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Labelling with radioisotopes, release and dispersal of the rove beetle, *Aleochara bilineata* Gyll. *(Coleoptera: Staphylinidae)* in a Danish cauliflower field

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Abstract

In 1975 and 1976 the dispersal of *Aleochara bilineata* in a cauliflower field was investigated using radioactively labelled beetles from laboratory cultures. In 1975, 920 beetles were labelled with $^{54}MnCl_2$. 900 of these were released in two batches of 600 and 300 individuals respectively. 20 were kept for observations in the laboratory. In 1976, 1033 beetles were labelled with $^{65}ZnCl_2$. These beetles were released in 7 batches of 130–200 specimens each.

Optimal labelling was obtained with $^{65}ZnCl_2$, which had a durability of 40 days. $^{54}MnCl_2$ labelling, on the contrary, only lasted for 20 days. Also labelling with fluorescent dust and oil-soluble dye was tried, but proved to be ineffective. 100 pitfalls placed up to 30 metres from the release point were used for recapture of the labelled beetles. 143 were recaptured in 1975, and 47 were recaptured in 1976.

Dispersal rates up to 6.5 metres per day were ascertained. For biological control of cabbage root flies *(Hylemya brassicae)* spread of few batches of several hundred beetles each is sufficient. However, a maximum distance of 20 metres between release points is recommended to ensure quick dispersal over the whole area.

Key-words: *Aleochara bilineata, Hylemya brassicae,* dispersal, radioisotopes.

Resumé

Rovbillen, *Aleochara bilineata,* er en vigtig naturlig fjende af den lille kålflue, *Hylemya brassicae*. Den er både rovdyr med æg og larver som bytte og snylter på pupperne. Under naturlige forhold kommer rovbillerne om foråret så meget senere frem end den lille kålflue, at dennes første generation af æg og små larver ikke udsættes nævneværdigt for rovbillerne. Det er imidlertid netop denne generation af kålfluelarver, der anretter de alvorligste skader, fordi det er den mest koncentrerede, og fordi planterne endnu er så små. Biologisk bekæmpelse ved hjælp af *A. bilineata* sigter på at rette op på denne skævhed ved udsætning af laboratorieopdrættede rovbiller, mens æggene til første generation lægges. Det har imidlertid været et ubesvaret spørgsmål, om man blot kan udsætte større partier af rovbiller hist og her, eller om en omhyggelig fordeling i marken er nødvendig.

I 1975 og 1976 blev *A. bilineatas* spredningsevne undersøgt ved udsættelse af radioaktivt mærkede biller i en blomkålsmark. I 1975 blev 920 biller mærket med Mangan-54. Først blev 620 mærket og 600 blev udsat, mens 20 blev tilbageholdt til laboratorieobservationer. Senere blev 300 mærket og udsat.

I 1976 blev 1033 individer mærket med Zink-65. Disse blev udsat i 7 hold à 130–200 individer (se tabel 1).

Den bedste mærkning blev opnået med Zink-65, der holdt i 40 dage. Mangan-54 varede kun i 20 dage.

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Også mærkning med fluorescenspulver og oliemaling blev forsøgt, men var utilfredsstillende med hensyn til holdbarhed.

De mærkede dyr blev genfanget i 100 faldgruber (se figur 2, 3 og 4), placeret i en afstand af op til 30 meter fra udsætningsstedet. I 1975 blev 143 dyr genfanget, og i 1976 genfangedes 47; det vil sige at genfangstprocenten var meget ringere i 1976. Denne forskel kan skyldes den ændrede fældetæthed og eventuel sammenklumpning af billerne i 1975. Efter genfangst blev dyrene udsat 10 centimeter syd for den fælde, hvori de blev fanget.

Der blev konstateret spredningshastigheder på op til 6,5 meter pr. døgn. Figur 3 og 4 viser i form af »frontlinier« billernes spredning fra udsætningsstedet.

På baggrund af billernes spredning kan det konkluderes, at omhyggelig fordeling af enkeltindivider er unødvendig ved udsætning til biologisk bekæmpelse af den lille kålflue. Udsætning af hold på flere hundrede biller hver er tilstrækkeligt, blot afstanden mellem udsætningsstederne ikke overstiger 20 meter (til markrand 10 meter).

Nøgleord: *Aleochara bilineata, Hylemya brassicae,* spredning, isotopmærkning.

Introduction

The rove beetle *Aleochara bilineata* Gyll. is a parasitoid and moreover an important predator of the cabbage root fly (*Hylemya brassicae* Bouché) (*Wishardt* et al., 1956; *Coaker,* 1965; *Yaman,* 1960; *Bromand,* 1974). However, under natural conditions the predation of the first generation of cabbage root fly eggs in May is negligible, as *A. bilineata* in most cases emerges too late (*Bromand,* 1974). If however, it has been possible to release laboratory reared *A. bilineata* simultaneously with the first egglaying of cabbage root flies predation of these eggs should be ensured, a viewpoint which is the basic idea for this paper.

In establishing such release it is important to know the ability for dispersal of the beetles, and whether they will stay in the field or not. That the beetles are well fit for searching their prey is well known (*Yaman,* 1960). Yet how big an area they may cover within a certain time needs further investigation. In the following an attempt will be made to elucidate this to some extent, especially dealing with a sufficiently reliable method of labelling the beetles.

Materials and methods

In a preliminar test 50 *A. bilineata* were dusted with yellow or red fluorescent powder and 25 beetles were dotted on the pronotum with oil-soluble dye.

The labelling with radioisotopes was based on offering radioactive drinking water on strips (5 × 50 millimetres) of filter paper. The laboratory-reared specimens of *A. bilineata* were kept in plastic boxes of 17 × 22 (bottom) × 7 (height) centimetres. The bottom of each box was covered with one centimetre of dry sand. In this layer an inverted petri dish was placed with the bottom flushing with the sand surface. During labelling the radioactive strips were placed on the petri dish. In cultures to be labelled all *A. bilineata* were denied drinking water and food 24 hours prior to the labelling.

In 1975, 620 *A. bilineata* (2 boxes of 310 each) were labelled with $^{54}MnCl_2$ (halflife 314 days, gamma radiation from all disintegrations) on the 27th–28th of May and further 300 animals on 18th–19th of June. The first 620 beetles emerged 1–2 days before labelling, while the latter group emerged 1–7 days before labelling.

The drinking material used was a solution of $^{54}MnCl_2$ in 0.05 N HCl (0.1 μCurie per μlitre). Each of the two boxes of 310 beetles was supplied with 500 μlitres of drinking material on 8 filterpaper strips on the 27th of May in the morning. In the afternoon each box received further 500 μlitres on the same strips.

On the 28th again each box was supplied with 500 μlitres of drinking material plus an additional amount of 250 μlitres of destilled water. Thus

Table 1. The amounts of $^{65}ZnCl_2$ solution and water supplied to the groups of *A. bilineata* labelled in 1976. Each group received its supply on 4 filterpaper strips. In brackets the total radioactivity of the strips including the former supply is shown.

Mængder af $^{65}ZnCl_2$-opløsning og vand som blev tilført A. bilineata mærket i 1976. Hvert hold modtog forsyningen på 4 filtrerpapirstrimler. Strimlernes totale radioaktivitet, inklusive tidligere tilførsel er anført i parentes.

Group	1	2	3	4	5	6	7
Number of *A. bilineata*	200	142	130	117	144	152	148
Supplies of $^{65}ZnCl_2$ solution and H_2O	10/6 500 µl 300 µCi 11/6 500 µl H_2O	11/6 500 µl 300 µCi 13/6 500 µl H_2O 14/6 500 µl H_2O	14/6 500 µl 300 µCi 15/6 500 µl H_2O 16/6 500 µl H_2O	16/6 500 µl 300 µCi 17/6 500 µl H_2O 18/6 500 µl H_2O	18/6 500 µl 300 µCi 20/6 500 µl H_2O 21/6 500 µl H_2O	21/6 500 µl 150 µCi 22/6 500 µl H_2O 23/6 500 µl H_2O	26/6 500 µl 150 µCi 28/6 500 µl H_2O 29/6 500 µl H_2O
Total supply	1000 µl 300 µCi	1500 µl 300 µCi (600 µCi)	1500 µl 300 µCi	1500 µl 300 µCi (900 µCi)	1500 µl 300 µCi (600 µCi)	1500 µl 150 µCi (1050 µCi)	1500 µl 150 µCi (750 µCi)
Date of release	11/6	15/6	17/6	18/6	22/6	24/6	30/6

each box of 310 beetles received a total of 150 μCurie. 10 beetles from each box were kept in the laboratory for control. They were supplied with water and fly larvae every day. Radiation of these beetles and of the sand in the boxes was measured regularly.

On the 18th of June (afternoon) the second group of *A. bilineata* (300) was supplied with 1000 μlitres of drinking material on 8 filterpaper strips. An equal amount of drinking material was supplied on the same strips in the morning of the 19th. Thus these 300 beetles were treated with a total of 200 μCurie. Radioactivity of 20 individuals was measured before release.

In 1976 $^{65}ZnCl_2$ (halflife 244 days, gamma radiation from 50.7 per cent of all disintegrations) dissolved in 0.1 N HCl was used for the labelling. The initial solution was 3 μCurie per μlitre. A total of 1033 *A. bilineata* were labelled in 7 groups. Dates of labelling and release, numbers of individuals and amounts used are listed in table 1. As a control the radioactivity of 15 specimens from group 1 and of 20 specimens from each of the other groups was measured. The beetles in group 1 to 5 were 1 day old at labelling time, whereas the beetles in groups 6 and 7 hatched 1–3 days before labelling.

Measurements were carried out with a portable BASC scintillation counter using a 1'' by 1'' sodium iodide crystal as the detector. The beetles were placed as shown in figure 1. Under the chosen measuring conditions 1.3 per cent of total gamma radiation from ^{34}Mn can be registered. From ^{65}Zn 1.2 per cent of the total gamma radiation can be registered. Except one all releases took place after sunset to avoid provocation of flight. All these evenings the weather was dry with no or low wind and temperatures were between 15 and 20 degrees Celsius. The release on the 19th of June 1975 took place at 3 p.m. in hot weather with sunshine. Just before this release the soil on the release spot was cooled by watering.

Both years the month of May was rather cold but the summers were extremely hot and dry. At the time of the first release in 1975 the cauliflower plants were only at the 4 leave stage. In 1976 at the time of the first release they had reached the same stage, although the leaves were slightly bigger than the previous year. In both years emergence of cabbage root flies started about the 10th of May.

The release spot was in a cauliflower field, which is shown on figure 2. The distance between

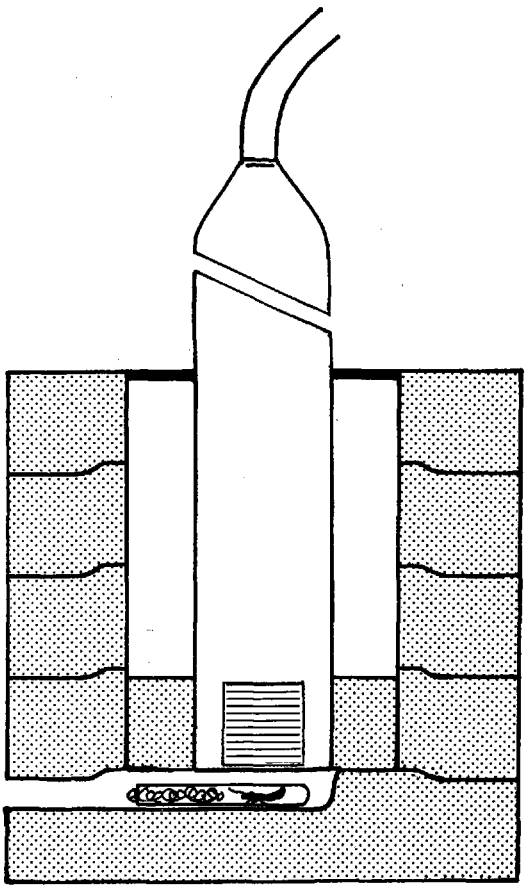


Fig. 1. A section diagramme showing the placement of the beetle under measurement of radioactivety. The outer shaded area is a lead-well. In the center the probe is seen with the radiation-absorbing sodium-iodide-crystal (the lineshaded area). Just below it a cottonwool sealed glass tube with one bettle.
Tværsnitdiagram af den benyttede radioaktivitetsmåleopstilling. Yderst ses blybrønden og i midten af den kolben med den strålingsabsorberende natrium jodidkrystal (linieskraveret). Herunder er en bille anbragt i en glastube lukket med vat.

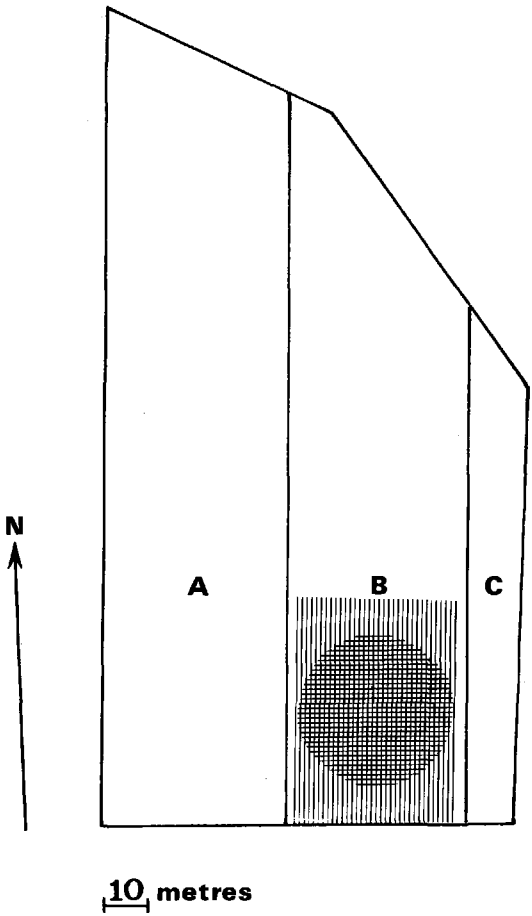


Fig. 2. The experimental field. A: Sweedes, B: Cauliflowers, C: Carrots. The crosshaded circle is the trapping area of 1975. In 1976 the trapping area was extended by the lineshaded area.
Forsøgsarealet. A: Kålroer, B: Blomkål, C: Gulerødder. Det cirkulære krydsskraverede areal viser fangstarealet i 1975. I 1976 blev fangstarealet udvidet med det linieskraverede område.

rows was 55 centimetres and the distance between plants was roughly 40 centimetres.

Two different arrangements of pitfalls (diameter 10 and 11 centimetres) were used in 1975 and 1976 respectively, but the release spot was the same. Trap distribution can be seen from figures 3 and 4.

The trapped *A. bilineata* were tested for radioactivity and released again the same day. They were released 10 centimetres south of the pitfalls in which they were caught.

Results

Use of fluorescent dust for labelling *A. bilineata* was unacceptable due to the active cleaning behaviour of the animals and due to the sweeping off caused by their movement through the soil. With the naked eye the dust labelled beetles were recognizable for 3 days and under UV light for maximum one week.

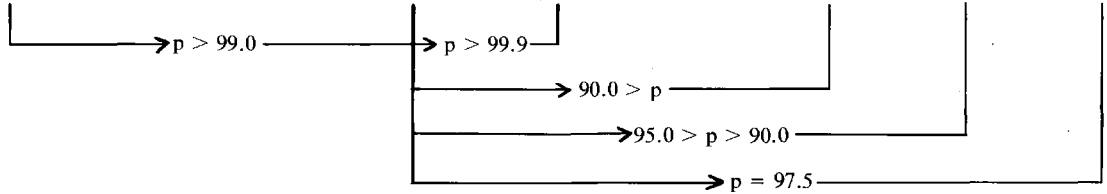
Dotting with oil-soluble dyes was very time consuming and difficult because of size and shape of the beetles. Furthermore, the dye tended to spread on the pronotum. When reaching the membranous regiones of the segmentations the beetles showed signs of strong irritation. All the dotted beetles were clean after 2–3 weeks.

The results of radioactivity determination of control specimens are shown in table 2. Table 3 shows counting results of 20 control specimens and of some batches of recaptured specimens, all from the first ^{54}Mn labelling. The results give an impression of how the radioactivity of the beetles gradually decreases. To test some of the differences seen the nonparametric Mann-Whitney U test (S. Siegel, 19 pp. 116–127) has been used. The control specimens (table 3) were significantly more radioactive on the 28th May than on the 29th ($p > 99.0$ per cent), and on the 29th they were significantly more radioactive than on the 30th ($p > 95.0$ per cent). On the 3rd June the recaptured specimens were significantly more radioactive than the control specimens ($p > 99.0$ per cent) and again on the 9th the recaptured specimens were significantly more radioactive than the control specimens ($p > 99.9$ per cent). The same test was used for some of the results seen in table 2. The beetles in batch A were significantly more radioactive than those in batch 2 ($p > 99.0$ per cent). Beetles in batch 2 were significantly more radioactive than beetles in batch 3 ($p > 99.9$ per cent). There was no difference between batches 2 and 4. Batch 2 beetles were significantly more radioactive than batch 7 beetles ($p = 99.5$) but not significantly more radioactive than batch 6 beetles (90.0 per cent $> p >$ 95.0 per cent).

Table 2. The radioactivity (in cpm) of the control batches of 1975 and of 1976. A is significantly higher than 2. 2 is significantly higher than 3 and 7 respectively but not significantly higher than 6.

Kontrolholdenes radioaktivitet (i cpm) i 1975 og 1976. A er signifikant højere end 2. 2 er signifikant højere end henholdsvis 3 og 7, men ikke signifikant højere end 6.

Group	A	B	1	2	3	4	5	6	7
	^{54}Mn	^{54}Mn	^{65}Zn	^{65}Zn	^{65}Zn	^{65}Zn	^{65}Zn	^{65}Zn	^{65}Zn
Date of release	28/5–75	19/6–75	11/6–76	15/6–76	17/6–76	18/6–76	22/6–76	24/6–76	30/6–76
	9,480	1,245	2,085	6,276	3,145	6,714	7,208	4,373	4,105
	7,746	1,228	1,980	5,621	2,345	4,990	5,052	3,859	4,085
	7,390	1,136	1,664	4,884	2,170	4,579	4,896	3,285	3,595
	6,080	1,119	1,634	4,514	2,145	4,172	3,849	3,070	2,915
	5,927	883	1,387	4,038	2,140	3,804	3,698	2,860	2,895
	5,700	878	1,346	3,601	1,968	3,521	3,522	2,801	2,495
	5,628	829	823	3,292	1,924	3,385	3,140	2,639	2,285
	5,157	825	716	3,207	1,803	3,215	2,797	2,534	2,235
	5,058	809	627	3,203	1,621	3,149	2,590	2,331	2,065
	4,971	756	596	2,729	1,533	2,986	2,049	2,015	1,985
	4,313	713	513	2,401	1,389	2,630	1,991	1,855	1,935
	4,038	609	493	2,064	1,327	2,400	1,839	1,828	1,555
	3,849	540	314	2,063	1,198	2,366	1,782	1,766	1,475
	3,748	417	283	1,969	1,141	2,043	1,514	1,698	1,435
	3,491	381	262	1,954	1,041	1,961	1,445	1,590	1,365
	3,284	376		1,607	988	1,606	1,432	1,589	1,335
	3,130	367		1,570	969	1,529	1,090	1,501	1,305
	3,048	347		1,476	933	1,502	983	1,482	1,085
	2,506	345		1,398	884	1,222	883	1,047	925
	1,330	224		1,260	657	478	31	997	735
Sum	95,874	14,027	14,723	59,127	31,321	58,252	51,791	45,120	41,810
Mean	4.794	701	982	2.956	1,566	2,913	2,590	2,256	2.091



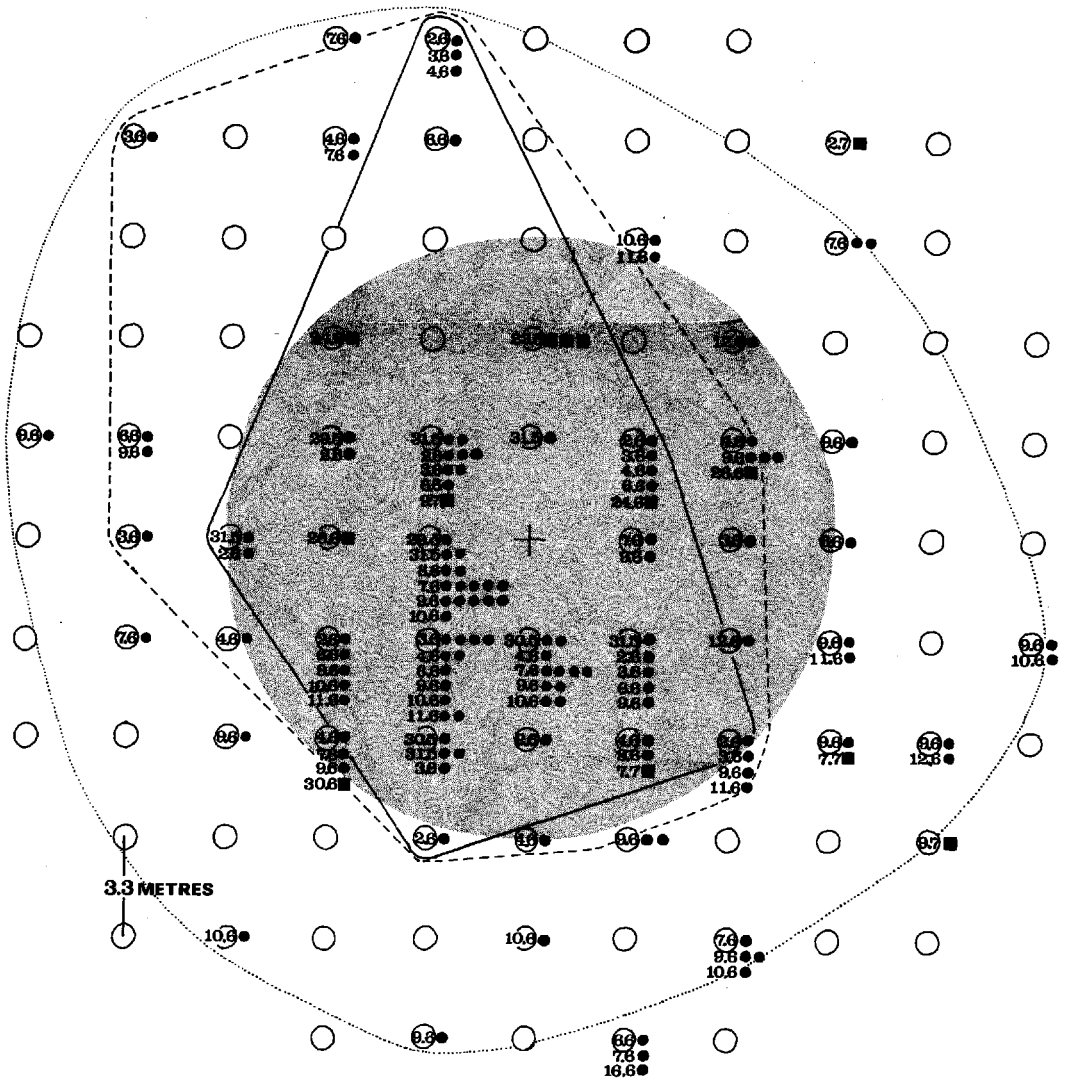


Fig. 3. Trapdistribution, dates of recapturing, numbers recaptured, and their distribution in 1975. The line indicates the area covered 5 days after the first release. The inner dotted line (- - - -) shows the covering after 7 days and the outer dotted line (. . . .) shows the covering after 13 days. The shaded area is a circle with a 10 metre radius.
Signatures:
Cross: Release spot.
Small circle: Pit fall.
Black dot: 1 *A. bilineata* from first release.
Black square: 1 *A. bilineata* trapped after second release.
Fældefordeling, genfangstdatoer, antal genfangne dyr og deres fordeling i 1975. Den optrukne linie angiver udbredelsen 5 dage efter første udsætning, den stiplede linie efter 7 dage og den prikkede efter 13 dage. Det skyggede areal viser en cirkulær flade med radius 10 meter.
Signaturer:
Kors: udsætningspunkt.
Lille cirkel: Faldgrube.
Rund sort plet: 1 A. bilineata *fra første udsætning.*
Firkantet sort plet: 1 A. bilineata *fanget efter anden udsætning.*

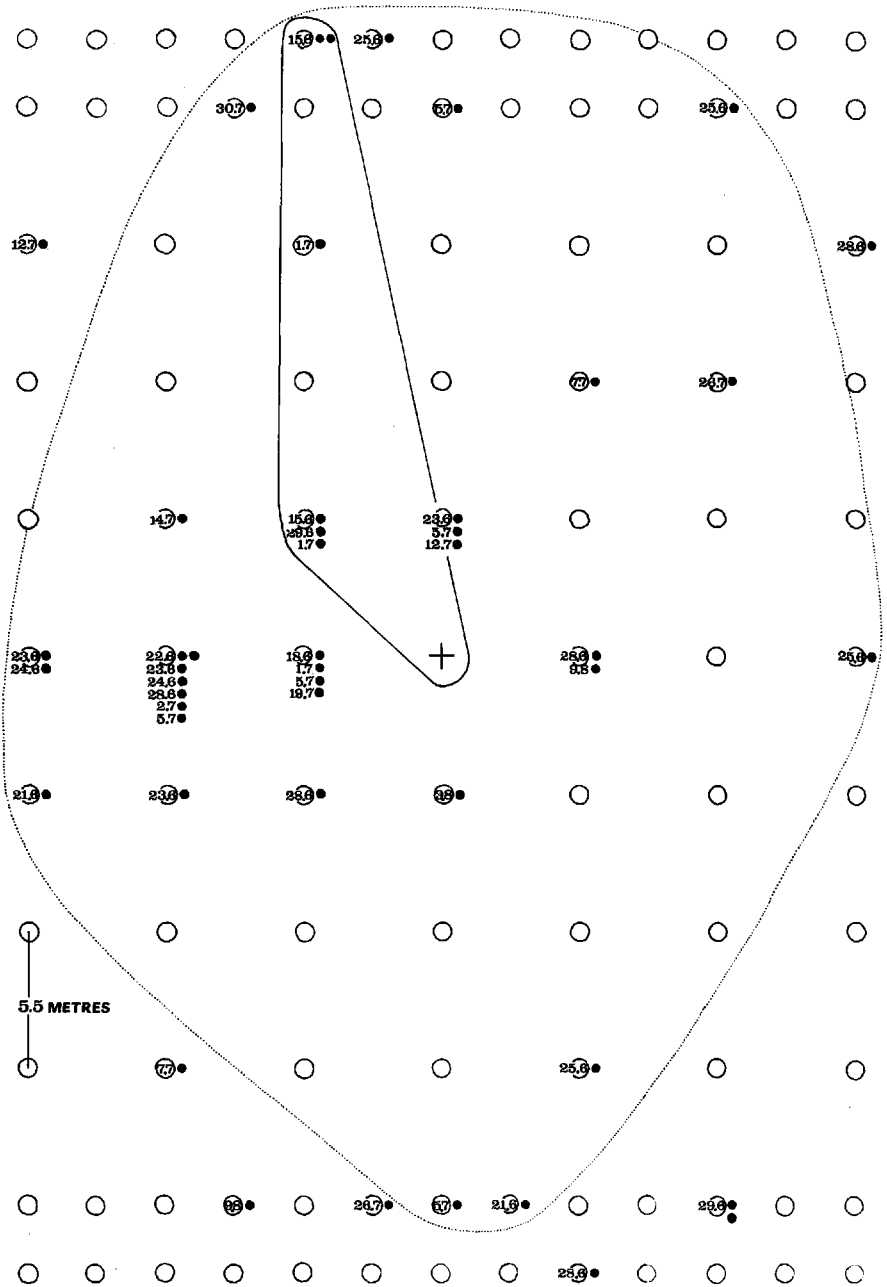


Fig. 4. Trap distribution, dates of recapturing, numbers recaptured and their distribution in 1976. The drawn line shows the area covered after 4 days from the first release; the dotted line (. . . .) shows the covering after 14 days.
Signatures:
Cross: Release spot.
Small circle: Pit fall.
Black dot: 1 *A. bilineata*.

Fældefordeling, genfangstdatoer, antal genfangne og deres fordeling i 1976. Den optrukne linie viser udbredelsen 4 dage efter første udsætning, den prikkede linie efter 14 dage.
Signaturer:
Kors: Udsætningspunkt.
Lille cirkel: Faldgrube.
Rund sort plet: 1 A. bilineata.

Table 3. Decline of radioactivity (in cpm) of *A. bilineata* in the control batch from group A compared with that of recaptured specimens from the same group. I is significantly higher than II. II is significantly higher than III. VI is significantly higher than V. VIII is significantly higher than VII.

Faldende radioaktivitet (i cpm) hos A. bilinetata fra kontrolgruppen fra hold A sammenlignet med genfangne dyr fra samme hold. I er signifikant højere end II. II er signifikant højere end III. IV er signifikant højere end V. VIII er signifikant højere end VII.

	I control 28/5–75 cpm	II control 29/5–75 cpm	III control 30/5–75 cpm	IV recaptured 2/6–75 cpm	V control 3/6–75 cpm	VI recaptured 3/6–75 cpm	VII control 9/6–75 cpm	VIII recaptured 9/6–75 cpm	IX control 19/6–75 cpm
	9,480	7,505	5,948	9,877	5,169	9,049	1,112	2,708	606
	7,746	5,693	4,236	8,681	3,124	7,638	1,086	2,514	563
	7,390	4,737	4,043	6,340	2,986	5,117	1,033	2,459	337
	6,080	4,602	3,969	5,044	2,695	4,313	974	2,268	240
	5,927	4,278	3,780	4,660	1,994	3,828	931	2,232	231
	5,700	4,220	3,126	4,471	1,952	3,823	717	2,041	198
	5,628	4,162	3,046	4,260	1,918	3,538	659	1,938	
	5,157	3,536	3,018	3,656	1,824	3,349	631	1,901	
	5,058	3,254	2,825	2,908	1,740	2,579	593	1,719	
	4,971	3,124	2,733	2,785	1,660	2,575	530	1,701	
	4,313	3,064	2,617	2,364	1,444	2,537	522	1,692	
	4,038	2,789	2,441	1,974	1,259	2,010	494	1,639	dead
	3,849	2,753	2,097		1,198	1,726	489	1,622	
	3,748	2,626	2,079		1,154	1,078	473	1,542	
	3,491	2,549	2,060		1,126		396	1,390	
	3,284	2,252	1,627		1,119			1,249	
	3,130	1,816	1,373		1,088		dead	1,185	
	3,048	1,227	1,062		1,032			1,145	
	2,506	1,126	1,043		dead			1,105	
	1,330	dead	dead					1,030	
Sum	95,874	65,311	53,113	57,020	34,482	53,160	10,640	35,060	2,175
Mean	4,794	3,437	2,795	4,752	1,916	3,997	709	1,753	272
		$p > 99.0$	$p > 95.0$		$p > 99.0$		$p > 99.9$		

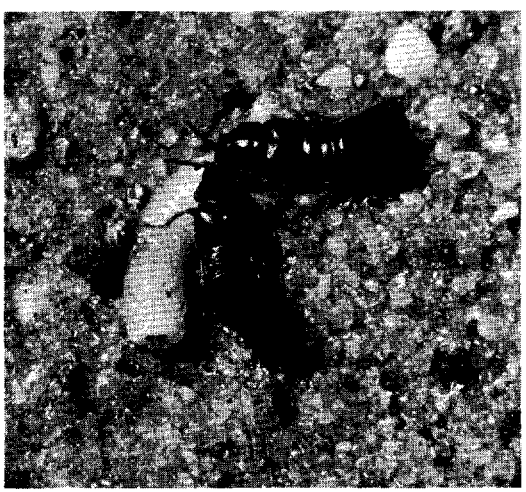
During 20 days of observation the 20 control specimens from the first labelling (^{54}Mn) ate, mated, oviposited and moved normally. The sand in their box became more and more radioactive as faeces were deposited. Observation of these 20 specimens and the other groups before and during labelling indicated a strong need for water just after emergence. Already 2–3 days after emer-

Table 4. Dates of trap inspections
Datoer på hvilke faldgruberne blev efterset

1975:			1976:		
May	28.	Release	June	11.	Release
	29.			14.	
	30.			15.	Release
	31.			17.	Release
June	2.			18.	Release
	3.			21.	
	4.			22.	Release
	6.			23.	
	7.			24.	Release
	9.			25.	
	10.			28.	
	11.			29.	
	12.			30.	Release
	13.		July	1.	
	16.			2.	
	19.	Release		5.	
	20.			6.	
	21.			7.	
	23.			8.	
	24.			9.	
	26.			12.	
	30.			13.	
July	2.			14.	
	7.			15.	
	9.	Last recapture		16.	
	14.			19.	
	16.			20.	
	18.			21.	
	21.			22.	
	23.			23.	
	25.			26.	
	28.			28.	
	29.			30.	
	30.		Aug.	2.	
Aug.	1.			4.	
	4.			6.	
	6.			9.	Last recapture
	8.			11.	
	11.			13.	
	13.			16.	
	15.			18.	
	18.			20.	
	20.			23.	
	25.			25.	
				27.	
				30.	
			Sept.	1.	
				3.	
				7.	

gence this need seemed to decrease as wet material was much less attractive even to beetles which had spent 24 hours without water. The tendency to start flying seemed to be strongest the first 2–3 days after emergence. When the beetles were released in sunshine many started flying.

The frequency of trap inspections appears from table 4. Dates of recaptures, numbers recaptured and their distribution are shown in figures 3 (1975) and 4 (1976). In 1975 a total of 143 specimens of the 900 released were recaptured. Of these recaptured animals 130 were from the first release of 600 and 13 could be from either of the two releases. Of the 300 *A. bilineata* released the 19th of June 1975 many were still on the release spot the next day. 10–15 were found dead. 1033 specimens were released in 1976 and of these beetles 47 were recaptured. In 1975 the labelling was efficient for about 20 days and in 1976 for at least 40 days. In 1975 the maximum distance of dispersal proved by trapping was 17 metres and in 1976 26 metres. The maximum distance was reached within 5 days in 1975 and within 4 days in 1976. On figure 3 different lines indicate the covering area after 5, 7 and 13 days after first release. On figure 4 similar lines indicate the covering area after 4 and 14 days.



Two *A. bilineata* from a culture eating a house fly larva. *To A. bilineata i færd med at æde en stuefluelarve.*

Discussion

Of the three labelling methods investigated the method using radioisotopes was obviously the best one because of its simplicity and the durability of labelling (up to 40 days).

The strong variation of radioactivity per animal within the single batch (conf. table 2) presumably reflects a variation of the water need of the beetles. In accordance with the observations of water need in proportion to age groups A and 2 became significantly stronger labelled than groups B, 6 and 7 respectively (conf. table 2).

Both $^{54}MnCl_2$ and $^{65}ZnCl_2$ are »loose labels« as they are diurinated with the faeces rather quickly. Table 3 shows the rate of decrease of the radioactivity among $^{54}MnCl_2$ labelled specimens. It should be noted that the control specimens have the highest rate of decrease. This may be due to a higher flux through the alimentary canal because the control specimens were supplied with unlimited amounts of food and water.

A comparison of A with 2 in table 2 indicates that $^{54}MnCl_2$ may give a stronger labelling than $^{65}ZnCl_2$. However, the strength of labelling with $^{65}ZnCl_2$ was sufficient and the durability much better. Thus $^{65}ZnCl_2$ appears to be the label of choice for this purpose. The second labelling with the same strips gave a better labelling than the first one – 2 and 5 compared with 1 and 3 in table 2; for comparison of supply see table 1. – Further reuse of the strips and corresponding increase of radioactivity (4, 6 and 7 in table 1) did not increase the radioactivity of the beetles significantly (table 2: 4 compared with 2 and 5). Thus about 600 μCurie of $^{65}ZnCl_2$ was the optimal amount used under the chosen conditions.

A better retention of ^{65}Zn was obtained by Nordink (1971) and Loosjes (1976), who labelled larvae and adults of the onion fly (*Hylemya antiqua*). Queens of bumblebees, *Bombus terrestris* and *B. agorum*, labelled with $^{54}MnCl_2$ (in sugar solution) were easily recognizable for 2 months (Esbjerg, unpublished results from 1971).

The recapture of 130 specimens of the first 600 beetles released in 1975 is so high (22 per cent) that it is unlikely that more than a few of the released beetles have flown away from the field.

The much lower recapture of the 300 beetles released later in 1975 is presumably due both to poor labelling (conf. table 2) and to stress after the release. The observation of dead beetles at the release spot on the day after release indicates that »something went wrong«. Presumably the release on wet soil in strong sunshine in some way has been hazardous to the beetles.

In 1976 the recapture of only 47 of 1033 (4.5 per cent recapture) released *A. bilineata* may seem rather low. It should, however, be remembered that the trap distribution was changed from 1975 to 1976. Hence each trap in 1975 covered 10 m^2 (3.3 × 3.3) while in 1976 each trap of the »inner« area covered 30 m^2 (5.5 × 5.5). Thus in 1976 the recapture within the area of »1975-size« should be 3 times lower. It should also be remarked that in 1975 there was a number of cases with recapture of several specimens in the same trap. This might be due to pheromone-based aggregation, and if so the chance of this sort of catch was highest in 1975, because many more beetles were released at just the same time and the covering area per trap was smaller. If aggregation accounts for 20–25 specimens in 1975 this and the different trap distribution may explain the difference in recapture between 1975 and 1976.

The dispersal of the beetles over the area is visualized by the »front lines« on figures 3 and 4. They should be compared with the circularshaded area on figure 3. This area has a radius of 10 metres. Release of 20,000 *A bilineata* per hectare for control would mean 628 specimens in the shaded area, which could be compared with the first release of 600 specimens in 1975.

The conclusion of the dispersal results is, that realease of high numbers of *A. bilineata* (i.e. 20,000 per hectare) for biological control of cabbage root flies does not require a careful spread of the beetles all over the field. A spread of batches with a maximum of 10 metres to field edges and 20 metres between batches should be sufficent to ensure quick covering of the total area. Hence this part of a biological control programme with *A. bilineata* will be very simple.

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