4.1 Introduction

Perhaps no other animal upon this planet has attracted so much attention and mysticism as surrounds the deer that inhabit our forests, plains and mountains. Deer have achieved an archetypal status in the collective mind of both modern and ancient human cultures, embodying many of our views of the natural world in their innocence and wildness. Despite the intimacy of the complicated relationship between humans and deer, and despite our attempts to understand these animals, there will always be a degree of mystery surrounding these magical creatures. The intensity of human interest in deer is evident from the extent of hunting, domestication and conservation of their kind. Indeed, perhaps one of the most well-recognized artistic depictions of an animal in our history is the ‘Monarch of the Glen’ by Edwin Landseer (Fig. 1). With advances in scientific understanding, it has now become possible to delve deeper into the biology of these creatures, and in particular into their genetics and genomic biology, which is the focus of this chapter.

4.1.1 Taxonomic Description

Deer are ruminants that exist in a wide variety of habitats across the globe and are considerably diverse in their morphology. Decisions upon the taxonomic classification of deer species have been the subject of intense discussion in more recent times, often due to developments and findings from molecular genetic data. Most living deer species have been assigned to the Cervidae family, encapsulating at least 40 species of deer, and an additional five species have been assigned to the Moschidae family (Grubb and Groves 2003). The subfamily Cervinae are found in Eurasia, with the exception of the North American wapiti (Cervus elaphus), and are referred to as the Old World deer species. The Odocoileinae, or New World deer species, can be found in both North America, such as the white-tailed deer (Odocoileus virginianus), in South America such as the brocket deer (Mazama), and in Eurasia, such as the roe deer (Capreolus capreolus). Tribal status within the Cervidae has been assigned to the holarctic deer species of reindeer (caribou; Rangifer sp.) and moose (Alces alces). More difficult to place have been the muntjac deer, which now have subfamily status within the Cervidae (Muntiacinae), and even more so the Chinese water deer (Hydropotes inermis) which is the only extant species in the subfamily of Hydropotinae. Complicating the taxonomic designations are the various hybridizations that occur between deer species, such as the well-described hybridizations between members of the genera Cervus, particularly for sika (C. nippon), red deer and North American wapiti (C. elaphus). Further complications have arisen due to the various morphotypes of C. elaphus, where the subspecies status has been much debated (Ludt et al. 2004).

Anthropogenic influence on deer has been profound and includes the management of deer populations as a game species (particularly the roe deer and red deer of Europe), habitat destruction or modification, and the gross over-exploitation of deer that has often adversely affected the genetic diversity of endemic deer species. The introduction of foreign deer species has often been shown to have negative effects on endemic deer populations either through increased competition or through hybridization. Indeed, introductions of foreign deer species can be highly destructive in a ‘naive’ ecosystem. Even in an
existing ecological niche of an endemic deer species, the extinction its natural predators (and thus population control) can be highly disruptive to the ecological balance (Côte et al. 2004).

4.1.2 Economic Importance

The semi-domestication of the reindeer by humans (Rangifer tarandus spp.) has occurred over many thousands of years, over a greater range than just the holoarctic region that it inhabits today (Gordon 2003). Various ancient human cultures have tended herds of reindeer for the supply of meat, milk, fur, spiritual influences and transportation (Gordon 2003), a relationship that still continues today for the indigenous peoples of the arctic regions. Domestication of the other deer species has not necessarily been achieved, although deer are kept in captive populations for a number of purposes, and the fallow deer has flourished in a close semi-domestic relationship with humans (Hemmer 1990).

During the last 100 years, there has been increased activity in the farming of species other than the traditional livestock. Various attributes of the products produced by deer such as meat (venison), pelt and antler have attracted a great deal of interest in certain market places. Farming of deer species mitigates the environmental impact of taking deer from wild populations and has also allowed for genetic selection to be applied to traits of interest (such as antler development). Deer are now farmed worldwide, and the red deer and North American wapiti (Cervus elaphus sp.) are the prominent species. Deer farming has been particularly successful in New Zealand where approximately 800,000 deer are processed annually for export of venison and velvet antler products (O’Conner 2006). The development of genetic knowledge in deer will assist selection strategies, although the application of this technology is still very much in its infancy.

4.1.3 Karotype of Cervids

The karyotype of the cervid genome has been well described for a number of species (Huang et al. 2006) where the ancestral cervid karyotype has been proposed to be \(2n = 70\) (Neitzl 1987), with the diversity of chromosomal rearrangements observed between the species being attributable to Robertsonian translocations in the Cervinae and Odocoileinae subfamilies (Fontana and Rubini 1990), and tandem chromosome fusions in the Muntiacinae (Fontana and Rubini 1990).

In addition to cytogenetic studies, there has been extensive examination of cervid genetic variation at the molecular level, including the analysis of specific genes and molecular polymorphism in the mitochondrial and nuclear genomes. The genetic analysis of deer and current body of knowledge about the cervid genome are reviewed here.

4.2 Molecular Genetics

4.2.1 Genetic Analysis Using Molecular Markers

The development of genetic markers in deer has followed the development of biochemistry and molecular biology, from the initial studies that utilized...