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Sexual Identification

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Synonyms

Sex check; Sexing; Sexual classification

Definition

Sexual identification allows the classification of animals as males, females, or hermaphrodites and the intersex condition and can be performed in a simplified way for species with apparent sexual organs and/or marked differences between the sexes, known as sexual dimorphism, or through specific sexing methods for species that do not have such differences.

Description

Identifying sex in animals may seem, at first, a simple and straightforward task. In fact, some species have apparent sexual organs or marked morphological characteristics, a condition known as sexual dimorphism, which makes visual distinction between the sexes simple. On the contrary, there are species in which males and females present extremely similar external characteristics, so no significant differences between the sexes can be perceived, making the application of sexing methods necessary for sexual identification.

Sexual dimorphism occurs in many groups of living beings: protists, plants, and animals. The function of these differences is usually related to the reproductive process; the different characteristics are used to conquer or to fight for a partner.

A difference in size between the sexes is the prevailing characteristic in the majority of animals that show sexual dimorphism (Blanckenhorn 2000). Ornamentation is another common type of dimorphism and is often observed in many species of birds and reptiles (Johnsen et al. 2003). In most species, sexual dimorphism becomes more evident as organisms grow, which makes sexual identification difficult in the early stages of development. In birds, which have internal reproductive organs, confusion in defining the sex of young individuals is common.

Most fish species have a well-defined pattern of sexual development as female or male, which characterizes gonochoristic species, although a small fraction of species is hermaphroditic. Recognizing sex in most species of teleost fish is a difficult task, and to facilitate the sexing process, it must be performed during the reproductive period.

Sexual dimorphism is also present in fish, but in most instances, it is expressed only during the

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reproductive period. Species that exhibit transient dimorphism develop forms of sexual attraction, such as protuberances, color change of the scales, and emission of sounds, during the period of reproduction only. However, permanent dimorphism evidences, such as differences in size, differences between the sexes at sexual maturity.

The biological process that determines the development of sexual characteristics of an organism is called sexual determination. Throughout the evolution of the species, several mechanisms of determination and regulation of sexual development have been generated, creating a complex system of sexual determination. In most cases, sex determination is genetic, through sex chromosomes whose action is complemented by a wide variety of regulatory mechanisms. In addition, some species have a chromosomal basis involving both monogenic and polygenic systems, located in the autosomal chromosomes and in the sex chromosomes and regulated by different genetic and/or environmental factors.

The various mechanisms of sex determination began to be elucidated after 1930, through studies that identified different models involving sex chromosomes. These studies have shown that most mechanisms are genetic, involving sex chromosomes of the XY, X0, ZW, and Z0 systems. In some cases, sex may be determined by haploid-diploid systems or by environmental and/or social variables, such as the surrounding temperature or the dominance of males or females in certain species. Usually in animals, the distinction between the sexes occurs through chromosomal differences, with one sex presenting two distinct sex chromosomes (heterogametic) that produce two types of different gametes and the other sex presenting two of the same sexual chromosomes (homogametic), which produce a single type of gamete.

In insects, dimorphism in the sex chromosomes can be cytologically distinguished. In the order Lepidoptera, which comprises all the insects popularly known as butterflies and moths, the sex chromosomes are designated as W and Z, with the W chromosome associated with female characteristics. The influence of temperature is crucial in the determination of sex in some species of this order, favoring the generation of a specific sex according to the available environmental resources, which increases the probability of reproduction.

In *Drosophila melanogaster* (order Diptera), a highly studied laboratory model, development as female or male is related to a change in a so-called lethal sex gene (Sxl) in response to the balance between the number of sex chromosomes X (female sex) and the number of autosomal chromosomes (male sex). In this case, the Y chromosome present in the males does not influence the sex determination. Depending on the balance between these chromosomes, sterile male animals (metamales), intersex animals (animals with male and female characteristics), or female animals with developmental problems (metafemales) may occur (Manolakou et al. 2006).

In other insects, such as bees and ants, the haploid-diploid system is seen, in which the male is haploid (n) and the female is diploid (2n). Males, generated from unfertilized eggs (parthenogenesis), are called drones and have only one chromosome of maternal origin. Females are heterogametic, originating from an ovum fertilized by a spermatozoon.

In reptiles (order Squamata), several patterns of sexual determination have been found. The snakes present a ZZ/ZW pattern of sex chromosomes and lizards have a ZZ/ZW or XX/XY system. In contrast, there are species of turtles and crocodiles that do not have distinct sex chromosomes or genes related to sex determination. In these cases, the temperature of the environment during a specific period of egg incubation is preponderant in determining sex. In this process, the enzyme aromatase catalyzes the conversion of androgen hormones into estrogen, influencing the differentiation of gonads. At high temperatures, the aromatase has high activity, differentiating the gonads into ovaries, and in lower temperatures, activity is reduced, leading the gonads to differentiate into testicles.

Although in amphibians the sexual determination is genetic, both sexes are heterogametic and are not influenced by the environment or polygenic conditions. In some species, spontaneous sexual inversion occurs, which produces animals genotypically and phenotypically discordant in relation to sex. Sex chromosomes can be of type ZZ/ZW or XX/XY.

In birds, the Z and W chromosomes determine sex, with females being heterogametic (ZW) and the males homogametic (ZZ). The Z chromosome has a uniform size in all species, but the W chromosome varies in size in most of them. Only in the ratite birds (Struthioniphormes), the sexual chromosomes are morphologically similar to the autosomes, with little difference in size.

Fish exhibit a wide variety of mechanisms of sexual determination and patterns of sexual differentiation. In many species, the determination of sex depends on a chromosomal basis that involves monogenic and polygenic systems located in the autosomal and sexual chromosomes, in addition to being influenced by different environmental factors. In fish, the genotype can affect the differentiation to testis or ovary, termed Genotypic Sex Determination (GSD), with or without the participation of chromosomes in the definition of each sex (ZZ in males and ZW in females or XY in males and XX in females). Environmental factors, including photoperiod, social environment, and temperature, may also influence sex determination in some species of fish, for which two terms with equivalent meaning are also used: environmental sex determination (ESD) and temperature-dependent sex determination (TSD).

In placental mammal species, the females usually have XX sexual chromosomes, whereas males present XY. The marsupials show the smallest Y chromosome among mammals, but testicular formation does not control the remainder of the sexual differentiation, because the formation of the scrotum and the mammary glands occurs before gonadal differentiation and is controlled by genes located on the X chromosome.

Due to the complex systems of sexual determination and differentiation in animals and to the absence and/or late presence of sexual dimorphism in many species, different methods have been developed for the identification of sex. The emergence and improvement of these methods of sexing are linked to the importance of identifying sex in certain situations, that is, advancements tend to occur proportional to the environmental and/or economic interest involved.

Sexing birds is difficult because at least half of bird species do not show sexual dimorphism and when it is present it is usually very subtle, occurring only at sexual maturity. The sexing of the true parrot (*Amazona aestiva*), a bird that does not present sexual dimorphism, can be performed by pubic palpation. This method requires experience to perceive the separation between the bones of the pubis, where a greater spacing may indicate the egg passageway. However, other, more accurate, methods are also used, such as the analysis of sex chromosomes, endoscopy (an invasive method requiring sedation), and hormonal analysis (levels vary according to sex).

The most precise methods for sexual identification are genetic ones, based on the application of modern techniques of molecular biology. These involve the direct analysis of genetic variations and can be performed on chromosomes or on DNA and RNA sequences.

The best-known methods involve the visualization of the sex chromosomes from the karyotype, the set of chromosomes of an organism, with cytogenetic techniques that allow visualization during cell division through conventional staining such as giemsa or hematoxylin/eosin. In these methods, the objective is to visualize the chromosomal pair responsible for determining the genetic sex, and due to their precision, they have been used to test the accuracy of other methods of sexing.

Another way to perform sexing is to detect a Y chromosome-specific DNA sequence after amplification using the polymerase chain reaction (PCR) technique. Sexing by the PCR technique can be applied to various tissues or cells and, as the genetic sex is determined by the presence of the Y chromosome in mammals, the detection of a specific gene from this chromosome is the basis for this technique. Several such genes have been described, of which the SRY (sex-determining region Y) is best known as a testicular differentiation factor (Bronwyn and Andrew 2002).

In birds, the sex chromosomes Z and W have the genes CHD-Z and CHD-W (CHD: chromohelicase-DNA-binding), respectively, and through the PCR technique, it is possible to perform sexing by gene detection.

In fish, research into the genetic identification of sex uses homology to genes involved with sexual determination found in other species. The genes involved in the process of sexual development can be classified into functional groups, with genes involved in the development of the bipotential gonad and genes involved in determining and differentiating the sex of males or females.

Measuring levels of steroid hormones has also been investigated as a method of sexing in fish and has the advantage of being a less invasive technique when compared with laparoscopy or gonadal biopsy. The measurement of these steroids is performed with great precision at the plasma level, mainly through enzyme-linked immunosorbent assay (ELISA) or radioimmunoassay (RIA), which identify the variations of sexual steroids according to each sex.

Cross-References

- ▶ Autosome
- ▶ Chromosomes
- ▶ DNA
- ▶ DNA Marker
- ▶ Endocrine System
- ▶ Gene Expression
- ▶ Gene Map
- ▶ Hermaphrodite
- ▶ Heterogametic
- ▶ Homogametic
- ▶ Sex Role Reversal
- ▶ Sexual Dimorphism
- ▶ Sexual Selection

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