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# Experiments on calling and mating of codling moths as a measure of competitiveness

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Calling of female codling moths was studied with reared and wild insects under different light regimes in the laboratory. After mating females interrupt calling for some days. This effect studied in reared insects was the same for females mated with fertile males and for females mated with sterile males. Mating of wild fertile and reared sterile insects was compared in the laboratory and in a field cage. In the field cage reared sterile females mated more often than wild females. Differences in males were less pronounced and were in favour of wild moths.

The success of the Sterile Insect Technique for controlling insect pests depends on the quality of the released sterile insects. Two of the most important factors contributing to the overall quality of sterilized insects are their ability to compete successfully with wild adults in meeting the other sex and in mating.

The female codling moth, *Laspeyresia pomonella* (L.), like other Lepidoptera, attracts males with a volatile sex pheromone. During attraction the female assumes a typical calling position in which she stretches the abdomen and bends the ovipositor downwards (FLURI *et al.,* 1974). It has been shown that newly copulated females are not attractive (GEHRING & MADSEN, 1963; HOWELL & THORP, 1972; PROVERBS, 1973) and that they recommence calling only partially and after some time (FLURI *et al.,* 1974). But do females that are copulated by sterile males recommence calling sooner and more often than those copulated by fertile males (HUTT & WHITE, 1974)? Another question included in our study was the mating frequency of reared sterile and wild fertile insects in a situation of competition in the laboratory and in a field cage.

## MATERIALS AND METHODS

Wild and reared codling moths were used in our 1975 study. The wild insects for experimentation were caught as full grown larvae in 1974 by band traps on unsprayed apple trees. The reared insects were produced in the laboratory on artificial diets (WILDBOLZ & MANI, 1971) from a strain restarted from field stock in 1974. Reared moths were easily identified by the red colour of the fat body caused by the addition of «Calco Red» to the larval diet.

Sterilization was achieved by irradiation of up to 1-day-old moths with 35 krad of gamma radiation in a cobalt-60 source. Under our conditions of irradiation this dose induces, on the basis of egg hatch, complete sterility in the

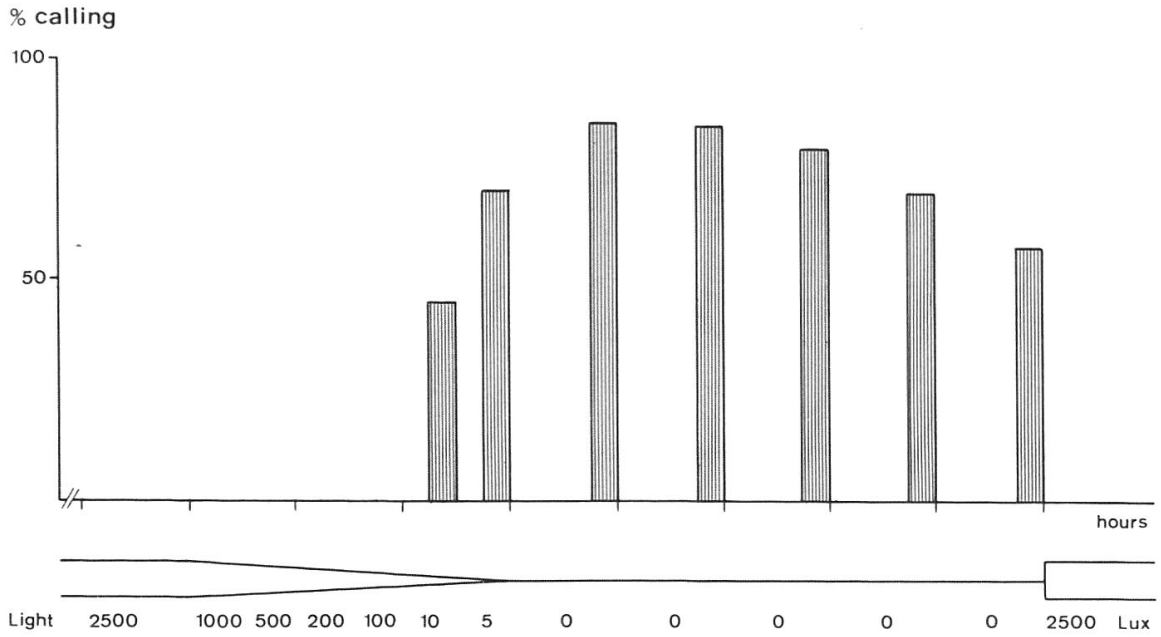


Fig. 1: Calling of reared virgin females in the laboratory under a regime of full light (2500 lux: 16 hours), twilight (1000-5 lux: 3 hours) and darkness (0 lux: 5 hours).

female moth and about 98,5% sterility in the male. The dose rate was approximately 2 krad/min. Insects to be sterilized and control insects were immobilized for handling by exposure to 2 °C.

Laboratory experiments were conducted in a climatized chamber: 24 °C, 70–80% R.H. In most experiments the chamber was illuminated with the following light regime: 16 hours at 2500 lux, 30 minutes each at 1000, 500, 200, 100, 10 and 5 lux, 5 hours (10.00–15.00 h) in darkness. In a few experiments the insects were kept 23 hours in darkness and 1 hour at 10 lux.

When mated female moths were included in experiments the females were dissected for spermatophores after death to confirm that mating had been successful.

*Calling of females* was observed in glass vials (60 x 23 mm) containing a single 2-day-old nonirradiated female, virgin or newly copulated. Twelve to 20 females were used in each treatment of 2 similar experiments. Continuous observations on calling were made during exposure at 1000 to 5 lux; during the period of full darkness observations were made for 1 min. (at 2 lux) every hour.

*Competitiveness of moths in mating* was assessed by tests in which wild fertile moths and reared sterile moths were compared. Such experiments were made in the laboratory by observing copulations of newly emerged virgin moths kept in cylindrical plastic boxes, 90 x 75 mm. Each control box contained either 1 reared sterile female and 1 reared sterile male (fig. 4, a) or 1 wild fertile female and 1 wild fertile male (fig. 4, b). Boxes in which competitiveness was measured always contained 3 moths, either 1 wild fertile female, 1 reared sterile female, and 1 reared sterile male, or 1 wild fertile female, 1 reared sterile male, and 1 wild fertile male (fig. 4, c, d). Sixty boxes per treatment were used in the experiment.

Observations for mating were made every 30 min. during the 8-hour period of twilight and darkness in each of 3 consecutive evenings. Darkness was interrupted for observation by a period of a few seconds at 2 lux.

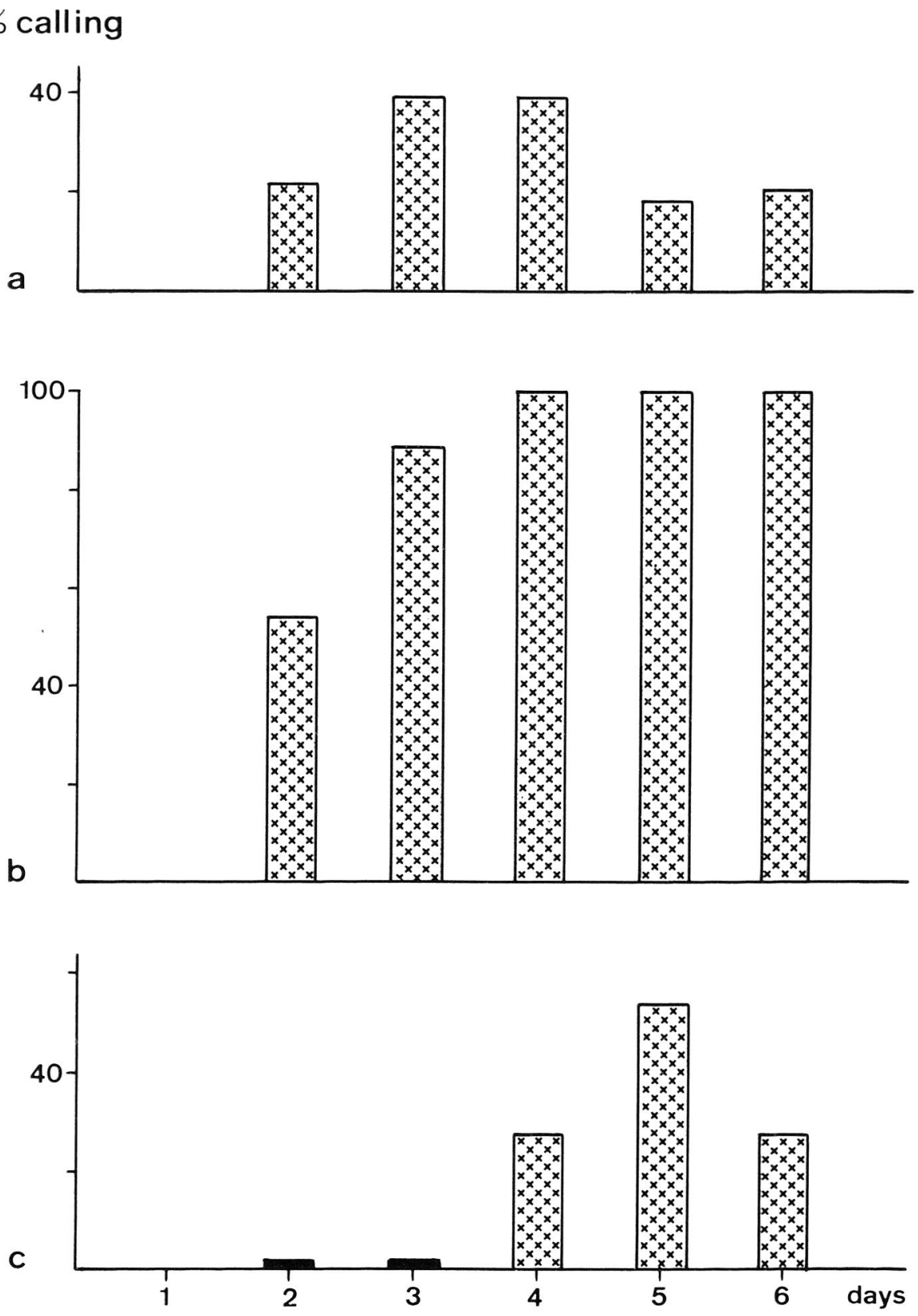


Fig. 2: Calling of females in the laboratory 1 to 6 days after eclosion. a, wild virgin females (photoperiod 19 hours); b, reared virgin females (photoperiod 19 h); c, reared virgin females (photoperiod 1 h).

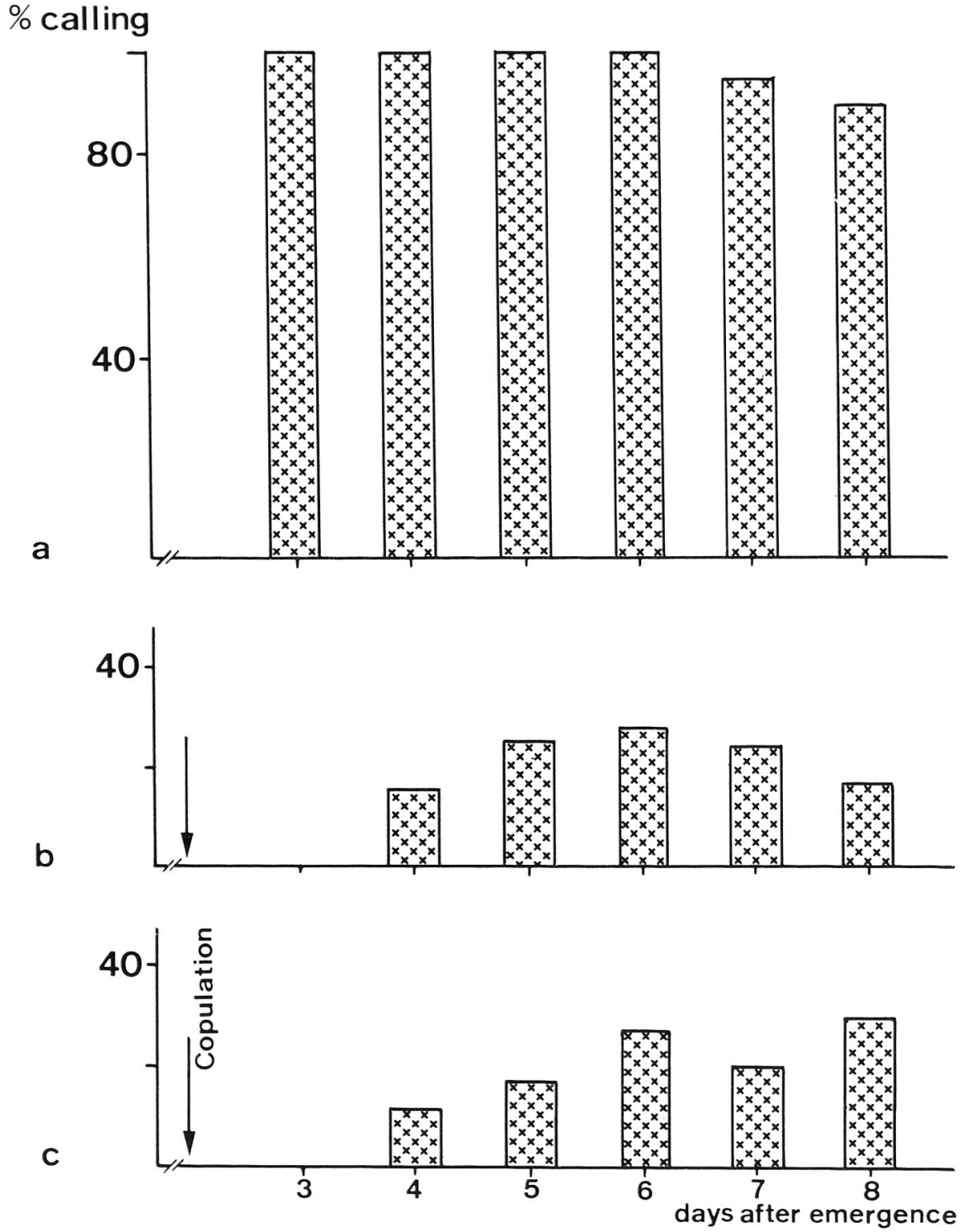


Fig. 3: Calling of reared fertile females in the laboratory. a, virgin females; b, females copulated the second day after eclosion with a reared fertile male; c, females copulated the second day after eclosion with a reared sterile male.

Further experiments on competitiveness were carried out in a field cage (2 x 2 x 2 m) containing an apple spindle. Sixty pairs each of newly emerged, wild fertile and reared sterile moths were introduced into the cage at 16.00 h. In the late afternoon and in the evening of the same and of the following day copulating pairs were collected, removed from the cage, and then registered and identified.

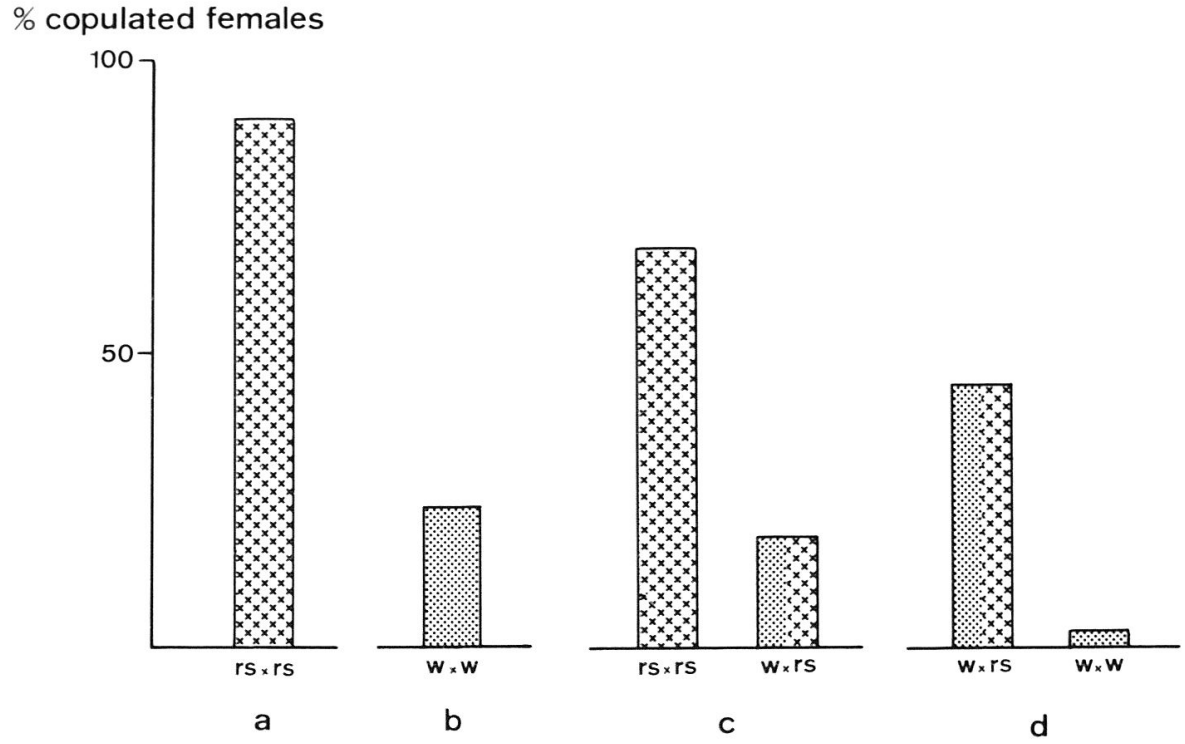


Fig. 4: Copulation of females held as pairs (a, b) or as triplets (c, d) in the laboratory. a, pairs: female reared sterile x male reared sterile; b, pairs: female wild fertile x male wild fertile; c, triplets: female reared sterile and female wild fertile x male reared sterile; d, triplets: female wild fertile x male reared sterile and male wild fertile.

## RESULTS

### Calling

Reared fertile virgin females called at a higher rate than wild insects (fig. 2). Calling in reared females was also clearly more steady than in wild moths. Wild females often ceased calling when disturbed. These findings are obviously due to a better adaptation of the laboratory strain to the conditions of the experiments. Calling started at 10 lux, reached a frequency peak just after the onset of darkness and then gradually decreased during the final 4 h of darkness (fig. 1).

In the normal light regime (L/D = 19/5 h) calling by reared and wild females started on the second day of life and reached a peak on the 3rd or 4th day. However, the L/D regime of 1/23 h retarded the start of calling to the 4th day of life and reduced the frequency of calling from 100% to 50% (fig. 2).

Newly mated reared females did not call for at least 2 days, whereas FLURI *et al.* (1974) found that first females started to call again only after 3 days. After 3–4 days about 25% of the mated females recommenced calling. This was true whether the females had copulated with reared fertile or with reared sterile males (fig. 3).

## Copulation

The percentage of moths that copulated in the laboratory was much greater between pairs of reared insects than between pairs of wild ones. Reared moths of both sexes also surpassed wild moths in situations of competition (fig. 4). These results reflect the selection of the laboratory strain to the conditions of the rearing facilities and should not be extrapolated to field conditions.

Four experiments were carried out in the field cage (7.-8.7., 23.-24.7., 28.-29.7., 5.9.75) with a total of 7 evenings of observation (table 1). Weather conditions varied between warm and sunny, and cool and rainy. On most sunny evenings copulations started after astronomical sunset at light intensities of 5-2 lux. Mating lasted for about 2 hours with a distinct peak. On rainy evenings copulations started earlier and at higher light intensities.

Most of the experiments as well as the total of all data showed that reared sterile females mated more often than wild fertile females (121 vs. 44). This tendency was more obvious on warm clear evenings than on rainy overcast evenings. Wild males on the other hand mated more readily than reared sterile males (103 vs. 62) but the difference was less pronounced than in females.

Table 1: Mating experiments in a field cage with equal numbers of wild fertile and reared sterile moths of both sexes.

| combination | mated pairs in 4 experiments | | | | total mated pairs |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | |
| ♀ w x ♂ w | 3 | 6 | 12 | 3 | 24 |
| ♀ w x ♂ rs | 4 | 1 | 8 | 3 | 16 |
| ♀ rs x ♂ w | 21 | 19 | 18 | 18 | 76 |
| ♀ rs x ♂ rs | 17 | 12 | 9 | 7 | 45 |

w = wild fertile moths rs = reared sterile moths

## DISCUSSION

Our study has clearly shown that mating with sterile males of our laboratory strain inhibited calling of fertile reared females as effectively and for the same period as mating with fertile males. PROVERBS *et al.* (1973), using field traps baited with laboratory-reared or wild female codling moths that were previously mated with sterile laboratory males, reported essentially similar results with the laboratory females, but with the wild females sexual attractiveness was regained somewhat sooner. Field experiments with nonconfined insects are required to confirm whether there is indeed an appreciable difference in resumption of calling between laboratory strains and wild females that are mated by sterile males.

Our field cage data on competitivity in mating give indications which are also of interest for sterile insect release programs. Results of field cage tests are somewhat biased by the fact that mating pairs are taken away and that numerical relations are altered thereby. However, tendencies found were consistent form the beginning and sufficiently clear. Sterile females of our laboratory strain and wild males mated more often than wild females and reared sterile males. The question remains open in how far these differences are due to irradiation (HUTT & WHITE, 1974, 1975) or to laboratory colonization. It has been shown that sterile females released in a control program are as effective as sterile males (WHITE *et al.*, 1976). Therefore, more successful reared sterile females and more successful wild males might largely balance their effects. These data should be followed up in further experiments.

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