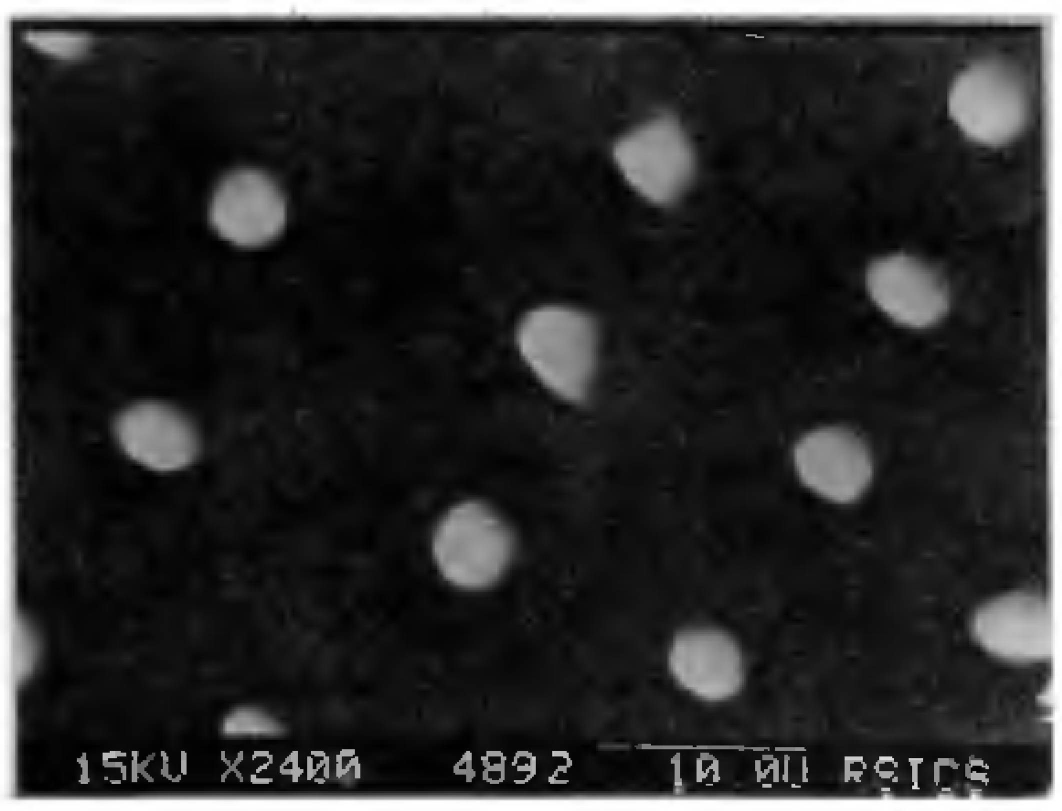

Figure 3. Scanning electron micrograph of the ventral surface of the coloured spot (bar = 10 µm).

about 1.6 µm thick, and tapers towards the tip with a thickness of 0.4 µm (Figure 2). It is interesting to note that the occurrence of intact small spherical bodies and the arrangement of spines and sensilla around a larger sphere is unique for the dorsal surface of the coloured spot. Further, the surface feature of the yellow spot, the location and arrangement of spines and sensilla do not show any individual variation in different specimens of the same species. A similar type of surface feature, however, is not observed on the inner surface of the coloured cuticular spot, which is smooth, but contains some cuticular processes (Figure 3). The general elytral cuticle other than the coloured spots is also smooth.

The spherical bodies on the external surface of the coloured cuticular spot appear to be related to the position and shape of the cells lodging the pigments responsible for the colour of the spot, since it is known that the surface pattern of the epicuticle reflects the outline of epidermal cells[1,8]. In fact, the structural pattern on the cuticular surface corresponds to the position of epidermal cells at the time of outer epicuticle deposition[9].

The intactness of the small spherical bodies on the surface of the coloured cuticular spot, suggests a similar kind of intact nature of the pigment cells in the epidermis. In this context, it can be mentioned that intactness of the tegumental pigment cells in some wasps was reported to be essential for photoconductive activity of the cuticle covering the pigment containing region[6].

Further, it is well known that many pigments such as melanins, carotenoids, haemoglobins and chlorophylls possess properties of organic semi-conductors[10], and are sensitive to changes in temperature and light intensity[11]. In the present case also, it is logical that the pigments associated with the cuticular spots serve as a sensitizer for light and temperature change. Such changes are expected to be transmitted to the nervous system through the sensilla associated with the pigment bodies. The changes in intensity of light and/or temperature are perceived by the sensitizing pigment, which transmits those changes to the cellular elements of the cuticular sensilla and thence to the nervous system.

A point of interest to be noted here is that, for conversion of heat and/or light into electricity, for sensing capacitive pressure, for detecting thermal conductivity and for sensing temperature, the present day electronic technology relies on semiconductor thin film device. The questions that are debatable in this context are, whether or not the semiconductive properties of coloured cuticle in general are utilized by the insects for sensory detection of temperature, light, humidity, pressure, etc. and whether or not they store the electric energy produced in the transduction process.

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SUDIP DEY

Electron Microscope Laboratory,
Regional Sophisticated Instrumentation Centre,
North-Eastern Hill University,
Shillong 793 003, India

Lepidontal alterations of the circuli on the scales of freshwater snakehead, *Channa punctatus* (Bloch) upon exposure to malathion

Malathion, an organophosphorous insecticide, has been widely used to combat the attack of insect pests in northern India, without realizing the adverse effects on the aquatic organisms when it enters the waterbodies as run-off. It is a proven fact that it has higher toxicity even at low concentration levels to the aquatic organisms and comparatively lower toxicity to terrestrial mammals.

In the past, various organs have been employed (qualitatively and quantitatively) to assess the toxicity of various toxicants, but the use of scale as pollution indicator is of recent inception[1,2]. The detailed study of marginal circuli and mineral composition[1,2] of various parts of the scale of *Channa punctatus* (Bloch) has been used as an indicator of pollution upon exposure to different concentrations of endosulfan. We confirm here the earlier observations.

Live adults of *Channa punctatus* (29 g ± 1.58 S.D.; 4.4 cm ± 0.47 S.D.)

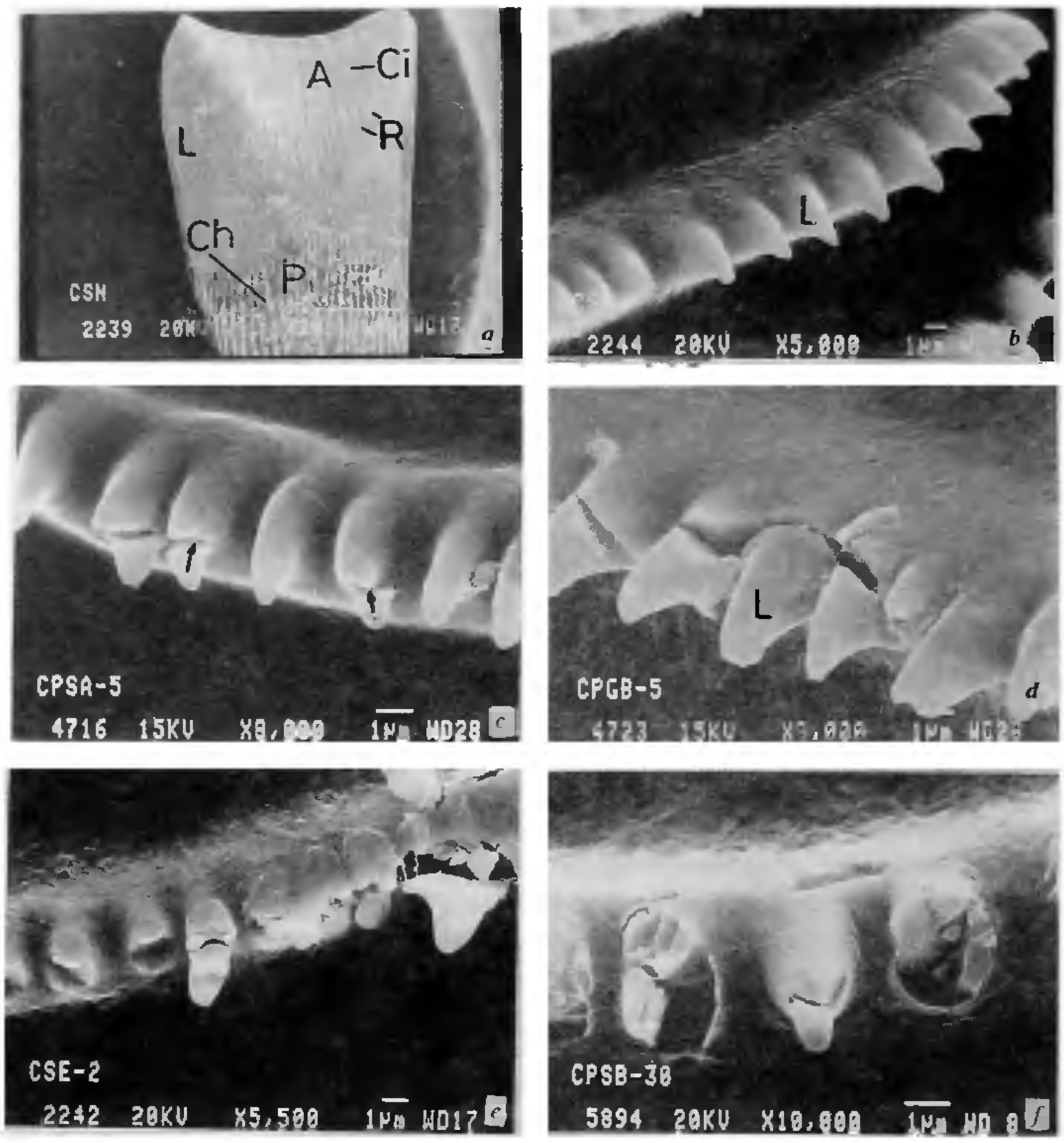

Figure 1 ***a–f.*** ***a***, Scanning electron micrograph of normal scale of *Channa punctatus*. (Anterior, A; Posterior, P; Lateral, L; Chromatophore, Ch; Radii, R; Circuli, Ci); ***b***, Normal lepidonts (L) attached on circulus of the scale; ***c***, Lepidonts showing breakage (arrows) from the tip portion after an exposure of 0.05 mg/l malathion for 5 days; ***d***, Lepidonts (L) in a row rooted out from the base (conc. 0.10 mg/l; 5 days). ***e***, Complete damage of circulus showing lepidontal breakage (conc. 0.25 mg/l; 15 days). ***f***, Disorganized lepidonts and circulus exposed at 0.10 mg/l malathion for 30 days.

were purchased from the local fish market of Chandigarh (76°46'30"E; 30°40'0"N). Fish were acclimatized for 7 days and fed once daily either with minced goat liver or live mosquito fish *Gambusia affinis patruelis* (Baird and Girard) collected from the pond located in the Botanical Garden of the Panjab University, Chandigarh. The LC_{50} value (96 h) of malathion (50% EC) for *Channa punctatus* was found to be 0.62 mg/l (ref. 3). The desired concentrations, i.e. 0.05, 0.10 and 0.25 mg/l of the pesticide in tanks were achieved by adding appropriate quantity of the stock solution. A parallel control group was maintained in toxicant free tap water (pH 6.8; dissolved oxygen 8.91 mg/l and total hardness 84 mg/l). A batch of 8 acclimatized fish was released in each tank of 20 l capacity. After 5, 15 and 30 days exposures, scales overlying the lateral line, leaving 7–8 dorsal fin rays, preferably from the second row were removed. These scales were sonicated for about 15 min to remove the extraneous material. Dried and cleaned scales were mounted on aluminium stubs, sputter coated with gold (100 Å thickness) and studied under vacuum using JEOL, JSM-6100 scanning electron microscope.

The cycloid scale of *Channa punctatus* (Bloch) is semioval in shape (Figure 1 *a*) and consists of three distinct parts, viz. anterior, posterior and lateral. The circuli are widely spaced on lateral sides and bifurcate when they enter the anterior region (Figure 1 *a*). In the posterior side, thick circuli are present. Each circulus in this region is formed by the fusion of 2–4 circuli present on the lateral side. This region also has several vertical rows of chromatophores. In the anterior region several radii, mostly tertiary ones, cut the circuli at a right angle. The SEM studies revealed that the anterior circuli bear rows of minute hook-like structures known as lepidonts (Figure 1 *b*). Lepidonts help the scale to anchor on fish body[1,4]. A lepidont is pointed at its free end and has a broad base. Each lepidont is firmly attached to the circuli (Figure 1 *b*). Initial observations revealed that upon prolonged exposure, one of the effects of toxicant is the loosening of the scale on the fish body as the main function of the lepidonts is to fix the scale on body of fish. The present study is restricted to discussing the toxicological impact of malathion on the lepidonts.

It has been observed that tips of approximately 5% of the lepidonts were broken from the anterior one third portion at 0.05 mg/l of malathion at an exposure of 5 days (Figure 1 *c*). With the increase in the concentration, i.e. 0.10 mg/l for 5 days, about similar percentage of lepidonts showed complete breakage from the base portion too (Figure 1 *d*).

Further increase in exposure period to 15 days at a concentration of 0.25 mg/l level of malathion caused complete damage to the circuli and the entire calcareous material became disorganized (Figure 1 *e*) accompanied by the loosening of the scale on the body, envisaging that the lepidonts play a significant role in anchoring the scale on the body of the fish.

Upon exposure for 5 days and 15 days to lower concentration levels of malathion, lepidonts beckoned less occurrence of breakage but with an increase in exposure duration to the extent of 30 days the frequency of the breakage showed drastic increase. At an exposure of 0.10 mg/l for a prolonged period of 30 days, 40% of lepidonts showed extreme breakage exhibited in various forms. Circuli on which the lepidonts are attached also showed certain level of damage (Figure 1 *f*).

Endosulfan[1,2] appears to be more toxic than malathion as even the lower concentrations of endosulfan damage both the circuli and lepidonts. The mineral composition of the different parts of the scale particularly the calcium also showed variations[2].

The present studies have clearly indicated that the lepidonts on the scale of *Channa punctatus* gave excellent response in the form of varying degree of damage to the varying concentrations of malathion. This damage is related to both, the dose and the exposure period. It is, however, difficult to conclude at this moment which one is more disastrous. Circuli showed less response at lower concentrations of pesticide exposure, but prolonged exposures certainly damage them too. Hence it can be concluded that lepidonts present on the circuli of the scale of *Channa punctatus* can be employed as a reliable pollution indicator with a high degree of exactitude.

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ACKNOWLEDGEMENTS. We thank the University Grants Commission, New Delhi for financial assistance; Prof. S. M. Handa, Panjab University, for providing the necessary laboratory facilities and Mr M. L. Sharma of CIL for his help in carrying out SEM.

M. S. JOHAL
A. K. SAWHNEY

Department of Zoology,
Panjab University,
Chandigarh 160 014, India