CARABID AND STAPHYLINID BEETLES FROM AGRICULTURAL LAND IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

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ABSTRACT

Pit-traps were emptied every two or three days for two seasons in crop, fallow, and grass plots to determine the species and population density of Carabidae and Staphylinidae associated with agricultural land, and their relationship with brassica crops. Half of the plots were enclosed by plastic barriers and the beetles were trapped to extinction; half were not enclosed. Thirty-three carabid and 16 staphylinid species were captured. The dominant species was the small, generalized, European carabid predator, *Bembidion lampros*, which had a population on crop and fallow land of about 29000/hectare. It was almost absent in grass. Other numerous carabids were *Harpalus aeneus*, *Calathus fuscipes*, and *Clivina fossor*, all introduced European spp., with populations of almost 2000, 5600, and 11000/hectare respectively. The first and third of these were scarce in grassland but the second was abundant. In plots of Brussels sprouts *Aleochara bilineata*, a staphylinid, was effectively parasitic on root maggots, and averaged more than 6000/hectare. Soil cores taken in October centred on a Brussels sprouts plant averaged 26.4 *Hylemya* puparia per core of which 44% were parasitized by *A. bilineata*.

INTRODUCTION

In 1916 Gibson and Treherne reported several important parasites of root maggots. They included several species of Carabidae, which readily devoured eggs, larvae and puparia of *Hylemya brassicae* (Bouché) in the laboratory with other species of Staphylinidae which they believed to be predacious. Included also was the staphylinid *Baryodma ontarionis* Csy. (= *Aleochara bilineata* Gyll.) a well-documented parasite of the pupal stage of the cabbage root maggot, *H. brassicae*. Investigations of the biotic factors acting against root maggots (Wilkes and Wishart 1953) revealed a second staphylind parasite, *A. bipustulata* (L) which parasitized considerably fewer cabbage root maggots than *A. bilineata*, but was four times as abundant on seed-corn maggots *H. platura* (Meig.), a smaller host.

Wright (1956) and Wishart *et al.* (1956) demonstrated the importance of carabid and staphylinid beetles as predators of the immature stages of the cabbage root fly, especially of eggs. In 1960, Wright *et al.* exposed untreated crops to the first generation of the cabbage root fly and showed that predatory beetles could greatly reduce the root maggots and the crop damage. They discovered and Coaker confirmed (1965) that the principal predator in England was the small carabid, *Bembidion lampros* (Hrbst.). To determine which beetles were predators of eggs, Coaker and Williams (1963) trapped beetles at Wellesbourne, exposed them to cabbage root fly eggs, and identified the egg-feeding species by means of the precipitin test.

In 1972 and 1973, at Wellesbourne, England and Agassiz, B.C., Finlayson *et al.* (1975) examined the effects of several herbicides and insecticides on carabid and staphylinid beetles associated with minicauliflowers. The identity and numbers of beetles present in the treated and untreated plots were determined by pitfall trapping, a method discussed at length by Greenslade (1964). We investigated these predator populations in the lower Fraser Valley, mainly to determine their species and population density in agricultural land, and their relationship with cropping practices, especially in brassicas.

METHODS

The work was done at the Agriculture Canada Sub-station at Abbotsford. Three agricultural conditions were sampled: crop, fallow and grassland. In 1974 the plots were 400 m^2. Three of the plots were open so that the beetles could migrate freely, and three were enclosed by 4 mil black polyethylene barriers 15 cm high. The barriers were made by folding a strip of polyethylene, 60 cm wide, over a nylon cord, stapling the cord and polyethylene to 15 cm stakes about 2.5 m apart, and anchoring the bottom flaps by covering them with soil. In 1975, the plots were reduced to 100 m^2. There were 12 plots, two each of crop, fallow and grass enclosed by the barrier and two each left open.

The pitfall traps (pit-traps) were new tin cans, 7 cm diam x 11 cm deep. A hole, 2 cm diam, was cut in the bottom and covered with 40-mesh Lumite screen to allow rain water to drain while retaining the beetles. The pit-traps were sunk in the ground with their rims level with the soil surface. After heavy rains the pit-traps were wiped clean around the upper 5 cm to remove accumulated dirt and ensure a smooth surface and thus to prevent the beetles from climbing out of the trap and escaping. In 1974 predation by birds, especially crows, *Corvus brachyrhynchos hesperis* Ridgway, in the pit-traps set in grass led us to insert a cone-shaped wire barrier of 1 cm mesh chicken netting, which allowed the beetles to enter but kept out the birds.

In 1974 there were 45 pit-traps in each 10 x 40 m plot, three rows of 15 traps spaced 2.5 m apart. Grass and fallow plots were sampled from April 26, but the cropped plots only from July 5 because barriers could not be erected until the Brussels sprouts crop, seeded June 17, was established. In 1975 each plot contained 16 pit-traps, evenly spaced throughout the plot, four in each of four rows, 2 m apart. The pit-traps and barriers were set in place in late March. Brussels sprouts plants were transplanted on April 1, and collecting started immediately.

The beetles were removed from the pit-traps usually on Monday, Wednesday and Friday of each week, identified and recorded. The beetles were identified in the field or if necessary submitted to the Biosystematic Unit in Ottawa for identification or confirmation. Beetles captured in the enclosed plots were released outside the barrier, but those captured in the open area were immediately released within the plot. Thus the total numbers captured in the enclosed area revealed the number per unit area, whereas those taken in the open area revealed their habitat preference and the cycle of the adult stage. The numbers of beetles of each species were recorded separately on each collecting period during the week, then summed to give a weekly total for each species.

Soil samples were taken from the Brussels sprouts plots at harvest in 1975 to determine the percentage parasitism of the overwintering population of puparia of *H. brassicae*. Ten samples were taken from each of the four plots of Brussels sprouts. Each sample, 15 cm diam x 12 cm deep, with the topped plant as the centre of the sample, was cut with a core sampler on October 7. The core was placed in a cardboard tub, 18 cm diam x 13 cm deep, sealed with a lid, placed in the greenhouse for 21 days to allow immature larvae to complete development, then stored at 3°C for 100 days to break diapause in *H. brassicae*. The puparia were recovered from the soil cores by floatation, placed in 30 ml bottles, and held at room temperature till the emergence of a fly or a parasite. Those puparia which did not produce either were dissected to determine if parasites were present but had failed to emerge.

RESULTS AND DISCUSSION

Thirty-three species of Carabidae and 16 species of Staphylinidae were taken from the pit-traps. They are listed alphabetically in accordance with Hatch (1953, 1957).

Carabidae

Amara apricaria (Payk.)
Amara californica Dej.
Amara familiaris (Duft)*
Amara obesa Say
Amara sp. (lunicollis group)
Anisodactylus binotatus (F)*
Agonum mulleri (Hbst.)*
Agonum subsericeum LeC.
Bembidion lampros (Hrbst.)*
Bembidion obscurellum Mots.
Bembidion petrosum Gebl.
Bembidion sp.
Blethisa oregonensis LeC.
Bradycellus congener LeC.
Bradycellus nigrinus Dej.
Calathus fuscipes (Goeze)*
Calasoma tepidum LeC.
Carabus granulatus L.*
**Carabus nemoralis* Müll.*
Clivina fossor (L.)*
Harpalus aeneus (F.)*
Harpalus opacipennis Hald.
Harpalus somnulentus Dej.
Leistus ferruginosus Mann.
Loricera decempunctata Esch.
Notiophilus nitens LeC.
Pterostichus adstrictus Esch.
Pterostichus lama Men.
Pterostichus vulgaris L.*
Scaphinotus marginatus Fisch.
Scaphinotus angusticollis Mannh.
Trachypachus holmbergi Mots.
Trechus obtusus Er.*

Staphylinidae

Aleochara bilineata Gyll.*
Aleochara montanica Cys.
Atheta sp.
Hyponygrus angustatus Steph.*
Lathrobium sp.
Megalinus linearis Ol.*
Morychus oblongus LeC.
Ocypus aeneocephalus DeG.*
Oxytelus rugosus (F.)*
Philonthus concinnus Grav.*
Philonthus fuscipennis (Mann)*
Philonthus varius Grav.*
Quedius curtipennis Csy.
Rugilus oregonus Csy.
Tachyporus chrysomelinus L.*
Tachyporus n. sp. near *chrysomelinus*
*Introduced species

Of the species captured, six carabids, *A. familiaris*, *B. lampros*, *C. fossor*, *H. aeneus*, *P. vulgaris* and *T. obtusus*, and two staphylinids, *A. bilineata* and *O. rugosus* are listed as predators of eggs of the cabbage root fly by Coaker

TABLE 1. Carabid and staphylinid beetles taken from pit-traps in crop, fallow and grass plots, enclosed by barriers at Abbotsford, British Columbia in 1974 and 1975.

	Number of beetles per hectare					
	Cropped		Fallowed		Grass	
	1974	1975	1974	1975	1974	1975
*Aleochara bilineata**	0	6200	75	25	0	0
Amara spp.	1550	5350	3225	4650	325	2400
Anisodactylus binotatus	25	550	700	400	100	400
Bembidion lampros	325	31100	16100	38500	275	650
Bembidion obscurellum	475	1950	1100	1850	0	0
Bembidion sp	25	0	350	0	1525	50
Calathus fuscipes	5875	550	7900	2800	9775	6800
Carabus nemoralis	50	0	25	100	100	50
Clivina fossor	175	15500	6400	10850	25	450
Harpalus aeneus	525	2000	4300	1600	325	150
*Megalinus linearis**	275	1000	2025	650	1650	15100
*Ocypus aeneocephalus**	0	50	0	150	1050	1450
*Philonthus concinnus**	100	950	375	250	300	3850
*Philonthus fuscipennis**	75	50	50	0	1275	1400
*Philonthus varius**	25	450	250	250	375	500
Pterostichus vulgaris	2275	1950	4625	700	500	700
Trachypachus holmbergi	0	600	125	650	0	50

*Staphylinidae

and Williams (1963). Although the smaller species feed on eggs and probably early instar maggots, the larger species of *Amara*, *Calathus*, *Harpalus*, *Pterostichus* and *Philonthus* are capable of feeding on third instar maggots and even of cracking the puparia.

Some species were considerably more abundant than others. At Abbotsford, 19 species (13 carabids and 6 staphylinids) appeared most frequently; the other 30 species were taken only occasionally.

The numbers of 19 of the common species trapped have been collated so that those from the barrier plots afford a reasonable estimate of the numbers of each species per hectare (Table 1). The numbers of the same species from the open plots show preferences for any of three habitats (Table 2). Because of the difficulty in separating the three common *Amara* spp. in the field (*apricaria*, *californica*, and *familiaris*), they have been grouped under *Amara* spp. All three species appeared in crop, fallow and grassland, and appeared to show only a slight preference for the cropped area.

The populations of Carabidae tended to be highest on cultivated land. *B. lampros*, *B. obscurellum*, *C. fossor*, and *H. aeneus* on crop and fallow land averaged approximately 35,000, 1,900, 13,000 and 1,800 respectively per hectare in 1975. These are very high numbers. The large species, especially *C. fuscipes* and *P. vulgaris*, were present in cultivated and sod land in comparable numbers. Conversely, the Staphylinidae appeared in greatest numbers in grass, with *M. linearis* the most common followed by *P. concinnus*, *O. aeneocephalus* and *P. fuscipennis*. *A. bilineata* appeared almost exclusively in the cropped area. Its numbers are directly dependent on the available numbers of its host, *Hylemya* puparia.

When the numbers of beetles from the barrier plots (Table 1) are compared with those from the open plots (Table 2), it is obvious that the increase in numbers results from recapture of the same beetle. The numbers of the larger species of beetles tended to be more uniform from year to year.

Of the 19 species most commonly captured, six were examined in greater detail to establish the period of greatest frequency, the number of generations per year and the adult cycle in relation to generations of root maggots. The data tabulated as weekly totals were plotted to show the numbers captured per week in barrier (Fig. 1) and open (Fig. 2), plots.

B. lampros and *C. fossor* were collected in early spring, i.e. late March and very early April. The peak of the cycle for *B. lampros* in both years (Fig. 2a, 2g) centered around the last week of May and the first week of June. It coincided well with the heavy oviposition of the first generation of the onion fly *H. antiqua* (Meig.), and the cabbage root fly. *C. fossor* (Fig. 2d, 2j) was present at an early date but in much smaller numbers. This species is consider-

TABLE 2. Carabid and staphylinid beetles taken from pit-traps in crop, fallow and grass plots, not enclosed by barriers at Abbotsford, British Columbia in 1974 and 1975.

	Number of beetles per hectare					
	Cropped		Fallowed		Grass	
	1974	1975	1974	1975	1974	1975
*Aleochara bilineata**	300	4550	25	250	0	0
Amara spp.	11075	8500	4375	4500	350	2800
Anisodactylus binotatus	25	1800	400	1350	375	950
Bembidion lampros	1500	108250	38950	73250	450	850
Bembidion obscurellum	975	7650	2475	16300	0	0
Bembidion sp.	0	50	125	50	3175	300
Calathus fuscipes	47250	26800	18150	13550	29750	29900
Carabus nemoralis	75	0	75	0	1175	700
Clivina fossor	50	3400	3850	4500	250	500
Harpalus aeneus	3450	26000	28100	21100	350	750
*Megalinus linearis**	525	1400	1900	550	3350	15650
*Ocypus aeneocephalus**	125	50	375	0	1450	2400
*Philonthus concinnus**	75	1100	100	500	625	6600
*Philonthus fuscipennis**	75	150	175	200	1600	2950
*Philonthus varius**	25	400	125	100	175	800
Pterostichus vulgaris	7225	1050	2300	500	6550	3100
Trachypachus holmbergi	0	5850	275	4300	0	50

*Staphylinidae

ed beneficial as a predator of eggs of root maggots, but it is also listed as a minor pest, causing damage to corn seed similar to that caused by wireworms (Tsinovskii 1961). Some of the larger species including *H. aeneus*, *H. rufipes* (found in eastern Canada), and *P. vulgaris*, have also been reported to feed on strawberry fruits (Briggs 1957).

C. fuscipes (Fig. 1c,i and 2c,i) was much more numerous in 1974 than it was in 1975. It peaked late in the year. Specimens were taken from April through October, but the greatest number coincided with the oviposition of the third generation of cabbage root fly. Its ability to feed on mature maggots and puparia could assist considerably in reducing over-wintering populations.

Amara spp., *B. obscurellum* and *H. aeneus* were generally common at the beginning of the growing season but were still present over the full period of trapping. *H. aeneus* showed a tendency towards a spring emergence period (Fig. 1e,k) but the *Amara* spp. were most numerous in late summer and fall (Fig. 2f,l).

From the soil cores taken in October 1975, 20 plants within the barrier plots yielded 432 puparia and 20 plants in the open plots yielded 623. *Hylemya* flies emerged from 52.5% and 59.6% of these respectively. From the puparia from the barrier plots which did not produce flies 193 *A. billineata*, 44.7%, and 12 (2.8%) cynipid wasps, *Trybliographa* probably *rapae*, were recovered. From the puparia from the open plots which did not produce flies 267 (42.8%) *A. bilineata* and 41 (6.6%) *Trybliographa* were recovered. It is important to note that the 40 plants sampled averaged only 26.4 puparia each and that these plants, transplanted on April 1, withstood the attack of three generations of root maggots without the protection of pesticides. For that reason it is essential that research be continued to develop chemical controls for brassica crops which are not detrimental to the parasites and predators of the root maggot complex.

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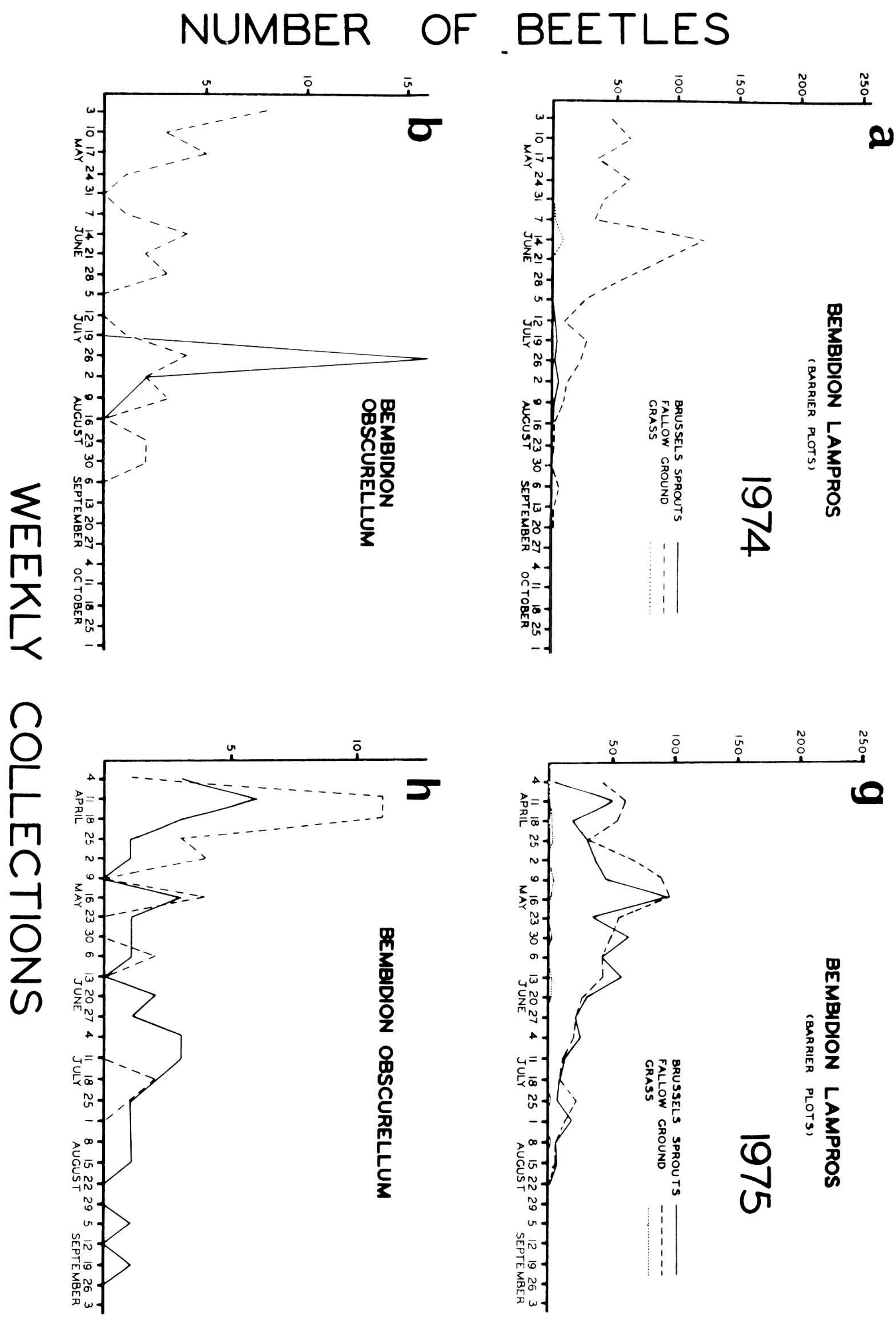
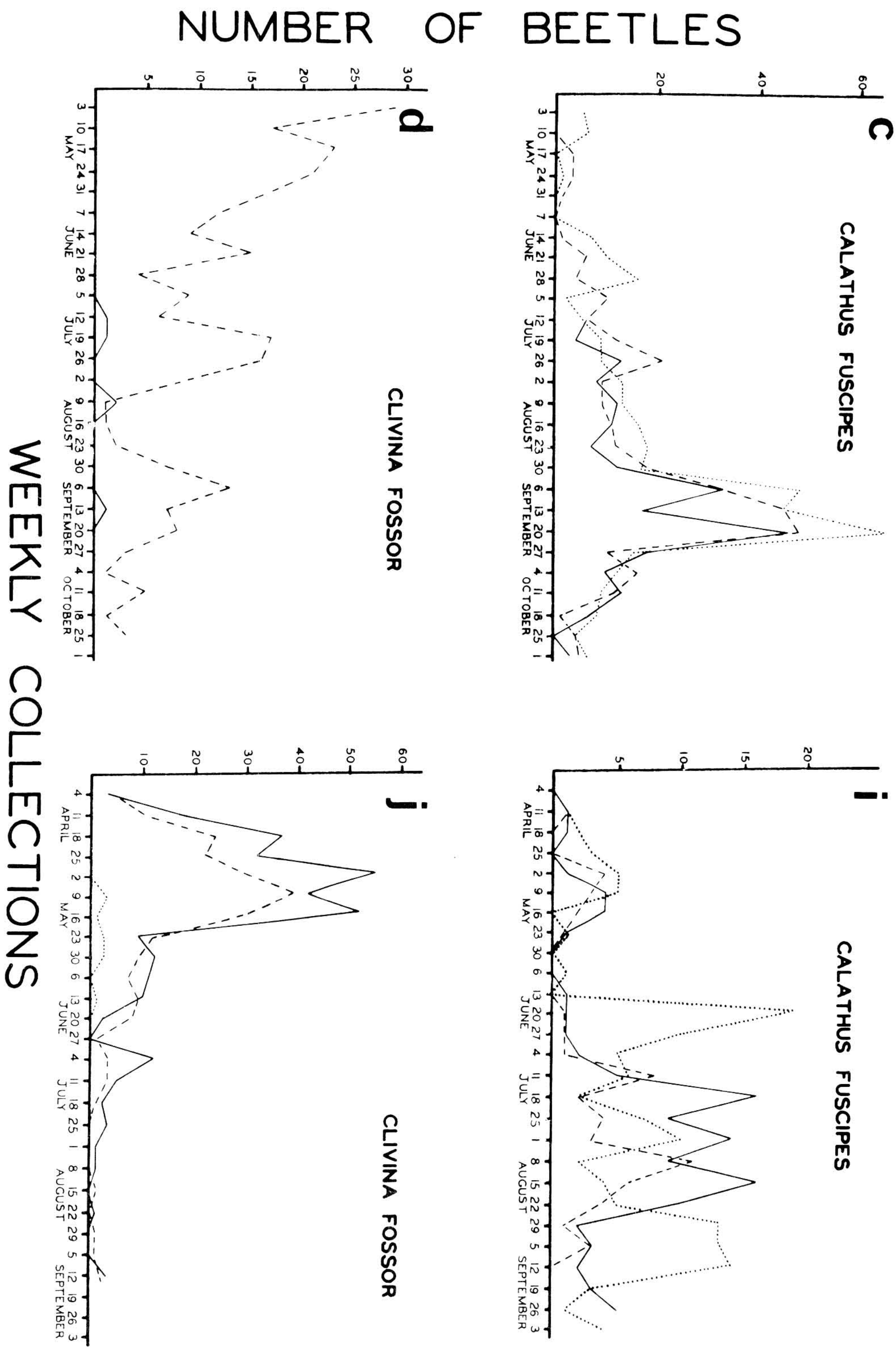
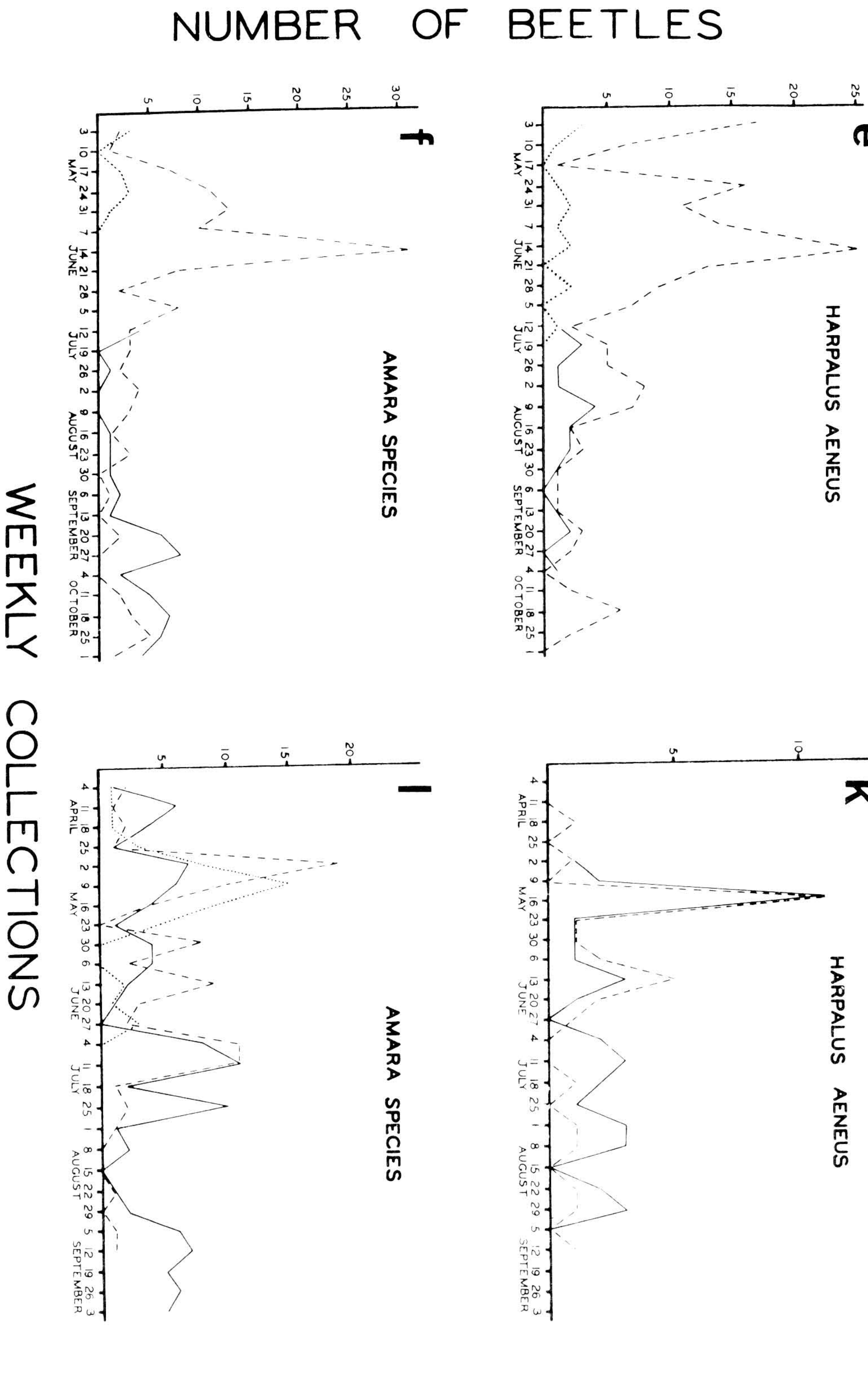
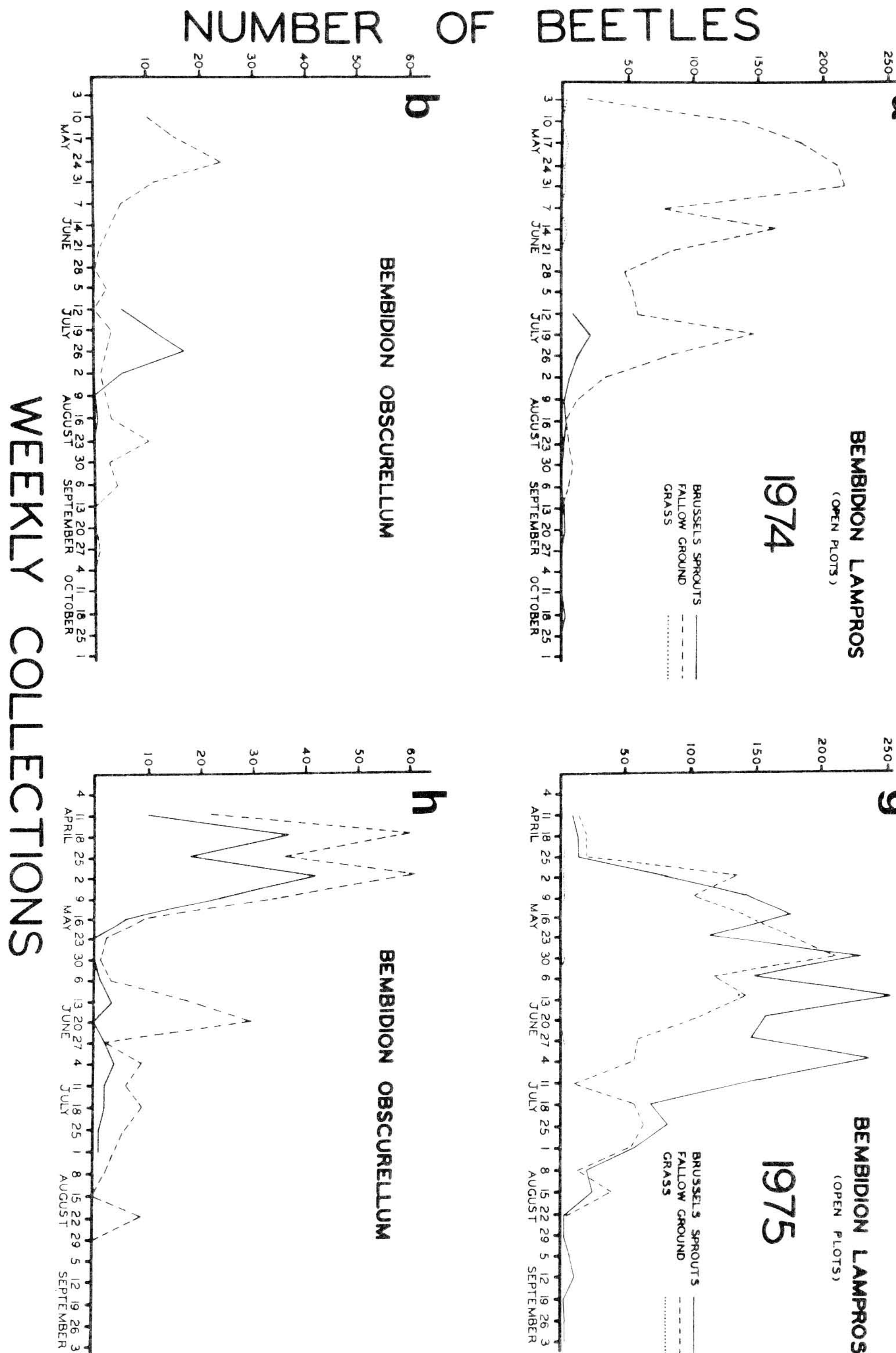
Fig. 1. Population curves for six carabid beetles on crop, fallow and grass plots, enclosed by barriers, at Abbotsford, B.C. in 1974 (a-f) and 1975 (g-l).

Fig. 2. Population curves for six carabid beetles on crop, fallow and grass plots, not enclosed by barriers, at Abbotsford, B.C. in 1974 (a-f) and 1975 (g-l).

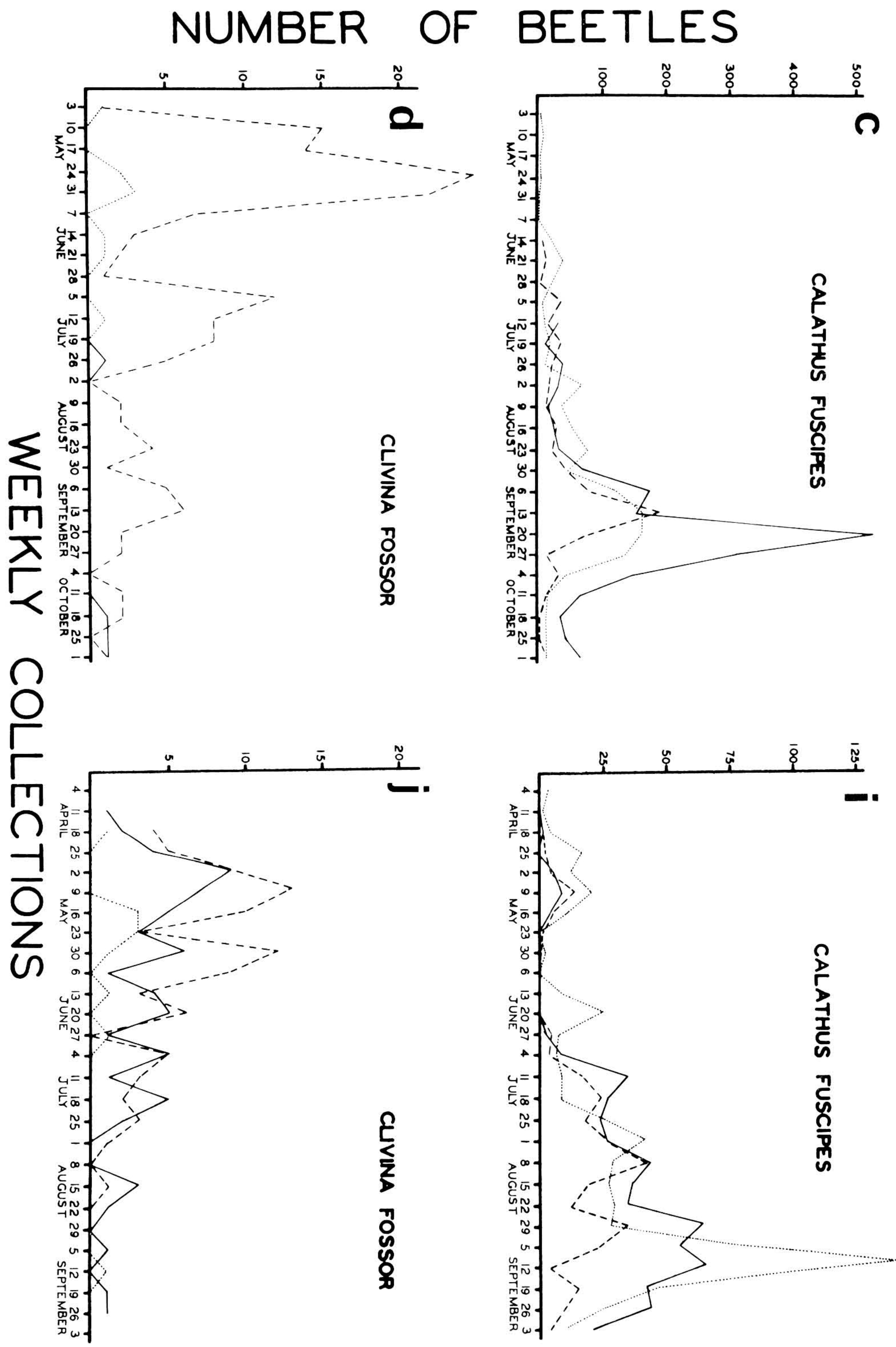

NUMBER OF BEETLES
WEEKLY COLLECTIONS
a
BEMBIDION LAMPROS
(BARRIER PLOTS)
1974
BRUSSELS SPROUTS
FALLOW GROUND
GRASS
b
BEMBIDION OBSCURELLUM
g
BEMBIDION LAMPROS
(BARRIER PLOTS)
1975
BRUSSELS SPROUTS
FALLOW GROUND
GRASS
h
BEMBIDION OBSCURELLUM
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

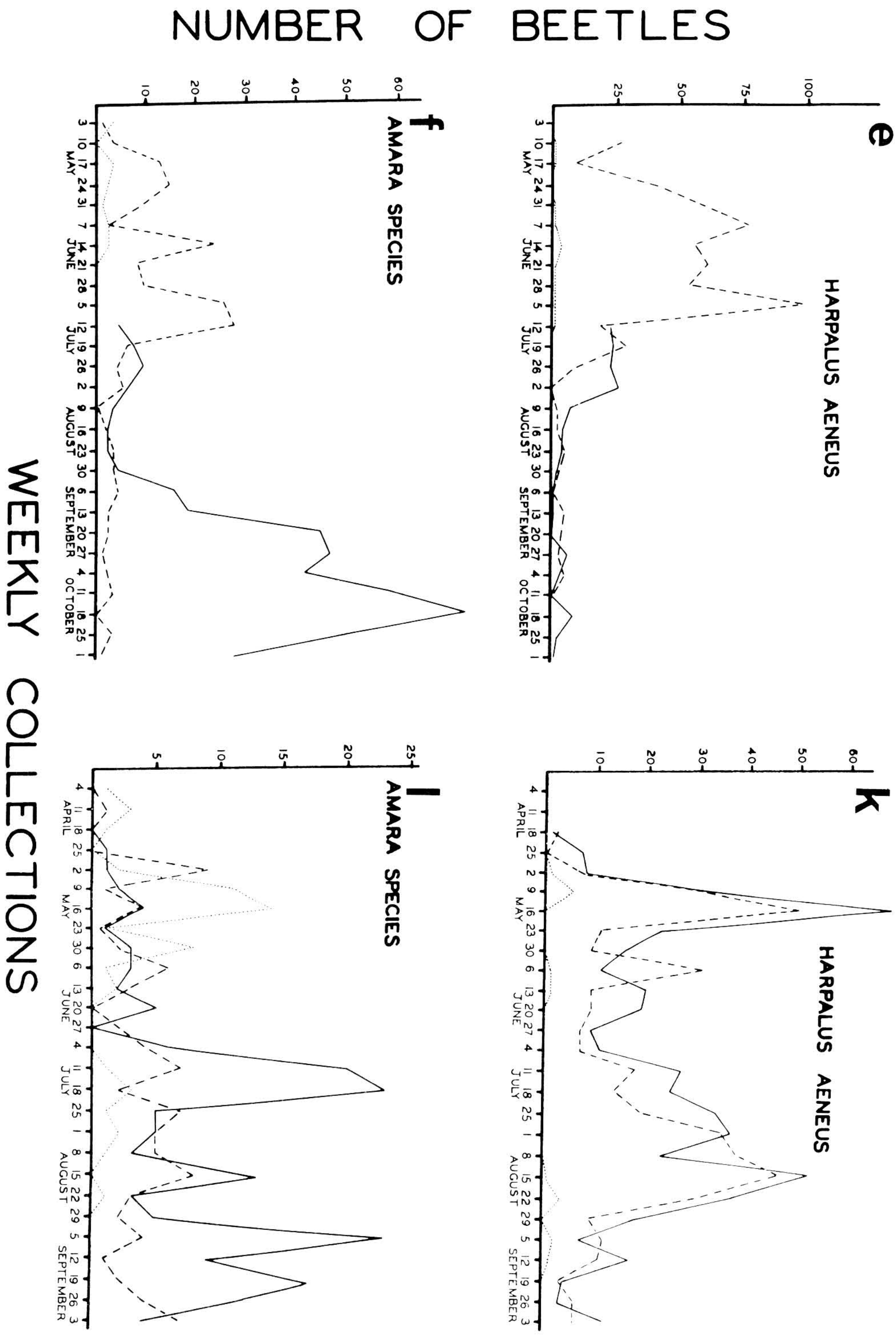

NUMBER OF BEETLES
WEEKLY COLLECTIONS
c
CALATHUS FUSCIPES
d
CLIVINA FOSSOR
i
CALATHUS FUSCIPES
j
CLIVINA FOSSOR
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
APRIL


NUMBER OF BEETLES
WEEKLY COLLECTIONS
e
HARPALUS AENEUS
f
AMARA SPECIES
k
HARPALUS AENEUS
l
AMARA SPECIES
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
APRIL



NUMBER OF BEETLES
WEEKLY COLLECTIONS
a
BEMBIDION LAMPROS
(OPEN PLOTS)
1974
BRUSSELS SPROUTS
FALLOW GROUND
GRASS
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
b
BEMBIDION OBSCURELLUM
g
BEMBIDION LAMPROS
(OPEN PLOTS)
1975
BRUSSELS SPROUTS
FALLOW GROUND
GRASS
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
h
BEMBIDION OBSCURELLUM


NUMBER OF BEETLES
WEEKLY COLLECTIONS
c
CALATHUS FUSCIPES
d
CLIVINA FOSSOR
i
CALATHUS FUSCIPES
j
CLIVINA FOSSOR
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
APRIL


NUMBER OF BEETLES
WEEKLY COLLECTIONS
e
HARPALUS AENEUS
f
AMARA SPECIES
k
HARPALUS AENEUS
l
AMARA SPECIES

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