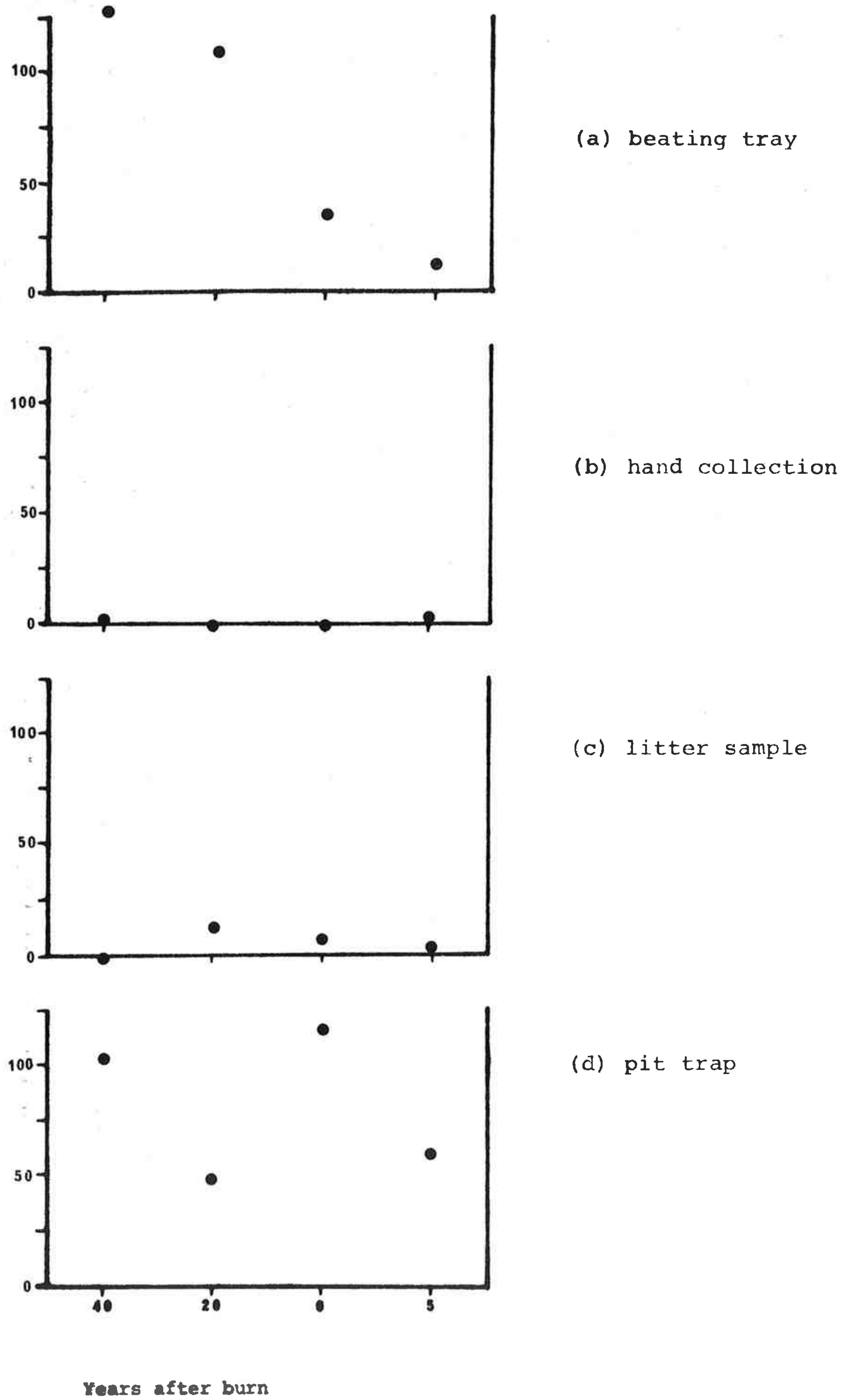


FIGURE 10 : Distribution of COLLEMBOLA in the study areas using four sampling methods.

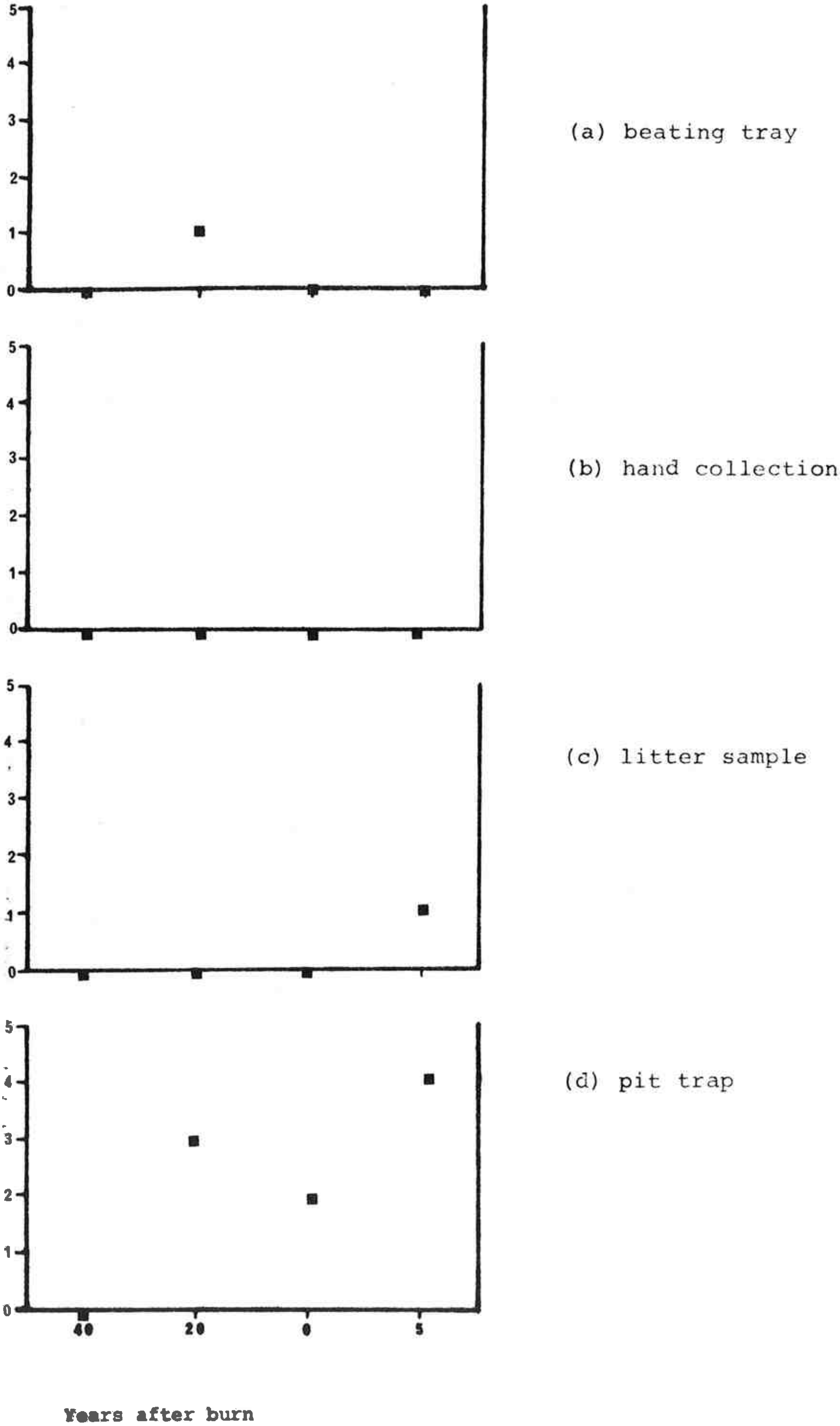


FIGURE 11 : Distribution of GRYLLIDAE in the study areas using four sampling methods.

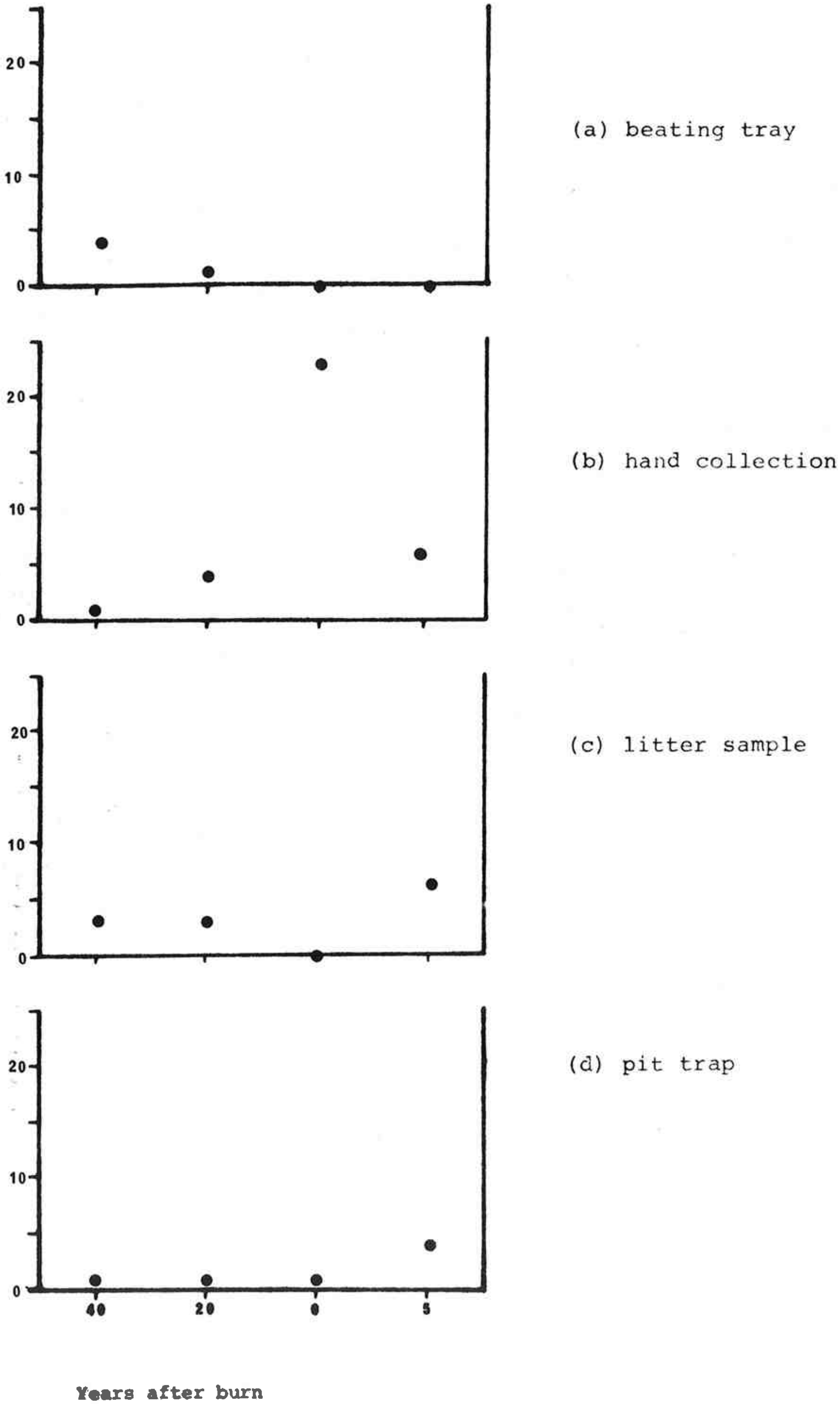


FIGURE 12 : Distribution of BLATTODEA in the study areas using four sampling methods.

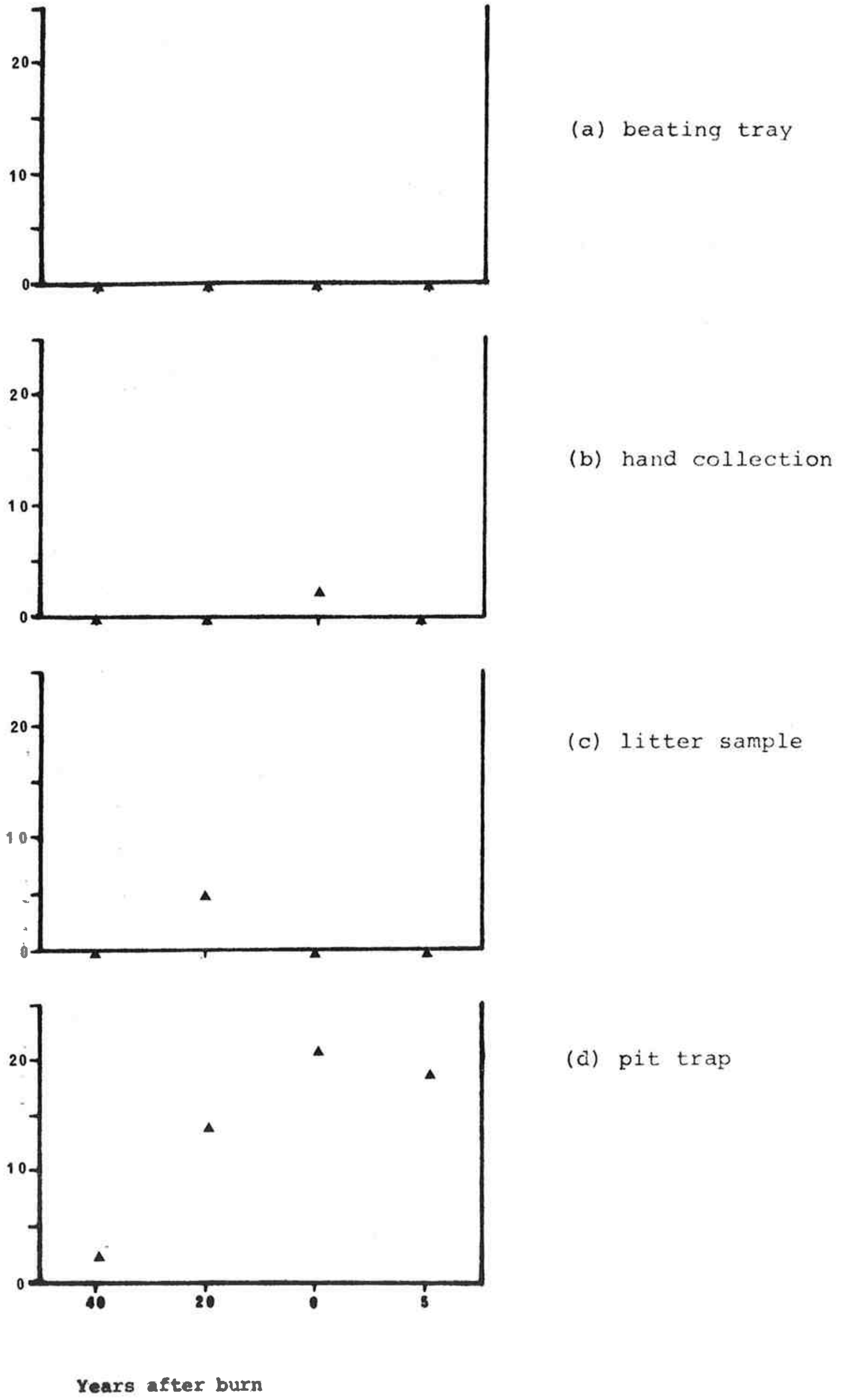


FIGURE 13 : Distribution of DERMAPTERA in the study areas using four sampling methods.

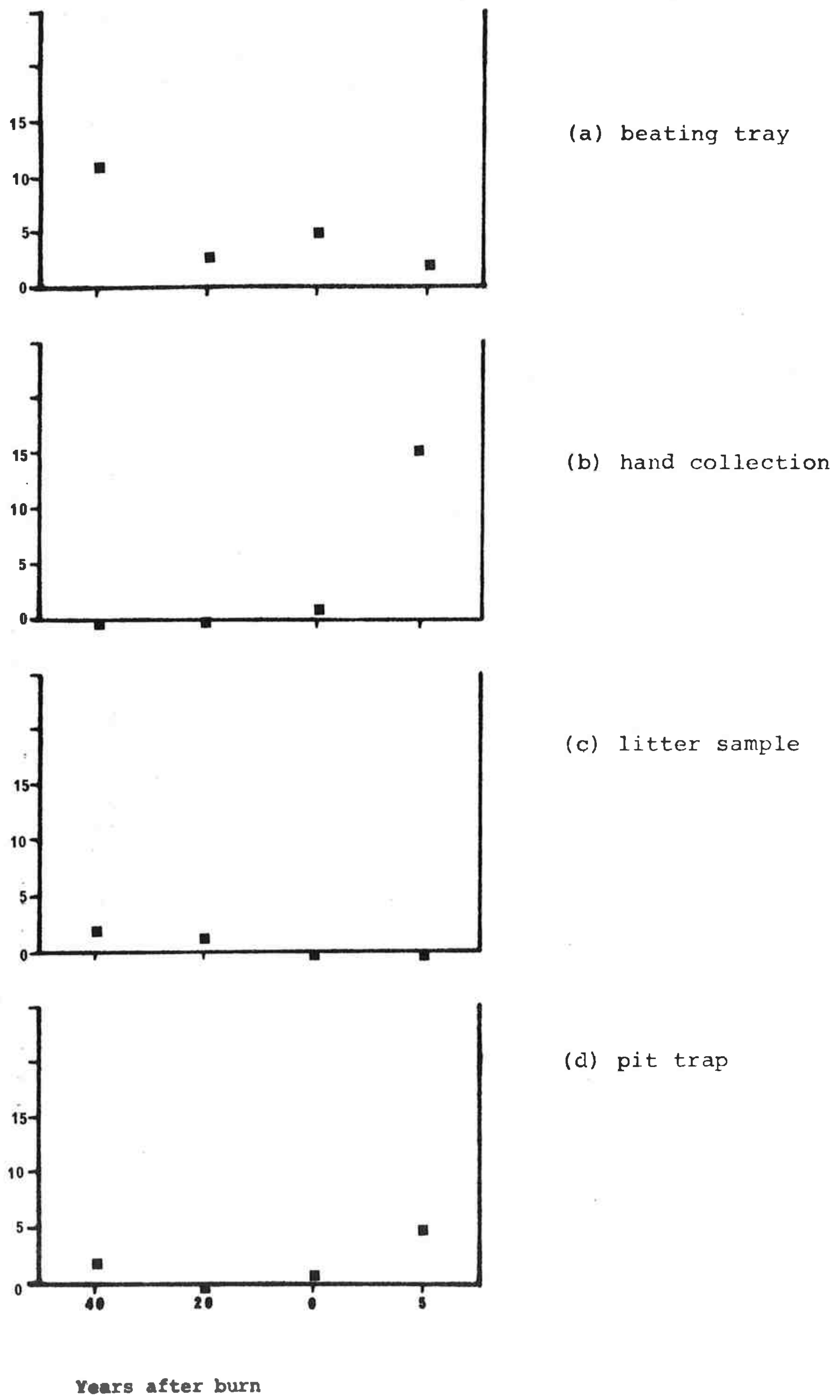
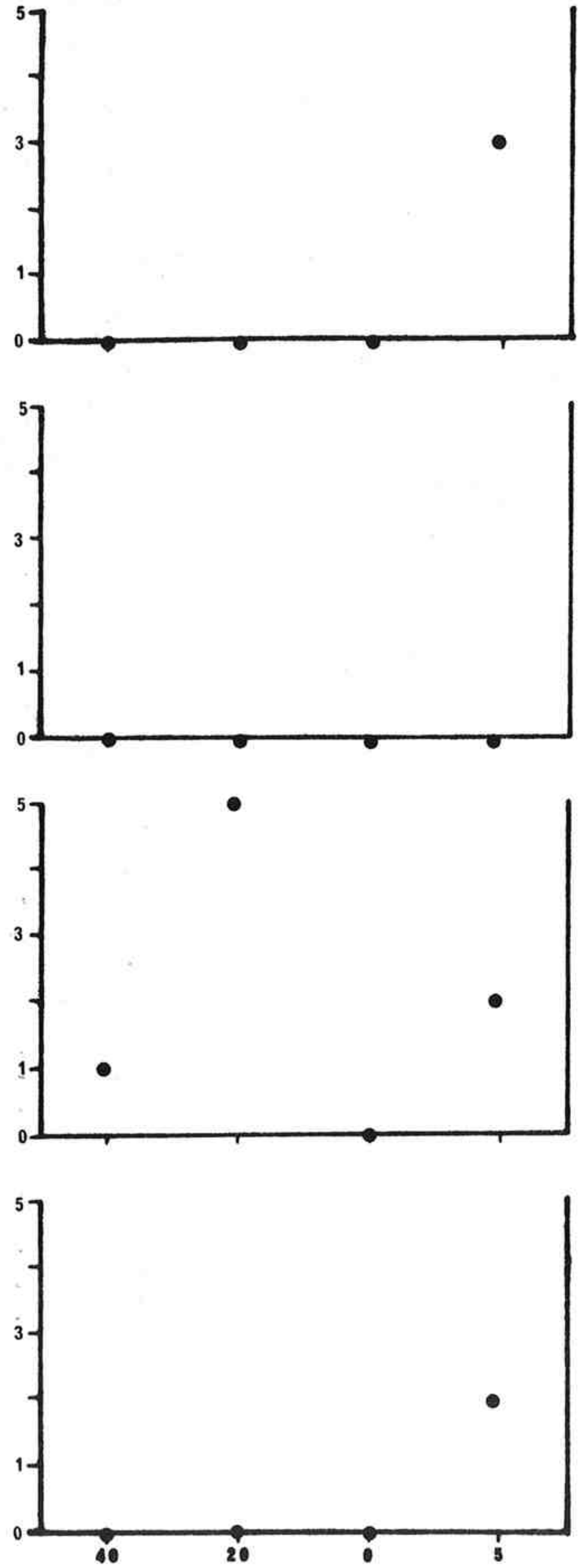


FIGURE 14 : Distribution of HOMOPTERA in the study areas using four sampling methods.



(a) beating tray

(b) hand collection

(c) litter sample

(d) pit trap

Years after burn

FIGURE 15 : Distribution of HETEROPTERA in the study areas using four sampling methods.

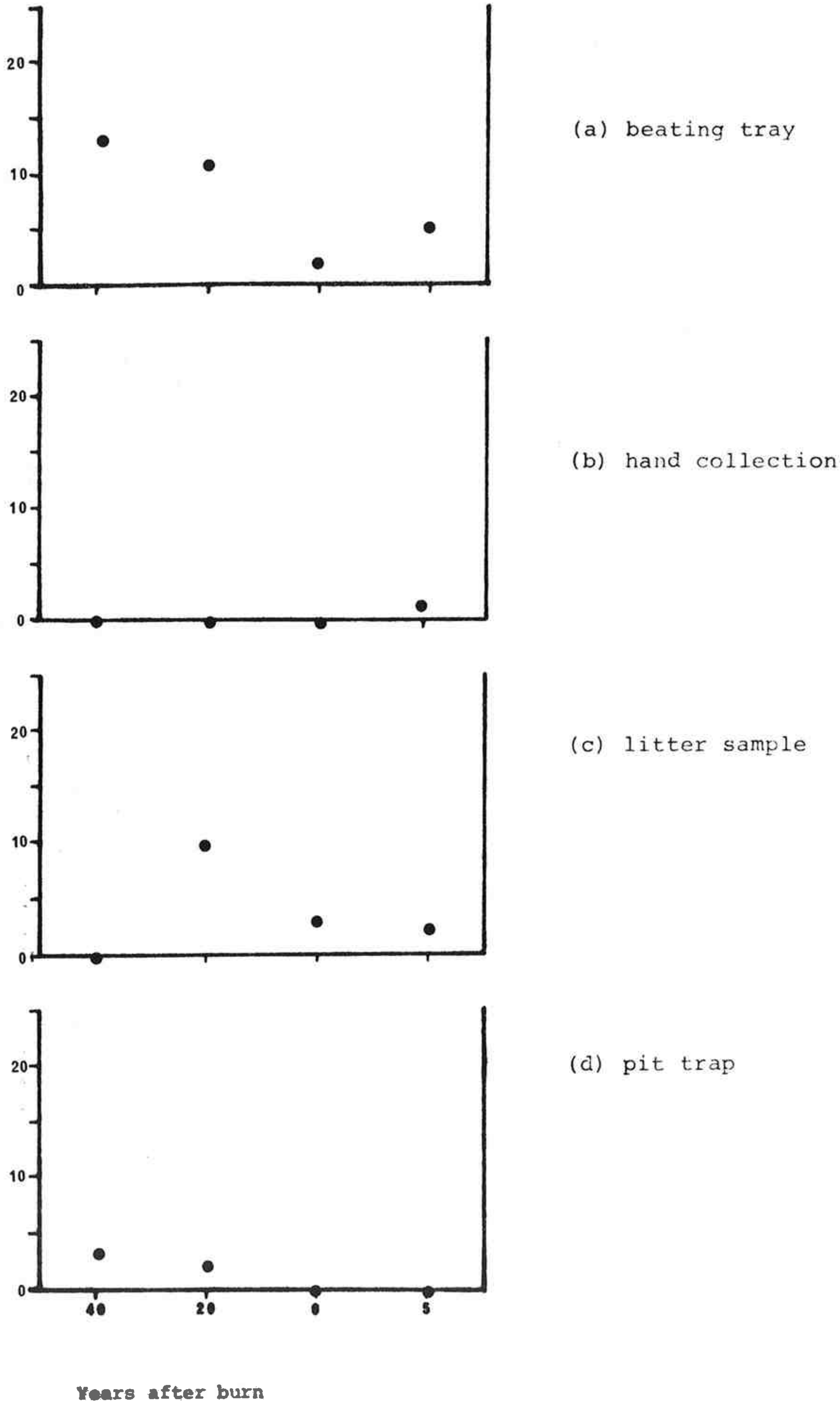


FIGURE 16 : Distribution of LEPIDOPTERA LARVAE in the study areas using four sampling methods.

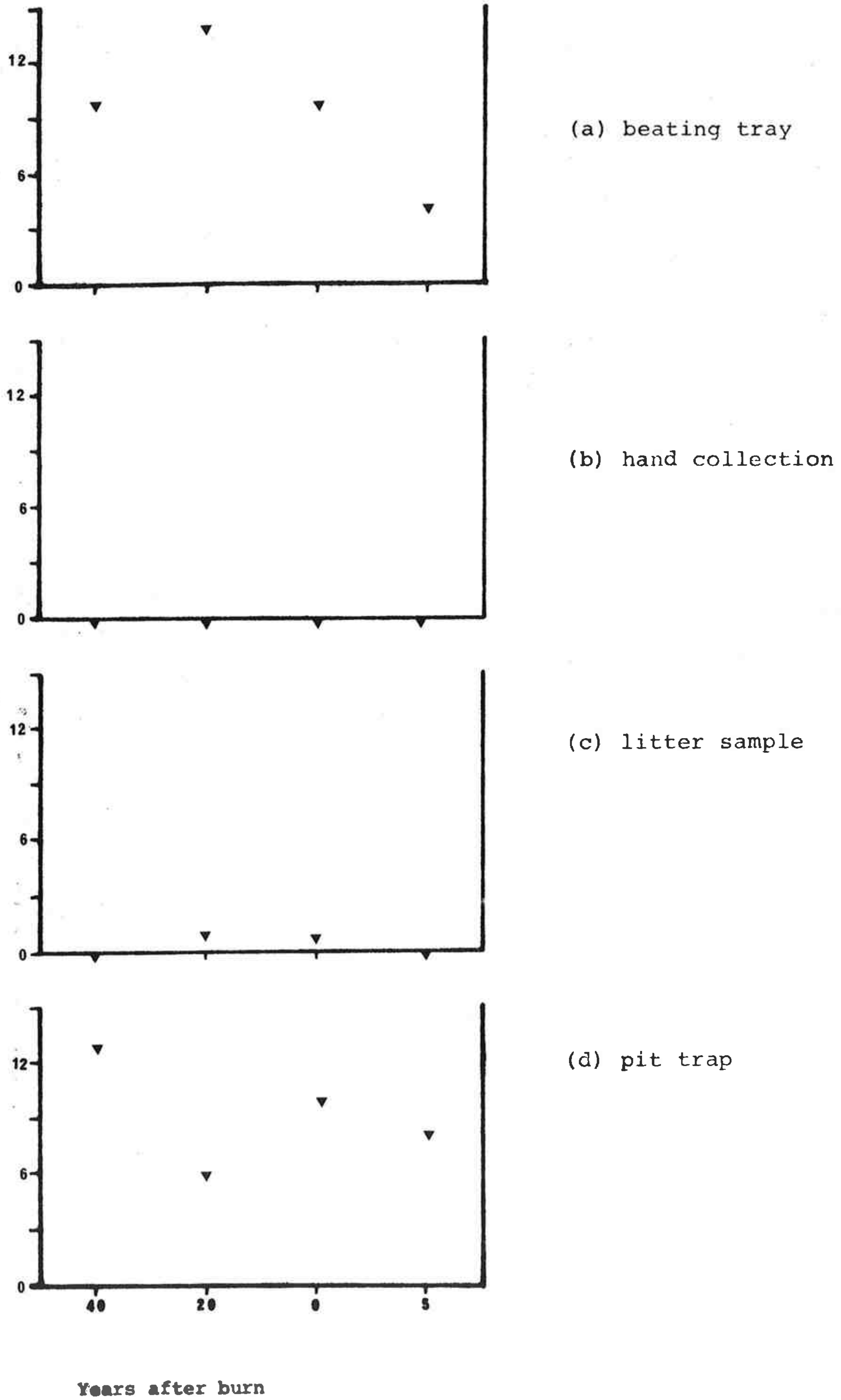


FIGURE 17 : Distribution of DIPTERA in the study area using four sampling methods.

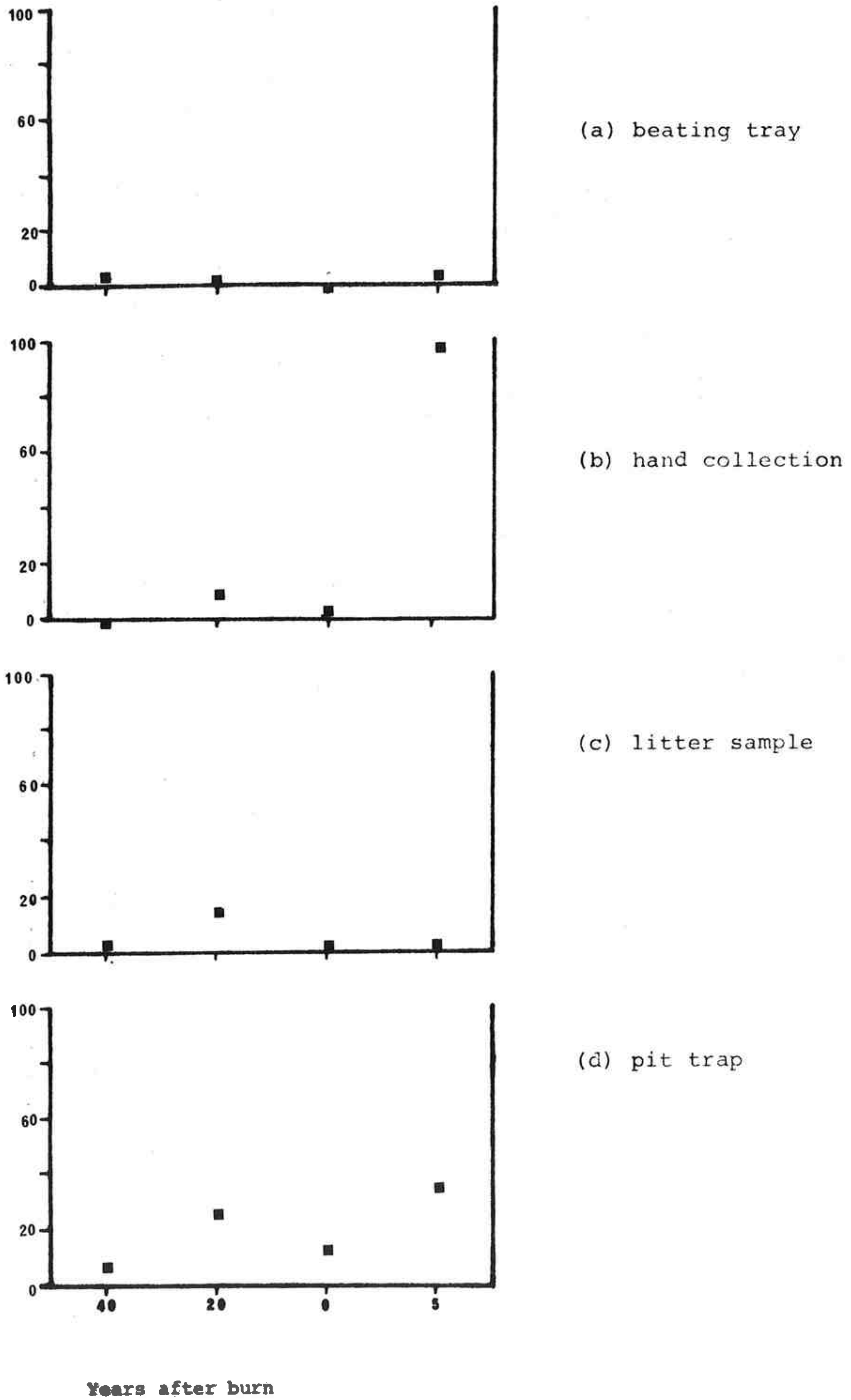


FIGURE 18 : Distribution of FORMICIDAE in the study areas using four sampling methods.

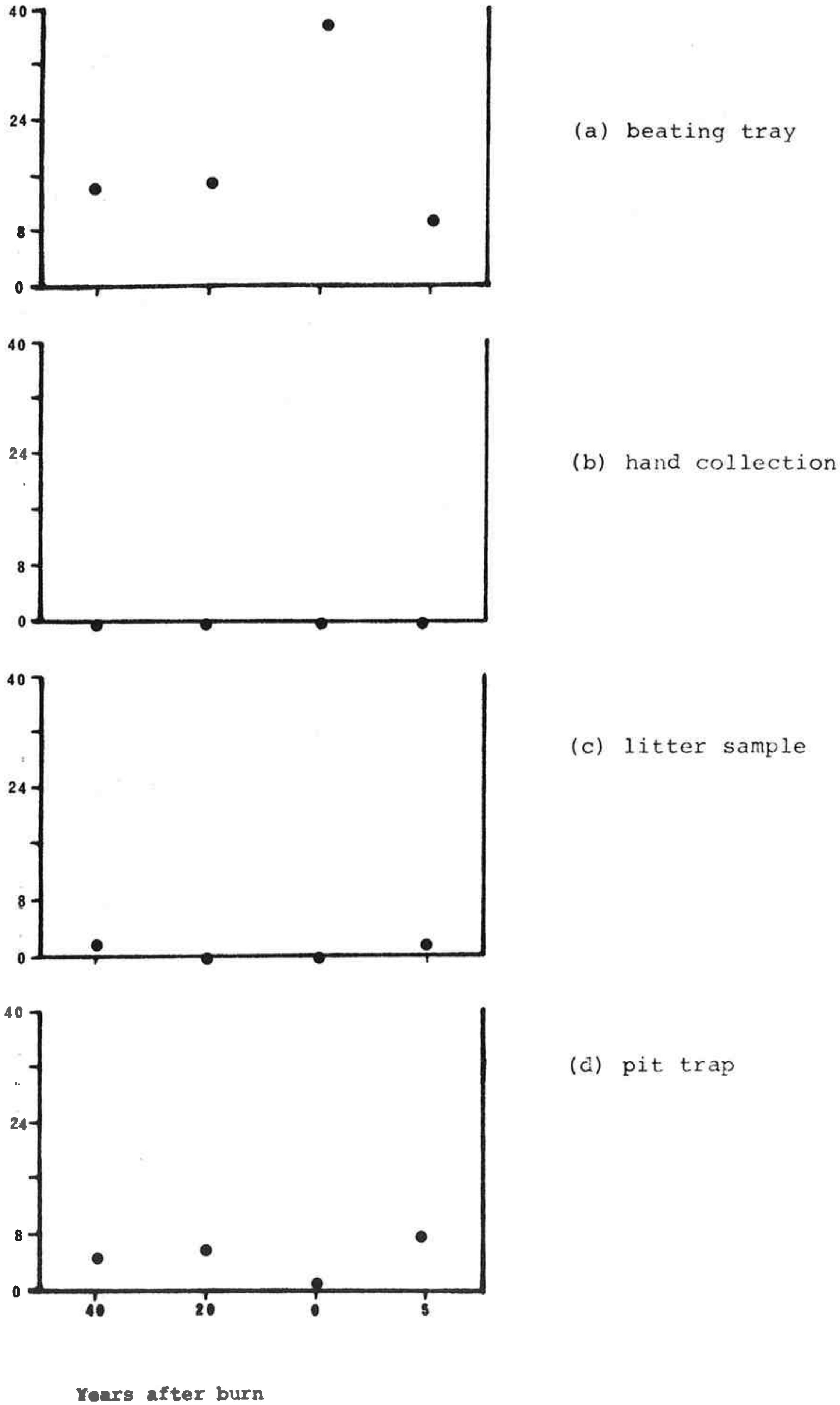


FIGURE 19 : Distribution of OTHER HYMENOPTERA in the study areas using four sampling methods.

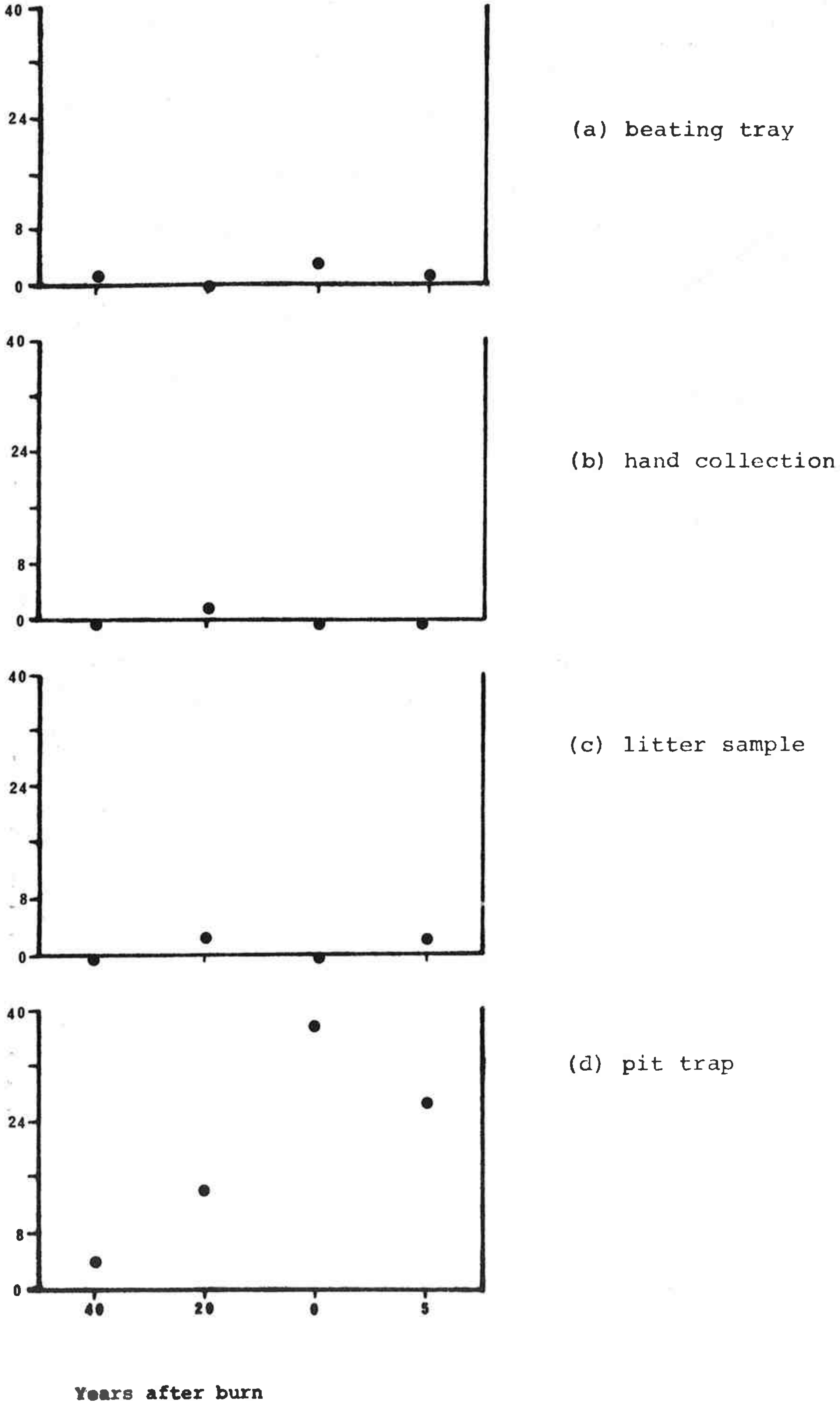


FIGURE 20 : Distribution of STAPHYLINIDAE in the study areas using four sampling methods.

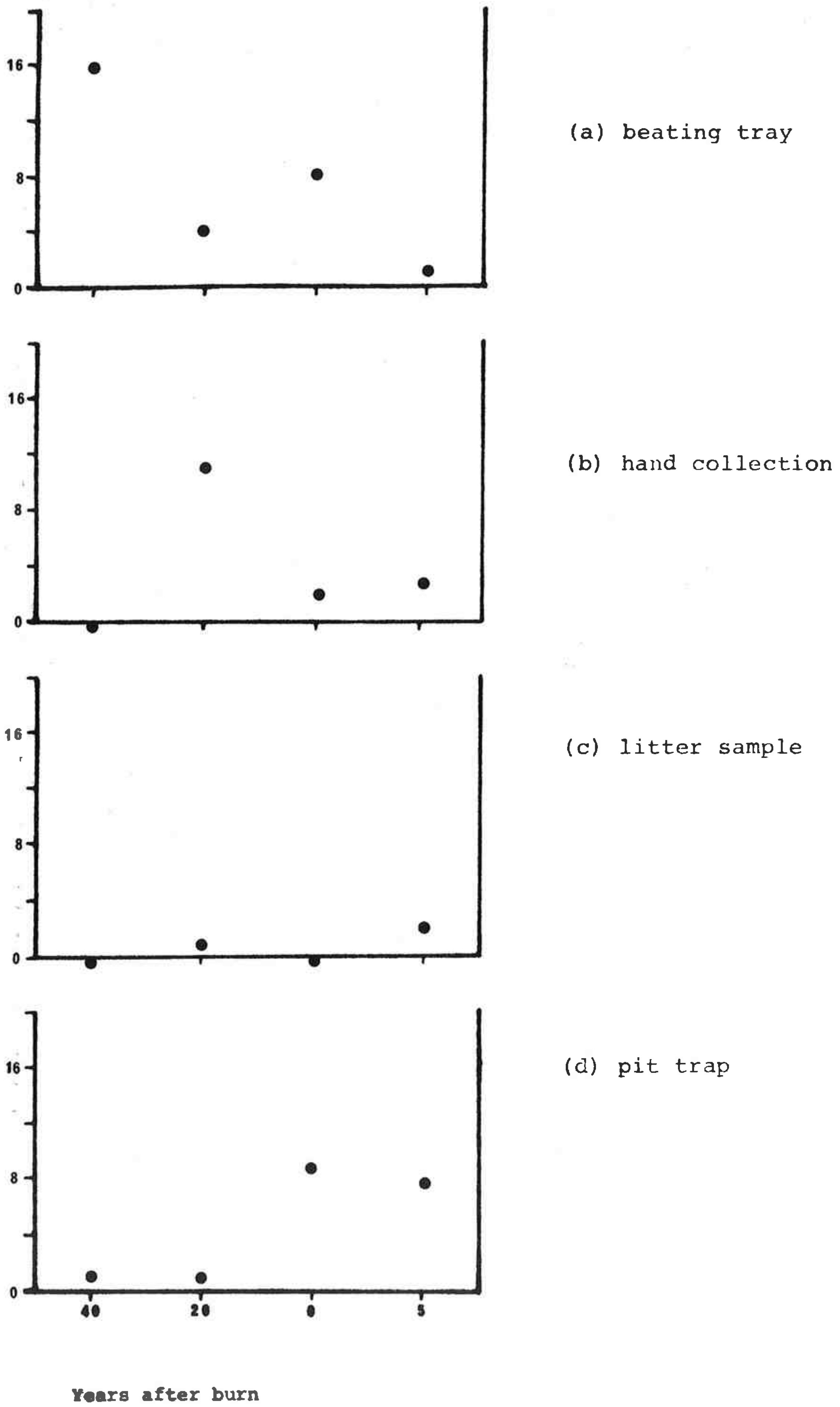
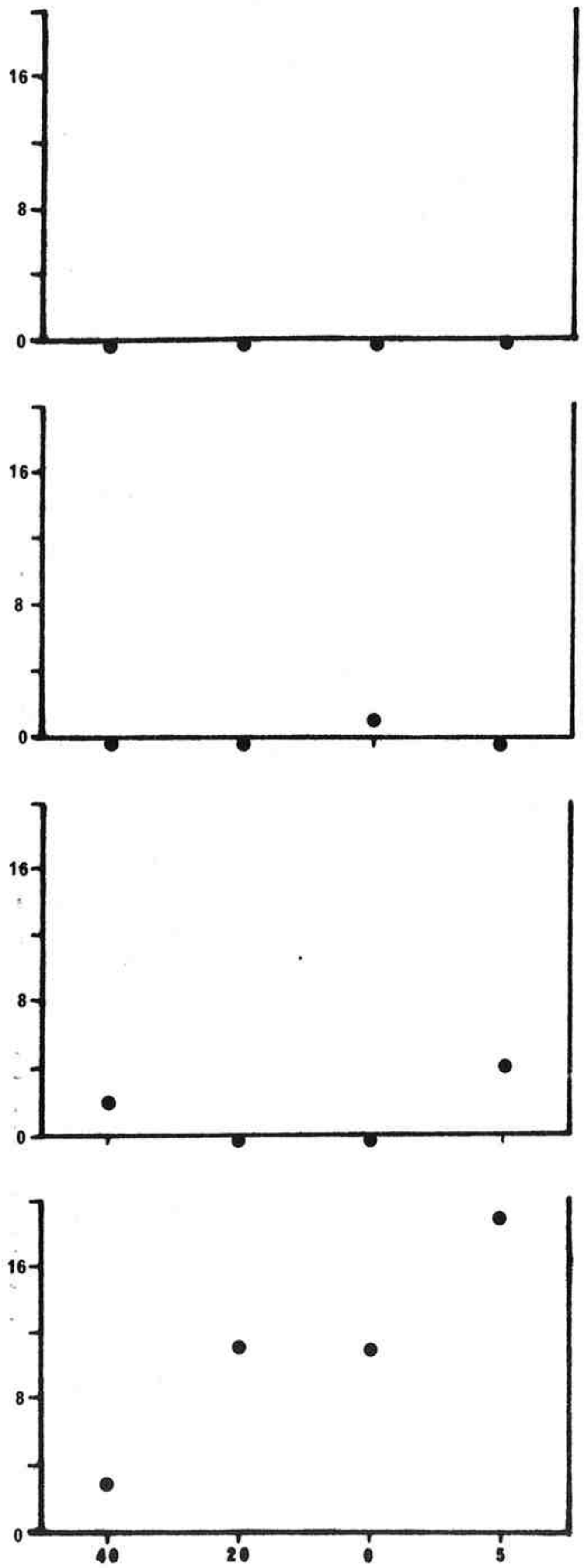


FIGURE 21 : Distribution of CURCULIONIDAE in the study areas using four sampling methods.



(a) beating tray

(b) hand collection

(c) litter sample

(d) pit trap

Years after burn

FIGURE 22 : Distribution of CARABIDAE in the study areas using four sampling methods.

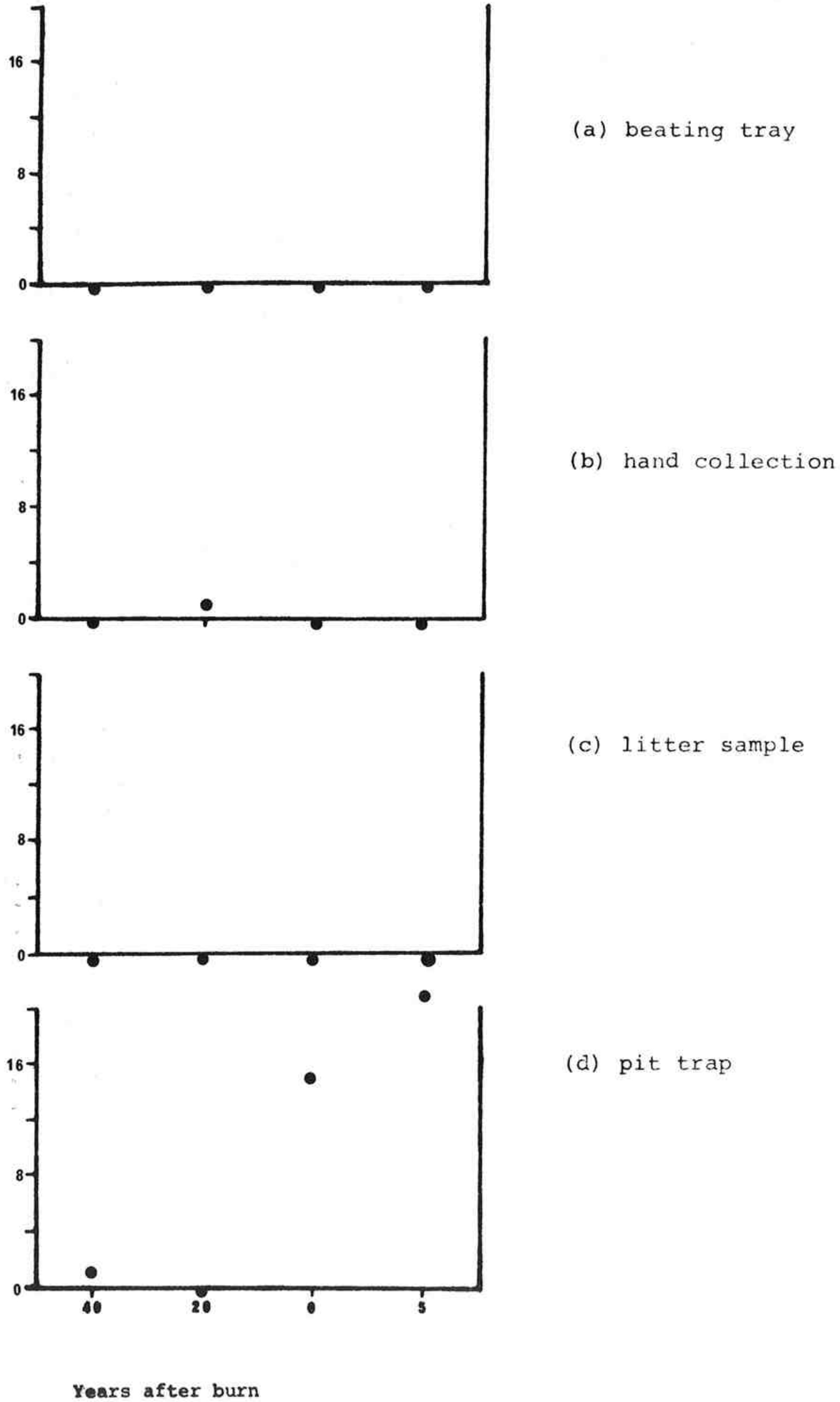
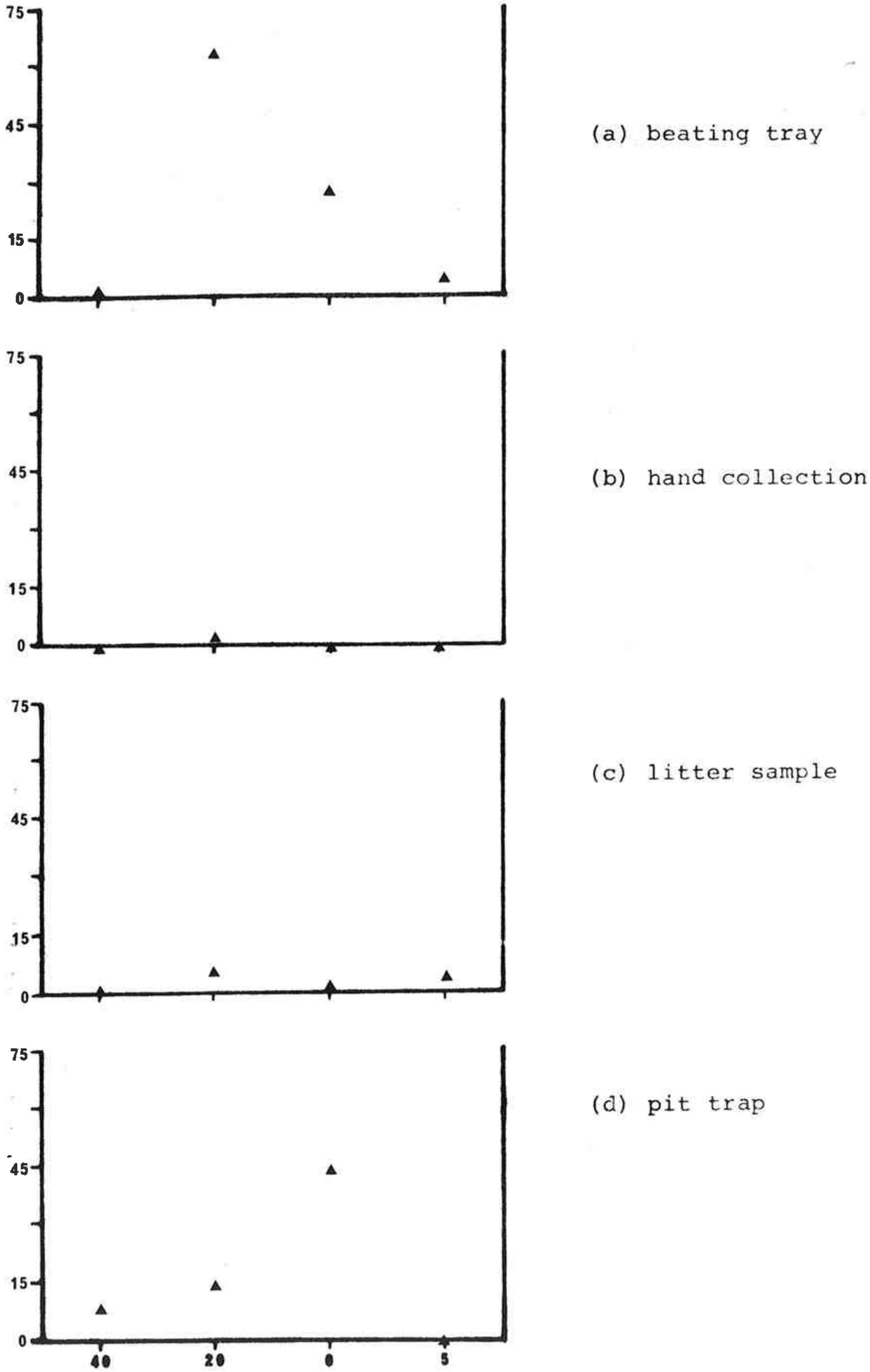


FIGURE 23 : Distribution of SCARABIDAE in the study areas using four sampling methods.



Years after burn

FIGURE 24 : Distribution of OTHER COLEOPTERA in the study area using four sampling methods.

APPENDIX C

1. Colour plates of some of the invertebrates trapped in the study areas near Pemberton. Specimens identified using "Survey of Soil Fauna" by J.A. Springett, 1971-72 (Manuscript)

2. Identification of the Formicidae trapped in the study areas carried out by J. Wallace.

PLATE 1. SCORPIONIDA Actual size: 10mm

Lychas marmoreus Area: 0 years

PLATE 2: PSEUDOSCORPION Actual size: 2mm

Area: 0 years

PLATE 3: OPILIONES LANIATORE

Actual size; 4mm
Area: 5 years

PLATE 4: OPILIONES PALPATORE

Actual size: 4mm
Area: 0 years

PLATE 5: ACARINA

Actual size: 2mm

Area: o years.

PLATE 6: ARANEAE

Actual size: 4mm (Abdomen)

Area: 5 years

PLATE7: ARANEAE

Actual size: 5mm (Abdomen)

Area: 5 years

PLATE 8: AMPHIPODA

Actual size: 15mm, 10mm

Area: 40 years

PLATE 9: ISOPODA

<u>Buddelundia monticola</u>

Actual size: 5 mm

Area: 0 years

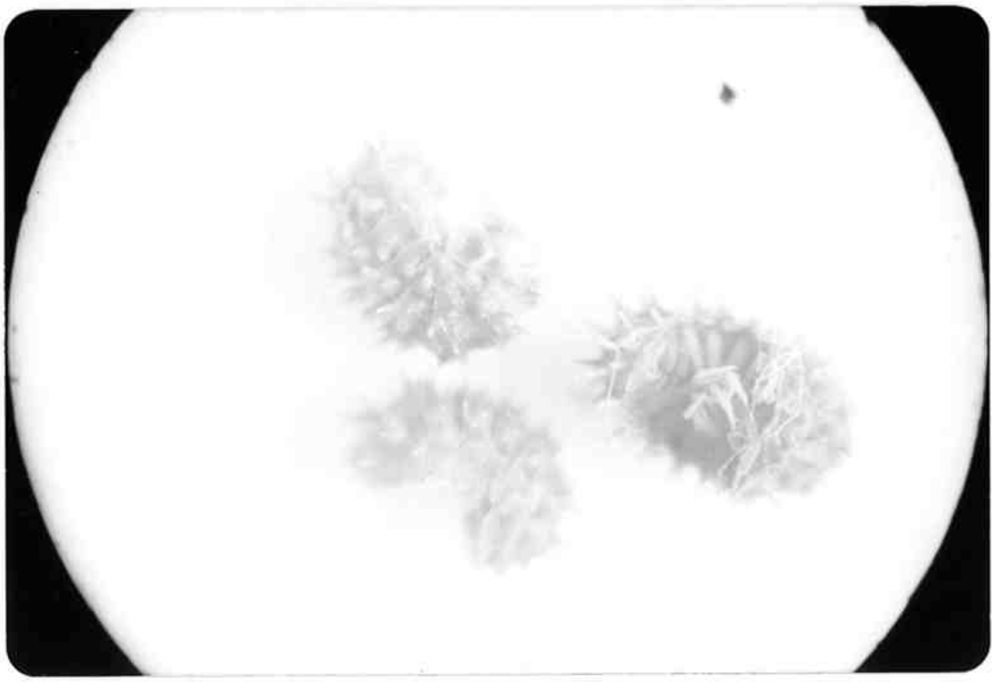


PLATE 10: ISOPODA

<u>Cubaris sp</u>

Actual size: 3mm

Area: 40 years

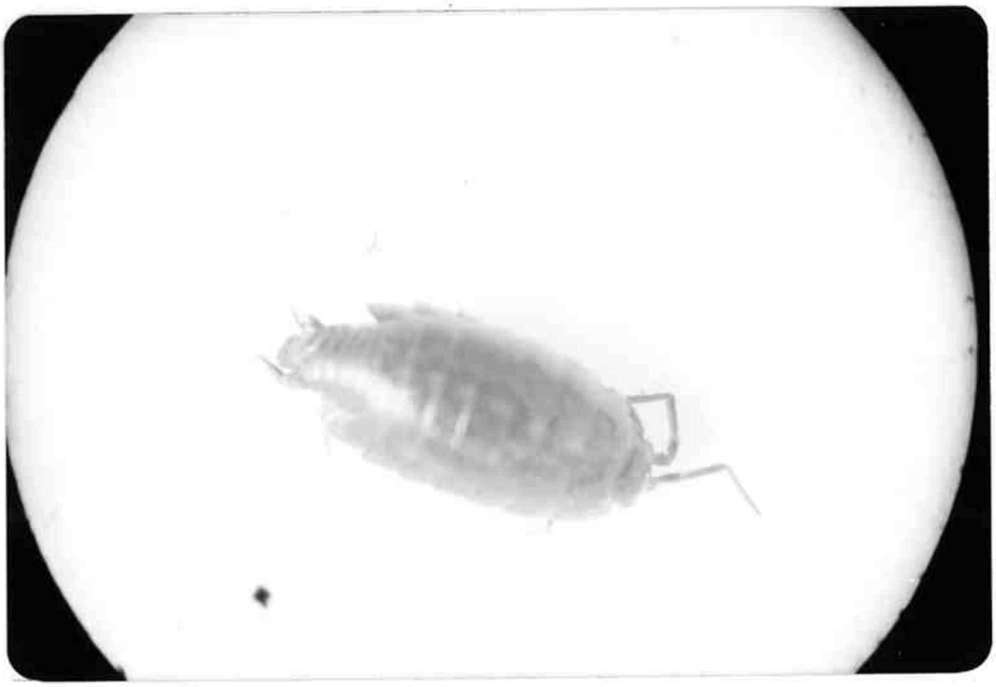


PLATE 11: ISOPODA — *Laevophiloscia sp.*

Actual size: 8mm
Area: 0 years

PLATE 12: DIPLOPODA
Rhinotus sp.

Actual size; 10mm
Area: 20 years

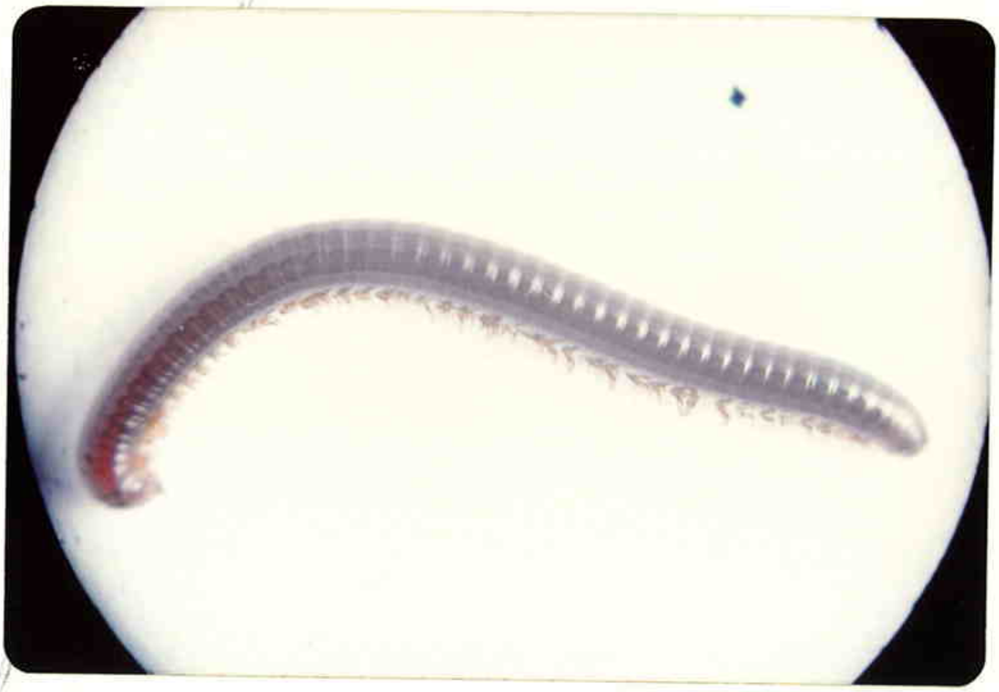


PLATE 13: DIPLOPODA
Atelomastix sp.

Actual size: 25 mm
Area: 40 years

PLATE 14: DIPLOPODA — *Antichiropus* sp.

Actual size; 20mm

Area: 20 years

PLATE 15: CHILOPODA Actual size: 40mm, 20mm

Scolopendridae Area: 0 years

PLATE 16 : CHILOPODA Actual size: 10 mm

Lithobiidae Area: 0 years

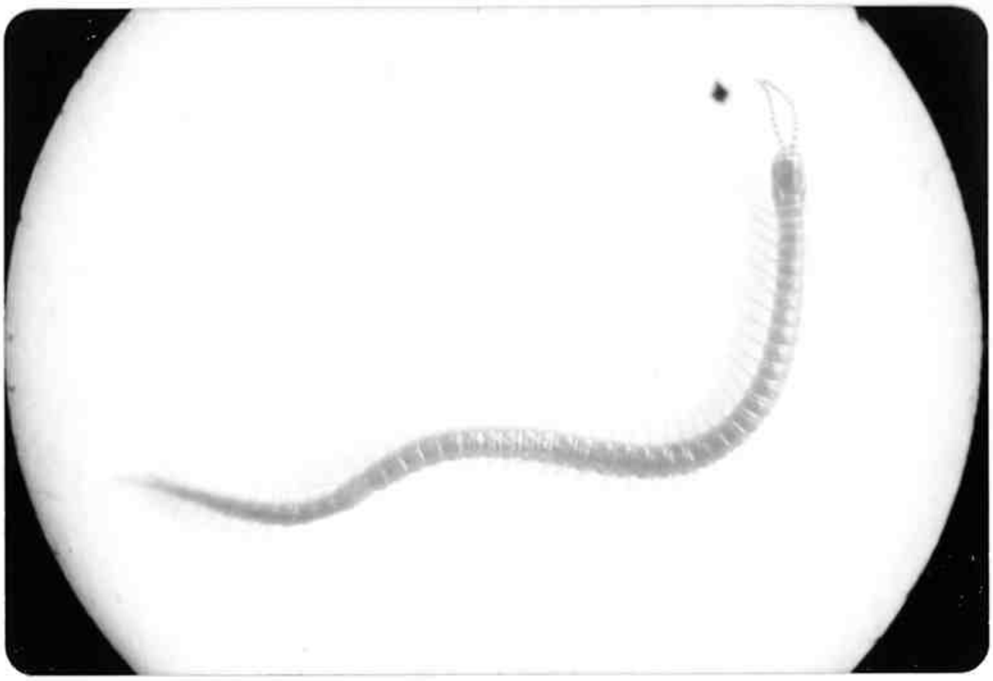


PLATE 17: CHILOPODA Geophilidae

Actual size: 25mm

Area: 20 years

PLATE 18: BLATTODEA

Actual size: 25mm

Area: 0 years

PLATE 19 : BLATTODEA

<u>Platyzosteria sp.</u>

Actual size: 25mm

Area: 0 years

PLATE 20: BLATTODEA
Blaberidae
Laxta sp.

Actual Size: 20mm
Area: 0 years

PLATE 21 : COLEOPTERA Curculionidae

Actual size: 5mm
Area: 20 years

PLATE 22: COLEOPTERA Curculionidae

Actual size: 2mm
Area: 40 years

PLATE 23: COLEOPTERA

Actual size: 10mm

Area: 0 years

PLATE 24: COLEOPTERA

Nitidulidae

Actual size: 2-4mm

PLATE 25: GASTROPODA

Actual size: 6-7mm
Area: 20 years

PLATE 26: GASTROPODA

Actual size: 4mm
Area: 20 years.

TABLE 1: Identification of the Formicidae trapped in the study areas.

CODE	AREA	NAME	NUMBER
Mn 22	*40 year		7
Mn 17	"	Camponotus	2
Mn 11	"	Strumigenys perplexa	1
Mn 46	"		1
Mn 43	"		4
Mn 42	"		1
Mn 16	+"		1
Mn 29	"		1
Mn 8	"	Iridomyrmex	1
Mn 41	*20 year		1
Mn 29	"		2
Mn 30	"		30
Mn 17	"	Camponotus	1
Mn 5	"	Crematogaster	1
Mn 43	"		5
Mn 7	"	Trachymesopus	1
Mn 45	"		1
Mn 32	+"		1
Mn 30	*5 year		50
! Mn 8	"		69
Mn 22	"		1
Mn 17	"	Camponotus sp.	2
Mn 8	"	Iridomyrmex sp	7
Mn 14	"	Iridomyrmex sp.	1
Mn 7	"	Trachymesopus sp.	1
Mn 6	"	Monomorium sp.	1
Mn 30	+"		2
Mn 8	"	Iridomyrmex	3
Mn 7	*0 years	Trachymesopus	1
Mn 24	"		2
Mn 17	"	Camponotus	1
Mn 6	"	Monomorium	1
Mn 32	"		3
Mn 41	"		1
Mn 42	"		1
Mn 43	"		4
Mn 44	"		1
Mn 38	"		1

* Individuals trapped on the ground; + Individuals trapped on beating tray; ! May be = to worker caste Mn 8 (late)

APPENDIX D

Data relating to the analysis of the stomach contents of the *A. flavipes*.

PLATE 1: <u>Antechinus flavipes</u> (Forest Focus,1973)
Eastern Australia from Cape York to Vic., south eastern S.A., south-western W.A.; rain forest, sclerophyll forest and woodland. Mating takes place in the winter months between July and September; they reach sexual maturity in the year following their birth. The males usually die after the mating season, however, the females may reproduce in a second season . Gestation period is from twenty-six to thirty five days (Ride,1970).

TABLE 1: Data relating to A. flavipes trapped in May, 1974 in an area of 40 year old Karri regeneration.
Major understorey: netic, casuarina (most of the understorey has collapsed)
Located at House Brook Road/ Rainbow trail. Map ref.: 115° 59', 34° 24'
Last burnt 40 years ago.

NO.	SEX	WEIGHT (g)	STOMACH WEIGHT (g)	LENGTH BODY (cm)	STOMACH CONTENTS.
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 (Fulgoroideae- 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

* Creek area
\+ Small area burnt the previous year.
\- Contents unidentifiable.

TABLE 2: Data relating to A. flavipes trapped in May, 1974 in area of virgin Karri.
Major understorey: netic, Acacia urophylla, casuarina and hazel.
Located at Curd Road. Map ref: 115° 58', 34°31'
Fire history is unknown.

NO.	SEX	WEIGHT (g)	STOMACH WEIGHT (g)	LENGTH BODY (cm)	STOMACH CONTENTS
151	F	22.75	0.6	7.75	Coleoptera (Nitidulidae - 4+), Synphyta larva.
152	M	43.05	1.4	10.00	Araneae, 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)

TABLE 3: Data relating to A. flavipes trapped in May, 1974 in area of virgin Karri.
Major understorey: netic, hazel, Acacia urophylla
Located in Pine Creek Road Map ref.: 115°51', 34° 18'
Last burnt - wildfire 1969

NO	SEX	WEIGHT (g)	STOMACH WEIGHT (g)	LENGTH BODY (cm)	STOMACH CONTENTS
47	F	27.20	0.4	10.00	Araneae

TABLE 4: Data relating to A. flavipes trapped in May, 1974 in area of logged over Karri - seed trees remaining. Located in Pine Creek Road/ Henwood Road. Map ref. 115^{o} 53', 34^{o}16'
Major understorey : casuarina
Fire history unknown.

NO	SEX	WEIGHT (g)	STOMACH WEIGHT (g)	LENGTH BODY (cm)	STOMACH CONTENTS
*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.

* Creek area
\+ Hill area
! Between both areas.

TABLE 5: List of stomach contents for <u>A. flavipes</u> for which no relevant information was available.

NO	STOMACH CONTENTS
216	Myriopoda (Diplopoda or chilopoda), Araneae, Blattodea, Heteroptera?, Coleoptera?,
219	Blattodea
217	Scarabidae, Araneae.
228	Coleoptera (Nitidulidae), Araneae, Other coleoptera, Hymenoptera.
221	Blattodea, Araneae (2), Coleoptera, Scorpionida?, Chilopoda?, Heteroptera
220	Araneae, Larva (Lepidoptera ?), Homoptera.