

Establishment and Efficacy of *Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae) in Controlling *Carduus nutans* L. in North Carolina

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Musk thistle, *Carduus nutans* L., has become a serious weed pest in North Carolina since its accidental introduction in contaminated hay from the Midwest during drought periods in the late 1980's. Livestock will not graze near the thistles due to their sharp, spined leaves. A moderate infestation of musk thistle can reduce foragable land by 23% (Kates et al. 1972, in Trumble and Kok 1982). High reproductive rates and longevity of seed in the soil (5-7 years) makes this weed extremely persistent (Kok 1992).

A Eurasian weevil, *Rhinocyllus conicus* Froelich, also known as the flowerhead weevil, has been a successful biological control agent in Virginia, suppressing populations of musk thistle in 6 years (Kok and Surles 1975). Weevils lay eggs on the bracts of the musk thistle flowerheads. When the larvae emerge, they burrow into the receptacle where they feed, pupate and then emerge as adults. Larval feeding in the receptacle inhibits seed development by cutting off nutrients to the seeds.

On 8 May 1993, 1,970 flowerhead weevils collected from Tennessee were released at the Spruill Farm in Nash County, N.C. The farm was infested with dense stands of musk thistle in fields, around buildings and in unused hog lots. The objective of the study was to determine the impact of flowerhead weevil populations on musk thistle seed viability.

Materials and Methods

In 1993, a map of the infested site was drawn using ground surveys and aerial photos. The map was then split into four replicates based on adequate stands of thistles for sampling. The same map template and replicates were used in 1994 and 1995. On 28 April 1995, an absolute count of musk thistle plants was made. Each plant was represented by a dot on the map. On 12 May 1995, twelve plants from each of the four replicates were randomly selected and tagged with their replicate and plant number. Plant height was measured at terminal flowerhead bloom from the base of the stem to the blooming terminal flowerhead. Weekly collections of senescing terminal through fifth lateral flowerheads were made, so that each plant had a total of six flowerheads sampled. These were cut from the plant, placed in small coin envelopes, sealed and labeled by replicate, plant number and flowerhead ranking. The last of the flowerheads were collected on 22 June 1995.

In the lab, the diameter of the receptacle of each flowerhead was measured and recorded. Next, the bracts were cut off for easier handling of the flowerhead. Using a bone knife, thin slices were made through the receptacle in order to count and record the number of weevil pupal cells. Seeds were counted and stored in small envelopes with replicate, plant number and flowerhead ranking.

Seeds from each flowerhead were tested for viability using equipment in the NCDA Plant Industry Division's Seed Testing Laboratory. Thistle seeds were taken from the envelopes and placed in a General seed blower with the weight setting on 20, giving the blown air a velocity of 1680 linear feet per minute. This removed excess debris and light seeds. The remaining seeds

were then counted again, weighed and the weight and number of seeds was recorded. To determine germination viability of the seeds, they were placed in petri dishes on two layers of germination blotter paper. To break dormancy, KNO_3 was poured in each dish, then squeezed dry. Up to 100 seeds were placed in each dish. Petri dishes with seeds were then placed in germination chambers with a photoperiod of 16:8 light:dark hours and alternating day/night temperatures of 25/ 15 degrees Celsius. Seeds were left in the germination chamber from 3-21 days. During this period, sprouted seeds were removed from the petri dish and their numbers were recorded. If the seeds did not sprout after 21 days they were recorded as unviable.

Results and Discussion

The absolute count of musk thistle at the Spruill Farm is shown in Figure 1. The absolute count was 5885; last year's count was 1504 plants. The increase in plant number was probably due to an increase in rain in 1995, causing seeds in the soil from previous years to germinate. Ungerminated seeds can remain viable in the soil for 5-7 years. Plant height measurements averaged 141.14 cm for the 48 plants sampled. This compares to 125.28 cm for 1994 and 176.90 cm for 1993.

Flowerhead dissections revealed several parasites inside pupal cells, including two Eurytoma sp. (Hymenoptera: Eurytomidae) which develop in seed heads, 4 Pteromalidae spp. , 24 Nealiolis curculionis (Fitch) (Hymenoptera: Braconidae), one Bracon mellitor (Say) one Bracon analcids (Ashmead) (Hymenoptera: Braconidae) and one Eupelmus lyaniceps Ashmead (Hymenoptera: Eupelmidae). The total parasitization rate was 0.56%. Two of these species are new host records for Rhinocyllus conicus, B. analcids and E. lyaniceps.

Figure 2 shows the mean number of R. conicus pupal cells for terminal (n=48), first (n=48), second (n=48), third (n=48), fourth (n=45) and fifth (n=42) lateral flowerheads was 30.46, 23.44, 19.91, 17.36, 14.81, and 11.36 respectively. Average flowerhead diameter for terminals were 3.61 cm, first laterals were 3.13 cm, second laterals were 2.69 cm, third laterals were 2.19 cm, fourth laterals were 1.95 cm and fifth laterals were 1.93 cm. The correlation between flowerhead receptacle diameter and the number of pupal cells is shown in Figure 3. The average number of seeds before running them through the blower was: 24.02 for terminals, 17.55 for first laterals, 17.98 for second laterals, 17.36 for third laterals, 27.60 for fourth laterals and 29.65 for fifth lateral flowerheads. Figure 4 shows that as the number of pupal cells increases in the flowerhead, the number of seeds decreases. Average percentages of seeds germinated for terminal, first, second, third, fourth and fifth lateral flowerheads were 38.28%, 51.11%, 44.74%, 50.28%, 39.12% and 48.56% respectively (see Figure 5).

Uninfested musk thistle terminal flowerheads have an average of 1000 seeds; lateral flowerheads average 850 seeds (Rees 1982). Uninfested flowerheads have a 69% seed germination rate. Thus, uninfested terminal flowerheads average 690 viable seeds, while uninfested laterals average 587 viable seeds. our data from the Spruill Farm shows that terminals are averaging 9.19 viable seeds, while first through fifth lateral are averaging 8.97, 8.04, 11.77, 10.80, and 14.39 seeds respectively. This is a 98.67% decrease in viable seeds from the terminal flowerhead and a 98.16% reduction in viable seeds in the lateral flowerheads.

As the number of flowerhead weevil pupal cells increases, the number of viable thistle seeds will continue to decrease. The average number of pupal cells for terminal through fourth

lateral flowerheads increased by 226.65% over last year (1994). The percentage of terminal flowerheads with one or more pupal cells rose from 95.65% in 1994 to 100% in 1995, first laterals went from 95.65% to 100%, second laterals went from 95.55% to 97.92%, third laterals went from 73.33% to 93.75%, and fourth laterals remained at 73.33%. If current population trends of R. conicus continue, musk thistle seed production will remain low, causing populations of the thistle to be substantially suppressed by 70-90%, which would confirm results from similar studies in Missouri, Montana, and Virginia.

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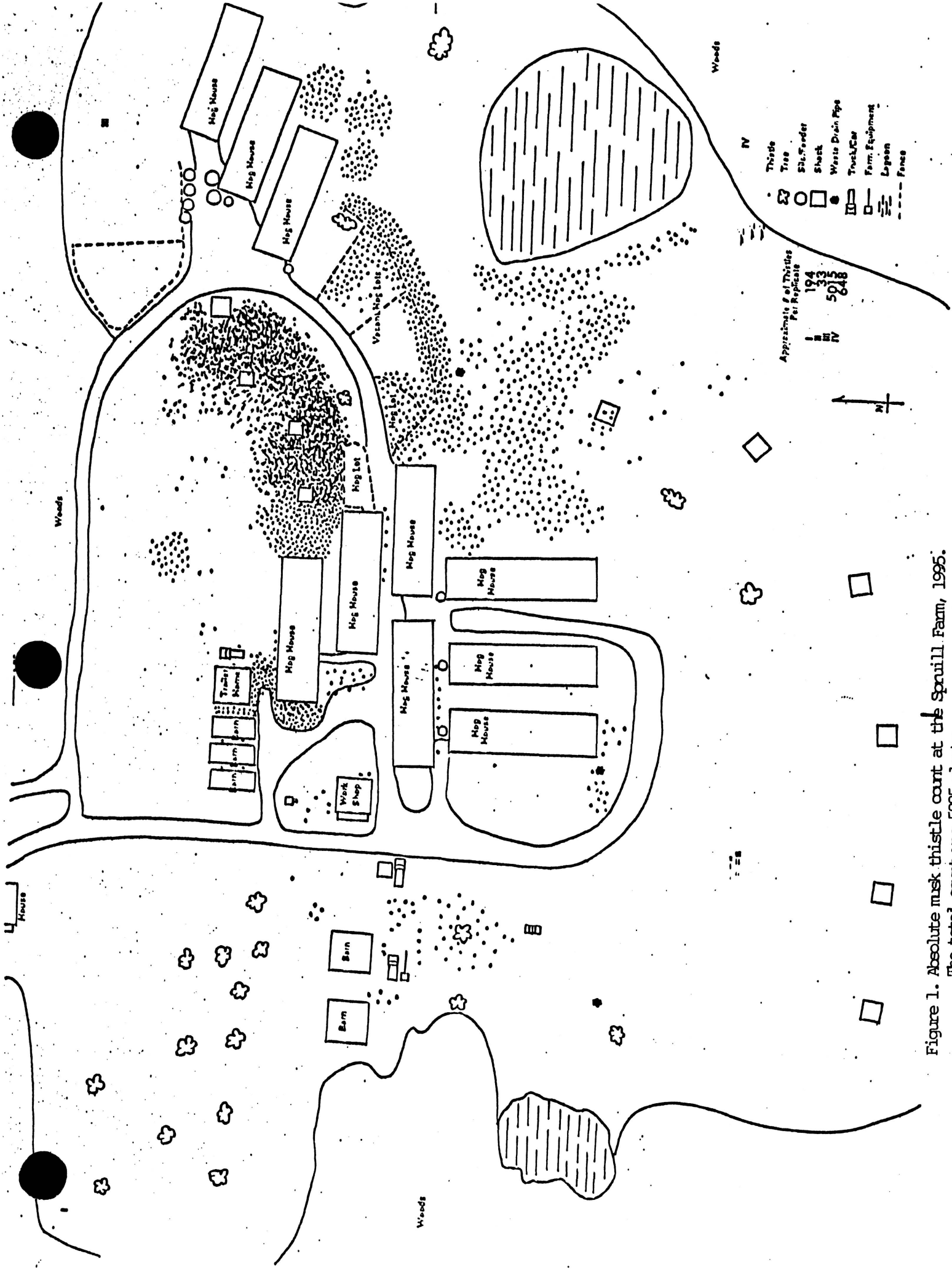


Figure 1. Absolute musk thistle count at the Spruill Farm, 1995.
The total count was 5008 thistles.

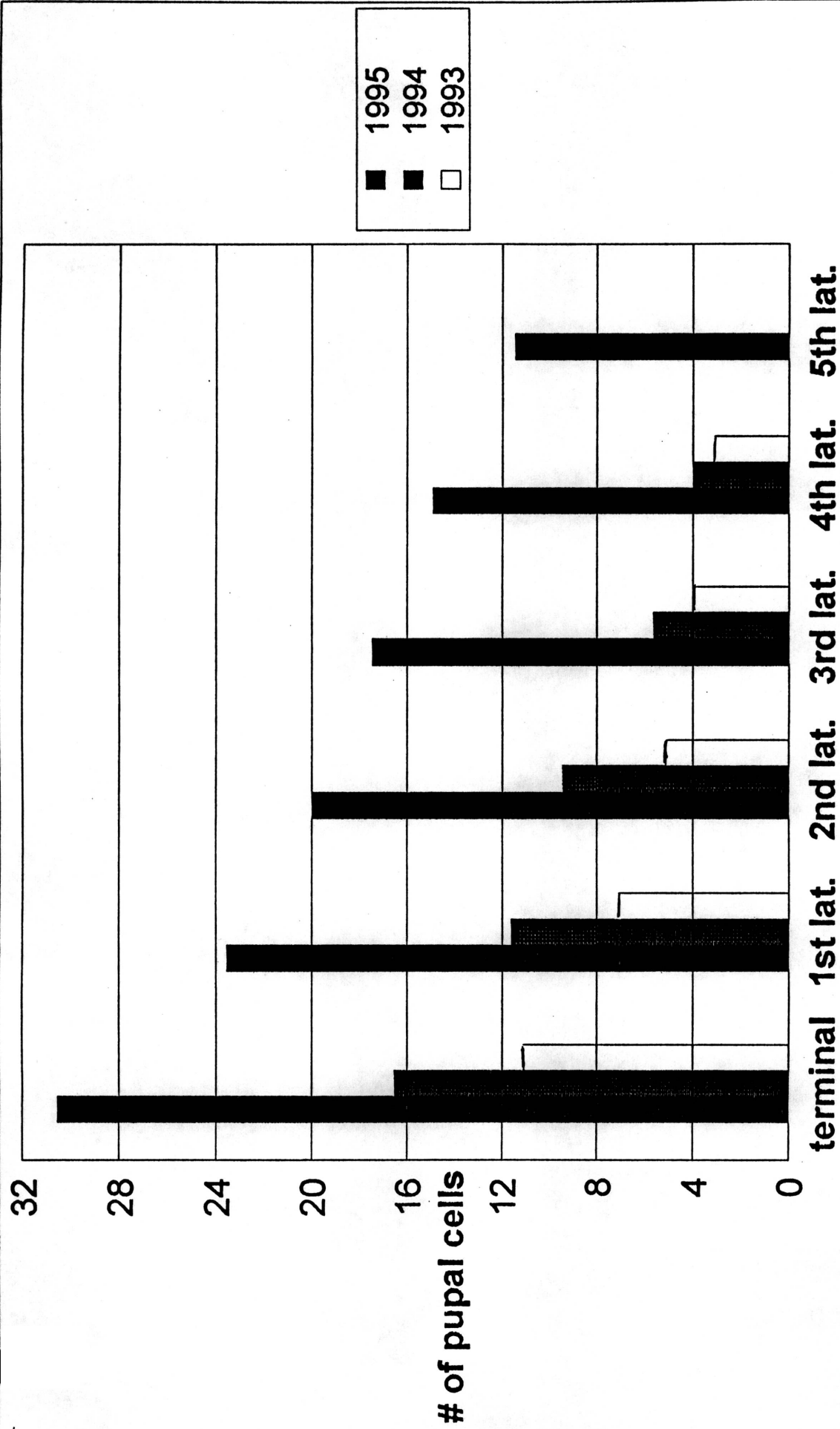


Fig. 2 Mean *R. conicus* Pupal Cells/Flowerhead.

1993-1995

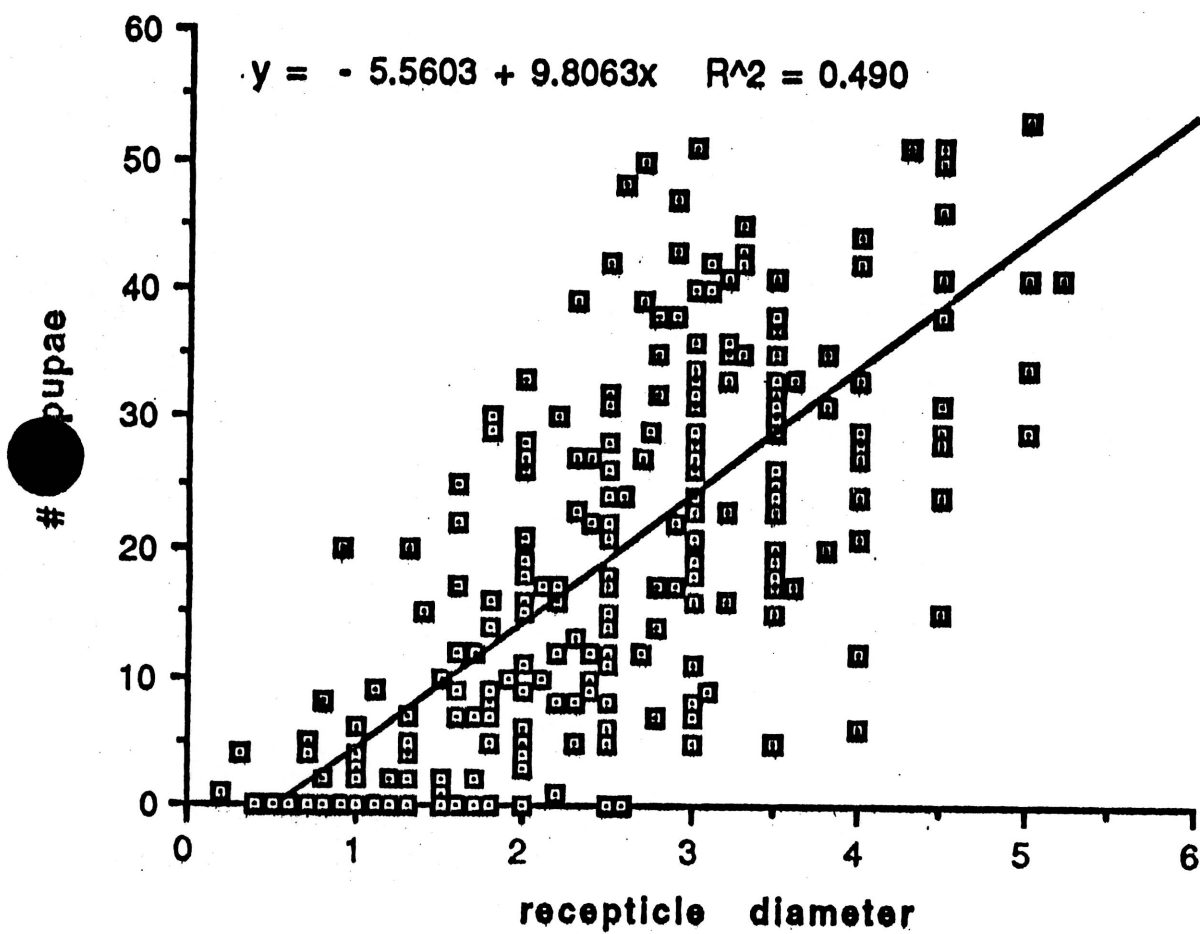


Fig. 3 Number of *R. conicus* pupal cells vs. receptical diameter.

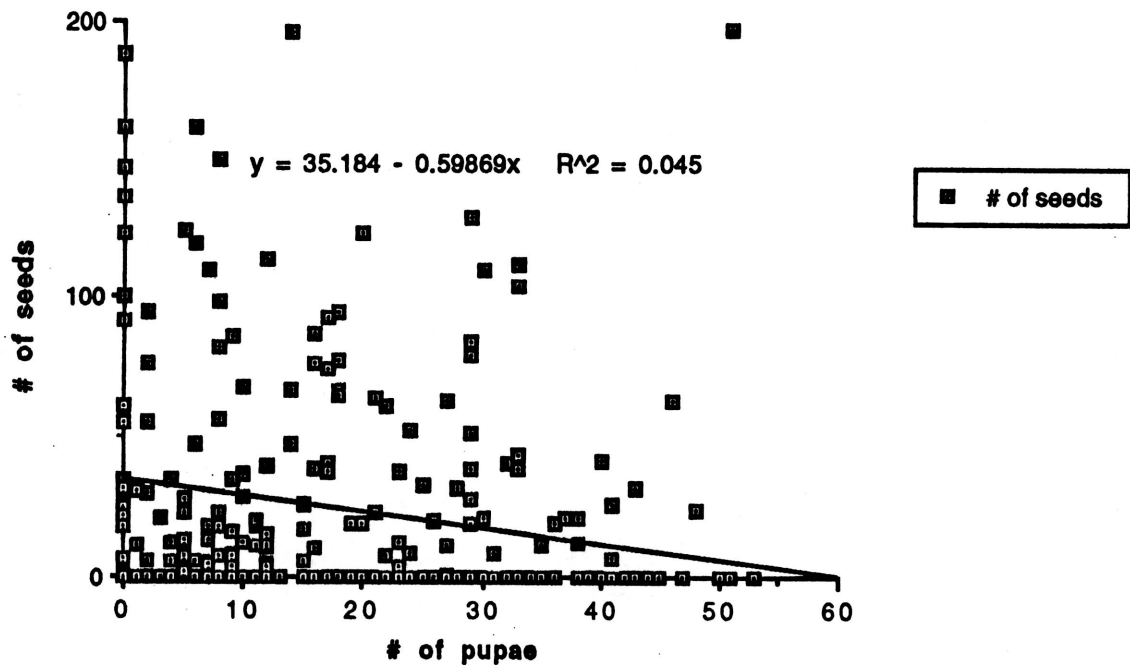


fig. 4 Number of seeds per flowerhead vs. number of R.
conicus pupal cells.

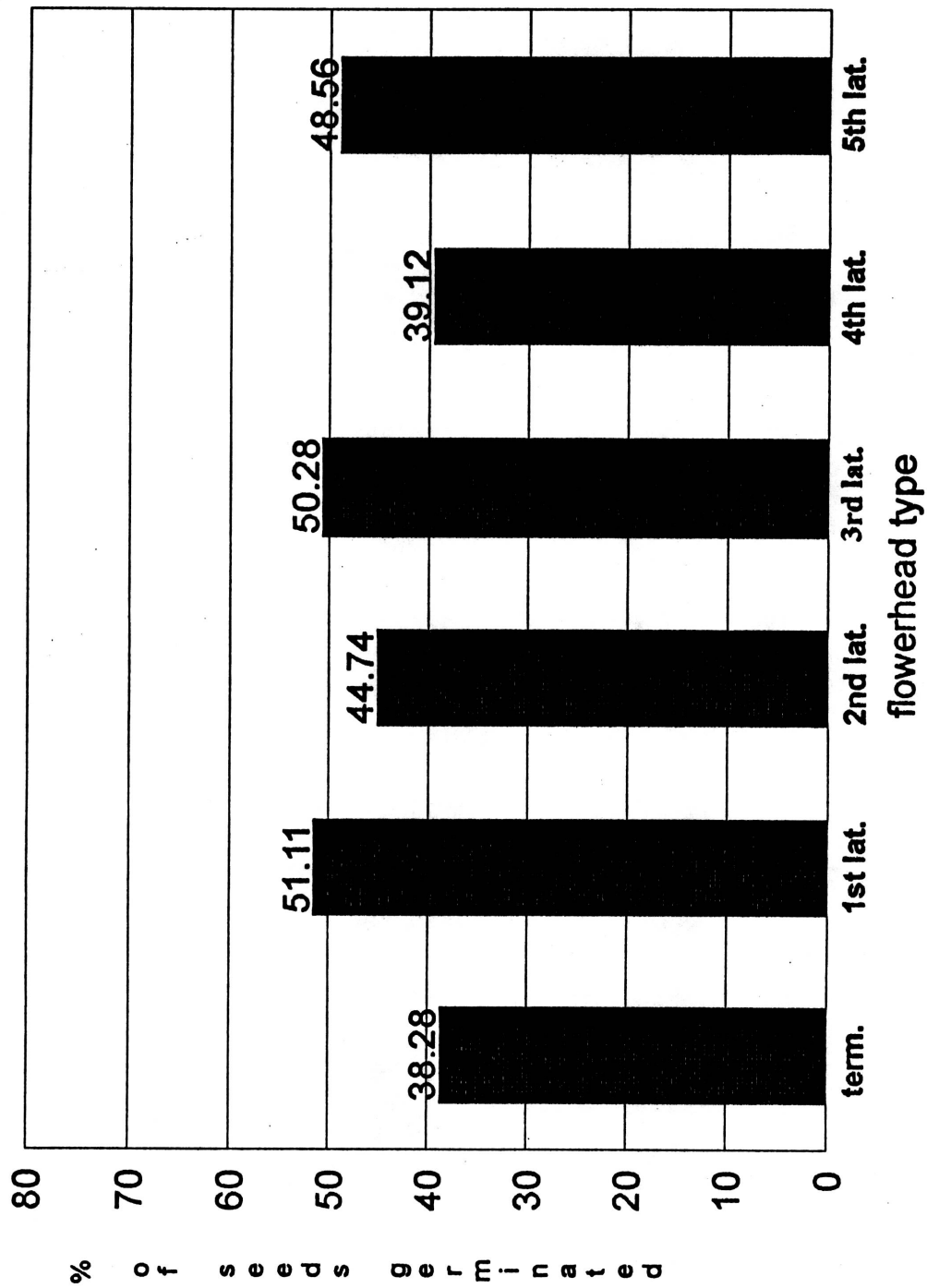


Figure 5. Seed germination % for *R. conicus* infested flowerheads.

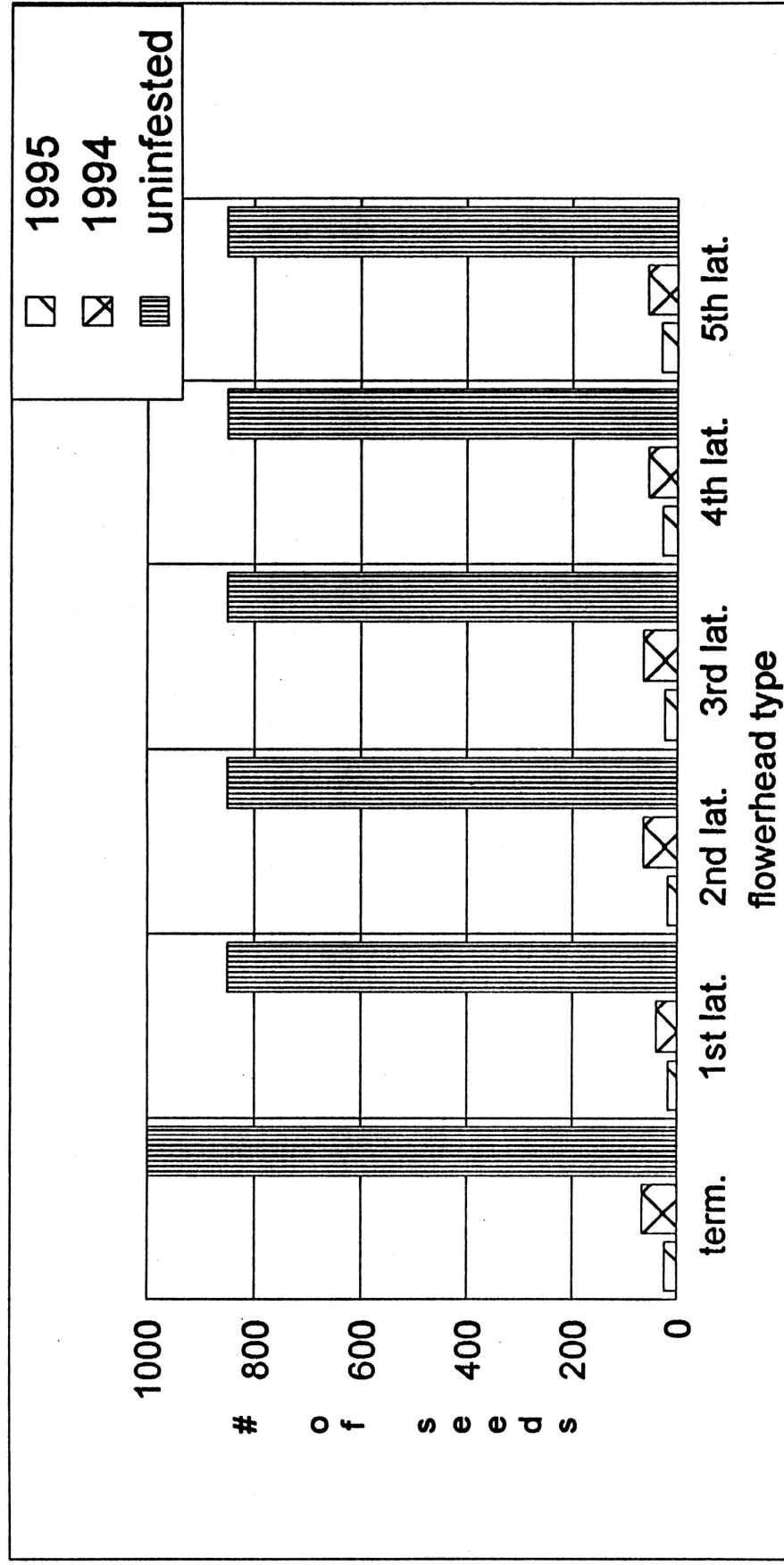


Fig 6. Average number of seeds/flowerhead type.