analogue of tepa, or imidazole; an antihistaminic compound. This might aid the chemists in synthesizing new compounds (by correlating structure with biological, i.e. sterilizing, activity or help entomologists to select better compounds to sterilize such an economically important insect.

REFERENCES

Chamberlain, W. F. (1962) *J. econ. Ent.* **55**: 240–248.

Chang, S. C., P. H. Terry and A. B. Boŕkovec (1964) *Science, N. Y.* **144** : 57–58.

El-Ibrashy, M. T. (1971) *Z. angew. Ent.* (*In press*).

El-Ibrashy, M. T. and M. S. Chenouda (1970) *Z. angew. Ent.* **65** : 146–156.

Pence, R. J. (1963) *J. econ. Ent.* **56** : 1–7.

Toppozada, A., S. Abdallah and M. E. Eldefrawi (1966) *J. econ. Ent.* **59** : 1125–1128.

M. T. El-Ibrashy
A. E. Aboul-Nasr[2]
Nadia F. Shehata

Laboratory of Plant Protection
National Research Centre
Dokki, Cairo, U. A. R.

Received July 15, 1971

[2] Present address: Department of Entomology, Faculty of Science, University of Cairo, Giza, U. A. R.

Preliminary Assay of Antifeeding Chemicals for the Brown Planthopper, *Nilaparvata lugens* (Stål)[1] (Hemiptera: Delphacidae)

The chemicals which inhibit the insect from feeding represent a different approach to plant protection. The induced plant resistance by such chemicals is of value to substitute or augument varietal resistance, and can play the role of a desirable partner in integrated control programs for crop pests. A number of chemicals displaying antifeeding properties against various chewing insects have been reported by many workers, for examples triazenes, triphenyltins, phenylcarbamates, etc. (Wright, 1967). However informations on antifeeding chemicals for plant-sucking insects have been very meager. Mittler (1967) observed that histidine, glutamic acid and arginine have a slightly deterrent effect on the feeding of *Myzus persicae* (Sulzer). Also Dahlman and Hibbs (1967) have studied the feeding responses of the potato leafhopper, *Empoasca fabae* (Harris) to solanaceous alkaloids, and found that tomatine, solanine, solanidine, demissidine and leptine I reduce the rate of initial imbibition of the leafhopper.

It is the purpose of this paper to present the results obtained from preliminary screening tests on the antifeeding activities of various amino acid derivatives against the brown planthopper, *Nilaparvata lugens* (Stål), an insect pest of economic significance, which causes serious damage to rice crops by sucking the plant sap.

More than 50 commercially available amino acid derivatives, including D-isomers of amino acids, were screened against the female adult of the laboratory-reared brown planthopper. Each chemical to be tested was dissolved in 5% sucrose solution at a concentration of 1000 ppm, and applied to the insects through a stretched parafilm membrane. Saturated solutions were used when the solubility of the chemicals was less than 1000 ppm. The several effective chemicals were further tested at lowered concentrations of 100 and 10 ppm. The method used for evaluation of antifeeding activities of the chemicals is the same as that described by Sōgawa (1971) for testing the phagostimulative effect of amino acids and sugars, where, the value of the ratio of honeydew droplets excreted to probings attemted during the test period (24 hrs) was used as an index of the feeding response of insects to the dietary solutions containing each of the chemicals to be tested.

The results are shown in Table 1. Among the chemicals tested, decarboxylated derivatives of aromatic amino acids, such as hordenine, methoxytryptamine, noradrenaline, phenethylamine, serotonine, tryptamine and tyramine

[1] Appl. Ent. Zool. **6** (4) : 215-218 (1971)

Table 1. Results of the Screening Tests for Antifeeding Activities of Various Amino Acid Derivatives at 1000 ppm

Chemicals tested	Av. No. of honeydew droplets	Av. No. of probings	No. of honeydew droplets/probing					
			I	II	III	IV	V	Average
Acetyl-DL-methionine	16.4	6.4	3.6	3.3	1.0	1.5	1.3	2.1
DL-Adrenaline	26.0	16.0	5.0	1.4	0.3	4.8	1.3	2.6
D-Alanine	25.0	9.0	5.0	3.6	4.0	3.3	1.5	3.5
β-Alanine	30.6	11.6	1.2	6.6	4.7	2.3	1.9	3.3
α-Amino-*iso*-butyric acid	33.0	14.4	1.2	2.3	2.8	3.1	2.5	2.4
γ-Amino-*n*-butyric acid	17.2	11.8	1.8	2.0	1.5	1.2	1.4	1.6
Benzoyl-DL-alanine	12.8	21.6	0.5	0.7	0.2	1.2	0.8	0.7
N-Benzoyl-L-arginine-amide HCl	12.2	6.0	3.3	2.1	1.3	1.3	2.3	2.1
Cadaverine 2HCl	25.6	8.2	2.2	7.5	2.1	4.0	4.3	4.0
L-Canavanine H_2SO_4	13.4	10.0	1.3	1.4	0.9	0.8	2.1	1.3
DL-3,4-Dihydroxy-phenylalanine	10.0	15.4	0.7	0.4	0.4	1.5	0.6	0.7
3, 5-Diiodo-L-tyrosine	19.0	5.8	2.8	4.3	4.0	3.0	3.0	3.4
N,N-Dimethylglycine HCl	6.4	17.6	0.3	1.1	0.3	0.2	0.3	0.4
α-DNP-L-asparagine	9.4	20.4	0.5	0.6	0.5	0.1	0.8	0.5
α-DNP-L-glutamine	8.0	86.0	*0.1*	0.2	*0.1*	*0.1*	0.3	0.1
DNP-L-hydroxyproline	9.8	59.0	*0.1*	0.5	*0.1*	0.2	0.3	0.2
DNP-L-isoleucine[a]	21.2	7.2	1.4	7.2	2.3	1.6	4.2	3.3
ε-DNP-L-lysine HCl H_2O[a]	4.2	47.0	0.1	*0.1*	*0.1*	0.2	0.1	0.1
DNP-DL-tryptophan[a]	15.4	14.6	2.3	1.8	1.2	2.3	0.5	1.6
o-DNP-L-tyrosine[a]	6.8	7.8	1.9	1.5	0.4	0.6	0.6	1.0
DL-Ethionine	26.8	10.8	1.6	3.4	3.2	2.7	2.6	2.7
Glycine ethylether HCl	22.6	10.6	1.4	2.6	4.2	1.8	3.0	2.6
γ-Guanidinobutyric acid	18.6	9.4	1.4	2.6	2.4	4.5	0.8	2.3
Histamine	17.8	7.8	1.6	3.2	2.5	3.4	1.6	2.5
Hordenine $H_2SO_4 2H_2O$	3.8	36.2	*0.1*	0.1	*0.1*	0.2	*0.1*	0.1
5-Hydroxytryptophan	15.8	7.8	2.1	2.4	2.6	1.7	1.3	2.0
3-Hydroxytyramine HCl	14.0	16.2	0.7	0.9	1.8	0.6	0.7	0.9
Hippuric acid	18.4	10.0	0.7	2.3	2.0	2.5	1.6	1.8
β-Indolacetic acid	0.8	32.6	*0.*1	0.2	0.0	0.0	0.0	*0.1*
Indolaldehyde[a]	8.6	5.8	2.7	1.2	2.0	0.9	1.8	1.4
Indolbutyric acid[a]	7.8	13.4	0.4	0.7	0.9	0.6	0.4	0.6
Indolpropionic acid	3.6	42.0	0.1	*0.1*	0.2	0.1	0.6	0.2
DL-Lanthionine[a]	15.8	10.4	1.5	0.8	0.8	2.9	1.7	1.5
Mescaline H_2SO_4	5.0	8.8	0.3	0.4	0.4	0.7	1.1	0.6
5-Methyltryptophan	11.8	14.8	0.5	1.0	0.7	1.0	0.9	0.8
D-Methionine	29.4	11.4	2.2	1.8	3.2	2.4	3.5	2.6
DL-Methionine sulfone	18.8	7.4	2.0	1.0	2.0	6.0	3.8	3.0
DL-Mrthionine sulfoxide	21.0	12.8	1.9	3.0	1.2	7.0	1.0	2.8
5-Methoxytryptamine	1.4	41.6	0.1	0.0	0.0	*0.1*	0.1	*0.1*

Chemicals tested	Av. No. of honeydew droplets	Av. No. of probings	No. of honeydew droplets/probing					
			I	II	III	IV	V	Average
DL-Noradrenaline	1.8	39.8	0.1	0.7	0.1	*0.1*	*0.1*	0.2
DL-Norleucine	20.0	6.0	2.8	3.3	2.8	5.5	3.7	3.6
DL-Norvaline	14.0	7.4	2.8	1.5	1.3	1.5	3.3	2.1
DL-Octopamine HCl	10.2	17.6	0.6	0.9	0.6	0.3	1.0	0.7
Phenaceturic acid	16.6	15.0	0.8	0.5	2.2	2.5	2.1	1.6
Phenethylamine	1.4	21.0	0.1	0.0	0.0	*0.1*	0.2	*0.1*
D-Phenylalanine	30.8	16.4	2.6	1.2	1.8	2.0	1.6	1.8
Putrescine 2HCl	31.4	19.8	1.8	1.1	1.8	1.7	2.0	1.7
Serotonine	8.2	64.2	0.2	*0.1*	0.1	0.2	0.3	0.2
Taurine	16.6	7.0	5.8	2.2	3.0	2.0	1.8	2.8
N,N,N′,N′-Tetramethyl-ethylenediamine	7.0	15.4	1.3	2.2	0.2	*0.1*	0.3	0.8
Tryptamine HCl	0.8	61.8	*0.1*	*0.1*	0.0	*0.1*	*0.1*	*0.1*
D-Tryptophan	22.6	7.6	5.4	2.5	2.8	3.2	2.0	3.1
Tyramine	0.8	50.0	*0.1*	0.0	0.0	0.0	*0.1*	*0.1*
Tyramine HCl	4.2	28.4	*0.1*	0.3	*0.1*	0.2	0.2	0.2
Control (5% sucrose)	12.0	5.8	1.0	1.5	3.2	2.2	2.3	2.0

DNP-: Dinitrophenyl, *0.1*: Less than 0.1.
[a] Saturated solution was used.

Table 2. Antifeeding Activities of Several Aromatic Amines

Chemicals tested	No. of honeydew droplets/probing		
	1000	100	10 ppm
Hordenine $H_2SO_4 2H_2O$[a]	0.1	0.4	1.2
Mescaline H_2SO_4	0.6	2.2	—
5-Methoxytryptamine	*0.1*	1.2	2.0
Phenethylamine[b]	*0.1*	0.6	1.1
Tryptamine HCl	*0.1*	1.1	1.5
Tyramine[c]	*0.1*	0.5	0.9

[a] : HO-C$_6$H$_4$-CH$_2$CH$_2$N(CH$_3$)$_2$, [b] : C$_6$H$_5$-CH$_2$CH$_2$NH$_2$, [c] : HO-C$_6$H$_4$-CH$_2$CH$_2$NH.

were found to elicit sharply defined feeding responses of the brown planthoppers. When these chemicals were added into the dietary solution, the honeydew excretion of the planthopper was drastically reduced and the probing frequency increased abnormally. This indicates that these chemicals act as gustatory stimuli to inhibit the meintenance of insect feeding. Especially, hordenine, phenethylamine and tyramine were potentially active as antifeeding chemicals for the brown planthopper. They were found to suppress planthopper feeding with test solutions down to a concentration of 10 ppm (Table 2). These aromatic amines have been known to widely occur in plants (Smith, 1971), but they, as far as the author knows, have not been reported as feeding inhibitors for phytophagous insects. The other kinds of aromatic and heterocyclic amines, such as adrenaline, histamine, hydroxytyramine, mescaline and octopamine were

less or not active as antifeeding chemicals for the brown planthopper. In addition to the aromatic amines, dinitrophenol conjugates of glutamine, hydroxyproline and lysine were found to inhibit planthopper feeding. Also it is of interest to note that indolacetic acid and indolpropionic acid have antifeeding effect at the concentration of 1000 ppm. Four kinds of D-isomers of amino acids, D-alanine, D-methionine, D-phenylalanine and D-tryptophan did not show any antifeeding activities.

REFERENCES

DAHLMAN, D. L. and E. T. HIBBS (1967) *Ann. ent. Soc. Am.* **60** : 732–740.

MITTLER, T. E. (1967) *Ent. Exp. Appl.* **10** : 87–96.

SMITH, T. A. (1971) *Biol. Rev.* **46** : 201–241.

SŌGAWA, K. (1971) *Jap. J. oppl. Ent. Zool.* (In press).

WRIGHT, D. P., Jr. (1967) *Pest control, antifeedants.* Academic Press, New York and London, p. 287–293.

Kazushige SŌGAWA

Laboratory of Applied Entomology and Nematology
Faculty of Agriculture, Nagoya University,
Chikusa-ku, Nagoya, 464 Japan

Received August 18, 1971

Increased Accumulation of Silk Protein Accompanying JH-Induced Prolongation of Larval Life in *Bombyx mori* L. (Lepidoptera: Bombycidae)[1]

The successful identification and synthesis of the juvenile hormone (JH) of the *Hyalophora cecropia* moths (RÖLLER *et al.*, 1967; DAHM *et al.*, 1967) has prompted the use of the JH as a new insecticide (VINSON and WILLIAMS, 1967; BOWERS, 1968, 1969). We undertook a study of JH administration in hopes of inducing a quantitative increase in silk production by the commercial silkmoth, *Bombyx mori*. A single administration of JH to *Bombyx* larvae in certain stages of the final larval instar prolonged their feeding time (AKAI and KOBAYASHI, 1971). In extending these studies we found that prolongation of the larval stage is easily controlled by suitable combinations of both doses and times of JH injection and that silk protein synthesis by the silk gland continues during the prolonged larval period. Consequently the cocoon shell weight which is the important measure of cocoon quality increased substantially. These findings are not only interesting in terms of their physiological significance, but also because of their applications to the sericulture.

Two experiments were carried out. In the first, test animals were reared in a 27°C culture room on an artificial diet (ITO *et al.*, 1968). At several times during the 5th instar (just after the 4th ecdysis, and on the 24th, 48th, 72nd, 96th, 120th and 144th hr thereafter), different doses of JH (0.1 μg/g of body weight, 1 μg and 10 μg) were injected with a microsyringe into the larvae anesthetized with ethyl ether. The JH used was the mixed isomers of the synthetic C18-JH (methyl 10,11-oxido-3,11-dimethyl-7-ethyltrideca-2,6-dienoate) (MORI et al., 1971), and it was diluted with peanut oil. After the injections the insects were reared under same conditions, and we could not detect any effects in response to the JH until they reached the just spinning stage. During the 7th day of the 5th instar (144th hr after the 4th ecdysis), control animals started spinning, whereas the animals which received JH continued feeding.

As shown in Table 1, most larvae given high doses of JH at the former half of the 5th instar continued feeding for an extra day. Both the cocoon weight and the cocoon shell weight of these animals were increased. These larvae produced additional about 30 per cent more silk than the controls. Administration of high doses of JH at the later half of the 5th instar prolonged larval development further. However, their development was irregularly, and the quality of their cocoons decreased.

The increase of silk protein synthesis in the silk gland cells induced by JH was studied further in terms of the rate of incorporation of both tritiated uridine (for RNA) and glycine (for fibroin protein) into the posterior silk gland as observed by quantitative autoradiography. Test animals used were also reared in a 27°C culture room on

[1] Appl. Ent. Zool. **6** (4) : 218–220 (1971)