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Research Article

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Biology study of white grub *Holotrichia nagpurensis* (Scarabaeidae: Melolonthinae)

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ABSTRACT
Biology of polyphagous insect pest *Holotrichia nagpurensis* was studies in laboratory during 2019-2020. *H. nagpurensis* beetles (all types mated, unmated, male and female) were collected by using Light traps (fitted with 6-8 watts mercury tube Light; ACTINIC BL, PHILIPS) placed nearby host Neem trees, *Azadirachta indica*, Guava, *Psidium guajava*, Bakayan, *Melia azedarach*, in evening time from 7:45 to 9: 45 pm in the moths of June-July from Noorpur village in Ghaziabad district of Uttar Pradesh, India (28.7444° N, 77.5526° E) and identified by National Bureau of Agricultural Insect Resources, Bengaluru, Indian Council of Agricultural Research. All collected beetles kept individually in 1 liter capacity containers with moist soil. The mated female laid eggs an average of 29.800±3.247 eggs singly at a depth of 5-10 cm in the moist soil. The incubation period of the eggs was 12.960±0.501 days. 1st instars lasted 17.660±0.510 days; subsequent 2nd and 3rd instars were lasted for 35.140±0.530 and 86.120±0.800 days, respectively. The pupal period was recorded about 25.860±0.515 days and adult longevity was observed 101.860±3.575 days. Total life cycle recorded 277.960±3.371 days with 59.840±4.676 % survival and 0.518±0.039, 3.548±0.080 and 0.368±0.026 larval growth index, pupal growth index and developmental index respectively. All grubs feed on live maize roots in controlled conditions up to pupation. The simple methodology for rearing of root grubs on live maize roots under laboratory conditions was attempted and life cycle of *H. nagpurensis* was studied successfully.
Keywords: *Holotrichia nagpurensis*, biology, white grub, maize.

INTRODUCTION
The dark brown with silver shine on elytral surface beetle of *Holotrichia nagpurensis* belong to family Scarabaeidae and sub family Melolonthinae and its C shaped grubs stages responsible for economic losses in major agricultural crops viz., sugarcane (*Saccharum officinarum*), groundnut (*Arachis hypogaea*), sorghum (*Sorghum bicolor*) and maize (*Zea mays*). *H. nagpurensis* is most abundant white grub species with 27.46% relative abundance in western Uttar Pradesh, India (Riazuddin *et al*. 2018). Due to accessibility of abundant roots and sufficient moisture for a longer time in these crops is responsible for its huge infestation. Generally, the damage caused by root grubs is in patches, but during severe outbreak crop losses recorded 40-70% in entire field in Uttar Pradesh, Rajasthan, Delhi, Maharashtra and Karnataka (Anonymous, 2010). All the three stages of *H. nagpurensis* grubs live underground and feed on plant roots cause stunting, nutritional deficiencies and stand loss easy to uproot. In comparison to younger grub the older grubs feed aggressively and easily move from root to root within the row. The grubs are often exposed during weeding operations or during land preparation otherwise not possible to become conscious of their presence and level of damage in crop field. The white grub species *Holotrichia nagpurensis* was dominant on sugarcane crop with a 254.5 days life cycle during 2011-12 and 2012-13 in western plain zone of Uttar Pradesh, India (Sandeep *et al.* 2020). The present pest studies was not done earlier in details, however the knowledge on detailed biology of any pest species is essential for devising efficient control measures.

MATERIALS AND METHODS
The detailed biology of *Holotrichia nagpurensis* was studies during 2019-2020 in FARMER laboratory Ghaziabad. *H. nagpurensis* beetles (all types mated, unmated, male and female) were collected by using Light traps (fitted with 6-8 watts mercury tube Light; ACTINIC BL, PHILIPS), placed nearby form host plants namely Neem, *Azadirachta indica*, Guava, *Psidium guajava*, Bakayan, *Melia azedarach*, in evening time from 7:45 to 9: 45 pm in the moths of June-July (pre monsoon and monsoon season) from Noorpur village in Ghaziabad district of Uttar Pradesh, India (28.7444° N, 77.5526° E). The collected beetles were identified by National Bureau of Agricultural

Insect Resources, Bengaluru, Indian Council of Agricultural Research. The field collected females were released individuality in the desiccators that containing 30% moist soil for oviposition. The mated female laid eggs singly at a depth of 5-10 cm in the moist soil in laboratory conditions. The female beetles laid eggs from 7- 14 days and then died. The experiment was done in controlled conditions at 30±5ºC temperature, 65±5% RH and 16h Dark and 8h Light environment.

A total of 149 eggs obtained from five field mated females were kept in petridish with 30 % moist soil and wait for hatching to record egg period, fertility and fecundity. The newly hatched neonates (0-24h old) grubs obtained were shifted individually on live roots of maize (*Zea mays*) to avoid cannibalism. The host plant maize was grown (1 liter capacity) containers in sandy soil and after 7-10 days from sowing the planted roots ready to feed. The growing of host plants in pots is a continuous process during the entire study so that the growing grubs were feed on it. The grubs were transferred into fresh live roots of maize with adequate moisture at weekly interval to avoid food and environmental stress. This process was continued up to pupation. Grub period of each three stages, number of pupation, pupal period, number of beetles emergence and beetle period was recorded for further calculation.

All data were subjected to one-way analysis of variance (ANOVA) using SPSS 22.0. The results were expressed as mean ± SEM (standard error of the mean) and developmental indexes were calculated according to Deshmukh et al. (1982) and Tamhankar (1992).

RESULTS AND DISCUSSION

The mated female laid eggs singly in the soil at a depth of 5-10 cm and protected by constructing earthen cells of fine soil particles around them. The female beetles laid eggs from 7-14 days and then died. Female laid 5-7 eggs per day with a total of 29.800±3.247eggs during the entire life span. The freshly laid eggs were oval in shape and white in colour (Figure 1).

Later eggs become enlarge and yellowish embryo was clearly visible before hatching (Figure 1). The incubation period was 12.960±0.501 days (Table 1). Biological attributes recorded showed only three developmental instars lasted 137.280±1.436 days. The grubs were profound and feed on decaying organic matter initially and then on growing roots of the host plants (Figure 1). First instars grub was whitish in colour with light brown head and lasted 17.660±0.510 days (Figure 1, Table 1). Morphologically, 2nd instars resembles to the 1st instars grub except that its last abdominal segment was enlarged and slightly darker in colour than the 1st instars (Figure 1). The 2nd instars grubs lasted 35.140±0.530 days (Table 1).

Table 1. Biology of white grub *Holotrichia nagpurensis* (Scarabaeidae: Melolonthinae)

Biological attributes	Replicates					Mean	S.E±
	R_1	R_2	R_3	R_4	R_5		
Eggs/Female (Numbers)	27	22	25	38	37	29.800	3.247
Eggs period (days)	12.8	13.3	12.0	14.7	12.0	12.960	0.501
1st instar period (days)	17.8	16.5	18.5	16.5	19.0	17.660	0.510
2nd instar period (days)	33.5	36.3	34.8	36.3	34.8	35.140	0.530
3rd instar period (days)	88.2	85.8	83.5	87.3	85.8	86.120	0.800
Larval period (days)	139.5	138.6	136.8	131.9	139.6	137.280	1.436
Pupal period (days)	24.2	27.0	26.7	25.2	26.2	25.860	0.515
Adult period (days)	107.3	99.8	110.6	101.8	89.8	101.860	3.575
[1]Developmental period (days)	163.7	165.6	163.5	157.1	165.8	163.140	1.582
[2]Life cycle (days)	283.8	278.7	286.1	273.6	267.6	277.960	3.371
[3]Fertility* (%)	96.3	90.9	92.0	92.1	91.9	92.640	0.940
[4]Pupation* (%)	80.8	85.0	65.2	51.4	73.5	71.180	5.983
[5]Emergence* (%)	85.7	88.2	100.0	88.9	95.6	91.680	2.648
[6]Survival* (%)	66.7	68.2	60.0	42.1	62.2	59.840	4.676
[7]Larval growth index	0.58	0.61	0.48	0.39	0.53	0.518	0.039
[8]Pupal growth index	3.54	3.27	3.75	3.53	3.65	3.548	0.080
[9]Developmental index	0.41	0.41	0.37	0.27	0.38	0.368	0.026
SEm±						2.503	
CD @ 5%						7.079	

*Figures in parenthesis are arcsine values

[1]Developmental period (days) = larval period + pupal period (days)

[2]Life cycle = eggs period + larval period + pupal period + adult period (days)

[3]Fertility (%) = eggs to neonates emergence/female

[4]Pupation (%) = neonates to pupae/female

[5]Emergence (%) = pupae to adults/female

[6]Survival (%) = eggs to adult /female

[7]Larval growth index = percentage pupation/larval period

[8]Pupal growth index = percentage adult emergence/pupal period

[9]Developmental index = percentage survival/ developmental period

The fully grown large headed off-white colour grub with strong brown colour; antennae long slender and four segmented. Legs were well developed, similar in structure and provided with long setae. The thoracic region was provided with series of setae. There was one pair of spiracle located on the pro-thoracic region and eight in the abdominal region (Figure 1).

The 3rdinstars grub longevity was recorded 86.120±0.800 days. The full grown grub stops feeding and burrows deep in to the soil and prepared a small earthen cell for pupation (Figure 1) and transform into a pupa (Figure 8). The pupal period recorded 25.860±0.515 days. The cylindrical and robust beetle was dark brown with silver shine on elytral surface with strong labrum, separate from clypeus, clypeal incision broad medically, pronotum and elytra strongly pruinose, antennae ten segmented with three segmented lamellate club, pronotum without setae, lateral margins of pronotum strongly serrated and pointed downwards, terminal hind tibial spurs on one side of the tarsal segments, transverse ridge (carina) bearing setae in middle and hind tibiae, tarsal claws equal and dentate (Figure 9). Adults survived for 101.860±3.575 days under the laboratory conditions. First time this type of white grub rearing methodology on live maize root was successfully achieved under laboratory conditions, by weekly sowing the maize seed in 1 lit capacity containers, throughout the year. However, white grub rearing methodologies in field conditions and under laboratory, with soil and rooted saplings, were reported by (Anitha *et al.* 2006, Cock and Allard 2013, Danuta Wand and Lidia 2014, Theurkar *et al.*, 2013).

Figure 1. Developmental stages of *Holotrichia nagpurensis*, 1. Eggs, 2. Embryo inside egg, 3. Neonate (0-24hrs old grub), 4. 1st Instar, 5. 2nd instar, 6. 3rd instar, 7. Pre-pupa, 8. Pupa, 9. Adult (Beetle)

CONCLUSION

The knowledge of biology of any pest species is essential for devising efficient control measures. Laboratory culture of any pest population are also essential component of scientific research over field collection as they are largely uniform whereas field-collected population can be highly variable in age, nutritional condition, health, and genetic diversity. These differences can confound experimental results. Simultaneously, the methodology of rearing of white grub on live maize roots provides disease free spaceman with a known rearing history throughout the year, thereby reducing experimental variability. The information on the biological and ecological aspects of white grubs *H. nagpurensis* was spare and very less published. Hence detailed studies were conducted on life cycle of *H. nagpurensis* and a successful and simple methodology for rearing of root grubs on live maize roots under laboratory conditions was attempted.

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