Zoology Department
University of Allahabad
Allahabad (India)

V. P. Sharma[1] & A. N. Chattoraj[2]

On the possible cause of weight loss in treated insects

With 6 textfigures

Wigglesworth (1941) reported that during the first day, the loss of weight in the Pyrethrum treated insects (*Rhodnius*) is sometimes rather greater, than in the normal. Perhaps this is due to the spasmodic muscular contractions during the early stages of poisoning. Buck & Keister (1949) reported that poisoned flies lost more weight than unpoisoned. He concluded that both DDT and dry atmospheres enhances water loss, and DDT enhances loss of both metabolic and reserve water, and that loss of water is not the primary cause of death in DDT poisoning. Ingram (1955) observed that Pyrethrum treated flies lost approximately twice as much weight in two hours as did not-treated flies. Treated roaches lost approximately 5 times as much weight in 2 hrs. as did the controls. Chattoraj & Sharma (1964 a, 1964 b) reported loss in weight in *Periplaneta americana* (L.) with Aldrin, Dieldrin, Sevin, Lindane, Endrin, p,p'. DDT, Methoxychlor, Phosdrin, Dimecron, Nuvan, Parathion, and Allethrin treatments, in varying amounts and they interpreted, the weight loss, as solely due to the water loss and this water is lost from the general body surface of the insect excluding the antennea, wings, and legs. The above investigations prove, that one mode of action common to all insecticides is the loss of water.

Lees (1947) presents evidence that the rate of water loss from integument of the ticks may be controlled, in part, by the secretory activity of the epidermal cells. However, Ramsay (1935) has shown that, at temperatures above 30 °C, the body surface of the cockroaches becomes more permeable to water. Ingram (1955) concluded in Pyrethrum treated flies and cockroaches, that the portion of excess water loss that takes place through the integument can be accounted for in terms of neurotoxic action of Pyrethrum on a hypothetical regulatory mechanism that involves nervously controlled secretory activity on the part of epidermal cells.

Voegtlin, Dyer & Leonard (1923), Tareeva & Nenyukov (1931), Krüger (1931), Hartzell et al. (1932, 1933, 1934a, 1934b, 1935, 1942, 1944, 1945, 1946), Wilcoxon & Hartzell (1931, 1933), Klinger (1936), Pilat (1935), Woke (1940), Lillie & Smith (1944), Richards & Cutkomp (1945), Srivastava (1951), Chadbourne & Rainwater (1953), Sharma & Chattoraj (1962 a, 1962 b), and many other workers have reported various histological changes in the tissues of insects. These includes mainly the vacuolation, contraction, and many other

[1] Government of India, Senior Research Training Scholar.
[2] Assistant Professor.

DOI: 10.21248/contrib.entomol.14.3-4.533-539

Fig. 1. Crop (untreated). Mg. 12.5 × 10

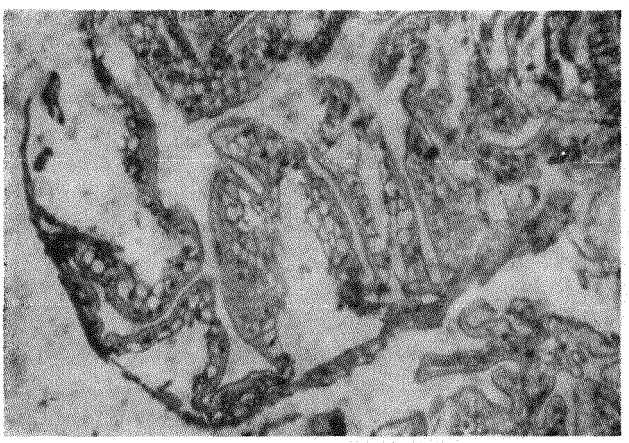

Fig. 2. Crop (treated with 18.9 r/gm Lindane) showing the shrinkage of epithelial cells, vacuolation, exfoliation of epithelium and other degenerative changes. Mg. 12.5 × 10

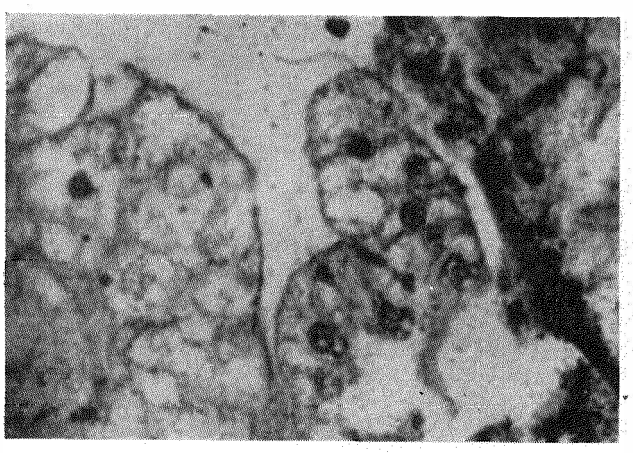

Fig. 3. Body fat (untreated). Mg. 25 × 10

DOI: 10.21248/contrib.entomol.14.3-4.533-539

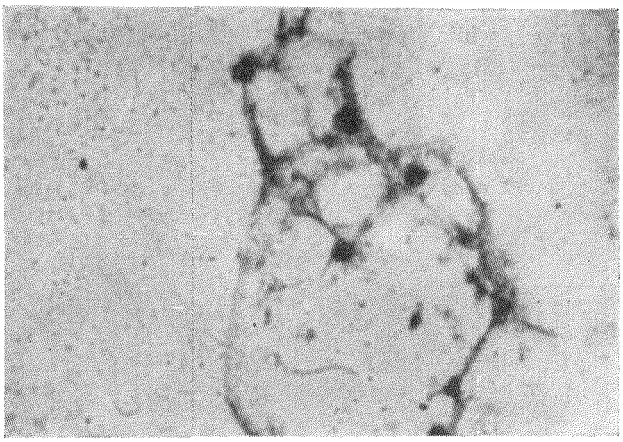

Fig. 4. Body fat (treated with 18.1 r/gm Endrin). Showing the complete dissolution of fat. Only thread like structures are left. Mg. 25 × 10

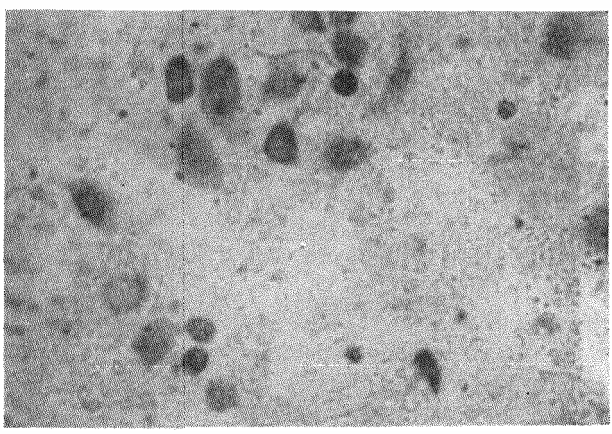

Fig. 5. Haemocytes of *Attacus* larvae (untreated). Mg. 6 × 63

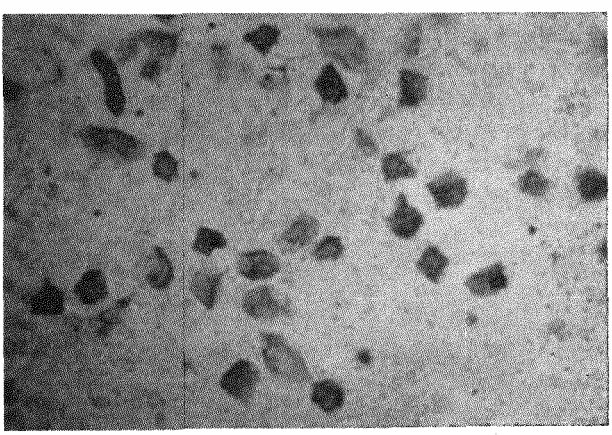

Fig. 6. Haemocytes of *Attacus* larvae (treated with 14.3 r/gm Dimecron). Showing shrinkage and pseudopodia like structures are given out. Mg. 6 × 63

DOI: 10.21248/contrib.entomol.14.3-4.533-539

types of degenerative changes in the tissues. More recently present workers observed, while studying the histological changes in the tissues of insects with the application of a number of insecticides, a general shrinkage in all the affected tissues (see Table 1 and Photomicrographs: Figs. 1—6).

Table 1
The shrinkage in crop with Lindane treatment

	Normal	Sub-lethal	Lethal survived	Moribund
Size of Muscle Nucleus				
Length	12.5±0.38	11.7±0.29	9.7±0.57	8.5±0.39
Breadth	5.6±0.47	5.5±0.35	3.1±0.60	3.0±0.27
Size of Epithelial cells				
Length	39.8±1.13	23.7±0.98	18.0±0.66	14.5±0.48
Breadth	15.9±1.20	12.5±0.85	12.2±0.56	5.2±0.37
Size of Nucleus of epithelium	9.8±0.48	8.6±0.41	5.3±0.36	2.62±0.17

All measurements are in μ.
Female adult cockroaches applied with 6.3 r/gm sub-lethal dose and 18.9 r/gm lethal dose.

Since, there is a general shrinkage and vacoulation in the tissues of insects, it can safely be presumed that his shrinkage is being caused by the expulsion of water (with or without certain dissolved organic and inorganic chemicals) from the tissues. This loss of water perhaps may be caused due to the withdrawal of water from the tissues accompanied by the liberation of water due to the direct chemical action of insecticides. This liberated water inside the body of the insects, possibly increases the pressure from within of the insects, and this increased pressure allows the water to go out on the surface of the body through the helical canals and other body openings, and there from, it evaporates.

CHATTORAJ & SHARMA (1964a, 1964b) reported that untreated cockroaches run in calcium chloride dried air at 1 to 2 °C, do not loose water, but Aldrin and Allethrin treated cockroaches, run under similar conditions loose 1.85 and 3.32 percent water respectively in the first two hours. RAMSAY (1935) claims that in cockroaches, permeability of water, through the body surface, increases at temperatures above 30 °C. The authors are of the opinion that at low temperatures, i.e., 1 to 2 °C, the activity of the secretory tissue cells, if there is any, has been inhibited in controlled roaches. However, they obtained significantly high rate of water loss in insecticide treated cockroaches at low temperatures, suggesting that, the nervously controlled secretory activity is activated somehow or other, to some extent, and also that the general body surface becomes more permeable to water even at low temperatures.

In view of the facts stated above, the authors conclude that, major part of the weight loss has been caused by the loss of water, however, some weight is also lost in the form of gases etc., during the process of breakdown of complex body substances. The loss of water in insecticide treated cockroaches takes place by a combination of several complex factors, either acting independently or jointly,

DOI: 10.21248/contrib.entomol.14.3-4.533-539

such as the withdrawal of water from tissues, liberation of water, if any, by the direct chemical action of insecticides, secretory activity of different tissues cells, and the ultimate increase of pressure from within the insect's body by the accumulation of water, thus expelling the water through the helical canals of the cuticle and other body openings. Further, the authors feel that such a high percentage of water loss reported by CHATTORAJ & SHARMA (1964a, 1964b) could not have resulted, alone, by the increased nervously controlled secretory activity of epidermal cells as has been reported by INGRAM (1955).

Acknowledgements

Authors owe thanks to Prof. M. D. L. SRIVASTAVA, Head of the Zoology Department for providing necassary facilities.

Summary

Insects treated with insecticides loose water at a significantly higher rate than the normal and control run insects. A general shrinkage in all the tissues suggests that the loss in weight presumably, may be caused due to the loss of water from the general body tissues rather than by the epidermal cells alone. The theory has been advanced that the water loss may be caused due to the withdrawal of water from the tissues accompanied by the liberation of water, if any, due to the direct chemical action of insecticides. The water thus released inside the body of the insects, presumably increases the pressure from within of the insects, and this increased pressure allows the water to go out on the surface of the body, through the helical canals, where from, it evaporates.

Zusammenfassung

Mit Insektiziden behandelte Insekten verlieren Flüssigkeit in einem beachtlich höheren Maße als normalerweise. Eine generelle Schrumpfung in allen Geweben deutet an, daß vermutlich der Gewichtsverlust vielmehr durch den Flüssigkeitsverlust des allgemeinen Körpergewebes verursacht wird als allein durch die Epidermalzellen. Es wird die Theorie vertreten, daß der Verlust an Flüssigkeit durch deren Entzug aus den Geweben verbunden mit der Befreiung derselben verursacht wird als Folge der direkten chemischen Wirkung der Insektizide. Die so im Insektenkörper frei gewordene Flüssigkeit vergrößert wahrscheinlich den inneren Druck und dieser wiederum ermöglicht den Austritt der Flüssigkeit an der Körperoberfläche durch die „helical canals", von denen aus sie dann verdunstet.

Резюме

Обработанные инсектицидами насекомые теряют влагу в значительно большей мере, чем обычно. Общее снижение содержания воды во всех тканях свидетельствует о том, что вероятно, потеря веса вызывается потерей влаги во всех тканях организма, а не только эпидермальными клетками. Выдвигается теорня, что следствием непосредственного химического действия инсектицидов является потеря жидкости путем выделения ее из тканей. Высвободившаяся таким образом в организме насекомого жидкость, вероятно, увеличивает внутреннее давление, которое в свою очередь делает возможным выделение жидкости на поверхность тела через „helical canals" с которых она затем испаряется.

DOI: 10.21248/contrib.entomol.14.3-4.533-539

References

BUCK, J. B. & KEISTER, M. L., Respiration and water loss in the adult blowfly, *Phormia regina*, and their relation to physiological action of DDT. Biol. Bull., **97**, 64—81; 1949.

CHADBOURNE, D. S. & RAINWATER, C. F., Histological effects of calcium arrenates, DDT, and Dieldrin on larval tissues of Boll-worm. Journ. econ. Ent., **46**, 44—48; 1953.

CHATTORAJ, A. N. & SHARMA, V. P., Water loss in *Periplaneta americana* (L.) with the application of certain insecticides. Beitr. Ent., **14**, 525—532; 1964a.

— & —, Weight loss in *Periplaneta americana* (L.) with the application of different insecticides. Indian Sci. Congress (In press), Abstr.; 1964b.

HARTZELL, A., Organic thiocyanogen compounds as insecticides. Contrib. Boyce Thompson Inst., **6**, 269—277; 1934a.

—, Histopathology of insect nerve lesions caused by insecticides. Contrib. Boyce Thompson Inst., **6**, 211—223; 1934b.

—, Histopathology of nerve lesions of Cicada after paralysis by the killer wasp. Contrib. Boyce Thompson Inst., **7**, 421—425; 1935.

—, Histological effects of certain sprays and activators on the nerves and muscles of the housefly. Contrib. Boyce Thompson Inst., **13**, 443—454; 1945.

HARTZELL, A. & SCUDDER, H. I., Histological effects of Pyrethrum and an activator on the central nervous system of the housefly. Journ. econ. Ent., **35**, 428—433; 1942.

HARTZELL, A. & STRONG, M., Histological effects of Piperine on the central nervous system of housefly. Contrib. Boyce Thompson Inst., **13**, 253—257; 1944.

HARTZELL, A. & WEXLER, E., Histological effects of Sesamin on the brain and muscles of housefly. Contrib. Boyce Thompson Inst., **14**, 123—126; 1946.

HARTZELL, A. & WILCOXON, F., Some factors influencing the efficiency of contact insecticides. II. Chemical and toxicological studies of Pyrethrum. Contrib. Boyce Thompson Inst., **4**, 107—117; 1932.

— & —, Experiments on the mode of action of Pyrethrum and its effects on insect tissues. V^e Congr. Internat. d'Ent., II — Travaux, p. 289—293; 1933.

INGRAM, R. L., Water loss from insects treated with Pyrethrum. Ann. ent. Soc. Amer., **48**, 481—485; 1955.

KLINGER, H., Die insektizide Wirkung von Pyrethrum- und Derrisgiften und ihre Abhängigkeit vom Insektenkörper. Arb. physiol. angew. Ent. Berlin-Dahlem, **3**, 115—151; 1936.

KRÜGER, F., Untersuchungen über die Giftwirkung von dalmatischem Insektenpulver auf die Larven von *Corethra plumicornis*. Ztschr. angew. Ent., **18**, 344—353; 1931.

LEES, A. D., Transpiration and the structure of epicuticle in ticks. Journ. exp. Biol., **23**, 379—410; 1947.

LILLIE, R. D. & SMITH, M. I., Pathology of experimental poisoning in cats, rabbits, and rats with 2,2 bis-parachlorophenyl-1,1,1 trichloroethane. Public Health Reports, **59**, 979—984; 1944.

MELLANBY, K., The site of loss of water from insects. Proc. R. Soc. London, (B) **116**, 139—149; 1934.

—, The evaporation of water from insects. Biol. Rev., **110**, 317—333; 1935.

PILAT, M., The effects of intestinal poisoning on the blood of locusts (*Locusta migratoria*). Bull. ent. Res., **26**, 283—292; 1935.

RAMSAY, J. A., The evaporation of water from cockroach. Journ. exp. Biol., **12**, 373—383; 1935.

RICHARDS JR., A. G. & CUTKOMP, L. K., Neuropathology in insects. Journ. New York Ent. Soc., **53**, 313—355; 1945.

SHARMA, V. P. & CHATTORAJ, A. N., Histological effect of Lindane on the alimentary canal of *Periplaneta americana* (L.) Pt. I. National Acad. Sci. Allahabad, India. 31st Annual Session. Abst., p. 20—21; 1962a.

DOI: 10.21248/contrib.entomol.14.3-4.533-539

— & —, Histological effect of Lindane on the nervous system of *Periplaneta americana* (L.) Pt. II. National Acad. Sci. Allahabad, India. 31st Annual Session. Abst., p. 21; 1962b.

Srivastava, A. S., Studies on the modern insecticides, mechanism of physiological action of gamma benzene hexachloride. Indian Med. Rec., **71**, 43—50; 1951.

Tareeva, A. I. & Nenyukov, D. V., Effect of poisons on the normal digestion and the blood of *Galliptamus*. Bull. Plant. Prot. Leningrad, **3**, 39—49; 1931.

Voegtlin, C., Dyer, H. A. & Leonard, C. S., On the mechanism of the action of arsenic upon protoplasm. Public Health Reports, **38**, 1882—1912; 1923.

Wigglesworth, V. B., The effect of Pyrethrum on the spiracular mechanism of insects. Proc. ent. Soc. London, (A) **16**, 11—14; 1941.

—, Transpiration through the cuticle of insects. Journ. exp. Biol., **21**, 97—114; 1945.

Wilcoxon, F. & Hartzell, A., Some factors affecting the efficiency of contact insecticides. I. Surface forces as related to wetting and tracheal penetration. Contrib. Boyce Thompson Inst., **3**, 1—12; 1931.

— & —, Some factors affecting the efficiency of contact insecticides. III. Further chemical and toxicological studies of Pyrethrum. Contrib. Boyce Thompson Inst., **5**, 115—127; 1933.

Woke, P. A., Effects of some ingested insecticides on the midgut wall of the southern armyworm larva. Journ. agric. Res. Washington, **61**, 321—329; 1940.

DOI: 10.21248/contrib.entomol.14.3-4.533-539