Eulophid seed borer, *Anselmella kerrichi* (Narayanan *et al.*; Hymenoptera), an emerging pest of jamun

Jamun, *Syzygium cumini* L. (Myrtaceae) is a common evergreen perennial fruit tree of tropical and subtropical regions. Being native to India and Myanmar, it is found throughout Southeast Asia and the Pacific regions[1,2]. The tree bears annually, sweetish and sour, dark-purple berries that are much sought after for their antioxidant, anti-inflammatory, anti-microbial and free-radical-scavenging properties[3]. The existing literature provides an exhaustive list of various insect pests (~78 species) that could infest *S. cumini* in India[4]. However, none of these studies reported seed borer, *Anselmella kerrichi* (Narayanan *et al*., 1958) (Hymenoptera: Eulophidae) as an insect pest of jamun. The database of insect pests hosted by the National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru, mentions the larval stages of *A. kerrichi* as phytophagous and feeding mainly on the seeds of jamun (http://www.nbair.res.in/insectpests/Anselmella-kerrichi.php); the species is the synonym of *Eugenia kerrichi* (Narayanan *et al.*, 1958)[5]. Unlike other eulophids which are predominantly parasitoids/hyperparasitoids, *A. kerrichi* is phytophagous[6] (http://www.nbair.res.in/insectpests/Anselmella-kerrichi.php). The other species of the genus *Anselmella*, viz. *Anselmella miltoni*, *Anselmella malacia* and *Anselmella occult* have been reported from Queensland, Malaysia and Papua New Guinea respectively, as serious pests of *Syzygium* species, viz. *Syzygium austral* (brush cherry), *Syzygium smithii* (lilly pilly), *Syzygium samarangense* (java apple) and *Syzygium pachyphyllum* (thick-leafed jambu)[7–9].

In India, *A. kerrichi* was reported from Pune, Maharashtra, way back in 1957. Besides this, no reports that highlight the economic importance and nature of damage of this eulophid seed borer in jamun are available[10], possibly due to its limited distribution/occurrence and pestilence. However, in the recent past, several incidences of *A. kerrichi* attacking *S. cumini* fruits causing extensive crop loss have been noticed in farmers' fields in rural Bengaluru by the present authors. This study identifies the critical fruit stages that are susceptible to *A. kerrichi* for planning management interventions.

To identify the critical fruit phenological stages that are highly susceptible to *A. kerrichi*, jamun fruits in different developmental stages were collected randomly from the infested trees. The collected fruits were separated into five groups, namely G1–G5 based on their size, colour and hardness (Figure 1).

Observations on fruit diameter, length, mesocarp thickness and seed diameter from all the phenological stages (G1–G5) were made. Fruits from all five stages were placed separately in plastic containers (15 × 12 × 20 cm) covered on top with muslin cloth to provide aeration. The containers were properly labelled and placed at room condition (25° ± 2°C, 60% relative humidity) until the emergence of adult wasps. Observations were recorded daily on the emergence of wasps, the number of exit holes per fruit and their diameter. Infested fruits ($n = 50$) were dissected to study the nature of internal damage and the same was digitized by a stereomicroscope Leica (M205C). Data were subjected to descriptive statistical analyses using Graphpad Prism (Ver. 7.0).

Heavy infestation (62.60% ± 5.99%) of jamun fruits by *A. kerrichi* rendering them unmarketable was observed. The infested fruits bore black, pinprick-sized oviposition punctures along with circular exit holes on the rind. Correlation analysis revealed significant positive relation between the fruit stage and wasp exit holes ($r = 0.63$, $P = 0.01$). The variability in the exit holes could be explained to the tune of 40% by fruit stage alone ($F = 62.36$; edf = 96, $P < 0.0001$).

The stages G1 and G2 were immune to infestation as revealed by the absence of

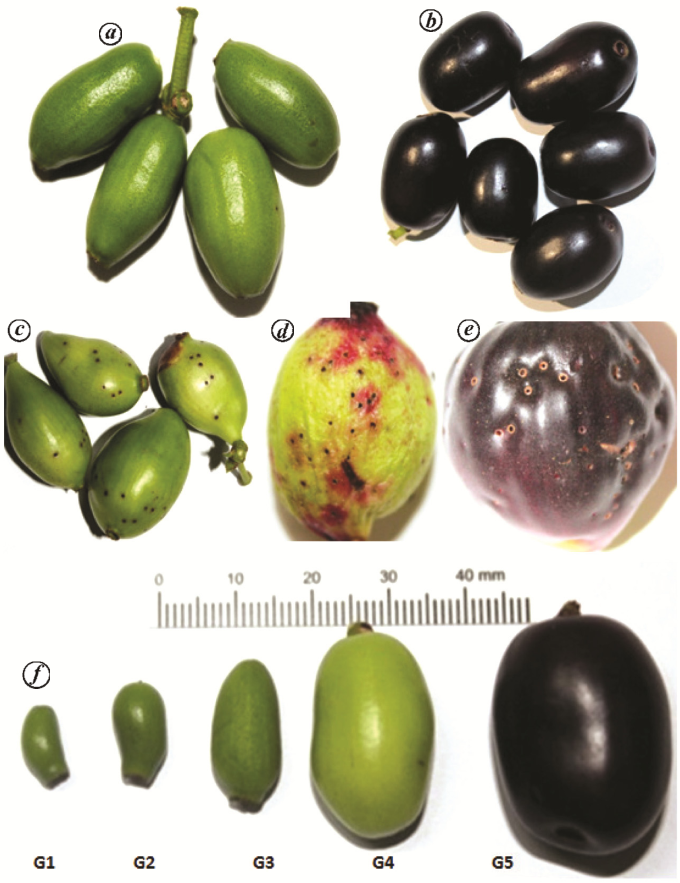

Figure 1. ***a***, ***b***, Jamun, *Syzygium cumini* healthy fruits: (***a***) Immature and (***b***) Ripe. ***c–e***, *Anselmella kerrichi* damaged fruits at different growth stages. ***f***, Phenological scale followed in the study showing G1–G5 stage fruits.

Table 1. Descriptive statistics of different phonological stages and fruit damage by *Anselmella kerrichi* in jamun

	Fruit measurements (mean ± SE, mm)				Numbers/fruit		
Phenological stage	Length	Diameter	Mesocarp thickness	Seed* diameter	Exit holes	Adults emerged	Sex ratio (♂ : ♀)
G1	4.47 ± 0.64	9.13 ± 0.84	1.08 ± 0.11	4.48 ± 0.52	0.00	0.00	0.00
G2	7.06 ± 0.91	15.75 ± 1.41	1.24 ± 0.10	6.34 ± 0.83	0.00	0.00	0.00
G3	11.29 ± 0.99	22.02 ± 1.84	2.78 ± 0.47	8.30 ± 0.68	0.00	0.00	0.00
G4	27.37 ± 1.79	31.25 ± 2.71	4.48 ± 0.46	9.62 ± 0.73	84.2 ± 22.24	32.52 ± 11.12	1 : 1.26
G5	24.02 ± 1.57	26.5 ± 2.25	5.58 ± 1.04	9.16 ± 1.32	31.6 ± 14.13	14.00 ± 11.03	1 : 1.54

*Seed kernel texture varied among the stages: G1, Soft, tender and juicy, light green in colour; G2, Tender and soft, light green to yellowish in colour; G3, Semi-hard, light green to creamy-white in colour; G4, Hard and creamy-white to hyaline in colour; G5, Harder compared to G4 with purplish tinge.

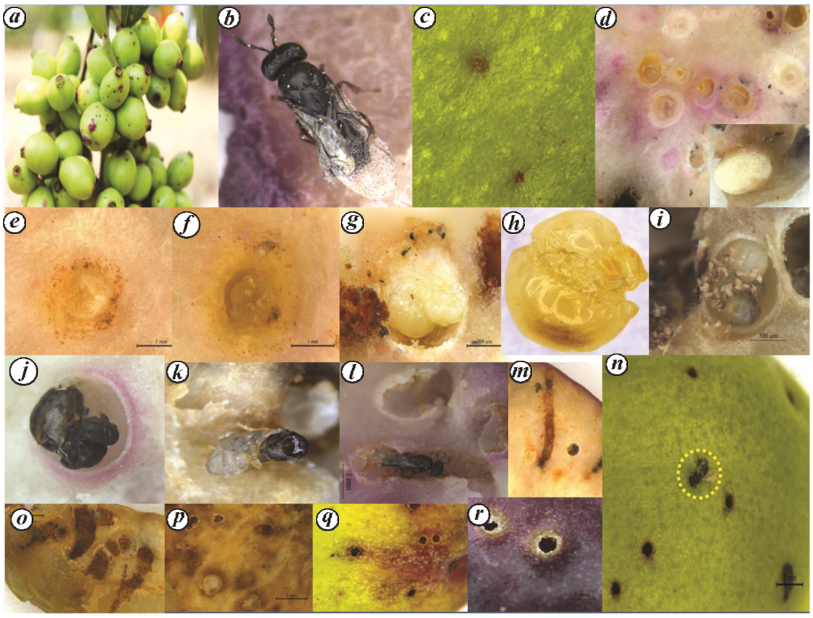

Figure 2. Damage symptoms of eulophid seed borer, *A. kerrichi* on jamun fruits. ***a***, Damaged fruits in the field. ***b***, Adult female; ***c***, Oviposition punctures on green fruit. ***d***, (Inset) Gall-like structures seen in the seed, individual gall-like shell dissected out. ***e–k***, Immature stages developing within the gall-like structure in the seed. ***l***, Teneral wasp ready to emerge. ***m***, Feeding tunnel/exit passage extending from seed to fruit surface. ***n***, Adult emerging from the fruit. ***o***, ***p***, Tunnelling damage seen in the seed. ***q***, ***r***, Exit holes.

oviposition punctures as well as exit holes (Table 1). This may be due to the fact that the larvae being kernel feeders could not use the immature seed kernels of G1 and G2 (Table 1). The tiny greenish-black oviposition punctures that resemble pinpricks were evident during the G3 stage, indicating active oviposition by female wasps. However, the G3 stage was devoid of any exit holes, indicating that it harbours only hidden infestation of *A. kerrichi* grubs. On the whole, zero eclosion was noticed during the first three stages (Table 1).

Dark-coloured circular exit holes with a white halo were noticed in fruit stages, viz. G4 and G5. The diameter of exit holes ranged from 1.24 to 1.39 mm. The mean number of exit holes was significantly ($P < 0.0001$) more in the G4 stage than G5 stage (Figure 1). The phenological stages, namely G4 and G5 recorded significant wasp emergence vis-à-vis exit holes (adults emerged: $P < 0.0001$; $F_{5,95} = 91.98$; exit holes: $P < 0.0001$, $F_{5,95} = 371.41$, Table 1, Figure 1). The sex ratio calculated was biased towards females (Table 1); such female-biased sex ratios have been reported in other eulophids as well[10].

The immature stages of wasps were found feeding exclusively on seed kernels and different life stages of *A. kerrichi*, including the adults were observed within the seed (Figure 2), indicating overlapping generations of *A. kerrichi*. The female wasps were seen inserting the eggs below the epidermis of the fruit. The mean length of the ovipositor was 1.46 ± 0.02 mm. The freshly hatched grubs were found tunnelling through the pulp towards the seed, and feeding on only seed tissues. The rear ends of each tunnel hold a compact gall-like shell case harbouring various developmental stages of the seed borer. No feeding damage was noticed in the mesocarp. The exit holes on the fruit epicarp through which the adult wasps emerged were found to connect through the mesocarp to the feeding galleries (7.48–8.12 mm in length, 1.39–2.85 mm in diameter) of the grubs within the seed. Each fruit when dissected had around 10–15 live, fully developed adults.

In jamun both whole fruit as well as seed are economically important. Considering the vast damage it can cause and the ability to build up in huge numbers (~85 per fruit) in overlapping generations, *A. kerrichi* can become a major problem to jamun growers. Further, larval feeding affects seed viability and rate of germination. As the critical stage for infestation is G2, application of safe botanical pesticides at this stage may help reduce seed borer infestation.

1. Patel, V. B., Pandey, S. N., Singh, S. K. and Bikash, D., *Indian J. Hortic.*, 2005, **62**, 244–247.
2. Rajesh, K., Ramamurthy, V. V. and Sharma, G., *Biol. Forum.*, 2010, **2**, 1–5.
3. Ramteke, V. and Kurrey, V. K., *Popular Kheti*, 2015, **3**, 188–190.
4. Butani, D. K., *Insects and Fruits*, Periodical Expert Book Agency, Delhi, 1979, p. 415.
5. Noyes, J. S., Universal Chalcidoidea Database. World Wide electronic publication, 2019; http://www.nhm.ac.uk/chalcidoids
6. Gadallah, N. S., Ghahari, H., Felipo, F. J. and Fischer, M., *Zootaxa*, 2015, **3794**.
7. Girault, A. A., *Can. Entomol.*, 1916, **48**, 337–344.
8. Boucek, Z., *Australasian Chalcidoidea (Hymenoptera), A Biosystematic Revision of Genera of Fourteen Families, with a Reclassification of Species*, CAB International, Wallingford, UK, 1988, p. 832.
9. Xiao, H., Xu, L., Huang, D. and Zhao, Z., *Phytoparasitica*, 2006, **34**, 261–264.
10. Jun Abe, Kamimura, Y., Kondo, N. and Shimad, M., *Behav. Ecol.*, 2005, **14**, 34–39.

ACKNOWLEDGEMENTS. We thank the Director, ICAR-Indian Institute of Horticultural Research, Bengaluru for providing the necessary research facilities. Technical support from T. S. Rajanna and J. Sagar is acknowledged.

Received 29 May 2019; revised accepted 6 August 2019

P. D. KAMALA JAYANTHI[1,*]
ANJANA SUBRAMONIAM[1]
A. REKHA[2]
B. R. JAYANTHI MALA[1]

[1]*Division of Entomology and Nematology, and*
[2]*Division of Fruit Crops,*
ICAR-Indian Institute of Horticultural Research,
Hesseraghatta Lake PO,
Bengaluru 560 089, India
**For correspondence.*
e-mail: jaiinsect@gmail.com

Interannual variation of clutch initiation of the great tit (*Parus major* Linnaeus) in relation to the local air temperature

The average global climate is changing rapidly[1] and increasing evidence indicates that global warming has consequences on numerous plant and animal species. Previous studies have shown significant fluctuations in the date advancement among wild species phenology in relation to warm springs. For instance, according to Szabó *et al.*[2], four out of six investigated plant species in Hungary showed a significant advance in flowering dates by 1.9–4.4 days per decade, and the wood frog (*Rana sylvatica*) showed a trend toward earlier emergence by 19 days[3]. In bird species, these impacts often manifest in geographical distribution[4], population size[5], interaction between bird species and other species[6], etc. However, long-term observations were mainly focused on spring migration[7–9] and breeding phenology[10,11] variations. Moreover, while most of the previous long-term monitorings were focused on interannual fluctuations of bird phenology in northern and western Europe, very few were conducted in southeastern Europe.

Here, I investigate how the timing of the great tit *Parus major* (Linnaeus, 1758) breeding was related to local spring surface temperatures. The trend of laying dates (first clutch) during the 33-year period (1984–2016) was examined. Great tit is a common, small resident and hole-nesting passerine species in the forests of northwestern Croatia[12].

Monitoring was done from 1984 until 2016, in the rural area of village Mokrice (lat. 46°00′N, long. 15°87′E, alt. 140 m, northwestern Croatia). This research area has a mixed landscape with small mixed deciduous forest. The dominant tree species in small forests are pedunculate oak (*Quercus robur*) and hornbeam (*Carpinus betulus*). In this study, wooden nestboxes of identical sizes were used (internal dimensions = 12 × 12 × 23 cm) and their entrances (diameter = 3.2 cm) were located at ca. 18 cm from the bottom of the nestbox. All the nestboxes were installed on the trees at 2.5 m above the ground, and at approximately 50 m distance from each other. Numerous ornithological studies have used nestboxes because of easier access to the eggs and hatchlings[13,14]. All boxes were cleaned after nesting period (August). The great tits lay one egg per day and modal clutch size is 11 eggs (Z. Dolenec, unpublished data). During the 33-year study period, nesting of 1,184 pairs of great tits was observed. The nestboxes (approximately 40–50 per year) were checked every five or six days during the breeding period in March and April to monitor egg laying. The day the first egg was laid was registered as the date of breeding onset. Only the breeding onset of the first ten pairs was calculated as the mean first laying date per year. The first clutches were only included for this study. Dates are expressed as progressive days, where 1 = 1 March. Fluctuations in laying date of the great tit in Mokrice were examined in relation to the mean local spring surface temperature variations. This method was also used by others[15]. The average surface temperature (March–April) was obtained from the meteorological station Maksimir (Meteorological Office in Zagreb); ca. 20 km from the study area, 123 m asl. Regression analysis and correlation were used to determine the association between the timing of laying on the one hand, and year and surface temperature on the other (tested using Pearson's correlations with