siveness of strain *E. coli* A 46 cannot be accounted for by its insensitivity against mutagenic agents. A control experiment to test the specificities of the respective strains was also set up. Hydroxylamine effects the single base change C → T, which is an analogous change to the G → A change effected by benzimidazole. Hydroxylamine should therefore be able to revert *S. typhimurium* G 46, but not *E. coli* A 46. For *E. coli* a very weak activity at the borderline of significance has been reported[9], whereas for *S. typhimurium* hydroxylamine has been described as a mutagen[7]. However, in a more recent publication, no mutagenic activity was found by using hydroxylamine hydrochloride in the Ames test[10].

We thus tested hydroxylamine according to the scheme given by Yanofsky et al.[9] in a fluctuation test, as the plate test has to be considered an unsuitable method for assaying hydroxylamine mutagenicity[12]. The treatment with 0.5 M hydroxylamine under addition of 10 mM EDTA, however, yielded a significant increase in the number of turbid tubes, but only so with strain *S. typhimurium* his G 46. The reversion of this strain is therefore possible by the transition C → T, whereas this transition does not revert the *E. coli* strain trp A 46. We can thus conclude that benzimidazole can effect only the GC → AT transition, as it reverts the *Salmonella* strain, which is also reverted by hydroxylamine, but cannot revert the *E. coli* strain, which cannot be reverted by hydroxylamine, too. The compound differs though from hydroxylamine in 1 important aspect; hydroxylamine acts directly on the DNA without the necessity of an active metabolism, whereas benzimidazole has to be metabolically converted to desoxyriboside and to be incorporated into DNA, before being able to exert its mutagenic activity. It shares however with hydroxylamine the singular property of inducing directed base changes in DNA, and it might be of interest to investigate its behaviour and molecular biology not only in bacteria but also in mammalian cell cultures.

Abbreviations: A, adenine; C, cytosine; G, guanine; T, thymine.

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2 J.P. Seiler, Mutat. Res. *15*, 273 (1972).
3 J.P. Seiler, Mutat. Res. *17*, 21 (1973).
4 J.P. Seiler, Analyt. Biochem. *75*, 45 (1976).
5 J.P. Seiler, Biochem. Genetics *13*, 635 (1975).
6 C. Yanofsky, in: Chemical Mutagens, vol. 1, p. 283. Ed. A. Hollaender. Plenum, New York 1971.
7 B.N. Ames, in: Chemical Mutagens, vol. 1, p. 267. Ed. A. Hollaender. Plenum, New York 1971.
8 M.H.L. Green, W.J. Muriel, and B.A. Bridges, Mutat. Res. *38*, 33 (1976).
9 C. Yanofsky, J. Ito, and V. Horn, Cold Spring Harbor Symp. Quant. Biol. *31*, 151 (1966).
10 J. McCann, E. Choi, E. Yamasaki, and B.N. Ames, Proc. nat. Acad. Sci. USA *72*, 5135 (1975).
11 S. Koller, in: Biochemisches Taschenbuch, vol. 2, p. 959. Ed. H.M. Rauen. Springer, Berlin 1964.
12 D.J. Brusick, and E. Zeiger, Mutat. Res. *14*, 271 (1972).

Sex attractants for male *Heliothis armigera* (Hbn.)

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Summary. (Z)-11-Hexadecenal and (Z)-11-tetradecenal were found to be sex attractants of male *Heliothis armigera* (Hbn.).

Heliothis armigera (Hübner) (Lep. Noctuidae) is a polyphagous insect widespread in Asia, Africa, Europe and Australia[4]. Because of its importance as a pest of field crops it was of interest to find attractants that could be used for monitoring its populations.

In evaluating synthetic compounds which cause electroantennogram response in insects[5], we found 3 aldehydes which elicited a significant electroantennogram response in male *H. armigera*. These were (Z)-11-hexadecenal [(Z)-11-HDA], (Z)-11-tetradecenal [(Z)-11-TDA] and (Z)-9-tetradecenal [(Z)-9-TDA]. (Z)-11-HDA and (Z)-9-TDA are known sex pheromone components of *H. virescens* (Fabricius)[6,7] and the former is a component of *H. zea* (Boddie) pheromone[6]. The behavioral reaction of male *H. armigera* to the 3 aldehydes was studied under laboratory and field conditions.

The experimental compounds (> 95% pure by capillary column gas chromatography) absorbed on 1 cm^2 filter paper (Whatman No. 1) were placed on top of a 30 × 30 × 30 cm screen cage containing 100 males. The males were observed for sexual reaction, i.e. exploratory flight towards the odor source and mating attempts. Each compound at 0.1, 1, and 10 µg dose was tested on 3 different cages. For field tests, the compounds were impregnated in 1 × 0.5 × 0.1 cm natural rubber and placed in traps[8] in cotton fields. 1 trap per treatment was used in tests 1-3 and 5 traps per treatment in tests 4 and 5. Traps were inspected daily and rotated from 1 trap location to the next[9].

(Z)-11-HDA and (Z)-11-TDA at 1 and 10 µg caused sexual excitation in caged males, but the latter did not stimulate the males at the lower concentration (table 1). (Z)-9-TDA had no stimulatory effect; moreover, it inhibited sexual

Table 1. Qualitative response* of caged male *Heliothis armigera* to synthetic compounds

Compound**	Amount loaded on filter paper (µg)		
	0.1	1.0	10.1
(Z)-11-HDA	+	+	+
(Z)-11-TDA	−	+	+
(Z)-9-TDA	−	−	−
(Z)-11-HDA + (Z)-11-TDA 10:1		+	
(Z)-11-TDA + (Z)-11-HDA 10:1		+	
(Z)-11-HDA + (Z)-9-TDA 10:1		−	
(Z)-11-TDA + (Z)-9-TDA 10:1		−	

* +, positive sexual reaction, in each replicate, of at least 5% of the males at one time during 1 min exposure to the chemical; −, no sexual response in all replicates. ** HDA-hexadecenal; TDA-tetradecenal.

Table 2. Field attractancy of male *Heliothis armigera* to synthetic compounds

Test*	Bait**	Mean No. of male catches per trap	Test*	Bait**	Mean No. of male catches per trap
1	5 mg (Z)-11-HDA	6		10 mg (Z)-9-TDA	0
	5 mg (Z)-11-TDA	3		5 mg (Z)-11-HDA + 5 mg (Z)-11-TDA	13
	5 mg (Z)-11-HDA + 5 mg (Z)-11-TDA	9		5 mg (Z)-11-HDA + 5 mg (Z)-9-TDA	0
	5 mg (Z)-11-HDA + 1 mg (Z)-9-TDA	2		Unbaited	0
	Unbaited	0	4	10 mg (Z)-11-HDA	3
2	10 mg (Z)-11-HDA	4		2 virgin females	2
	10 mg (Z)-11-TDA	12		Unbaited	0
	5 mg (Z)-11-HDA + 5 mg (Z)-11-TDA	11	5	10 mg (Z)-11-TDA	2
	Unbaited	0		2 virgin females	3
3	10 mg (Z)-11-HDA	21		Unbaited	0
	10 mg (Z)-11-TDA	7			

* Each test lasted 4 days; ** HDA-hexadecenal; TDA-tetradecenal.

response when combined at 1:10 ratio with one of the stimulatory compounds. This ratio of (Z)-9-TDA to (Z)-11-HDA was found by Roelofs et al.[6] to be the optimal combination for sexual excitation of *H. virescens.* The positive response of male *H. armigera* to (Z)-11-HDA and to (Z)-11-TDA was confirmed in field tests (table 2). The 2 compounds had approximately the same effect and their effect was similar to that of virgin females in attracting males. Combination of the 2 compounds at 1:1 ratio did not enhance attraction. (Z)-9-TDA was not effective and when combined with stimulatory compounds had an inhibitory effect on male catches. Since the natural pheromone of *H. armigera* is not yet known, we recommend the use of (Z)-11-HDA as a sex attractant in traps for monitoring populations of *H. armigera.*

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2 Agricultural Environmental Quality Institute, ARS, USDA, Beltsville (Md. 20705, USA).
3 This research was supported by a grant from the United States-Israel Binational Science Foundation (BSF), Jerusalem, Israel.
4 D.F. Hardwick, Mem. ent. Soc. Can. *1965,* 40.
5 S. Gothilf, M. Kehat, M. Jacobson and R. Galun, Envir. Entomol. *17,* 31 (1978).
6 W.L. Roelofs, A.S. Hill, R.T. Cardé and T.C. Baker, Life Sci. *14,* 1555 (1974).
7 J.H. Tumlinson, D.E. Hendricks, E.R. Mitchell, R.E. Doolittle and M.M. Brennan, J. chem. Ecol. *1,* 203 (1975).
8 M. Kehat, A. Genizi and S. Greenberg, Phytoparasitica *3,* 3 (1975).
9 The tests were made at different locations, up to 40 km apart, and were run during the 1977 season (June, July). Population of *H. armigera* was especially low in that year.

Is chemical memory transfer due to shock or behavior training?

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Summary. A memory transfer experiment was performed to determine whether the transfer effect is due to stress associated with the foot shock or to the specific behavioral training. Recipient animals were significantly better in the 'jump-out' testing than either the shock-control recipients or the control recipients, but the shock-control recipients performed significantly better than the control recipients. Foot shock has an effect on the transfer phenomena but is not responsible for the entire effect.

A number of transfer experiments have been reported over the years[2]. There have been a number of criticisms of the transfer paradigm, specifically of Ungar's design[3-5]. Goldstein[3] suggests that the transfer effect is induced by exposure to shock or to an increased emotionality.

This experiment is designed to test whether transfer is due to shock[3] or due to a transfer of a behavior training[6,7]. We followed the guidelines set by Ungar[7,8] for the study of chemical transfer of learned information as closely as possible.

The subjects were 163 female C57BL/6J mice; 136 subjects were approximately 16 weeks old (donors) and 27 were approximately 12 weeks old (recipients). All subjects weighed between 20 and 30 g. The animals were housed 5 animals per cage and were kept on a light/dark 12 h cycle with ad lib food and water.

All animals were trained and tested in a 15 cm × 15 cm plexiglas shock box 10 cm deep. The shock box had a floor made of a grid of 1.6 mm stainless steel bars 10 mm apart. A flat piece of masonite extended 17.5 cm from the rim of the shock box on all sides and was enclosed by 40 cm high aluminium walls. A 3.6 cm band of 0.6-cm hardware cloth was placed around the rim of the shock box. The subjects could therefore either jump or climb out of the shock box into the safe area.

For donor no-escape control training a clear plexiglas top was placed over the shock box. Then, the subjects could not escape from the foot shock. The shock box floor was wired through a diode bridge connecting every 5th bar. During training, experimental donors and shock-control donors obtained the foot shocks of 180 μA.

Donor animals were trained to jump out of the box within 5 sec to escape electric shock. Each subject received 30 trials with a 30 sec intertrial interval for 6 consecutive days. The subjects were trained in 4 groups of 13 animals each. Any animals failing to meet 90% or more correct responses on the 6th training day were discarded. 42 donor no-escape control animals were given random electric shock which was not related to any response contingency. Each subject received an amount of shock that was equal to the average amount that the experimental animals obtained in each of 6 days of training.