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Gynandromorphism in Tropical Tasar Silkworm, *Antheraea mylitta* D. (Lepidoptera: Saturniidae)

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SUMMARY

Gynandromorphism is the phenomena that leads to development of individuals that are genetically chimeric and have both the male and the female tissues. As a result, they behave as both male and female. Various factors as temperature, UV exposure, viral infections, radioactivity etc. may lead to development of these aberrant organisms. Such intriguing mechanisms helps us to explore the sex determination system in arthropods and unravels the neural, sensory signalling and developmental processes involved in occurrence of such a rare event. This article deals with the gynandromorphism in tasar (Antheraea mylitta) and muga (A. assamensis) silk moths and the reproductive performance of such moths. Additionally, the mechanism underlying occurrence of gynandromorphism, factors contributing to development of such individuals and types of gynandromorphism witnessed in order Lepidoptera is briefly summarized.

INTRODUCTION

Gynandromorphism is a rare phenomenon in organisms with half female (gyn-female) and half male (andro-male) characteristics. It is reported in 13 orders, 69 insect families of insects. Occurrence of this phenomena in lepidopterans is quite rare with an estimated frequency of 0.000125% meaning development of one gynandromorph in 8000 normal individuals (Mala et al. 2021). It is still rare among the Saturniids with an occurrence frequency of 0.000012%, i.e., one gynandromorph per 83,000 normal individuals [1]. Within order lepidoptera it is seen in saturniid, noctuid and geometrid moths and nymphalid and papilionid butterflies. Gynandromorphism is an excellent example of developmental plasticity in genetalic development and cell autonomous sex determination (sex of an organism is intrinsically determined by each cell). It is more evident and easily recognised in species that have sexual dimorphism.

Reason For Gynandromorph Development

Extrinsic factors as temperature fluctuations from normal, low temperature treatments, exposure to UV radiations, mutations, phage infections, exposure to nuclear radiations or radioactive compounds, interspecific hybridisation etc [1]. led to development of gynandromorphs. It can also be produced due to Wolbachia infections, that develops female characters in individuals that are genetically males. Continuous inbreeding and climatic factors may also induce gynandromorphism (Sourakov, A. 2015).

Mechanism Of Gynandromorphism

Lepidopterans have ZZ-ZW sex determination system. Unlike human beings, females are heterogametic (ZW) (gene *Fem* on W chromosome) and males are homogametic (ZZ) (Jahner, et al., 2015). If a female egg cell develops with two nuclei (binucleate oocytes) instead of one (as under normal conditions), one carrying the single Z chromosome and the other carrying single W chromosome, gynandromorphism occurs. When such abnormal eggs fertilise with sperms having ZZ chromosomes, the fertilised eggs have both ZZ (male) and ZW (female) chromosomes. This at further stages leads to development of an organism with half male and half female cells. If these aberrations occur at an early stage of embryonic development before the zygote divides to embryo, the organism has a body with 50% male and 50% female cells, i.e., a perfect bilateral split (Mala et al. 2021). If the same happens a little later, it forms mosaic gynandromorphs, wherein only certain patches of the body of an individual behaves as that of opposite sex. Further loss of sex chromosomes during mitosis and genetic modifications induced by endosymbionts also lead to development of gynandromorphs. Mosaic gynandromorphism may also result due to loss of W chromosome carrying less information for sex determination (sex is determined based on number of Z chromosome in the cell) during non-disjunction events (Mala et al. 2021).

Types Of Gynandromorphism

The bisexual behaviours exhibited by gynandromorphs can be classified into four types (Obara, Y., & Tamazawa, S. 1982).:

Dual personality: The moth sometimes behaves as male and other times as female

Schizophrenic: Some part of the body of an individual behaves as male and the other part as female. It further encompasses bilateral gynandromorphy or mosaics.

Intersex: The behaviours shown by individual is an intermediate between the male and female characters.

Sequence cross: The individual exhibits wrong sexual selection that is inappropriate in a given sexual condition or situation. For instance, a sequence cross gynandromorph approaches a female showing the male type behaviours, but behaves as a female when in contact with her.

Gynandromorphism In Tropical Tasar Silkworm

Tropical tasar silkworm, *Antheraea mylitta* is a commercially exploited serigenous insect. It thrives in the geographical region of 12°N to 31°N lat. and 72°E to 96°E long., and is polyphagous with the primary hosts being Terminalia and Shorea species . It has 44 ecoraces with Daba (bivoltine and trivoltine) and Sukinda races being commercially exploited. It is an oviparous species with egg incubation period being 8-9 days. Gynandromorphism is witnessed in wild and semi-domesticated tasar silkworms.

Male characters were prominent in the right side of the gynandromorph individual, while the left side shows female characters. The characters as form of antennae and pattern and colour of wings can be easily conceivable. The female (left) side has a small, less feathery bipectinate antennae as compared to the male (right) side where the antennae is highly feathery and large. Similarly, the wing colour is yellowish on the female (left) side in contrast to brown in the male (right) side. The females have larger fore and hind wings as compared to male. The eyespots are more prominent and glassier on the female wings (Fig. 1). The abdomen and leg colour are also yellow and brown for female and male parts respectively. However, the size of gynandromorphic individual was smaller as compared to both normal male and female. The type of gynandromorphism in tasar silk moth is schizophrenic (displaying both male and female characters simultaneously). Contrary to these Kumar *et al.,* 2010 reported a muga gynandromorph with left side as male and right side as female.

Fig 1: Gynandromorphism in tasar silk moth **a** male; **b** gynandromorph; **c** female (Adopted from Mala *et al.,* 2021)

Gynandromorphism In Muga Silkworm

The muga silkworm was reported to have gynandromorphism with the female characters represented on the right side and the male characters on the left side. Wings are larger for females (80mm) against males

(75mm). However, the antennae are larger, feathery, and darker for the males and is quadripectinate in both males and females (Fig. 2).

Fig 2: Gynandromorphism in muga silk moth **a** normal male; **b** female; **c** dorsal view of gynandromorph; **d** ventral view of gynandromorph (Adopted from Kumar *et al.*, 2010)

Reproductive Performance of Tasar Gynandromorphs

It is relevant to understand the mating behaviour and the reproductive potential of the gynandromorph individual. The economics characters of the individuals as larval weight, pupal weight, cocoon weight, shell weight, shell ratio, etc throw light on the reproductive performance of such abnormal individuals and determine its reproductive ability and suitability in commercial rearing. The development of female gynandromorph and its ability to lay fertile eggs was documented by Mala *et al.*, 2021 (Fig. 3). They reported that though the moth was able to mate and produce fertile offsprings, it had significantly lowered fecundity (133) as compared to the normal female (200-250).

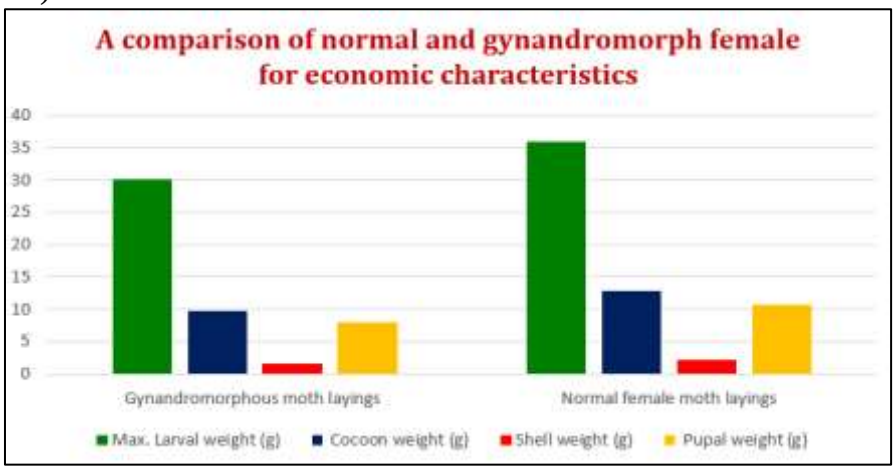

Fig 3: A comparison of normal and gynandromorph tasar females for economic characters shows that normal female moth exhibit better economic characters as compared to gynandromorph through not statistically significant meaning that the gynandromorph is functionally female

CONCLUSION

Gynandromorphs are suitable biological models to resolve the mysteries of sex determination and its evolutionary significance. Such rare phenomena provide the scope for development of new phenotypes in insects that are genetically similar under selection pressure. However, issues and questions as whether the abnormal gynandromorph could mate with both male and female moths, why in some instances patches of male and female develops and in some other every cell express intermediate characters is still unanswered . Also, sex regulation is emerging arena of research. Since males are more efficient silk producers as compared to females (who divert nutrients and energy for oogenesis rather than silk protein synthesis), manipulation of sex system in favour of male can elevate silk production. Thus, understanding sex determination systems and mechanics is crucial.

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