weight and shell ratio showed distinct differences between trimoulters and tetramoulters.

Toyama[9] was the first to study the moultinism behaviour in silkworm. Later, several theories have been proposed to explain the appearance of trimoulters in different crosses such as two major genes and modifier gene[5], a recessive trimoulting gene on Z chromosome[6] and a two-gene hypothesis[7]. Our data demonstrate that there is no segregation of trimoulters in crosses involving trimoulter females and tetramoulter males. There is thus a possibility that the trimoulter used in this study is a weak and heterozygous strain.

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1. Williams, C. M., In: *Insect biology in the future "VBW80"*, (eds) M. Locke and D. S. Smith, Academic Press, New York, 1980, p. 369.
2. Russel, V. M., Schulten, G. G. M. and Roorda, F. A., *Z. Ang. Entomol.*, 1980, **89**, 488.
3. Morita, M. and Tojo, S., *J. Insect Physiol.*, 1985, **31**, 307.
4. Takamiya, K., *J. Seric. Sci. Jpn.*, 1975, **44**, 21.
5. Morohoshi, S., In: *Physiogenetical studies on the moultinism and voltinism in Bombyx mori, 'A new hormonal antagonistic balance theory on the growth'*, Uneo Park, Tokyo, Japan, 1957, p. 37.
6. Nagatomo, T., *J. Seric. Sci. Jpn.*, 1941, **12**, 171.
7. Nakamura, T., *Rep. Seric. Exp. Sta. Chosen*, 1932, **3**, 39.
8. Yamamoto, T., Enokijima, M., Kamijyou, I., Fukasawa, M., Maruyama, M., Nakayama, K. and Mimura, Y. *J. Seric. Sci. Jpn.*, 1986, **55**, 467.
9. Toyama, K., *Biol. Zbl.*, 1912, **32**, 593.

NEW RECORD OF HYPERPARASITOIDS ON *CAMPOLETIS CHLORIDAE* UCHIDA AND *EUCELATORIA BRYANI* SABROSKWY PARASITIZING *HELIOTHIS ARMIGERA* (HUBNER) ON TOMATO

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HELIOTHIS ARMIGERA (Hb.) is a key pest of tomato in India. It is attacked by several parasitoids in tomato ecosystem. *Campoletis chloridae* Uchida (Hymenoptera: Ichneumonidae) is an important indigenous parasitoid[1] and *Eucelatoria bryani* Sabroskwy (Diptera: Tachinidae), an exotic parasitoid was introduced in India from USA in 1978[2]. During field collection of *H. armigera*, these two parasitoids were observed to be attacked by hyperparasitoids, which may apparently reduce the efficiency of primary parasitoids under field condition. *E. bryani* was recovered from field after 3 years of last release in 1986. Mani and Krishnamoorthy[3], and Pawar *et al*[4] reported its establishment in tomato ecosystem.

Nesolynx? flavipes Ashmead (Hymenoptera: Eulopridae), a polyembryonic hyperparasitoid was recorded from *E. bryani* puparia collected from the field. Adults (10–28 in number) were observed emerging from one puparia. The total developmental period under laboratory condition was 14 days and the adult parasitoid lived for 21 days. Sixty per cent *E. bryani* puparia was observed to be parasitized. This is the first record of *Nesolynx? flavipes* Ashmead parasitizing tachinid parasitoid *E. bryani*. This species was earlier recorded from Philippines as a primary parasitoid of *Penthocrates* sp. by Cock *et al*[5] who reported it as facultatively hyperparasitic through *Apanteles* sp.

Field collected cocoons of *Campoletis chloridae* (which is a most important parasitoid of *H. armigera* throughout the country) were found to be hyperparasitized by *Tetrastichus? ayyari* Rhower. The specimens collected were slightly different from typical *ayyari* Rhower. *T. ayyari* is considered to be a primary pupal parasitoid of a number of pest species[6]. This is the first record of *T.? ayyari* as a hyperparasitoid of ichneumonid parasitoid, *C. chloridae* from India although *Tetrastichus* spp. are known to be hyperparasitoids of *Apanteles* spp. The total life cycle was 14 days and adults lived for 24 days.

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1. Divakar, B. J. and Pawar, A. D., *Plant Protect. Bull. India*, 1982, **34**, 31.
2. Sankaran, T. and Nagaraja, H., *Entomon.*, 1979, **4**, 379.
3. Mani, M. and Krishnamoorthy, A., *Entomophaga.*, 1983, **28**, 401.

4. Pawar, A. D., Divakar, B. J. and Singh, S. N., *Entomon*, 1981, **6**, 175.
5. Cock, M. J. W., Gallego, C. K. and Godfray, H. C. J., *Trop. Pest Manage.*, 1986, **32**, 201.
6. Cherian, M. C. and Subramaniam, C. K., *Indian J. Entomol.*, 1940, **2**, 75.

DISSOLVED OXYGEN REQUIREMENTS OF MAYFLY NYMPHS

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If oxygen requirements of different species of aquatic insects were better known, it should be possible to estimate, in retrospect and with considerable accuracy, what oxygen levels have existed in a given aquatic environment during the life history of the organism[1]. Closely adjacent areas may harbour individuals of different respiratory capacity[2]. Critical oxygen demand of two heptageniid species, namely *Epeorus* sp. nov.†, which inhabits exclusively the torrential areas of rock-bottomed streams, and *Cinygmina* sp. nov.†, which inhabits side pools of the same stream, was determined to assess the scope for the use of mayfly nymphs as bioindicators of dissolved oxygen levels.

Mature nymphs of *Epeorus* sp. nov. (6 ± 0.5 mm) and *Cinygmina* sp. nov. (2 ± 0.5 mm) were collected from Kumbakkarai stream of Palni hills in South India. This stream is subjected to organic pollution because of its tourist attraction. A series of micro-Winkler bottles filled with stream water was set up. Five nymphs of selected species were introduced in each bottle. The bottles were closed and kept immersed up to neck level in the shallow region of the stream to maintain a constant temperature (25 ± 0.5°C). Two control bottles were maintained simultaneously. Preliminary experiments were conducted to find out the time to death of nymphs of *Epeorus* sp. nov. and *Cinygmina* sp. nov. in a closed Winkler bottle filled with stream water and it was found that the time to death was about an hour for the former and about 5 h for the latter. Hence one experimental bottle was taken out every 15 min in the case of *Epeorus* sp. nov. and every 1 h in the case of *Cinygmina* sp. nov. The rate of oxygen consumption was determined by the micro-Winkler technique developed by Job[3]. The experiments were continued till dissolved oxygen reached asphyxial level, the level at which 50% of the animals fell flat and died. The experiments lasted 1–5 h. From the amount of dissolved oxygen in each bottle, partial pressure of oxygen (PO_2) was calculated by referring to the table of Whipple[4].

In *Cinygmina* sp. nov., the oxygen consumption was more or less uniform (0.62 mg/mg dry wt/h) at oxygen tension between 80 mm Hg and 20 mm Hg and dropped considerably (0.38 mg/mg dry wt/h) at 20 mm Hg. In *Epeorus* sp. nov., oxygen consumption decreased with falling oxygen tension (table 1).

The critical oxygen level (pc) for *Epeorus* sp. nov. (40 mm Hg or 2 mg/l) was found to be higher than for *Cinygmina* sp. nov. (16 mm Hg or 0.8 mg/l). In general, animals from high-oxygen environment have higher pc than animals from low-oxygen environment[5].

Of the two heptageniids investigated, *Epeorus* sp. nov. appears to be more sensitive to reduced oxygen content and it can be used as bioindicator of minimum oxygen level, particularly in waters with relatively small ranges of temperature fluctuations (e.g. mountain streams or tropical waters). The presence of nymphs of *Epeorus* sp. nov. in a stream (water temperature 25°C) is an indication that the minimum oxygen level of that area is approximately 2 mg/l (40 mm Hg) and the presence of nymphs of

†The taxonomy of these new species will be published elsewhere.

Table 1 *Oxygen uptake in mg/mg dry wt/h at different PO_2 levels in two different Heptageniidae*

Species	PO_2 (mm Hg) 20	30	40	50	60	70	80
Epeorus sp. nov.	—	—	0.12 ± 0.01	0.18 ± 0.01	0.36 ± 0.01	0.41 ± 0.01	0.61 ± 0.01
Cinygmina sp. nov.	0.38 ± 0.02	0.57 ± 0.01	0.58 ± 0.01	0.61 ± 0.01	0.62 ± 0.01	0.62 ± 0.01	0.72 ± 0.04