A Preliminary Experiment in the Use of Co^{60} in Studies of Small Mammal Predation on the Swaine Sawfly, Neodiprion swainei Midd.—This note describes a preliminary experiment in the use of cocoons tagged with Co^{60} in the study of small mammal predation on the Swaine sawfly. It is reported now because the work must be discontinued for a number of years, and the information may be of value to anyone contemplating a similar experiment.

The Swaine sawfly passes the winter in the cocoon stage in the soil and during that time it is subject to attack by small mammals. These predators leave characteristic markings on the opened cocoons so that it is possible to separate them from others taken from soil samples. However, after one winter in the soil it is not possible to separate even the most recent generation of cocoons from the many generations present. Buckner (1959, Can. Ent. 91: 275-282) encountered a similar situation in studies on the larch sawfly, *Pristiphora erichsonii* (Htg.). He suggested that cocoons attached to the short wires of a wooden tree tag could be placed in the soil and examined periodically to determine the timing and level of predation on the current generation of the sawfly. This method proved to be unsuccessful with *N. swainei* cocoons because a large percentage (up to 20 per cent) were lost from the wire loops; there was no way of determining whether these had been removed by predators or had collapsed and fallen out after the death of the insect. The technique was modified by attaching five cocoons at one-foot intervals along a five-foot length of wire, by means of short lengths (about 2 inches) of fine copper condenser wire. Each unit was placed in a slit in the soil, and care was taken to see that all the wires were below the level of the cocoons before the slit was closed. The use of the condenser wire had the advantages that it was soft enough to allow the loops to collapse with

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the cocoons if they collapsed and it was weak enough to be broken by small mammals. The latter factor enabled the mammals to remove the cocoon for caching, or consumption at a more protected location. This necessitated the assumption that any broken wires could be attributed to small mammals. This technique was more successful in that more collapsed cocoons were recovered, but it still had some drawbacks when used with *N. swainei* cocoons in jack pine stands. These were: (1) the recovery process was time consuming and involved a marked disturbance to the soil which could well influence the response of predators, if the cocoons were to be examined periodically; (2) the cocoons, particularly those of the males, were so small that the operation of tying wires to them was tedious and time consuming, and (3) a small number of the cocoons were still lost from the wire loops so that their fate remained unknown. It was reasoned that if a radioactive tag were used these objections could be overcome. Any missing cocoons could be assumed to have been carried off by predators and the soil disturbance factor would be reduced to a minimum.

The radioactive tagging substance was prepared by adding about 1 c.c. solution of acetone-soluble deKotinsky cement (the consistency being such that a small drop could be raised from it on the head of a pin) to 5 millicuries of radioactive dried cobalt as nitrate. The entire mixture was then carefully diluted with acetone until two small drops placed on opposite sides of the centre of a cocoon gave a source of about 10 μc. The tag on each cocoon was maintained at this level by the addition of acetone to the solution when necessary. The level of activity on each cocoon was estimated by means of a Geiger counter that had been calibrated against a known source.

The vial containing the tagging material was kept in a lead castle which was surrounded by a lead shield on a fume hood work table. To facilitate the application of the cement to the cocoons, they were placed 10 at a time on the sticky surface of a strip of masking tape which had been fastened to a small piece of wood. They were left on this board until dry. The tags can be applied very rapidly by the use of a number of these boards.

A total of 495 cocoons were tagged. These were packed in a lead-protected container and shipped from Chalk River, Ontario, to Clova, Quebec, on October 1, 1958, and were distributed in the field on October 23. Two hundred and forty-five were set out 16 miles south of Clova in groups of 5 at one-chain intervals in a grid which measured 4 chains by 9 chains. Each group of five cocoons was set out in a line with individual cocoons at one-foot intervals. The remaining 250 were set out in similar fashion in an area 43 miles south of Clova. One week prior to this the same number of untagged cocoons had been set out in both areas in similar fashion with each cocoon fastened to a wire as described above. The cocoons for both types of plants were obtained through rearing larvae in the laboratory.

The study area was visited on April 27, 1959 but the presence of snow at the Mile 16 plot prevented an examination of all the cocoons; Mile 43 area could not be reached because of impassable roads. However, five of the stations at Mile 16 were examined. The cocoons were located with the aid of a Geiger counter, at the rate of about one per minute and all 25 were in good condition.

The area was visited again on October 1, 1959. This time the tagged cocoons were very difficult to find owing to the contamination of the soil for one to two inches around each cocoon. This made recovery a laborious process as the soil had to be lifted out and searched carefully.

An analysis of the cocoons recovered from the plot at Mile 16 is shown in Table I. The data in this table indicate that the experiment was unsuccessful in attaining its purpose because some factor inhibited the development of the sawflies and parasites, and it cannot be stated with certainty whether the missing cocoons (131 out of 245) were carried off by predators or were merely overlooked in searching the soil.

TABLE 1

The Analysis of Cocoons Planted at Mile 16, Clova, in October 1958 and Recovered in October 1959

	No. of cocoons	Sawfly emerged	Parasite emerged	Preyed on		Living	Dead	Missing
				Mammal	Insect			
Co^{60} tag...	245	0	1	14	24	18*	57	131
Wire.....	245	40	26	109	31	9	23	7

* All larvae were flaccid and appeared unhealthy.

The lack of emergence and high mortality encountered in this experiment was unexpected as much stronger sources of radiation have been used successfully in experiments with other insects. Baldwin (in Litt.) has used tags up to 100 μc. on individual adult moths which still produced viable eggs after one or two weeks, and Hassett and Jenkins (Science 110: 109-110, 1949) successfully reared second instar mosquito larvae in a solution with a strength of 10 μc/ml. It is possible that the solvent used (acetone) may have been a factor but this seems unlikely since it dried very rapidly and very little of it came in contact with the individual cocoons.

The contamination of the soil around the cocoons was also surprising since both the cement and the cobalt nitrate were insoluble in water. It is possible that soil insects chewed the tag and dispersed particles of it.

The planting of cocoons promises to be a valuable tool in studies on the population dynamics of the Swaine jack pine sawfly and other insects with similar life cycles. In addition to the assessment of mortality due to mammal predation, other sources of mortality functioning during the cocoon stage can be measured. The recovery of planted cocoons can be accomplished by tying them to wires, but this is a time consuming process and results in undesirable disturbance to the soil if the cocoons are examined frequently. The use of a radioactive tag can overcome these difficulties but the present experiment indicates that the tolerance levels of the pre-pupa and pupa should be investigated before additional experiments are conducted in the field. Should these levels prove to be sufficiently high it would not be difficult to develop a carrier for the isotope that would prevent contamination of the soil.

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