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EUREMA HECABE (LINNAEUS, 1758) [LEPIDOPTERA: PIERIDAE], A SERIOUS SEEDLING PEST OF *ACACIA STENOPHYLLA* A. CUNN. EX. BENTH., IN KARACHI

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ABSTRACT

The pest relationship of Common grass yellow [*Eurema hecabe* (Linnaeus, 1758)] with *Acacia stenophylla* A. Cunn. Ex. Benth., an Australian plant grown in the department of Botany, University of Karachi, Pakistan is described. The larva of this beautiful moth is a serious pest of seedlings of *A. stenophylla* and rapidly devours their young leaves but not the phyllodes.

Key Words: *Eurema hecabe, Acacia stenophylla* seedlings, Karachi

INTRODUCTION

Nearly half of the earth's biodiversity is constituted by insects (May, 1992). Butterflies are beautiful insects of diurnal habit (Javaid, 1978; Rafi *et al.*, 2000) and of ecologic and economic significance (Guptha *et al.*, 2012). They are rapid indicators of habitat quality (Ahsan and Javaid, 1975) and climate change (Venkata Ramana, 2010). They accomplish pollination. Butterflies have been studied for long and some 19238 species have been catalogued worldwide (Heppner, 1998). There are around 1504 species in Indian sub-continent (Gaonkar, 1996; Smetacek, 1997; Kunte, 2009; Roy *et al.*, 2010). More than 400 species of butterflies and moths have so far been reported from Pakistan (Khan *et al*., 2000; 2007). They have complex feeding relations with plants which are specific. Larvae are typically host specific and show a botanical instinct in the sense that closely related butterfly species show association with closely related plants. This paper describes the pest relationship of Common grass yellow [*Eurema hecace* (Linnaeus, 1758)] with *Acacia stenophylla* A. Cunn. Ex. Benth. (Shoestring Acacia), an Australian plant, that have been growing in the department of Botany, University of Karachi since 1986.

MATERIALS AND METHODS

A seedling crop was raised from the seeds collected from a tree of *Acacia stenophylla* growing in the field of Biosaline Research, Department of Botany, University of Karachi, Karachi, Pakistan from the viewpoint of an eco-physiological experiment. When seedlings were 15 days old, several larvae and pupae were detected on the seedlings (Fig. 1A) and a number of butterflies of different kinds were observed flying around. Eight butterflies were captured from the field. The infested and eaten seedlings were separated from the healthy seedlings (Fig. 1B).

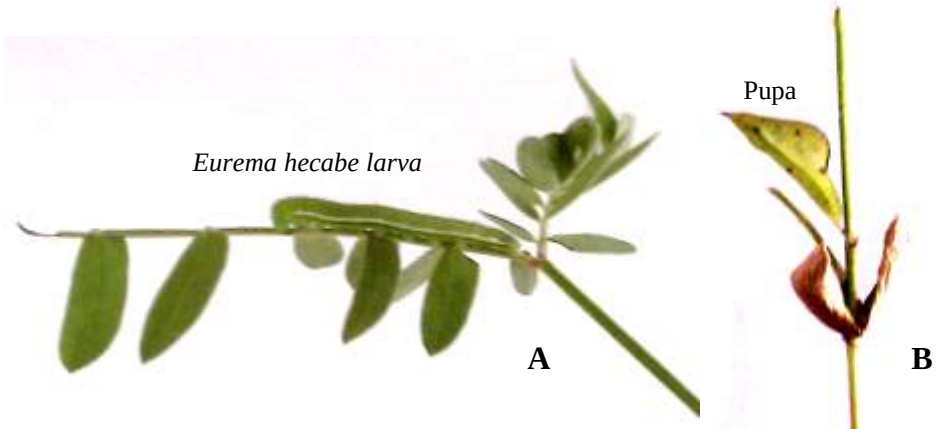


Fig.1. A larva (c. 2.5 cm in length) of *Eurema hecabe* (green and camouflaged), a pest on the seedling of *Acacia stenophylla* (**A**); and a pupa of the same insect attached to the stem (**B**). The larva has eaten all leaves of the seedling leaving behind only the stem and phyllodes in some cases. Note the white lateral band all along just above spiracles.

Three infected seedlings each with one larva were kept in a glass vessel plugged at mouth with a thin cotton cloth and monitored for the larval development. The butterfly emerging in the laboratory was compared with the

captured butterflies (8 in number). The important keys for identification were those of Grund (1999) and Jeratthitikul *et al.* (2009) and Perveen and Ahmad (2012a).

RESULTS AND OBSERVATION

Eurema hecabe (Linnaeus, 1758)

Classification

Order: Lepidoptera; Family: Pieridae; Genus: *Eurema* Hübner (1819); Species: *E. Hecabe* (Linnaeus, 1758)

Abridged synonymy: There is long list of synonyms. Following is the abridged synonymy.

Papilio hecabe Linnaeus, 1758; *Syst. Nat.* (Edn 10) 1 : 470, TL: S.China, Hong Kong; *Papilio luzoniensis* Linnaeus, 1764; *Mus. Lud. Ulr.*: 249, TL: Luzon; *Papilio rahel* Fabricius, 1787; *Mantissa Insectorum* 2: 22, TL: India; *Papilio chrysopterus* Gmelin, 1790; in Linnaeus, *Syst. Nat.* (edn 13) 1 (5) : 2261; *Terias suava* Boisduval, 1836; *Hist. nat. Ins., Spec. Gén. Lépid.* 1 : 670; *Terias sinensis* Lucas, 1852; *Revue Mag. Zool.* (2) 4 (9): 429, TL: China; *Terias hecabeoides* Ménétriés, 1855; *Cat. lep. Petersb.* 2: 85, 1: pl. 2, f. 2; *Terias aesiope* Ménétriés, 1855; *Cat. lep. Petersb.* 2: 85, 1: pl. 2, f. 3, TL: "Haiti"; *Terias anemone* C. & R. Felder, 1862; *Wien. ent. Monats.* 6 (1): 23, TL: Ningpo; Hong Kong; *Terias nikobariensis* Felder, 1862; *Verh. zool.-bot. Ges. Wien* 12 (1/2): 480; *Terias fimbriata* Wallace, 1867; *Trans. ent. Soc. Lond.* (3) 4 (3): 323, TL: Mussooree; *Terias hebridina* Butler, [1876]; *Proc. zool. Soc. Lond.* 1875 (4): 617, pl. 67, f. 8, TL: Tanna, New Hebrides; *Terias inanata* Butler, [1876]; *Proc. zool. Soc. Lond.* 1875 (4): 617, TL: Mota I.; Erromango, New Hebrides; *Terias pumilaris* Butler, [1876]; *Proc. zool. Soc. Lond.* 1875 (4) : 617, pl. 67, f. 7, TL: Tanna, New Hebrides; *Terias lifuana* Butler, 1877; *Ann. Mag. nat. Hist.* (4) 20 (118) : 355, TL: Lifu, Loyalty Is. ; *Terias sinapina* Butler, 1877; *Ann. Mag. nat. Hist.* (4) 20 (118) : 355, TL: Lifu, Loyalty Is.; *Terias arcuata* Moore, 1878; *Proc. zool. Soc. Lond.* 1878 (3): 700, TL: Hainan; *Terias attenuata* Moore, 1878; *Proc. zool. Soc. Lond.* 1878 (3): 700, TL: Hainan; *Terias subdecorata* Moore, 1878; *Proc. zool. Soc. Lond.* 1878 (3): 699, TL: Hainan; *Terias connexiva* Butler, 1880; *Trans. ent. Soc. Lond.* 1880 (4): 199, pl. 6, f. 12; *Terias hybrida* Butler, 1880; *Trans. ent. Soc. Lond.* 1880 (4): 199; *Terias mariesii* Butler, 1880; *Trans. ent. Soc. Lond.* 1880 (4): 198, pl. 6, f. 1; *Terias unduligera* Butler, 1880; *Proc. zool. Soc. Lond.* 1880: 668, TL: Formosa; *Terias simulata* Moore, [1881]; *Lepid. Ceylon* 1 (3): 110, pl. 45, f. 2, 2a; *Terias apicalis* Moore, 1882; *Proc. zool. Soc. Lond.* 1882 (1): 253, pl. 12, f. 2, TL: Kangra; *Terias excavata* Moore, 1882; *Proc. zool. Soc. Lond.* 1882 (1): 252, TL: Kangra; *Terias irregularis* Moore, 1882; *Proc. zool. Soc. Lond.* 1882 (1): 253, pl. 12, f. 3, TL: Kangra; *Terias purrea* Moore, 1882; *Proc. zool. Soc. Lond.* 1882 (1): 252, TL: Kangra; *Terias multiformis* Pryer, 1882; *Terias narcissus* Butler, 1883; *Terias asphodelus* Butler, 1884; *Terias curiosa* Swinhoe, 1884; *Terias fraterna* Moore, 1886; *J. Linn. Soc. Lond., Zool.* 21 (1): 46, pl. 4, f. 6, TL: Mergui; *Terias kana* Moore, 1886; *Terias merguiana* Moore, 1886; *J. Linn. Soc. Lond., Zool.* 21 (1): 47, pl. 4, f. 7, TL: Mergui; *Terias patruelis* Moore, 1886; *J. Linn. Soc. Lond., Zool.* 21 (1): 46, pl. 4, f. 5, TL: Mergui ; *Terias anguligera* Butler, 1886; *Terias simplex* Butler, 1886; *Terias swinhoei* Butler, 1886; *Terias orientis* Butler, 1888; *Terias aesiopeoides* Moore, 1906; *Terias andamana* Moore, 1907; *Terias blairiana* Moore, 1907; *Terias hecabe stankapura* Fruhstorfer, 1910; in Seitz, *Gross-Schmett. Erde* 9: 167, TL: Bawean, Java, Bali and Lombok; *Terias blanda acandra* Fruhstorfer, 1910; in Seitz, *Gross-Schmett. Erde* 9 : 169, TL: Hong Kong; *Terias enganica* Fruhstorfer, 1910; *Terias locana* Fruhstorfer, 1910 ; *Terias sintica* Fruhstorfer, 1910; *Terias yaksha* Fruhstorfer, 1910; *Eurema cephrens* Corbet, 1941; *Eurema telloana* Corbet, 1941; *Eurema ab. jacouleti* Nakahara, 1941;*Zephyrus* 9: 1-3; *Eurema hecabe*, NSG Voucher Specimen [Wahlberg; www.nic.funet.fi.pub/sci/bio/life/insect /lepidoptera/ditrysia/papilionoidea/pieridae/colinadinae/eurema/#Wahberg)]; *Eurema hecabe hecabe*, Butterflies in Indo-China ;[Yutaka Inayoshi; www.nic.funet.fi.pub/sci/bio/life/insect/lepidoptera/ditrysia/papilionoidea/pieridae/colinadinae/eurema/#yutaka; *Eurema hecabe*, Lepidoptera Larvae of Australia [Don Herbison-Evans;www.nic.funet.fi.pub/sci/bio/life/insect/lepidoptera/ditrysia/papillionoidea/pieridae/ colinadinae/eurema/# Don Herbison-Evans] (Source: www.nic.funet.fi.pub/sci/bio/life/warp/lepidopera-16-list-html#eurema)

Distribution: British India [Bingham 1905)]; Pakistan -Karachi, Tando Adam, Peshawar (Malik, 1970), Rawalpindi-Islamabad (Iqbal, 1978), Murree Hills (Hasan, 1994); Kohat (Shah, *et al.*, 2001; Perveen and Ahmad, 2012a & b); Azad Kashmir (Khan *et al.*, 2007)], India [Andhra Pradesh (Guptha *et al.*, 2012); Karnataka (Raghavendra Gowda, 2011); Arunachal Pradesh (Fleming Jr., 2006); Madhaya Pradesh, Tiple, 2012); Tamil Nadu (Alagumurugan *et al.*, 2011); Hussain *et al*., 2011; Rajagopala *et al.*, 2011)]; Nepal [(Khanal, 2006]; Sri Lanka, Myanmar and Australia [Khanal, 2006)]; Australia (Grund, 1999; Braby, 2000); Bangla Desh [(Islam *et al.*, 2011]; Yemen [Sabah (Abe, 1983)], Cape Verde Islands [(Mendes and de Sousa, 2010)], Singapore and Malaysia [(Quek, *et al.*,1999; Chye, 2009)]; Thailand [Jeratthitikul *et al.*, 2009]. Southern Africa (Henning *et al.*, 1997), Madagascar (Yata, 1994); Japan (www. Yutaka.it-njp/pie/20560001.htm); Korea (www.nfc. co.kr /nat /ins /lep /lerp8/29); Zambia (http:// www.ird.pc/BASE/Biodiversite/orig-dta/papilion/genre/hgen_104.htm).

Host plants: In Asia, larvae have been recorded feeding on plants of several Families – Apocynaceae, Arecaeae, Asteraceae, Connaraceae, Cucurbitaceae, Euphorbiceae, Rhamnaceae, Rubiaceae, Santalaceae, Theaceae, Verbenaceae (more details in Vane-Wright and de Jong, 2003; Herbison-Evans and Crossley, 2010). Family Leguminosae is one the most preferred one. Such plants as *Senna alata*, *Caeselpinnia pulcherima* (Chye, 2009), *Cassia fistula*, *Albizzia sp.*, *Pithecellobium sp.* (www.learnaboutbutterflies.com) are noticeable food of the larvae. *Acacia mangium* is the favourite food in Sabah forest plantation (Abe, 1983). *Acacia stenophylla* (seedlings) is a new addendum to this list. The location and selection of host plant is a complex phenomenon in *E. hecabe*. Hirota and Kato (2001) have conducted experiments on visual stimuli on female host location. They have suggested that female discerns the pattern which resembles the leaf of their main host plant consisting of many small leaflets.

Culture Experiment: Three infested plants with one larva each were incubated in laboratory. Two larvae of them died prematurely but one survived. The larva ate all the leaves of the seedling but not the phyllodes. This green last -instar larva changed into pupa on third day. Since larva takes generally 16 days to change into pupa (Chye, 2009), larva on the day it was incubated in laboratory should have been 12-13 days old. Pupa, which is green, gradually turned to dusty colour and after five days gave rise to an adult male butterfly (Fig. 2 A- E. Chye (2009)

has reported eclosion by the sixth day. On comparison with the referred keys, the reared butterfly was identified as *Eurema hecabe* (Linnaeus, 1758). The salient characters of the insect were as follows:

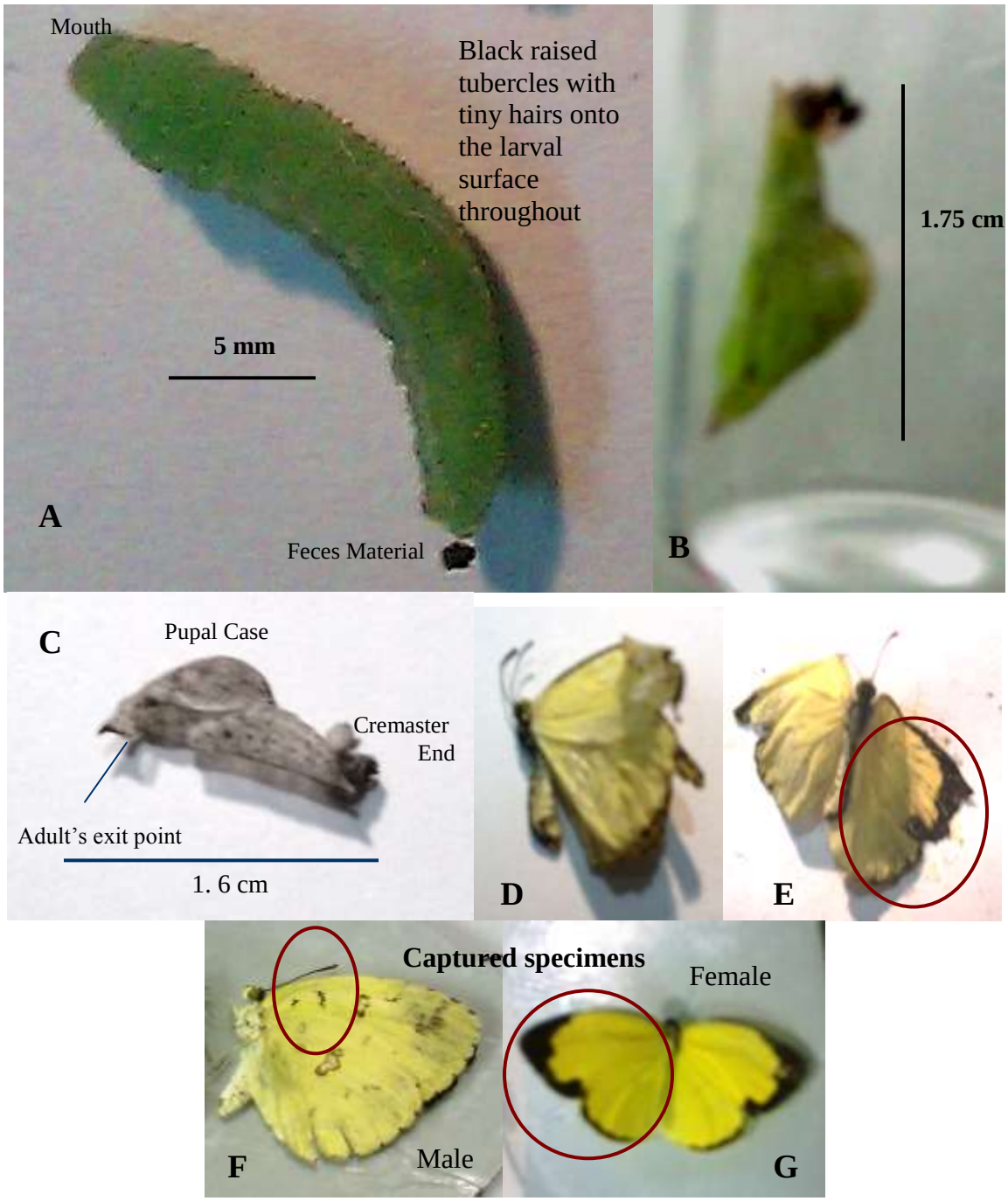
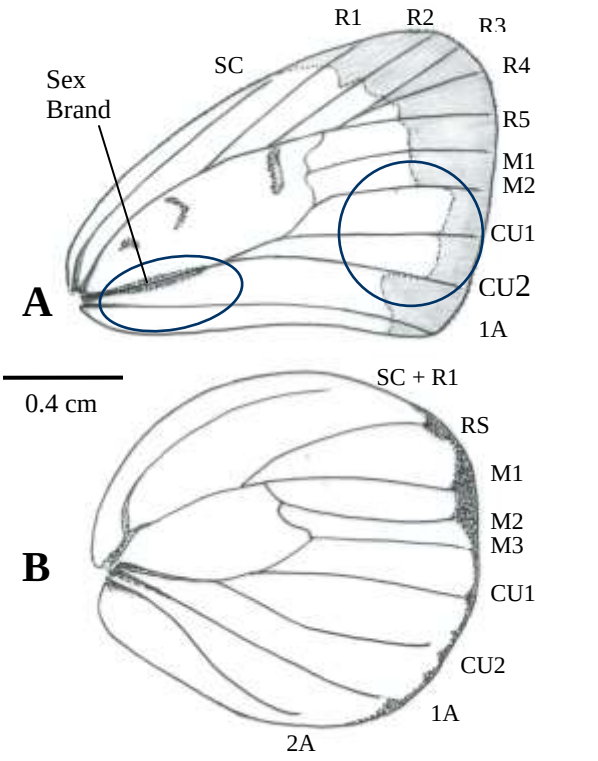


Fig.2. The developmental stages of the insect (**A – E**, cultured in laboratory). **A**, Larva – voracious eater of leaves of seedlings; **B**, pupa hanging by the posterior end from the wall of the test tube by means of the cremaster; **C**, Exuvy (exoskeleton) after eclosion of the adult **D**, Lateral view of the butterfly just emerging from the pupa; **E**, Dorsal view of the insect – characteristic markings on upper side of the wings. **F** and **G** are, respectively, the ventral and dorsal sides of *Eurema hecabe* specimens captured from the field near the seedling crop to show the markings on upper and lower side of fore wing. Gender identification as in Jeratthitikul *et al.* (2009).

Head: Eyes large, Antennae c 6-7mm in length, alternate white spots throughout, club shaped at the apex, and black.

Wing Expansion: c 34 mm in reared individual and c 40 mm in the captured individual.

Colouration: Prominent yellow with black markings and dusting.



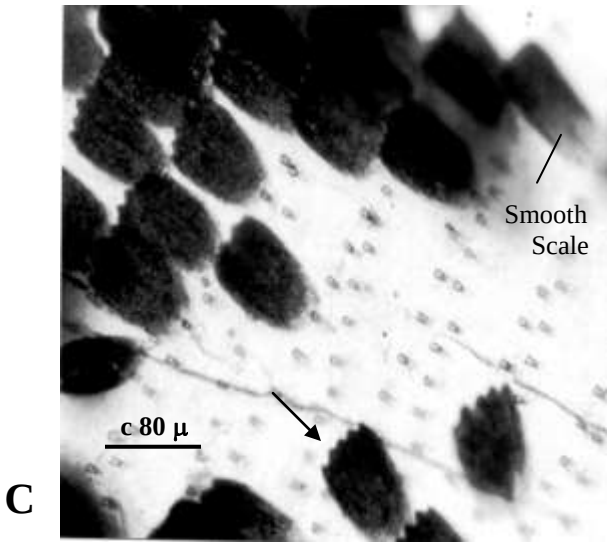


Fig.3. Venation, sex brand and markings of wings. **A**, Fore wing ventral surface showing venation and two ventral specks in the discal cell.- note the peeping dorsal apical marking running along termen. **B,** Hind wing dorsal view to show venation and the termen markings. **C,** Microscopic details of the dorsal surface of the forewing showing smooth and notched scales. The points of scales attachment onto wings are visible. Arrow indicates a scale with 4 grooves. A smooth scale is present in upper corner.

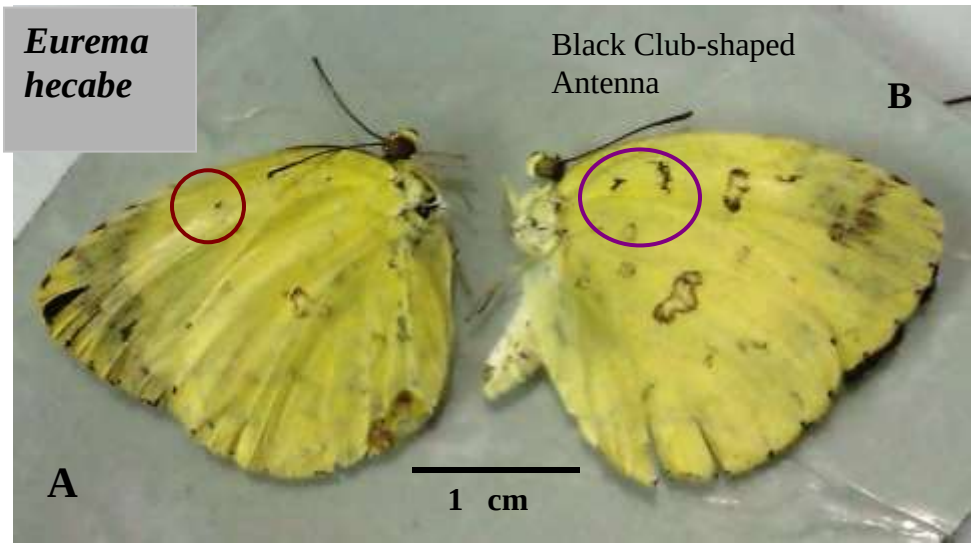


Fig.4.Two *Eurema* specimens captured from the experimental field flying near the *A. stenophylla* seedlings. There was one marking cell on FW underside in left side specimen (**A**) whereas there were two specks on the forewing underside in other specimen (**B**). The antenna in both cases is black and club-shaped.

Fore wing: Elongated, apex rounded, vein SC originate separately from upper angle of cell, veins R1 to R4 stalked largely and originate from upper angle of cell, M1 and M2 originate separately from near middle angle of cell, CU1 originates separately from lower angle of cell. One anal vein (1A) is present and originates separately (Fig. 3A). The apical and termen portion of the fore wing upper side has a black area which covers about 10% of the whole wing. This black area excavates between M2 and CU2 running more or less parallel to termen between M2 and CU2 to form a characteristic hollowing. Basal part of the wing's lower side of reared individual had a narrow linear black streak (sex brand) running on either side of the vein and ending before the origin of CU1 indicating it to be male.

On the underside there were two cells (markings) in individual reared in the laboratory (Fig. 2F and 4B) However, in captured individuals, number of such cells varied from two (Fig. 4B) to one (Fig.4A) to none. The individuals with two and one cells differed in markings of the fore wings (Fig. 4 A and B). Black dust on wing, relatively heavier in female.

Hind wing: Broad and rounded, Vein SC + R1 originate separately from upper angle of cell, RS also originates separately, M1, M2 and M3 originate separately. CU1 and CU2 are present and originate separately from lower angle of cell. Two anal veins 1A and 2A are present and originate separately (Fig. 3B). The Hind wing has the narrow and irregular black markings dorsally restricted to the termen region only. Black dust on wing.

Wing Scales: There were several types of scales – piliform, lamellar, smooth (no groove at the posterior end), 1-6-grooves at the posterior end. Scales attaching to the wing surface through a small stalk or pedicel at its anterior end into the socket like structure on wing surface (Fig. 3C). The scales with four grooves (visible in Fig. 3C) measured around 82.9 ± 4.0 μm. Detailed studies are needed to elucidate the scales structure and their orientation patterns on microscopic level.

Comparison of reared specimen with captured butterflies: The captured specimens from the field were identified to belong to three species. *Danaus chrysippus* (2 ♂), *Papilio polytes* (1 ♂) and *Eurema hecabe* (2 ♂ and 3 ♀). The reared specimen remarkably resembled to *Eurema hecabe*, which confirmed that the larva infesting *A. stenophylla* belonged to *Eurema hecabe*.

DISCUSSION

It is medium-sized, sulphur to rich lemon yellow butterfly flying low near the ground, showing light-loving proclivity and occurring at various altitudes in Ethiopian, South African, Indo-Australian regions extending northwards to Korea and Japan and Pakistan. It has likely a wide range of food plants (Chye, 2009; Van–Wright and de Jong, 2003; Herbison-Evans and Crossley, 2010). The main external morphological characters used for identification of *Eurema hecabe* as mentioned in the referred keys are prominent yellow colour of the wings, black club shaped antenna, and black markings on the dorsal side of the fore wings (the prominent apical marking running along the termen to the inner margin excavating in terminal space between M2 and CU2) and no humeral vein in hind wing. A black narrow streak on either side of the third vein and ending before the origin of CU1 is considered to be a sex brand in *E. hecabe*. The reared specimen with its above characters was, therefore, identified as *Eurema hecabe* (Linnaeus, 1758) according to the keys proposed by Grund (1999), Perveen and Ahmad (2012) and Jeratthitikul *et al. (*2009). The specimens with two black specks in the discal cell on the ventral side of the fore wing, or one speck or none are considered to be the variants by Jeratthitikul *et al.* (2009). This butterfly may be seen round the year. The dry season's forms are known to be somewhat different from wet season's forms. The variations in this species may be affected by changes in environmental factors during larval development, such as temperature, photoperiod or food plant quality (Jones, 1992; Braby, 2000). Sexes in this species are closely similar but male sex brand (Jeratthitikul *et al. (*2009) may help in differentiating male from the female to an extent and characterizing the subspecies if genitalia characters are known. It may be mentioned here that a symbiotic bacterium (*Wolbachia*) with *E. hecabe* bring reversal of sex of the insect from genetic male to female during larval development (Hiroki *et al.*, 2002; Nirita *et al.*, 2007).

This is quite paradoxical with the butterflies that they are common pollinators as adult but their larvae enact as pest and thus as a primary herbivore transferring energy to the next trophic level. The present work indicates that larvae of *E. hecabe*, besides some other hosts, are a serious pest on *A. stenophylla* young seedlings which puts the host in seriously jeopardy at reproduction level in Karachi. Whatever is the case butterflies are the essential part of our ecosystems. Special care at the younger stages of the plants till phyllodes develop, are, therefore, imperative if *A. stenophylla* planting is desired through seeds.

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REFERENCES

Abe, K.I. (1983). *Plantation Forest pests in Sabah.* F.R.C. publication No. 8 pp. iii + 119 pp.

Ahsan, M. and Javaid, I. (1975) A contribution to the butterflies of Lahore with the addition of new records. *Biologia* 24 (2): 238-247.

Alagumurugan, C.M.Pavaraj and M.K. Rajan (2011). Seasonal and relative abundance of butterfly in a scrub jungle habitat of Peraiyur Taluk, Madurai District, TamilNadu, *India. J. Res. Biol*. 1: 44-50.

Bingham, C.T. (1905). *The Fauna of British India including Ceylon and Burma Butterflies*. Vol. 1 and 2. Taylor & Francis ltd. London. Xv + 528 pp.

Braby, M.F. (2000). *Butterflies of Australia*: their identification, biology and distributions. CRISO Publ., Melbourne. 458 pp.

Chye, S. (2009). Early stages of *Eurema hecabe contubernalis*. Butterflies of Singapore and peninsular Malaysia. (http://sgbug.blog.spot.com/2009/07/early-stages-of-Eurema-hecabe.html.)

Fleming Jr., R.L. (2006). Butterflies and natural history of the Siang valley, Arunachal Pradesh, India. occasional paper No.7. Future Generations Graduate school.. *Appl. Comm. Change and Conserv*. (www. Future.com).

Gaonkar, H., 1996. *Butterflies of Western Ghats with notes on those of Sri Lanka*. A Report to the Center of Ecological Sciences, Indian Institute of Science, Bangalore, Zoological Museum, Copenhagen and Natural History Museum, London, pp: 89.

Grund, R. (1999). South Australian Butterflies- What butterfly is that? A key of identifying South Australian butterflies. (http://sabutterflies.org.au/pier/hecabe.htm)

Guptha, M.B., P.V. Chalapathi Rao, D.S. Reddy, S.R .S. C. Sekhar Maddala and P. Madhu Babu (2012). A preliminary observation on butterflies of Seshachalaam Biosphere Reserve, Eastern Ghats, Andhra Pradesh, India. *World J. Zool*. 7(1): 83-89.

Hassan, S. A. (1994). *Butterflies of Islamabad and Murree Hills*. Asian Study Group, Islamabad 1-68

Henning, G.A., S.F. Henning, J.G. Joannou, S.E. Southwood (1997). *Living butterflies of Southern Africa. Biology, Ecology, Conservation. Vol. 1. Hesperiiidae, Papilionidae, Pierridae of South Africa.* Pp. 1-394. Hatfield, South Africa.

Heppner, J., (1998). *Classification of Lepidoptera*. Part I. Introduction. *Holarctic Lepid*. 5: 148.

Herbison-Evans, D. and S. Crossley (2010). *Eurema hecabe* (Linnaeus, 1758). (http:// lepidoptera.butterflyhouse .com. au/ pier /Pieridae.html).

Hiroki, M., Y. Kato, T. Kamito and K. Miura (2002). Feminization of genetic males by a symbiotic bacterium in a butterfly *Eurema hecabe* (Lepidoptera: Pieridae). *Naturwissenschaften* 89: 167-170.

Hirota, T. and Y. Kato (2001). Influence of visual stimuli on host location in the butterfly, *Eurema hecabe*. *Entomologia Experimentalis et Applicata* 101: 199-206.

Hussain, K.J., T. Ramesh, K.K. Setpathy and M. Selvanayagam (2011). Seasonal dynamics of butterfly population in DAE campus, Kapakkam, Tamil Nadu, India. *J. Threatened Taxa* 3(1): 1401-1414.

Iqbal, J. (1978). Preliminary report on butterflies of district Rawalpindi and Islamabad. *Biologia* 24(2): 237-247.

Islam, A.T.M., M.H. Islam, A.S.M. Saifullah, K. Endo and A. Yamanaka (2011), New records of butterflies and their species diversity in four different areas of Savar, Dhaka, Bangla Desh. *Univ. J. Zool., Rajshahi Univ*. 30: 9-15.

Javaid, I. (1978) Preliminary report of butterflies of district Rawalpindi and Islamabad. *Biologia* 24(2): 238-247.

Jeratthitikul, E., A. Lewvanich, B. A. Butcher and C. Lekprayoon (2009). A taxonomic study of the genus Eurema Hubner, [1819] (Lepidoptera: Pieridae) in Thailand. *The Nat. Hist. J. Chulalongkorn University* 9 (1): 1-20.

Jones, R.E. (1992). Phenotypic variation in Australian *Eurema* species. *Aust. J. Zool*. 40: 371-383.

Khan, M. R., Rafi, M. A., Ilyas, M. and Safder, M. (2000) Distribution and diversity of *Papilio spp.* (Lepidoptera: Papilionid) Rawalpindi and Islamabad. *Pakistan Journal of Scientific Research* 52(1-2): 1-3.

Khan, M. R., Rafi, M. A., Munir, M., Shoukat, H., Baig, M. W. and Khan, M. W. (2007). Biodiversity of butterflies from districts Kotli, Mirpur and Azad Kashmir. *Pakistan Journal of Zoology* 39(1): 27-34.

Khanal, B. (2006). The late season butterflies of Koshi Tappu wildlife Reserve, Eastern Nepal. *Our Nature* 4: 42-47.

Khanal, B. (2008). Diversity and status of butterflies in lowland districts of West Nepal. *J. Nat. Hist. Mus*. 23: 92-97.

Kunte, K., 2009. Occurrence of *Elymnias obnubila* Marshall and de Nicéville, 1883 (Lepidoptera: Nymphalidae: Satyrinae) in southern Mizoram: Range extension of the species and an addition to the Indian butterfly fauna. *J. Threatened Taxa*, 1(11): 567-568.

Malik, J.M. (1970). *Notes on the butterflies of Pakistan in the collection of Zoological Survey Department*. Report of Zoological Department, Pakistan 2(2): 24-54.

May, P.G., 1992. Flower selection and the dynamics of lipid reserves in two nectarivorous butterflies. *Ecology* 73: 2181-2191.

Mendes, L.F. and A.B. de Sousa (2010). New data on Herperioidea and Papillionoidea (Lepidoptera) from Cape Verde Islands, with a review of previous records. *Zool. Caboverdiana* 1 (1): 45-48.

Nirita, S, D. Kageyama, M. Nomura, and T. Fukatsu (2007). Unexpected mechanism of symboint induced reversal of insect sex : feminizing *Wolbachia* continuously acts on butterfly Eurema hecabe during larval development. Appl. & Environ. Microbiol 73(13): 4332-4341.

Perveen, F. and A. Ahmad (2012a). Exploring butterfly fauna (Lepidoptera) of Kohat, Khyber Pakhtunkhwa, Pakistan. *SOAJ Entomological Studies* 1(2): 94-107.

Perveen, F. and A. Ahmad (2012b). Checklist of butterfly fauna of Kauhat, Khyber Pakhtunkhwa, Pakistan. *Arthropods* 1(3): 112-117.

Quek, K.L., N.S. Sodhi and L.H. Lion (1999). New records of butterfly species for Pulau Tioman peninsular Malaysia. *The Raffles Bull. Zool. Suppl.* No. 6: 271-276 (National Univ., Singapore).

Raghavendra Gowda, H.T., V. Kumara, A.F. Pramod and B.B. Hosetti (2011). Butterfly diversity, seasonality and status in Lakka Valli range of Bhadra wildlife sanctuary, Karnataka. *World J. Sci. & Technol*. 1 (11): 67-72.

Rajagopala, J. M. Sekar, a. Manimozhi, N. Barkar and A.G. Archunan (2011). Diversity and community of butterfly of Arignar Anna Zoological park, Chinnai, TamilNadu, India. *J, Environ. Biol*. 32: 201-2107.

Roberts, T.J. (2001). *The Butterflies of Pakistan*. Oxford Univ. Press, Karachi. Pp 290.

Roy, A.B., U. Ghosh and K. Kunte, 2010. Sighting of *Elymnias panthera* (Lepidoptera: Nymphalidae: Satyrinae) in West Bengal, eastern India. *J. Threatened Taxa*, 2 (1): 670-671.

Shah, M., Rafi, M. A., Inayatullah, M. (2001) Some pierid butterflies of Kohat district. *Sarhad Journal of Agriculture* 17(3): 407-413.

Smetacek, P., 1992. Record of *Plebejus eversmanni* (Stgr.) from India. *J. the Bombay Natural History Society*, 89: 385-386.

Tiple. A.D. (2012). Butterfly species diversity, relative abundance and status in tropical Forest Research Institute, Jabalpur, M. P. Central India. *J. Threatened Taxa* 4 (7):2713-2717.

Vane-Wright, R.E. and R. de Jong (2003).*The Butterflies of Sulawasi: annotated Checklist for a Critical Island Fauna. Zool. Verh. Leiden* 343: 3-267.

Venkata Ramana, S.P. (2010). Biodiversity and Conservation of Butterflies in the Eastern Ghats. The *Ecoscan*, 4(1): 59-67.

Yata, O. (1994). A revision of the old world species of the genus *Eurema* (Lepidoptera: Pieridae) Part IV. Description of the hecabe group (part). *Bull. Kitakyushu Museum Nat. Hist*. 13: 59-105.

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