A bilateral gynandromorph Orange-tip *Anthocharis cardamines*: Some observations

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A strikingly aberrant Orange-tip *Anthocharis cardamines* was photographed by Mark Coates at Askham Bog (VC64 Mid-west Yorkshire) on 13 June 2016 (see Front cover). It shows a fine example of bilateral gynandromorphy where the insect is half male (in this case the left-side of the butterfly) and half female (right-side). This rare and intriguing sport of nature arises from the loss of one of the sex chromosomes from an initially typically-developing homogametic[1] sex zygote. If the loss of one Z chromosome occurs at the first mitotic division (when the fertilised cell first divides into two) then the zygote will produce one cell with two same-sex (ZZ) chromosomes and one cell with a single Z sex chromosome. The possession of the two Z sex chromosomes in a cell steers development along the male path while the possession of only one Z sex chromosome steers development along the female path. In all subsequent cell divisions one half of the cells will code for male and the other half for female. The resulting adult is entirely male on one side and entirely female on the other side (see Plate 2, centre pages) – the adult butterfly is perfectly bisected sexually.

This makes for a particularly arresting visual effect for those species of butterflies that possess strong sexual dimorphism, such as the Orange-tip where only the male possesses the striking orange colouration on its upper forewings. In the example shown we can also see present in the right-hand side female forewing other, less immediately obvious, sexually dimorphic wing features beyond the absence of the orange patch: these are the larger discoidal spot and the larger black tip to the upper wing. In this particular example of bilateral gynandromorphy, the female forewing and hindwing are noticeably larger than those of the male's, something which mirrors the slightly larger size of female to male Orange-tips in general, although to my thinking, the size discrepancy evident here is more marked than is typically the case between normally developed male and female Orange-tips. Though we cannot see it, the rest of the butterfly's body such as the antennae, thorax and abdomen, are presumably also bisected along the mid-line. This would most noticeably affect those areas of the body that differ most between male and female, such as the genitalia.

A *bilateral* gynandromorph is a specific *type* of gynandromorphy. Most examples of gynandromorphy (which are rare occurrences in themselves) occur at later mitotic divisions, i.e. when the cell numbers in the developing egg are much higher than just one. A later mitotic division deletion will cause *mosaic* gynandromorphy where only some part of the butterfly is female and the majority of the butterfly is male. Such an example may have a patch of one of its

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To confuse matters in butterflies the possession of the two same-sex chromosomes (*ZZ*) codes for male. In humans possession of the two same-sex chromosomes (*XX*) codes for female. Thus in butterflies the homogametic sex [from the Greek *homo*s and *gamos* meaning same and marriage respectively] is male while in humans it is female.

wings lacking the orange colouring. A simple experiment in logical reasoning tells us that the chance of sex chromosome loss must be many orders higher at the first mitotic division than at subsequent cycles: if we assume a very small but constant chance of sex chromosome deletion p at any cell division (presumably very small because most Orange-tips we will ever see are either entirely male or female) then mosaic gynandromorphy would outnumber bilateral gynandromorphy by a factor of $p2^n$ where n is the number of mitotic cycles. The argument would be that if any cell division runs the same tiny risk of Z chromosome deletion then this risk multiplies with the number of cells dividing in the organism – thus risk must rise exponentially the further along the development of the organism has progressed. Given the number of cells in a fully developed egg (not to mention further stages in the development of the butterfly) is very large, this would mean that if the chance of sex chromosome deletion was constant then the number of bilateral gynandromorphs must either be vanishingly small (such that you would never see one) or that the number of mosaic gynandromorphs would be astonishingly high. Neither situation is the case – bilateral gynandromorphs are rare but you do find them – and, though not as rare, we are not inundated with mosaic gynandromorphs either. We must conclude then that the chance of sex chromosome deletion is higher at the first mitotic cycle compared to later cycles.

People seem to take less interest in aberrations in general nowadays than they used to e.g. in the Victorian era (for some fascinating accounts see Salmon, 2000). Why this should be the case might be something to do with the rise of awareness of macro- and micro-moths (especially now with the ready availability of good moth field guides). Previously, the budding butterfly enthusiast might notch up sightings of all known British butterflies within a few years. For further challenge, they would start looking for the known butterfly aberrations and maybe even hope to discover a new one. Nowadays, the butterfly enthusiast is more likely to move on to the study of the moth groups. Perhaps also we should blame the mediocre weather with its poor summers. There are many aberrations arising from environmental affects – for instance, extremes of weather such as unseasonably high temperatures when pupae are developing can cause different expression of genes. The fine summer of 1976 was responsible for a large number of aberrations, such as the greater expression of the black markings (melanism) in fritillaries and especially Silver-washed Fritillary *Argynnis paphia* (Russwurm, 1978). It might be simplistic to suggest but might we expect an increase in aberrations showing lower expression of black marking (albinism) when we have colder temperatures during pupal development? Though I'm possibly cherry-picking my memories this does seem to be the case.

References

Harmer, A. S. & Russwurm, A.D.A. (2000) *Variation in British Butterflies*. Paphia Publishing Ltd
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Front cover. Bilateral gynandromorph Orange-tip *Anthocharis cardamines* found at Askham Bog (VC64 Mid-west Yorkshire) on 13 June 2016. Photo: *Mark Coates*

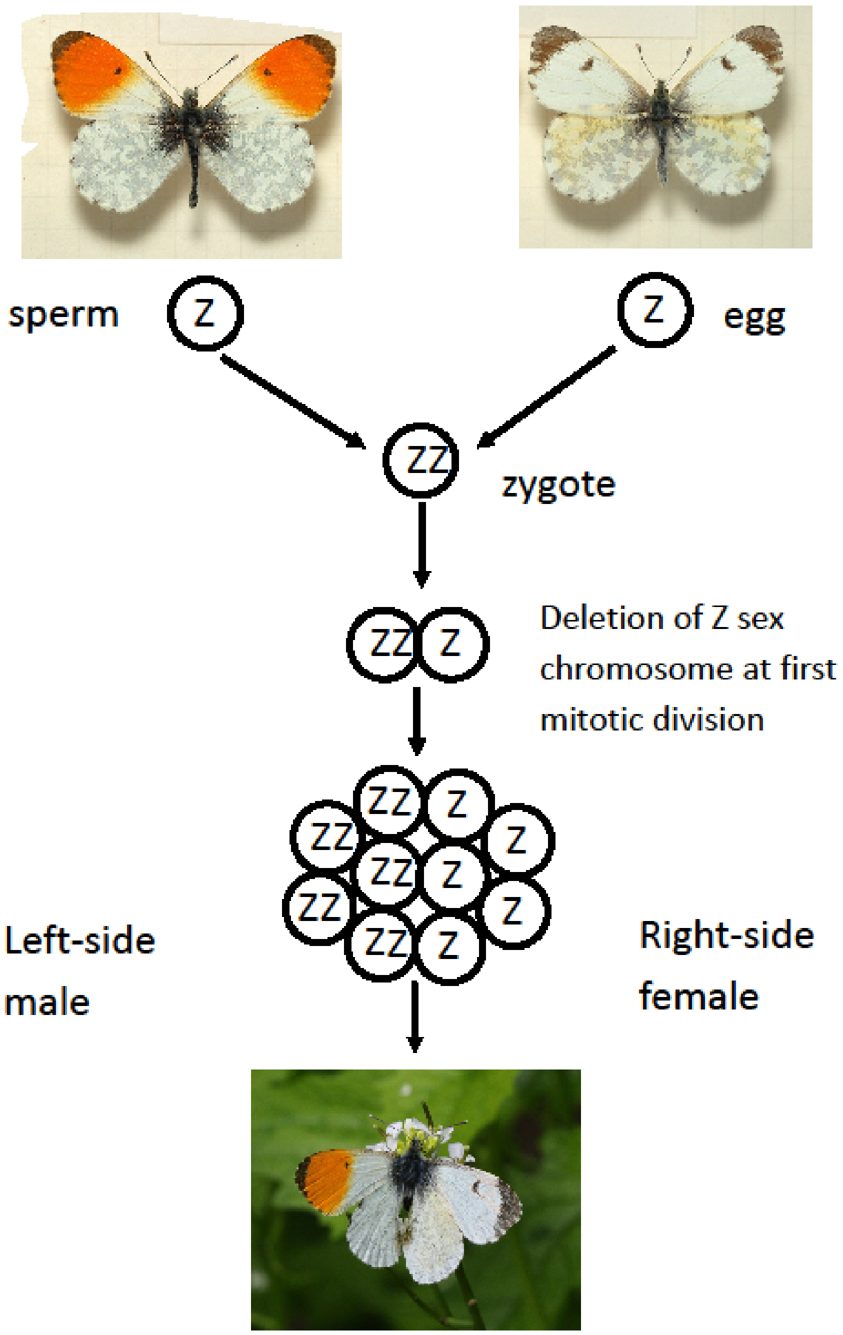

Plate 2. A gynandromorph Orange Tip *Anthocharis cardamines* butterfly (see p 167). Schematic diagram showing genesis of the bilateral gynandromorph form where the Z sex chromosome has been lost at the first mitotic division.
Adapted and redrawn from Harmer & Russwurm (2000). Typical male and female Orange-tip (top left and right respectively): images are from the collection of Cologne Zoo, Germany.
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