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A case of gynandromorphism in a parasitoid wasp of the subfamily Cryptinae (Ichneumonidae)

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An unidentified parasitoid wasp of the subfamiliy Cryptinae caught near Koedijk, The Netherlands, had an aberration in its antennae. One antenna was male, whereas the other was female. The rest of the external morphology was entirely female-like. This individual was thus an example of a gynandromorph, an individual that is part male, part female. The possible cause of this phenomenon depends on the sex determination system. In the parasitoid wasp *Nasonia vitripennis*, the occurrence of gynandromorphs is affected by mutations in a regulatory gene involved in sex determination, but also by the mitochondria and temperature during early development.

Introduction

The majority of animal taxa have two separate sexes, but the way in which sex is determined varies considerably. In some, like ourselves, sex is determined by the sex chromosomes, whereas in others sex is determined by temperature during embryonic development. The Hymenoptera (bees, ants and wasps) have haplo-diploid sex determination, in which unfertilized haploid eggs develop as males and fertilized diploid eggs develop as females. Although all Hymenoptera are haplo-diploid, the underlying sex determination mechanism varies among taxa. In the honey-bee (*Apis mellifera* Linnaeus), for example, sex is determined by a single gene. If there are two copies per cell, the individual will develop as a female, but if there is only one copy it will develop as a male. In the parasitoid wasp *Nasonia vitripennis* Walker (Hymenoptera: Pteromalidae) sex is determined by gene regulation (Verhulst *et al*. 2010). Female development requires the presence of a particular protein. The RNA encoding this protein is transferred to the egg by the mother. Later during development, the zygote starts producing the protein itself. However, one of the genes needed for this process is silenced in the mother. A son only has a mother, so it inherits only a silenced copy of the gene and therefore lacks the female-specific protein. A daughter, however, inherits an unsilenced copy from her father and can thus produce the female-specific protein.

Like most developmental programmes, sex determination systems have 'bugs'. Failures in the sex determination system may cause an individual to develop partly or completely as the wrong sex. A curious set of failures of the sex determination system is known as gynandromorphs. In gynandromorphs, some parts of the body are female, whereas other parts are male. Gynandromorphs should not be confused with hermaphrodites (individuals with both male and female reproductive organs) or intersexes (individuals in which the phenotype is intermediate between that of male and female). Gynandromorphs have been found in many taxonomic groups, including mammals, birds, reptiles, fish, crustaceans and many groups of insects, including Odonata, Lepidoptera, Coleoptera and Diptera (Stern 1968), but are always rare. The precise mechanism leading to gynandromorphism is unknown in most cases. Given the sex determination system described above, gynandromorphs in *Nasonia* are likely to result from changes in the levels of female-specific RNA or proteins during development, so that these are above or below the threshold needed for female development in different tissues.

Here we describe a case of gynandromorphy in an unidentified parasitoid wasp.

Observation

In the period April - September 1984 insects were caught by B. Brugge using a Malaise trap in the 'Kleimeer', a swamp area near Koedijk in the province of Noord-Holland, The Netherlands. All captured insects were collected and stored dried. Recently the parasitoid wasps of the family Ichneumonidae in this collection were pinned by the first author. One of the insects, a parasitoid wasp of the subfamiliy Cryptinae caught in the first week of August 1984, had an aberration in the antennae. The right antenna was multicoloured orange, white and black, whereas the left antenna was uniformly black (figure 1). If there are individuals with multicoloured and unicoloured antennae within an Icheumonidae species, then, as a rule, the individuals with multicoloured antennae are females and those with unicoloured antennae are males (personal communication C. van Achterberg). Otherwise, the individual was completely female-like, including a fully developed ovipositor (figure 2). The aberration in the antennae indicated that the wasp was a gynandromorph.

1. Antennae of the wasp specimen caught near Koedijk, The Netherlands. The left antenna is male-like, the right female-like. Photo: Kees Zwakhals
1. Antennes van de wesp gevangen te Koedijk. De linker antenne is mannelijk, de rechter vrouwelijk.

Possible causes of gynandromorphism

The mechanism causing gynandromorphism depends on the sex determination system (Stern 1968). The precise sex determination system of this wasp is unknown, but may resemble that of either honey-bee or *Nasonia* as described in the introduction. One possibility for the occurrence of gynandromorphism is that one set of chromosomes was lost from the tissue giving rise to the left antenna, but not from the remaining tissues. Individuals in which nuclei differ in ploidy level have been described in Hymenoptera, but the ploidy level of a given cell does not necessarily correspond to the sex of the tissue in which it is found (Yoshizawa *et al.* 2009). In *Nasonia*, gynandromorphs are not mosaics of different ploidy. Instead, the occurrence of gynandromorphism in this species is associated with genetic mutation, with additional roles for the mitochondria and temperature during development (Kamping *et al.* 2007). These factors presumably influence the level of female-specific RNA and/or protein. When their levels are low, fluctuations might cause them to be just below the threshold needed for female development in some tissues and just above it in other tissues. Which of these mechanisms is responsible for the gynandromorphic wasp described here is unknown.

2. The wasp specimen caught near Koedijk, The Netherlands. Only the left antenna is male-like, the rest of the body is entirely female-like. Note the well-developed ovipositor. Photo: Rob de Vos
2. De wesp die gevangen is bij Koedijk. Alleen de linker antenne is mannelijk, de rest van de morfologie is geheel vrouwelijk. Let op de goed ontwikkelde legboor.

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Samenvatting

Een waarneming van gynandromorfie in een ongedetermineerde parasitoïde wesp uit de subfamilie Cryptinae (Ichneumonidae)

Een parasitoïde wesp, gevangen bij Koedijk (Noord-Holland), bleek een afwijking in de antennen te hebben: een antenne was mannelijk, de andere vrouwelijk. De rest van de wesp was op het oog geheel vrouwelijk. Deze wesp is een voorbeeld van een gynandromorf, een individu dat deels mannelijke en deels vrouwelijke kenmerken heeft. Afhankelijk van de manier waarop sekse bepaald wordt in deze soort, kan gynandromorfie verschillende oorzaken hebben. In de parasitoïde wesp *Nasonia vitripennis* zijn mutaties in het DNA, de mitochondria en de temperatuur tijdens de ontwikkeling alle van invloed op het voorkomen van dergelijke gynandromorfen.

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