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Phenotypic Plasticity in Insects

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Introduction

Polyphenism has been used in a general sense to indicate variation in body form or color within species. It may be a result of under strict genetic control, or are product of the environment in which insect develops. Among insects, social insects are having caste polyphenism, in which individuals within a phenotype engage in a specific caste and castes within a colony. In a social-insect colony, different castes possess different characteristic morphologies, such as the enlarged mandibles of soldiers for defense, or the wings of alates for dispersal. In most cases, castes are determined during postembryonic development, responding to various extrinsic factors, such as physical environments and/or social interactions among colony members. However, little is known about the developmental genetic basis producing these alternative phenotypes. To be sure, polyphenisms are a significant purpose behind the accomplishment for the success of the insects. In all of these cases, the ecological conditions are distinguished by the sensory system and modulate the amounts or timing of hormone secretion. Juvenile hormone or ecdysteroids are often involved, but, in other cases neuropeptides from the brain provide the link between the nervous system and the tissues. Phenotypic plasticity is a ubiquitous process found in every single living life form. Polyphenism is an extraordinary instance of phenotypic plasticity which shares a typical plan in insects such as honeybees, locusts or aphids: an underlying impression of environmental stimuli, a neuroendocrine transmission of these signals to the target tissues, the enactment of epigenetic mechanisms permitting the arrangement of alternative transcriptional programs liable for the foundation of discrete phenotypes. Climate change can tweak the environmental stimuli setting off polyphenisms, and additionally epigenetics marks, along these lines altering on the short and long terms the discrete phenotype proportions within populations. This may bring about basic ecological change.

Seasonal and diet induced Morphs in Lepidoptera

- *Nemoria arizonaria* is an extreme example for larval polyphenism which is host plant specialist restricted to Oak involving differences in morphology as well as in color. The moth has two generations each year, one in spring which resembles the catkins of the oak trees on which it feeds and the second in summer which feeds on the same tree's leaves mimicking twig. They are greenish gray in color, rather than yellow and the lack many of the cuticular outgrowths which help to give insects in spring generation their resemblance to catkins. The development of the two phenotypes is determined by the food eaten by insects and since the leaves of these oaks are very tough, the insects of the summer generations develop relatively larger heads (Greene, 1989).
- *Bicyclus anynana* is a southern African butterfly which exhibit seasonal color polymorphism according to day length or temperature. Different morphs are often associated with presence or absence of a pupal dispause. The difference in wing pattern are produced by the exposure of larval stages to high or low temperature where it develops series of prominent

marginal eyespots on the under surface of their hind wings during wet season and the spots are greatly reduced giving cryptic pattern to butterfly during dry season. These natural impacts produce contrasts in the circumstance of the pinnacle of ecdysteroids hormones during pupal-adult development, which thusly influences wing pigmentation, collection of metabolic reserves and reproductive capacity. JH shows up not to be associated with determining phenetic fate in this insect.

Density- Dependent Phase Polyphenism

- Locusts respond to local population density which results in shifting between low density, cryptic 'solitarious' phenotype and the high density, swarm-forming 'gregarious' phase. The environmental signal regulate the behavioural response to crowding mediated by combination of visual and olfactory stimulation or by mechanical stimulation or by mechanical stimulation of the outer face of the hind femur alone, which occurs more frequently under crowded conditions (Anstey *et al.,* 2009). Behavioural changes occur and it has been shown that neurotransmitter serotonin is involved induced either by stimulation of the hind legs or a combination of sight and odour cues from other locusts; gregarious locusts have transiently elevated levels of serotonin in their metathoracic ganglion, but not the brain and serotonin antagonists inhibit gregarious behaviour while exogenous serotonin increases it. With response to population density locusts also exhibit color polymorphism. Solitary locusts are usually green with little black pigmentation; those reared in crowds are yellow or orange with extensive black pigmentation which is regulated by brain neuropeptide corazonin.
- Crowding larva of *Spodoptera littoralis* cause them to become darker, or to have darker patterning, than siblings reared in isolation. This is constrained by pheromone biosynthesis initiating neuropeptide (PBAN) which brings about deposition of greater quantities of melanin in the cuticle. This lepidopteran larva have higher hemolymph titers of PBAN and the hindrance of darkening by synthetic PBAN analogs strongly recommend that this peptide is the operator directing the polymorphism in vivo.

Beetle horn polyphenism

- Male *Onthophagus* beetles show horn polyphenism which depends on body size to express horn whereas, females are always hornless who digs big tunnels beneath dung piles, within which they feed, mate etc. Larger body sized male larvae develop into long horned adults which guard the tunnels entrances against the entry by other males and use their horns as their weapons. Smaller facilitate maneuverability in tunnels to gain clandestine mating as they employ 'sneaker male' rather than fight they gain access to females by sneaking larger males at the entrance (Moczek and Emlen, 2000). Juvenile hormone appears to play major roles in mediating horn polyphenism. The epidermal horn precursor cells of large male larva have JH levels below a critical threshold which undergo bursting of rapid pre-pupal growth and subsequently develop as fully formed horn comparing to higher JH levels above critical threshold in small male larva resulting fail in proliferation.

Wing polyphenism

- Aphids involve phenotypes with differential dispersal abilities, which are winged versus flightless morphs, developing in response to different environments, and are induced by crowding, short photoperiods and low temperature resulting in ultimate selective pressures. Aphid exhibits cyclic parthenogenesis with alternating sexual and asexual generations in winter and summer hosts. Movement between the two hosts demands the production of winged morphs (alates), whereas at the other time the aphids are commonly wingless (apterae) where most reproduction occurs through parthenogenesis, although winged forms may also be produced on the secondary, summer host in response to crowding or poor host quality. The sexual generation is generally produced in response to the short days of autumn acting on the parent aphid. Males are produced by the loss of an X chromosome during the single development division of the oocytes. Under long photoperiods, the largest embryos in the ovarioles and also influence of light passing directly through the cuticle of the head are determined for the production of more virginoparae which will form parthenogenetic forms. Juvenile hormone appears to be involved in virginoparae production, and low titers mimic short days. Under short photoperiods, however, the embryos become determined as gynoparae which give rise to sexual forms or directly as ovipare which is a sexual female.

Reproductive and worker caste in Eusocial insects

- Eusocial insects are well known for polyphenism. Among which Hymenoptera, where workers and queens are all female showing different traits like cooperative brood care, reproductive division of labour and overlapping generations. While sex is determined hereditarily where females are diploid while males are haploid, caste is determined by conditions experienced during larval life. In honey bee, *Apis mellifera* a newly hatched female larva has the potential to develop into either form. It subsequent development is determined by the quality and quantity of the food which is primarily a secretion of nurse bees' mandibular glands "Royal jelly". Larva which feed on low amounts of royal jelly by nurse bee develops into workers, while larvae feed on high amount of royal jelly develop into queen. The key component of royal jelly that triggers queen development is a 57kDa protein dubbed royalactin, which significantly increases the body size and ovary development, and shortens developmental times (Kamakura, 2011). Royalactin increases the JH to a peak in fourth larval stage of developing queens whereas constant low JH levels results in development of the worker caste. In the event that a larva receives larger proportions of secretion from the hypopharyngeal glands of the workers, it will end up being a worker itself.
- Among larval ants (Formicidae), a significant worker or soldier development is apparently the consequence of a high titer of JH early in the last larval stage. In the event that the JH titer is over a threshold, the critical size at which pupation occurs is reset so that the larva keeps on developing until it reaches a another threshold.
- Another interesting counterpoint to Eusocial Hymenoptera is Isoptera (Termite) which is diplo-diploid in nature. In most (~80%) termite species, there is an early developmental bifurcation that leads either to the winged, 'alate' caste, or to the wingless worker (or soldier) caste (Noirot and Pasteels, 1987). For differentiation of caste in termites there is a volatile compound n-butyl-n-butyrate and 2-methyl-1-butanol produced from queens of *Reticulitermes speratus* which inhibit the further development of secondary queen production from nymphs. The same two compounds also produced in eggs and serve to attract workers and inhibit reproductive differentiation. In *Hodotermopsis sjostedii*, development of the alate caste requires constantly low JH titres, while the development of workers requires a low JH tire with a peak around the time of ecdysis. The development of soldiers requires reliably high JH titres.

Conclusion

Altogether, an expanding number of studies recommend that intergenerational epigenetic inheritance could be of significance for species adaptation to environmental change in the case of insect polyphenic species and phenotypic plasticity as a rule. Nonetheless, most exploration on insect epigenetics just concerns intragenerational epigenetic inheritance (for example the within individual transmission of epigenetic information during mitosis) and not across ages, we despite still know minimal about the presence and significance of intergenerational epigenetic inheritance in insects. In any case, the relatively good knowledge of insect epigenetics in intragenerational polyphenisms ought to extraordinary help the impact of climate change on explicit epigenetic marks both in the short and long haul. Evaluating the effect of climate change on the epigenetic regulation of phenotypic plasticity at the intra- and intergenerational levels is potentially achievable in the specific case of polyphenism. The transform dispersion of polyphenic species could be used to evaluate climate change sway on, for instance, agroecosystems equilibrium, while considering the costs and benefits of insect pests.

References

Anstey ML, Rogers SM, Ott SR, Burrows M, Simpson SJ (2009) Serotonin mediates behavioral gregarization underlying swarm formation in desert locusts. Science, 323:627-630.

Greene E (1989) Diet induced developmental polymorphism in a caterpillar. Science, 243:643-646.

Kamakura M (2011) Royalactin induces queen differentiation in honey bee. Nature, 473:478-483.

Moczek AP, Emlen DJ (2000) Male horn dimorphism in the scarab beetle *Onthophagus taurus*: do alternative tactics favor alternative phenotypes? Animal Behaviour, 59:459-466.

Nairot C, Pasteels JM (1987) Ontogenetic development and evolution of the worker caste in termites. Experientia, 43:851-952.