GYNANDROMORPHISM: NATURE'S ODDITIES

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INTRODUCTION

In the intricate world of insects, nature often unfolds captivating phenomena that challenge our understanding of biological diversity. One such phenomenon that continues to pique the interest of scientists and enthusiasts alike is gynandromorphism. This rare and intriguing occurrence manifests as an organism displaying both male and female characteristics, blurring the lines between traditional sex distinctions.

A gynandromorph is an organism that contains both male and female characteristics. Gynandromorphism is most frequently recognized in organisms that have strong sexual dimorphism such as certain butterflies, spiders and birds, but has been recognized in numerous other types of organisms.

Gynandromorphism, observed across diverse insect orders and species, unveils a fascinating interplay of genetic, hormonal, and environmental factors during embryonic development, leading to a unique bilateral symmetry of the two sexes within a single organism. It also unveils a remarkable tapestry of genetic complexity, offering a unique lens through which we can explore the intricacies of sexual development and adaptation.

A photograph of a gynandromorph of the Rosy Gypsy Moth (*Lymantria mathura*)

OCCURRENCE:

Gynandromorphism has been noted in Lepidoptera (butterflies and moths) since the 1700s. It has also been observed in crustaceans (lobsters and crabs), spiders, ticks, flies, locusts, crickets, dragonflies, ants, termites, bees, lizards, snakes, rodents, birds etc. It is generally rare but reporting depends on ease of detecting it (whether a species is strongly sexually dimorphic) and how well-studied a region or organism is.

In the realm of insects, bilateral gynandromorphs stand out as a frequently observed phenomenon, where the left and right halves of an individual's body exhibit distinct sexes. This occurrence has been documented across 12 orders within the class Insecta. Within the specific order of Lepidoptera, encompassing butterflies and moths, gynandromorphism has been extensively recorded in 18 families, with a higher incidence observed notably in the families Papilionidae, Pieridae and Saturniidae.

While gynandromorph specimens have been documented across various butterfly families such as Lycaenidae, Nymphalidae, Pieridae, Papilionidae and Geometridae, cases have also been reported in specific moth species, including members of the Noctuidae family like *Agrotis segetum* and *Agrotis ipsilon*. This diversity of documented cases underscores the broad spectrum of gynandromorphism's occurrence in both butterflies and moths, providing a comprehensive view of this phenomenon within the Lepidoptera order.

TYPES OF GYNANDROMORPHISM:

Gynandromorphism in insects can manifest in several types, each presenting unique characteristics and implications. Understanding the various types of gynandromorphism is crucial for unraveling the complex interplay of genetic, hormonal and environmental factors influencing sexual development in insects.

Each type provides a unique perspective on the adaptability and flexibility inherent in the intricate mechanisms governing insect biology. The primary types include:

1. **Bilateral Gynandromorphs:** Insects classified as bilateral gynandromorphs present a distinctive feature - a clear division along a bilateral axis, showcasing male traits on one side and female characteristics on the other. This division is often manifested through unique bilateral patterns, visible in wing coloration or structural differences. One striking example is found in butterflies, such as the Eastern Tailed-Blue (Lycaenidae), where each wing displays a contrasting mix of male and female features.

2. **Mosaic Gynandromorphs:** Another intriguing category is mosaic gynandromorphs, characterized by a random and mixed distribution of male and female traits throughout their bodies. Their intricate bodies exhibit an irregular mosaic pattern, with individual cells or regions expressing either male or female characteristics. This phenomenon is exemplified by fruit flies (Drosophilidae) and ants (Formicidae), showcasing a fascinating patchwork of male and female traits distributed across their bodies.

3. **Gonadal Gynandromorphs:** The third type, gonadal gynandromorphs, is distinguished by the possession of both male and female reproductive organs (gonads) within a single individual. Despite external appearances often leaning towards one sex, internally, these insects house both testes and ovaries. Noteworthy examples include honeybees (Apidae) and various beetle species, where individuals display a combination of male and female reproductive structures.

Normal female of *Papilio androgeus* | Mosaic gynandromorph of *Papilio androgeus* | Normal male of *Papilio androgeus*

CAUSES OF GYNANDROMORPHISM:

The cause of this phenomenon is typically (but not always) an event in mitosis during early development. While the organism contains only a few cells, one of the dividing cells does not split its sex chromosomes typically. This leads to one of the two cells having sex chromosomes that cause male development and the other cell having chromosomes that cause female development.

For example, an XY cell undergoing mitosis duplicates its chromosomes, becoming XXYY. Usually this cell would divide into two XY cells, but in rare occasions the cell may divide into an X cell and an XYY cell. If this happens early in development, then a large portion of the cells are X and a large portion are XYY. Since X and XYY dictate different sexes, the organism has tissue that is female and tissue that is male.

REASON FOR GYNANDROMORPHISM:

Reason for Gynandromorphism	Example Insect	Explanation
Genetic Mosaicism	Fruit Fly (*Drosophila melanogaster*)	Gynandromorphism observed with one half of the body exhibiting male characteristics (e.g. male genitalia, wing patterns) and the other half showing female characteristics due to errors in cell division and sex chromosome segregation.
Hormonal Imbalances	Silverspot Butterflies (e.g. *Speyeria* spp.)	During the pupal stage, hormonal imbalances can disrupt normal sexual development, resulting in gynandromorphism. For instance, one wing may display typical male coloration, while the other wing exhibits female patterns.
Chimerism	Harvester Ant (*Pogonomyrmex rugosus*)	Fusion of two fertilized eggs during early development leads to chimerism. Gynandromorphic ants may have one side of the body with male characteristics (e.g. larger head, genitalia) and the other side with female features.
Temperature Effects	Loggerhead Sea Turtle (*Caretta caretta*)	Temperature-dependent sex determination in sea turtles can lead to gynandromorphism. Fluctuations in incubation temperature may cause an individual to develop with both male and female traits, such as mixed reproductive organs.
Genetic Mutations	Honeybee (*Apis mellifera*)	Genetic mutations affecting sex determination genes, like the complementary sex determiner (csd) gene, can result in gynandromorphism in honeybees. Workers with both worker and queen characteristics may be observed.
Hybridization	Heliconius Butterflies (e.g. *H. cydno*)	Hybridization between Heliconius species may lead to gynandromorphism. The genetic mixing between different species can disrupt normal developmental processes, resulting in individuals with a combination of male and female traits.

BENEFITS OF GYNANDROMORPHISM:

1. Studying gynandromorphs can provide valuable insights into the molecular and genetic mechanisms underlying sexual development.
2. Studying the sexual dimorphism can help researchers to better understand the factors that contribute to the evolutionary processes shaping the differences.
3. Gynandromorphs can be useful for comparative studies between sexes. By analyzing the morphology, behavior, and physiology of gynandromorphs alongside typical males and females, scientists can identify and explore the similarities and differences in these characteristics. This can provide insights into the roles of specific genes or hormones in shaping sex-specific traits.
4. Gynandromorphs offer a window into the intricate process of embryonic development. They provide visual evidence of how cells differentiate and interact during early development, offering valuable insights into the mechanisms involved in tissue patterning, cell signaling, and cell fate determination.
5. Gynandromorphs, being rare individuals, can have a special conservation value. These unique specimens can be of interest to collectors, museums, and scientific institutions, which can help raise awareness about the diversity and conservation needs of lepidopteran insects and their ecosystems.

6. Gynandromorphs offer unique opportunities to study the genetic basis of sexual development and sexual dimorphism.
7. Public engagement and education: Gynandromorphs can generate interest and curiosity about the natural world and provide opportunities for educational outreach.

AS A RESEARCH TOOL:

Gynandromorphs occasionally afford a powerful tool in genetic, developmental and behavioral analyses. In *Drosophila melanogaster*, for instance, they provided evidence that male courtship behavior originates in the brain, that males can distinguish conspecific females from males by the scent or some other characteristic of the posterior, dorsal, integument of females, that the germ cells originate in the posterior-most region of the blastoderm, and that somatic components of the gonads originate in the mesodermal region of the fourth and fifth abdominal segment.

CONCLUSION:

The study of gynandromorphy in lepidopterans provides a fascinating glimpse into the complex world of sexual development and phenotypic variation. By examining these unique individuals with a mosaic of male and female traits, researchers have gained valuable insights into sex determination mechanisms and the modular nature of lepidopteran morphology. The occurrence of gynandromorphic mutations also sheds light on the evolvability and adaptability of lepidopteran species. Overall, this article highlights the importance of gynandromorphy as a fascinating behavioral phenomenon that deepens our understanding of the intricate processes underlying the diversity and complexity of lepidopteran biology.