Donahaye, E.J., Navarro, S. and Varnava, A. [Eds.] (1997) Proc. Int. Conf. Controlled Atmosphere and Fumigation in Stored Products, 21–26 April 1996, Printco Ltd., Nicosia, Cyprus, pp. 25–29

SENSITIVITY OF NARCISSUS FLIES (GENERA: *EUMERUS* AND *MERODON*) TO METHYL BROMIDE

E.J. DONAHAYE, S. NAVARRO, R. DIAZ AND MIRIAM RINDNER
Department of Stored Products, Agricultural Research Organization,
The Volcani Center, P.O. Box 6, Bet Dagan 50-250, Israel

ABSTRACT

Two species of narcissus fly attack the bulbs of *Narcissus* and *Amaryllis*, posing a serious quarantine threat when these crops are exported from Israel. The only available fumigant for rapid treatment is methyl bromide (MB). However, recent indications of phytotoxic effects on these bulbs required re-evaluating the fumigation schedule.

The sensitivities of the large narcissus fly (*Merodon eques* F.) and the small narcissus fly (*Eumerus* spp.) to MB were examined in the laboratory. Maggots of both species and pupae of *Eumerus* were obtained from infested narcissus bulbs and exposed in glass chambers at 28°C to different dosages of MB for 4 h periods. Because the *Merodon* develops inside the bulb, maggots of this species were transferred to cells hollowed out inside sound bulbs, and the bulbs were then placed inside the fumigation chambers. For *Eumerus*, where infestation is superficial, maggots and pupae were suspended in cages inside the fumigation chambers. Probit analyses of mortalities revealed that the dose required to obtain 99% kill (LD_{99}) was 20.4 g/m^3 for *Merodon* sp., whereas for *Eumerus* larvae and pupae it was 8.6 and 6.5 g/m^3, respectively. The high dosage required to kill *Merodon* may be attributed to the necessity that the gas penetrate to the target site.

INTRODUCTION

Of the insects attacking the narcissus bulb the most important economic pests are the large and small narcissus bulb flies. In Israel two species of the genus *Merodon* (the large narcissus bulb fly) have been recorded, *M. eques* F. and *M. geniculata*. The fly *M. equestris* F. does not occur in Israel but is present in Southern Europe, and by the thirties its range had extended to North America (Hodson, 1932). The species *M. geniculata*, recorded as restricted to North Africa and the Middle East, was believed to be the species present in Israel. However, recently large narcissus flies from a consignment of bulbs destined for the USA were identified as *M. eques*. This species is very similar to *M. geniculata* so the previous recordings of the latter species are in doubt. Since neither of these species has been recorded in the USA they would both represent a serious quarantine threat. It is characteristic of the large narcissus fly that the damage caused is not clearly visible from outside. Generally a single larva in each infested bulb develops close to the base. Pupation takes place either in the bulb or in the soil. According to Hill (1987) the fully grown larva of *M. equestris* leaves the bulb and pupates in the soil, whereas Brosh and Hadar (1977) state that although the larva usually pupates in the soil, it sometimes does so within the bulb. During the bulb export season (June–July) only larvae are present in the bulbs; however, the possibility of pupation within the bulb in the autumn increases the danger that this insect could spread as a result of transportation unless quarantine measures are undertaken.

The genus *Eumerus* includes two species known collectively as the small narcissus bulb fly: *E. strigatus* Fall. and *E. tuberculatus* Rond. Both species are known in Europe, Asia and North America (Hodson, 1927). *E. amoenus* has been recorded from the Mediterranean basin including Israel (Hill, 1987). However, it has been suggested that the species found in Israel is a new one that has still to be described (Nestel *et al.*, 1994). Therefore this species should be considered of limited distribution until proven otherwise. It should be added that numerous species of both the genera *Merodon* and *Eumerus* that do not attack the narcissus bulb exist in Israel. The problematics of identifying the narcissus flies have been discussed recently by Nestel *et al.* (1994). It is characteristic of the small narcissus fly that damage is visible externally as a mass of rotting tissue within which can be found a group of developing maggots. Infested bulbs can be identified and removed fairly easily during sorting in the packing station, thereby reducing the danger that the small narcissus fly will be introduced into importing countries.

Clearly, uncertainty about the systematic status of the narcissus flies, incomplete knowledge of their distribution, and the failure of control measures in the field to produce a complete kill (Luria and Hokes, 1992), all contribute to the necessity that a fail-proof quarantine treatment be undertaken. The most widely used treatment for rapid insect kill before export is fumigation with methyl bromide (MB), and this has become the standard means of control in recent years.

The recommendation for commercial scale fumigation is exposure to 40 gm/m^3 for 4 h (Bond, 1984). In the past, dosage levels also took into account a decrease in concentration due to both leaky chambers and the sorption by the bulbs, but recently chambers made of flexible plastic have been introduced that are capable of containing the gas with minimum leakage. Therefore, in order to prevent bulb damage due to accumulation of high concentrations, it is necessary to amass laboratory information on the MB concentrations needed to kill the narcissus flies.

This study forms part of a series of experiments designed to establish recommended dosage levels that will ensure a complete kill of the flies on one hand and avoid phytotoxic effects on the bulbs on the other. The objective of this experiment was to determine the concentrations of MB lethal to the two insect species (*Merodon eques* and *Eumerus* sp.).

MATERIALS AND METHODS

Source

Larvae of the large narcissus fly (*Merodon eques*) and of the small narcissus fly (*Eumerus* sp.) used in the experiments were removed from infested narcissus bulbs obtained during sorting at the packing stations.

The large narcissus fly

Preparation. Live larvae were found and removed from the infested bulbs by cutting into the rotting material. Clean bulbs were then infested with these larvae as follows: a tunnel was bored through the bulb along its longitudinal axis using an instrument for cutting holes in rubber bungs. This tunnel was about 50 mm in length and 7 mm in diameter. A live larva was then inserted into the opening and the tunnel was sealed at both ends, with bulb material taken from the core, in order to prevent the larva from either abandoning the bulb or desiccating. From then until the end of the experiment the bulbs were held in a chamber at 30°C and 70% relative humidity.

Fumigation conditions. Fumigations were carried out in glass desiccators with a capacity of 6.3 L. The fumigant was pure MB (without chloropicrin). The dosage was calculated on the basis of the free air space within the desiccator less the volume of the bulbs. Bulb volume was calculated on the basis of bulb weight times specific weight of 1.072. The dosage of MB was injected into the desiccators and the gas was initially mixed for a few minutes by a magnetic stirrer placed on the floor of the desiccator. Samples for measuring gas concentrations were taken at the beginning and end of the exposure period using a pressure lock syringe. These samples were injected into a gas chromatograph with the FID detector calibrated for MB. For each treatment, 20 infected bulbs were exposed to different dosages of MB for 4 h. A further sample of 20 infected bulbs, held in a desiccator without fumigant, served as a control. When the exposure period had elapsed, the bulbs were removed from the desiccators, placed in net-bags, and left in a laboratory fumigation hood overnight for aeration. Mortality counts were made 24 h after exposure.

No pupae were found during the collection from infested bulbs; consequently, the study was carried out only on larvae. Hill (1987) states that the larva leaves the bulb to pupate in the soil. Conversely, Brosh and Hadar (1977) record pupae in the soil and also sometimes in the bulbs.

The small narcissus fly

Preparation. Larvae of the small narcissus fly *Eumerus* sp. are usually found in small groups between the outer layers of rotting bulb leaves. Infestation is characteristically more superficial than with the large narcissus fly. Consequently, since gas penetration into the bulb was not considered a crucial factor in determining the sensitivity of *Eumerus* to MB, the larvae were collected and exposed directly to the gas rather than being placed inside bulbs.

Fumigation conditions. Larvae and pupae were collected separately from the rotting material of infested bulbs and 30 individuals each were placed inside cages. The cages consisted of capped plastic vials 34 mm in length and 14 mm in diameter, to the top and bottom of which wire mesh (No. 25) had been heat soldered. Flat-bottomed glass flasks with a capacity of 3 L served as fumigation chambers. The vials were suspended in the centers of the flasks with nylon thread which was attached to hooks in the ground-glass stoppers with which the flasks were sealed. The stoppers were also equipped with a device for injecting the measured dosage of MB into the flasks. This device consisted of a rubber septum set into the opening of a glass tube attached to the stopper. Initial mixing of the gas was done with a magnetic stirrer for a few minutes. Fumigations were carried out inside a fumigation hood at 28°C for an exposure period of 4 h. Larval mortality was recorded 24 h after treatment. Pupal mortality was defined as the number of pupae that failed to develop into adults.

For both species of narcissus fly mortality results were subjected to probit analysis using the program developed by Daum (1979).

RESULTS

Figure 1 shows probit mortality rates of larvae and pupae of *Eumerus* and larvae of *Merodon* plotted against log dose while mortality rates at the levels of MB required to kill 50% (LD_{50}) and 99% (LD_{99}) of the population are given in Table 1.

From the figure and table, it can be seen that a higher dosage is required to kill 99% of the population of the large narcissus fly than that required for the small narcissus fly. Clearly the necessity of the penetration of the gas into the bulb in order for it to reach the *Merodon* larva is a significant factor, causing both a delay in exposure and a reduced concentration at the target site. In addition there are possible differences in sensitivity to MB between the two species.

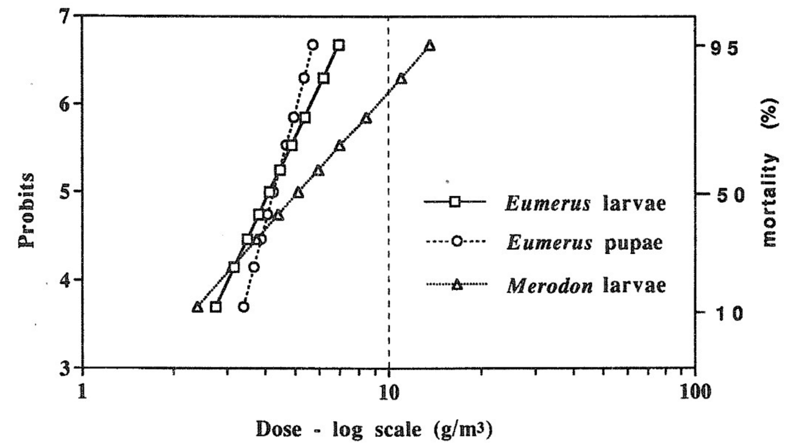

Fig. 1. Sensitivity of *Eumerus* larvae and pupae and *Merodon* larvae to MB (4-h exposure at 28°C).

TABLE 1

Mortality of *Merodon eques* and *Eumerus* sp. on exposure to methyl bromide for 4 h at 28°C

Stage	LD_{50}	Confidence limits	LD_{99}	Confidence limits	SE	Slope	Intercept
Merodon							
Larva	5.13	4.0–6.1	20.43	14.7–39.7	1.0	3.87	2.24
Eumerus							
Larva	4.13	3.1–.5–4.9	8.60	6.5–28.9	2.6	7.27	0.51
Pupa	4.28	3.8–4.6	6.49	5.9–8.0	1.0	12.86	–3.12

DISCUSSION

In spite of the recent decisions to phase out the use of MB, its status (UNEP, 1995) as a quarantine fumigant remains unchanged due to the fact that no alternative treatments exist. Therefore MB fumigations will continue to be carried out to control narcissus flies where quarantine regulations are in force. Previous fumigations were based on the fumigation schedule of Bond (1984) because no specific studies on the sensitivities of narcissus flies to MB were available. Zumreoglu and Erakay (1978) used a 2-h fumigation schedule at higher dosage rates. Though further studies are needed to confirm our findings, the results of these experiments will form the basis for the concentration levels to be achieved in future quarantine fumigations of narcissus bulbs in Israel.

REFERENCES

Bond, E. (1984) Manual of fumigation for insect control. *FAO Plant Production and Protection Paper* 54, Schedule N. Fumigation of flower bulbs and corms. p. 325.

Brosh, S. and Hadar, E. (1977) Seasonal appearance of the large narcissus fly in fields and in storage. *Hasaddeh* **15,** 493–497 (in Hebrew).

Daum, R.J. (1979) A revision of two computer programs for probit analysis *Bull. Ent. Soc. Am.* **16,** 10–15.

Hill, D.S. (1987) *Agricultural Insect Pests of Temperate Regions and Their Control.* Cambridge University Press, UK.

Hodson, W.E.H. (1927) The bionomics of the lesser bulb flies, *Eumerus strigatus*, Flyn., and *Eumerus tuberculatus*, Rond., in South-West England. *Bull. Ent. Res.* **17,** 373–384.

Hodson, W.E.H. (1932) The large narcissus fly, *Merodon equestris*, Fab. (Syrphidae). *Bull. Ent. Res.* **23,** 429–448.

Luria, G. and Hokes, M. (1992) *Control of Narcissus Flies.* Publication of the Israeli Ministry of Agriculture (in Hebrew).

Nestel, D., Ben Yakir, D. and Chen, M. (1994) The narcissus fly in Israel. *Hasaddeh* **75,** 81–83 (in Hebrew).

UNEP (1995) *Montreal Protocol on Substances That Deplete the Ozone Layer.* Methyl Bromide Technical Option Committee, Kenya. 304 pp.

Zumreoglu, S. and Erakay, S. (1978) Investigations on methyl bromide fumigation against Narcissus bulb fly larva (*Eumerus* spp.) in Aegean region. *Zinai Mucedele Arastirma Yilligi* **12,** 38–39 (in Turkish).