BDR-10, a Newly Authorized Tropical Tasar Silkworm Race: Its Maintenance, Mass-Multiplication and Popularization in India

Chandrashekharaiah, M., Rathore, M.S., Hasansab Nadaf, Vishaka, G.V. and Srinivas, C.

Tropical tasar silkworm, *Antheraea mylitta* (D.) (Lepidoptera: Saturniidae) is an endemic wild silk fauna in India. It is distributed in the Chhota Nagpur Plateau, Central, South and Eastern parts of India. In addition to *A. mylitta*, other silk-producing species under the genus *Antheraea* are *A. assamensis* Helfer (muga silkworm), *A. compta* Rothschild, *A. frithi* Moore, *A. pernyi* Guerin-Meneville (Chinese oak silk moth), *A. roylei* Moore, *A. helferi* Moore, *A. knyvetti* Hampson, *A. andamana* Moore and Indian oak silk moth *A. proylei* (*A. roylei* × *A. pernyi*) are also recorded in India (Arora and Gupta, 1979; Jolly, 1980; Moore, 1877). Among them, *A. mylitta* and *A. assamensis* are economically most important wild-fauna in India, as they produce cocoon (silk) of commercial value during the larval stage of their life cycle. *A. mylitta* is holometabolous and polyphagous insect with the specific seasonal activities (Fig. 1). Its eggs are oval and creamy white to yellowish in colour similar to jowar grain size. The caterpillars are polymorphic (Chandrashekharaiah *et al*., 2020A) having green type as a dominant over yellow, blue and almond (Jolly *et al*., 1969). *A mylitta* behaves like a univoltine or bivoltine (BV) or trivoltine (TV), depending on the elevation and climatic conditions (Jolly *et al*., 1969). The final stage of caterpillar (pre-pupae) spins a silken cocoon around itself and transform into a pupa. Adults are with reduced mouthparts and digestive system. They are phenotypically highly variable with prominent sexual dimorphism (Chandrashekharaiah *et al*., 2020A).

A. mylitta is known to have many eco-races. Among them, the DABA eco-race is a semi-domesticated tasar silkworm, amenable for human handling and largescale commercial rearing. Since *A. mylitta* exhibit polyphagy, a striking color variation is evident at the larval and adult stages, which may relate to mimicry or cryptic nature against predators and to overcome various abiotic pressures (Endler, 1978; Forsman *et al*. 2015; Chandrashekharaiah *et al*., 2020A). The larval color polymorphism in *A. mylitta* is governed by dominant and recessive genes (YYbb-yellow, yyBB-blue, YYBB-green and yybb-almond) and follow the Mendelian theory of inheritance (Jolly *et al*., 1969). The larval body color of *A. mylitta* is determined by the dominant and

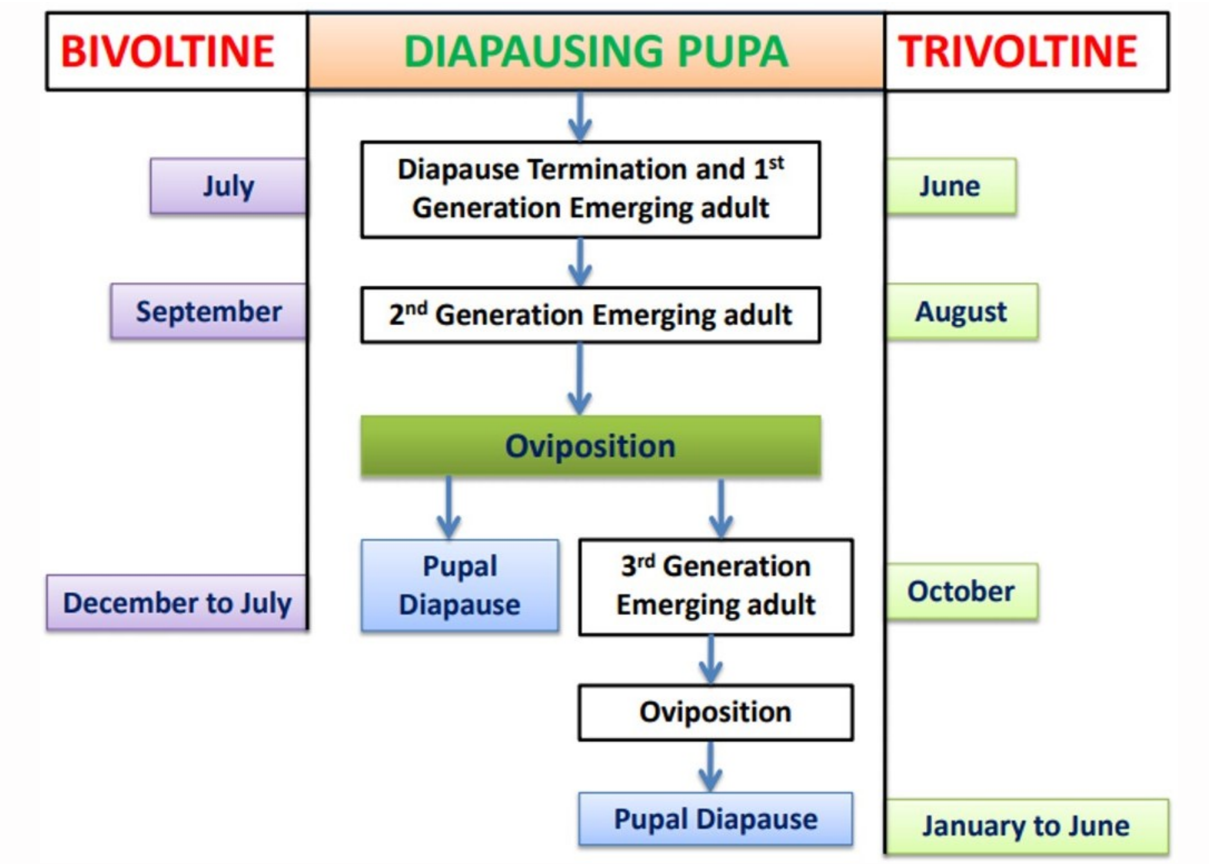

Fig. 1. Seasonal emergence pattern of *A. mylitta* in the DABA BV and TV

recessive genes. The green and almond larval types are genetically homozygous dominant and recessive in nature, respectively. The occurrences of green larval types are very prominent under natural conditions due to natural mimicry mechanism. On the other hand, almond larval types very rarely occur, due to strong predator pressure. The blue and yellow types are heterogeneous with variable resistance capacity against pathogens and environment variabilities. Relative allele frequencies do not change over a successive generation as per the Hardy-Weinberg equation. But, deviation in phenotypic ratio under natural conditions might be related to segregation, predation pressure, host-associated mimicry and environment (Mallet and Joron, 1999).

Development of BDR-10

In the year 1999, nearly 400 final instar yellow color larvae (Fig. 3A) were selected during the rearing of II crop DABA-BV (bivoltine) at Basic Seed Multiplication and Training Institute Boirdadar, Chhattisgarh. The selected larvae were reared separately and preserved for DFL (disease-free laying) preparation. Around 50 DFLs were prepared in the subsequent season from this stock. Further, these DFLs were reared and multiplied for 26 generations separately by following strict mass selection process at larval (color), pupal (weight) and moth (fecundity) stages. Finally, a new breed with phenotypically yellow body color larval type was developed and named as BDR-10.

Due to alfresco tending exercise of larvae, while rearing under outdoor conditions, the fitness may vary relatively in comparison to natural selection. The phenotypic variability also alters due to the

Fig. 2. BDR-10 adult moths (A&B) with different color polymorph and early-stage larvae (C). The sitting posture of the early emerged moths before wing expansion (A) and fully wing expanded adult moth (B).

quality of host plant and environmental factors. Strict selection imposed for economic characters at larval, cocoon and moth stages during rearing and seed production process might have led vicissitudes trait frequency over a period, which needs to be studied. Human interfered alteration of traits, through directional and random selection, alters fitness and eventually lost its wildness. The field observation on the phenotypic variation within the BDR-10 stock revealed that the majority of the worms with yellow body-color (96.75 %). In the remaining population, the phenotypic variation in the body color like the olive color (Fig 3B), apple-green (Fig. 3C) and green (Fig., 3D) types were recorded under outdoor rearing conditions. During early stage, almost all the larvae were yellow in color. Some larvae, after second instars, were turned into green types. However, such off-type larvae were further transformed into olive and apple-green color during fifth instars stage.

Economic characters of BDR-10

The BDR-10 cocoon, pupal and shell weight ranged from 9.59 g to 14.00 g, 9.60 g to 12.28 g and 1.50 g to 1.95 g, respectively. Correlation analysis also revealed that the cocoon weight, pupal weight, shell weight and silk ratio (%) were negatively influenced by the altitude (Chandrashekharaiah *et al.*, 2019). The clutch size in the BDR-10 varied from 215 to 230, cocoon usually grey color having 900-1100 m filament length, 50-60%

Fig. 3. Phenotypic segregation behavior in BDR-10 race (yellow larval type) under field conditions.

reelability and 60-65% silk recovery (Gupta VK *et al*., 2016). Further, observations indicated that the mortality of silkworm due to different pathogens was comparatively less in the BDR-10 compared to DABA-BV under outdoor rearing conditions (Chandrashekharaiah *et al*., 2020B). The coloration in insects linked to body temperature regulation and intraspecific communication (Brakefield, 1985). Since *A. mylitta* is distributed in the tropical parts of India, it will experience extreme high temperature, winter, predation pressure *etc*. In addition to these, food quality and management practices determine the stability and persistence of stock. Stability of parental stock is prerequisite in tropical tasar silkworm seed production, as its part of the life cycle exposes an outdoor condition while rearing. Greater phenotypic variability is also related to population fitness (Forsman *et al*., 2015). Therefore, the phenotypicvariability at larval and adult stages may help in overcoming effect of various abiotic pressures. But, ecological relevance of color types, the effect of predation pressure and climate change on its fitness are researchable issues for their conservation and economic welfare of rural populace in the tropical tasar sericulture practicing states.

The selection process has to follow for the elimination of off-types like larvae with other than yellow body color during reproductive and diapause seasons, early and late maturing individuals, poor feeding behavior, disease freeness, shell weight and fecundity as per the standard norms during each rearing. This selection process helps to preserve the seasonality, quality and commercial parameters within the stock. The minimum quality parameters observed in the BDR-10 like 1) Fecundity: ≥201; 2) Hatchability: ≥82 %; 3) Cocoon Yield/100 dfls (kg): >52; and 4) No. of cocoons/kg: ≥87.

BDR-10: An authorized race

The BDR-10 registration was published in the Gazette Notification: EXTRAORDINARY {PART II-SEC. 3(ii)} pp no. 4 published by Ministry of Textile, New Delhi, on Friday, June 8, 2018, and the same was authorized by Hybrid Authorization Committee (HAC) of Central Silk Board, on 25/11/2013. Rearing of BDR-10 recommended for the states like Jharkhand, Chhattisgarh, Odisha, West Bengal, Andhra Pradesh, Maharashtra, Madhya Pradesh, Bihar, Telangana and Uttar Pradesh. The crop schedule for brushing of dfls is around 15-20 July and 20-25 September for 1st and 2nd crop, respectively, which are similar to the brushing date followed in and around Raigarh, Chhattisgarh.

Mass multiplication and popularization of BDR-10

Mass multiplication and popularization of BDR-10 were initiated during 2017-18 at Central Tasar Silkworm Seed Station, Kargi Kota, Chhattisgarh through replenishment programme. A total of 9912 BDR-10 cocoons brought from the BSM&TC (Basic Seed Multiplication and Training Center), Boirdadar were processed under the grainage house and nearly 1100 dfls were produced during 1st grainage of 2017-18. Out of which, nearly 800 dfls were reared in the subsequent season. The strict selection was imposed while rearing for quality parameters as per the protocol and standard norms (Alok Sahay *et al.,* 2018) and about 59250 cocoons were produced. These cocoons were processed again during 2nd grainage and produced 22425 dfls. A total of 8950 dfls from this source were supplied to the BTSSO (Basic Tasar Silkworm Seed Organisation) units in Chhattisgarh, Jharkhand, Bihar, Odisha, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh in the biannual replenishment programme for mass multiplication. In addition to these, the units in the states like Maharashtra and Telangana were also covered in the subsequent year. Nearly, 47940, 242524 and 454367 dfls were produced during 2017-18, 2018-19 and 2019-20, respectively (Fig. 4). The cocoon yield and other commercial characters in the BDR-10 have highly convincing compared to DBV in the areas like Kargi Kota, Deoghar, Dudhi, Madhupur, Baripada, Nabrangpur, Pali and Bhagalpur (Alok Sahay *et al*., 2018). Maximum dfls were supplied to the Chhattisgarh, Jharkhand and Odisha during 2017-18 to 2019-20 (Fig. 5). However, the performance of BDR-10 was quite promising in the states like Jharkhand, Odisha and West Bengal.

Considering the importance of BDR-10 over the DABA eco-race in terms of economic characters like higher cocoon yield, disease resistance and acceptance of the rearers in the states like Odisha, Jharkhand and Chhattisgarh. Therefore, it is the need of the hour to further intensify and popularize the BDR-10 among the stockholders in all the states to improve the cocoon productivity.

References

Alok Sahay, Sinha R B, Rathore M S, Chandrashekharaiah. 2018. BTSSO Annual Report 2017-18 - replenishment programme during 2017-18. Basic Tasar Silkworm Seed Organisation - Central Silk Board, Bilaspur, pp 49.

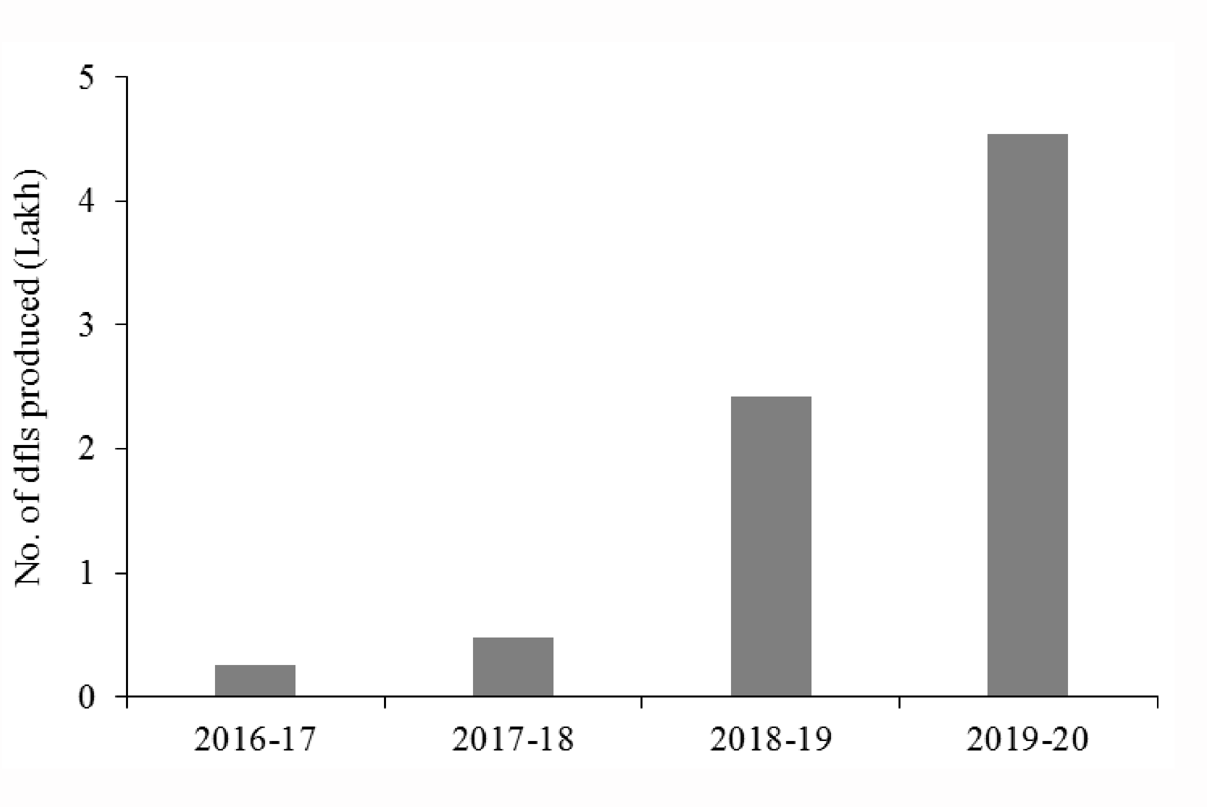

Fig. 4. BDR-10 DFLs produced under mass multiplication programme at BTSSO units during 2016-17 to 2019-20.

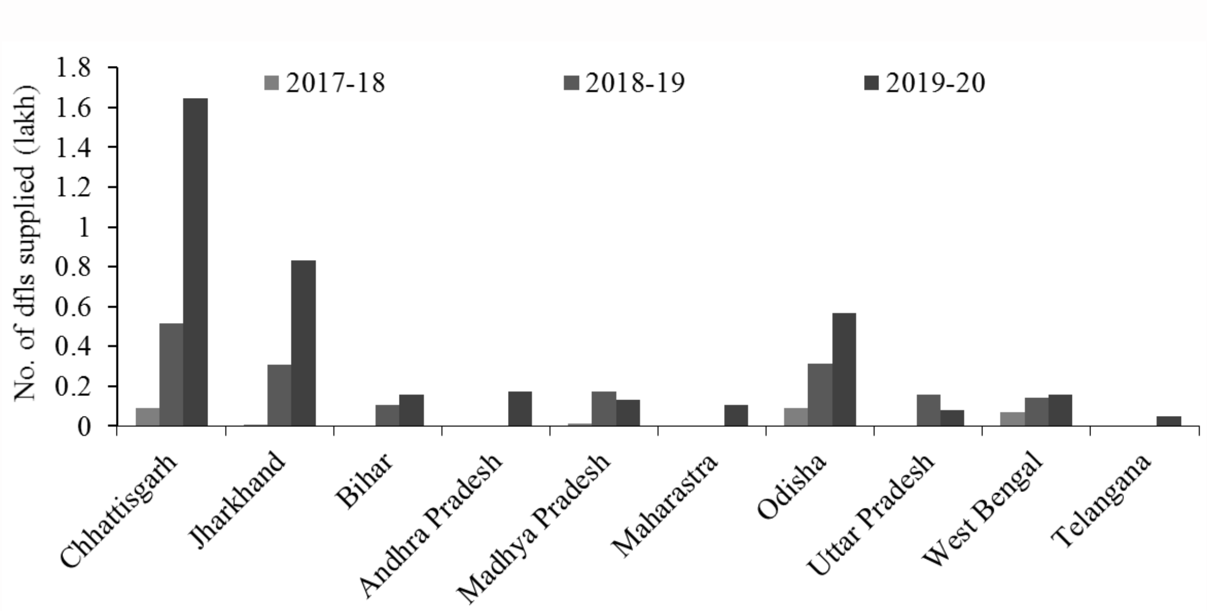

Fig. 5. BDR-10 DFLs supplied to different states during its popularization programme across tasar silk producing states

Alok Sahay, Sinha R B, Rathore M S, Chandrashekharaiah. 2018. Protocol for quality seed production in tropical tasar seed production - Basic Tasar Silkworm Seed Organisation - Central Silk Board (First Edition January 2018).

Arora G S, Gupta I J. 1979. Taxonomic Studies on some of the Indian Non-Mulberry Silk moths (Lepidoptera: Saturniidae: Saturniinae). Zoological Survey of India, Vol. 16 (Part 1). pp 63.

Brakefield P M. 1985. Polymorphism, Mullerian mimicry, and interactions with thermal melanism in ladybirds and soldier beetle and soldier beetle: an hypothesis. Biological Journal of the Linnean Society 26: 243-267.

Chandrashekharaiah M, Rathore M S, Sinha R B. 2019. Performance of BDR-10: A newly authorized race of *Antheraea mylitta* D. in different agro climatic zones in India. Journal of Pharmacognosy and Phytochemistry 8(6): 274-277.

Chandrashekharaiah M, Rathore M S, Thirupam Reddy B, Srinivas C. 2020A. Phenotypic variability in the Tropical Tasar Silkworm, *Antheraea mylitta*. The News of the Lepidopterists' Society 62(3): 143-145.

Chandrashekharaiah M, Selvaraj C, Hasansab Nadaf, Vishaka G V, Rathore M S, Srinivas C. 2020B. Studies on susceptibility of BDR-10 and DBV to different pathogens: indicating resistance behavior in BDR-10 against the virus, Souvenir - International Web Conference Perspective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020) (Wajid Hasan et al.), Agricultural & Environmental Technology Development Society (AETDS), Uttarakhand, India.

Endler J A. 1978. Frequency dependent predation, crypsis and aposematic coloration. Philosophical transactions of the Royal Society of London 319: 505-523.

Forsman A, Betzholtz P-E, Franzen M. 2015. Variable coloration is associated with dampened population fluctuations in noctuid moths. Proceedings of the Royal Society of London. Series B: Biological Sciences (London) 282:20142922.

Gupta V K, Susmita Das, Sinha S K. 2016. Tasar Technology Compendium 2016: Tropical and Temperate Tasar Culture - Host Plant, Silkworm Rearing, Seed Production & Post-Cocoon Technologies. Central Silk Board, Ranchi - Central Tasar Research and Training Institute.

Jolly M S. 1980. Distribution and differentiation in *Antheraea* species (Saturniidae: Lepidoptera). [Offprint of the paper presented at the XVI International Congress of Entomology, Kyoto, Japan, 3-9 August, 1980]: 1-20.

Jolly M S, Narasimhanna M N, Bardaiyar V N. 1969. Almond larval body colour in *Antheraea mylitta* D.: Its origin and pattern of inheritance. Genetica 40: 421-426.

Moore F. 1877. The lepidopterous fauna of the Andaman and Nicobar islands. Proceedings of the Zoological Society of London 40: 580-632.

AUTHORS

Chandrashekharaiah M (Corresponding author)**, Rathore M S, Hasansab Nadaf, Vishaka G V and Srinivas C,** Basic Tasar Silkworm Seed Organisation, Central Silk Board, Pendari-via-P.O Bharni, Bilaspur-495112 (Chhattisgarh), India email: chandu.raiah@gmail.com