46 Biotechnology for Wildlife

Abstract
Wildlife is of paramount significance to welfare of humans. In modern era, the wild animals are the sources of income, food, fur, micro-organisms, and other products besides its role in maintaining ecological balance. Shrinking habitat, diseases and pest prevalence, and illegal hunting are the major threats due to which many wild species have become extinct and many are endangered. Scientific interventions are being used to not only harnessing the potential of wildlife, but conserving them through assisted reproduction, genomics, and public awareness.

Key points

- Wildlife is an essential component of natural ecosystem
- Wild natural flora and fauna are declining rapidly
- Biotechnological interventions should be used conserve and increase wild animals.

Keywords
Wildlife · Biotechnology applications · Diversity conservation · Endangered animals · Wildlife conservation · Reproduction biotechnology

46.1 Introduction

46.1.1 Wildlife in Human Welfare

The term wildlife refers to animals, plants, and other things that are not domesticated by humans. Wildlife has important role in protecting and balancing the environment by providing stability to normal processes of ecosystem. Wildlife (Figs. 46.1 and 46.2) is important source of flora for therapeutics, biological macromolecules, micro-organisms, insects, birds, fish and seafood, reptiles and mammals as source of micro-organisms with health and economic importance (Ueda et al. 2018). The insects are of immense importance in agriculture and horticulture.

Hunting of wild animals provides livelihood and economic security to people in many parts of the world. The tribes in many parts of the world depend primarily on wildlife resources for asylum, food and well-being.

Large cat species or felids are important wild animals. Being strict carnivores, the wild big cats are recognized and admired animals that remain at the top of food chain, where they have indirect effect on plant life, and play an important ecological role in structuring the animal communities and regulating the prey populations, through

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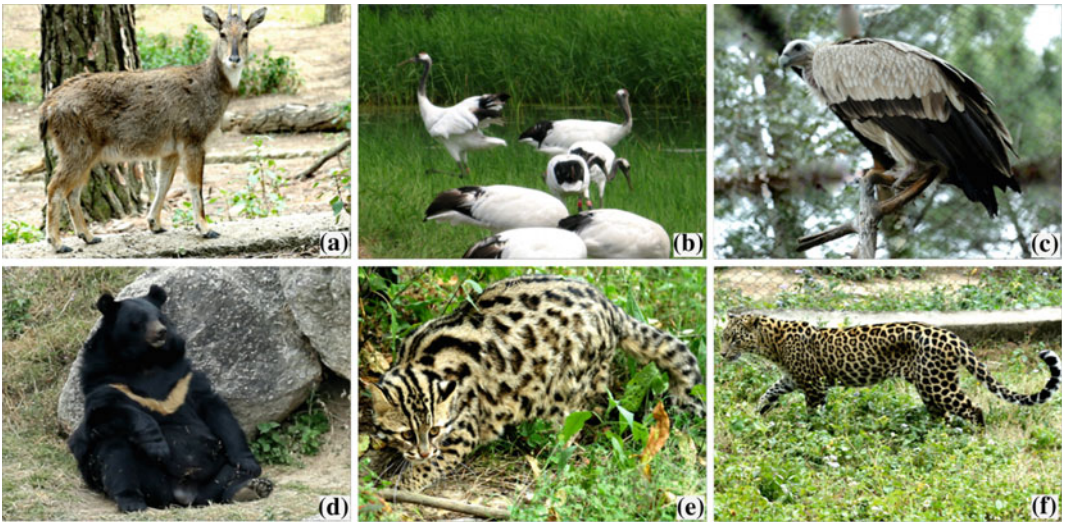

Fig. 46.1 Some important wild animals. Wild herbivores and carnivores constitute a natural ecosystem. Herbivores are important components of agriculture as they contribute to pollination and dispersal of seeds and plants

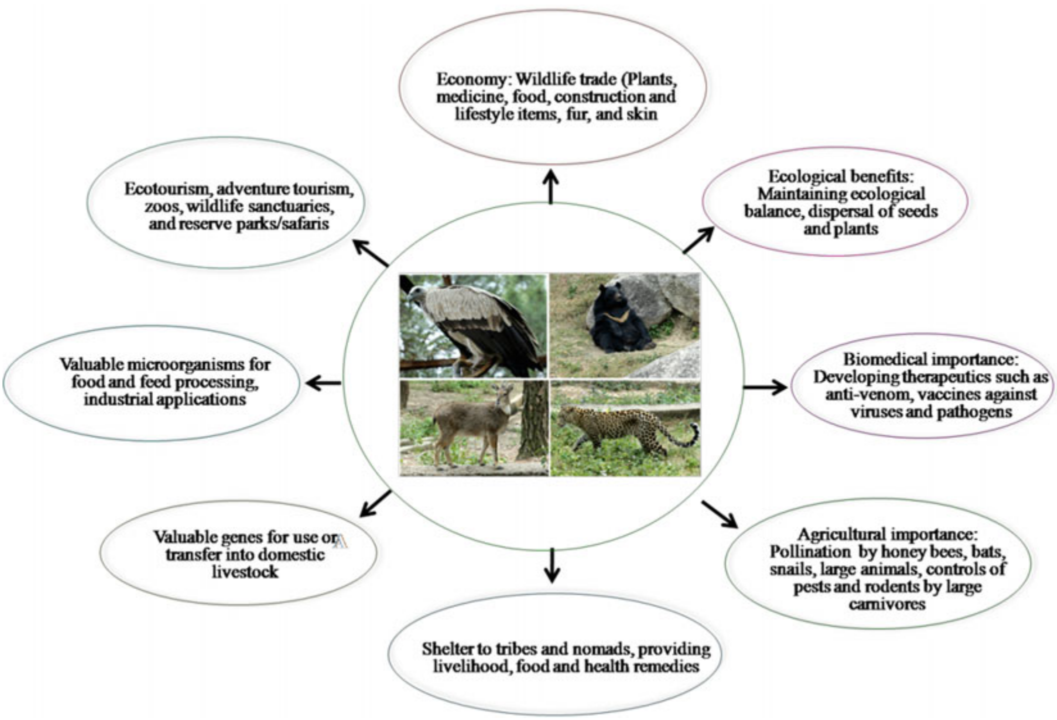

Fig. 46.2 Diagrammatic depiction of benefits of wildlife to humans and ecosystem

a process called "trophic cascade". In addition, some wild cats, for example, cougar (*Puma concolor*), a large and widely distributed feline plays important role in dispersal of seeds through their scat. When cougars eat doves, the seed predators in forests, the dove's digestive process is interrupted and seeds pass the gut of cougar. Similarly, other cats also assist long-distance dispersal of seeds.

As human population is growing, so is demand for wildlife resources including plants and animals. Importance of wildlife can be categorized as ecological importance, economic importance, investigatory importance, and conservation of flora and fauna diversity. In modern era, the wildlife is a source of economy to many countries. Educational TV shows such as National Geographic, Discovery Channel, and Animal Planet Channel shows are primarily motivated and inspired by wildlife.

Many wild animals are important for their biomedical applications. For instance, the classical mice strains are used in mapping immunological traits. As most of the classical mice strains originate from a limited number of founder stock (e.g., *Mus musculus domesticus* subspecies), their genetic diversity is finally limited which make them less suitable for exhaustive experimentation. Wild mice-derived strains with ability to breed with inbred mice strains are deemed to be more suitable for evolutionary and immunological studies (Poltorak et al. 2018).

Based on habitats, the wild animals may be terrestrial or aquatic. The animals including insects, wild herbivores (Bears, mountain goats, elk, rhinoceros, bison, deer, elephants, giraffe), carnivores (lions, tiger, leopard), and omnivorous animals (such as bear) are important (Box 1). Various programs are initiated to investigate the multiple aspects of wildlife bioresources and utilizing them for human and animal welfare and conserving them through management and biotechnological approaches.

Box 1. Benefits of Wildlife to Humans

- Maintenance of ecological balance through food habits and food chain.
- Maintenance of materials cycles such as carbon and nitrogen.
- Improvement and progress in agriculture, animal husbandry and fishery.
- Wild animals serve as valuable source of gene pool that can be introduced into domesticated animals.
- Wild animals as source of food, fur, and therapeutic products (e.g., venom for developing anti-venom).
- Role in agriculture—pollination (e.g., entomophily, ornithophily, and chiropterophily, malacophily), and dispersal of seeds and plants.
- Tourism and ecotourism, and establishing of herbal parks. Africa's ecotourism is the apt example of contribution of wildlife to human economy and livelihood.
- Economic contribution—the current education television shows.

46.2 Threats to Wild Animals

A large number of animal species are either endangered or at the brink of extinction. In addition to destruction of their habitat by human activities, loss of prey (herbivores) as food for carnivores, and accidental conflicts with humans, many of wild carnivores are culled or hunted illicitly by criminal cartels for smuggling of live animals and/or fur, bones, teeth, horns, and other body parts (Fig. 46.3). This has led to reduction in population of wildlife in many parts of the world. According to International Union for Conservation of Nature (IUCN) Red List of extinction categories, around 70 wild cat species are endangered (https://www.wildcatfamily.com/endangered-cat-species-list/, accessed on August 2, 2018). Amur leopards (*Panthera pardus orientalis*) of Primorye region of southeastern Russia and the Jilin Province of northeast China, Iberian lynx (*Lynx pardinus*) of Iberian Peninsula in southwestern Europe, Asiatic cheetahs (*Acinonyx jubatus venaticus*) in Iran, Japanese Iriomote cats (*Prionailurus bengalensis iriomotensis*), Scottish wildcats (*Felis silvestris grampia*), and South China tigers (*Panthera tigris amoyensis*) are among the most endangered

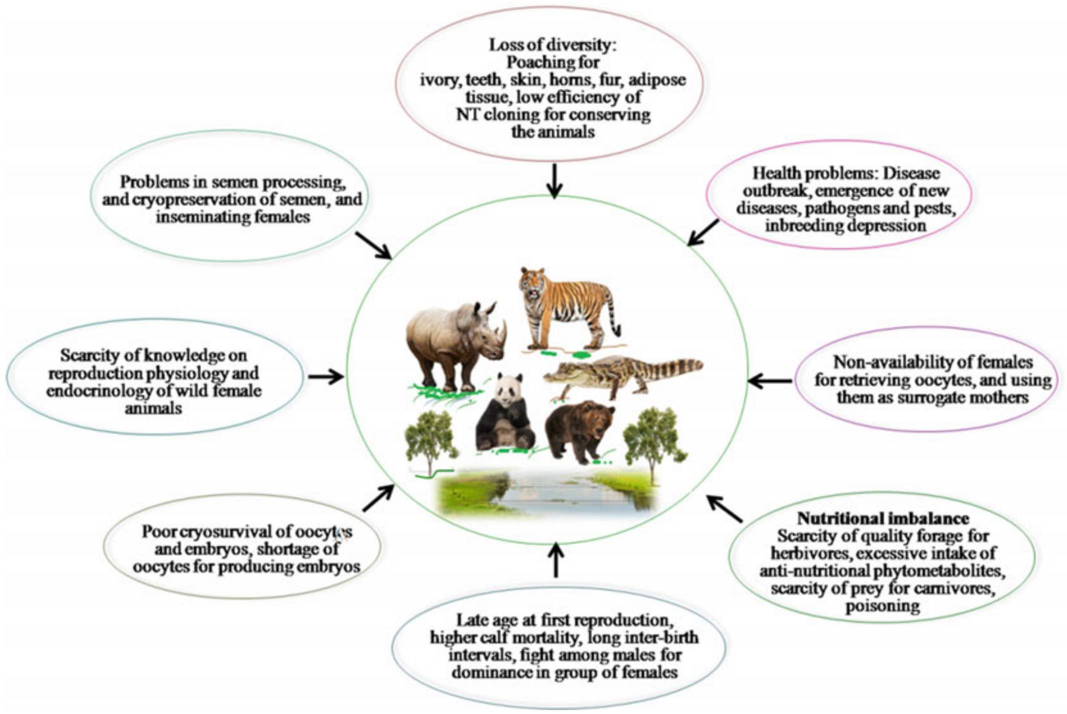

Fig. 46.3 Summary of threats to wildlife. Illegal trade, shrinking habitat, and food resources are the major factors contributing to decline in wildlife. The world is dealing with unprecedented spike in wildlife trade. A collapse in imminent in global biodiversity, especially in tropics, if stern preventive measures are not taken to reverse the species loss

wild felids (https://blogs.scientificamerican.com/extinction-countdown/6-most-endangered-feline-species/, accessed on August 2, 2018). Similarly, most large herbivores such as gorilla (*Gorilla beringei* and *Gorilla gorilla*) and Asian elephant (*Elephas maximus*) are among most endangered species. Some species such as mammoths, rhinoceros-sized marsupials and, marsupial lions are already in the list of extinct species.

46.3 Problems in Conservation of Wild Animals

Illegal hunting of wild animals for their body parts, skewing habitat due to expanding human populations and anthropological activities, high predation and break of infectious diseases are the major factors detrimental to survival of some wild animals. In some species, inbreeding depression is also a threat of serious concern. In addition, certain traits such as delayed puberty, age at first gestation, long-birth intervals, and low parturition density affect their population growth.

Assisted reproduction technologies (ARTs) have a limited success in wild animals, mostly due to non-availability of oocytes, and dearth of females to get large number of oocytes needed for producing embryos. Wherever feasible, gametes are obtained from wild and companion animals after death. In many cases, the intergenus females are used as surrogate mothers to give births to young one of other animal species.

Further, information is scarce on reproductive physiology, endocrinology, and behavior in many species of feral animals. Knowledge acquired on reproduction and endocrinological aspects in biological similar species is used to augment the reproductive success of the non-domesticated animals as well as humans (Prieto-Pablos et al. 2016; Comizzoli et al. 2018).

46.4 Wildlife Conservation

The list of endangered animal and plant species increases every day. Wildlife conservation refers to strategies aimed to maintain animals in their natural habitat, developing habitat to wild animals or conserving them through ARTs. Various nations have initiated programs to conserve their wildlife resources. For instance, University of Florida had initiated a program called Biotechnology for Ecological, Evolutionary and Conservation Sciences (BEECS) that apply biotechnological tools (DNA synthesis and genome, transcriptome and proteome sequencing, and others) to promote and conserve wildlife. The veterinary health management and biotechnological advances have been applied for conserving and repopulating endangered or threatened wild birds, reptiles, and mammals.

Endangered wild mammalian species can be repopulated by developing embryos in vivo and transferring them to estrus-synchronized surrogate mothers. Low availability of donor females and less number of oocytes recovered from females is one of the important limiting factors that impede production of embryos.

46.5 Conservation of Herbivore Feral Animals Through ARTs

Despite the difficulties in handling and getting animals to be studied, and getting the sample materials, the ARTs (semen, oocyte, and embryo cryopreservation, ICSI, IVF, in vitro production of embryos including SCNT embryos, intergenic embryo transfer, and pregnancy diagnosis) are now widely applied to breed endangered wild herbivores and carnivores. Researchers have used SCNT to disseminate wild species by nuclear transfer cloning.

Among the 200 deer subspecies are found across the globe, more than 40 are considered as endangered. At the moment, in vitro production of embryos is a promising strategy to increase and disseminate increase population of endangered feral mammalians.

Scarcity of oocytes is among the major constraints in wild mammalian species ARTs. In addition, retrieving oocytes and low availability of females for use as surrogate mothers impede implementation and success of embryo-related biotechniques. Collecting oocytes by laparoscopic ovum pick-up (LOPU) coupled with IVF and IVP may possibly assist increase the population of endangered captive or feral herbivores.

Embryo biotechnology programs were initiated in some endangered herbivores such as sika deer. The oocytes collected by using LOPU from sika deer were matured in vitro and fertilized using fresh or frozen-thawed sperm to produce embryos. The study shows that irrespective of breeding and non-breeding season, good-quality oocytes were obtained that could be used for obtaining embryos by IVF (Locatelli et al. 2006). A high developmental rate of embryos (30% of the oocytes used), their ability to withstand cryopreservation implies that LOPU–IVF might be a successful tool for establishing embryo banks from endangered sika deer species (Locatelli et al. 2006, 2012).

In 2007, eight red deer (*Cervus elaphus*) clones were produced using multipotent antler stem cells and their progeny as donor nuclei (Berg et al. 2007). Aimed at increasing the efficacy of SCNT in endangered sika deer, efforts were made for quick and accurate enucleation of oocytes to produce cytoplasts, cell–cytoplast fusion, forming cloned blastocysts (Yin et al. 2014), IVM and parthenogenetic activation to increase the embryo development efficiency. Table 46.1 summarizes the strategies used to produce embryos in vitro and their applications.

Studies are carried out to conserve and increase populations of large herbivorous animals such as rhinoceros (Hermes et al. 2018), elephants (Hermes et al. 2013; Saragusty et al. 2015; Arnold et al. 2017), giraffe (Wilsher et al. 2013), by assisted reproduction including collection and

Table 46.1 Examples of biotechnological applications applied to augment reproduction efficacy of endangered wild animals

Species	Targets	Technological interventions	Inferences and recommendations (references)
Mammalian herbivores			
Monkeys (*Macaca fascicularis*)	Establishing primate models	Using SCNT to produce NT clones animals	The first report on cloning in non-human primates, inferring that macaques could be cloned (Liu et al. 2018)
M. fuscata	Development and physiological studies using *M. fuscata* as model species	Developing iPSCs from dermal fibroblasts with Sendai virus or plasmids	The iPSCs had similarities with human iPSCs, expressed various pluripotency-specific markers. It is anticipated that cells would provide robust in vitro tools for studying mechanisms of development and physiology using *M. fuscata* as model species (Nakai et al. 2018)
Mouflon (*Ovis orientalis musimon*)	Rescue of an endangered animals	iSCNT	The SCNT explores the feasibility of reviving endangered species (Loi et al. 2001)
Rhesus macaque	Reprogramming of adult cells	SCNT	Development of pluripotent stem cell lines from adult skin fibroblasts through SCNT explore the feasibility of therapeutic cloning in primates (Byrne et al. 2007)
Rhinoceros (*Diceros bicornus*)	Genetic management	Microsatellite profiling	The study provides evidence of polygamy in black rhinoceros (Garnier et al. 2001)
	Prenatal sex determination	PCR-amplification of SRY-genes	The sex-determination envisaged to be a valuable tool for managing assisted reproduction of the managed in captivity (Stoops et al. 2018)
Sika deer (*Cervus nipon*)	Conservation	Using SCNT to produce cloned embryos	Various types of cells viz., antlerogenic periosteum, adipocytes and bone cells shown comparable reprogramming ability with no difference on development of SCNT cloned embryos, and births of cloned fawns (Berg et al. 2007)
Tapir (*Tapirus bairdii*)	Semen preservation	Cryopreservation and evaluation	The study shows feasibility of Tapir semen by cryopreservation (Pukazhenthi et al. 2011)
Vietnamese deer (*Cervus nipon*)	Collecting oocytes	Induction of super-ovulation by eFSH (0.25 and 0.5U) and collection	LOPU–IVF envisaged to be a promising method for retrieving oocytes for producing embryos from the species (Locatelli et al. 2012)
Wild ox (*Bos gaurus*)	Feasibility of repopulation by cloning	Using iSCNT to produce cloned embryos	Successful live birth of *B. gaurus* calves proved the feasibility of iSCNT to conserve NT wild mammalian cloning species (Lanza et al. 2000)

(continued)

Table 46.1 (continued)

Species	Targets	Technological interventions	Inferences and recommendations (references)
Wild sheep (*Ovis ammon*)	Salvaging endangered sheep	Using iSCNT to produce cloned embryos	The cloned embryos produced from fusion of fibroblasts from *O. amnon*, and cytoplasts prepared from IVM oocytes of domestic sheep, transferred to sheep to establish pregnancies indicating the feasibility of the iSCNT to conserve wild sheep (White et al. 1999)
Monkey (Macaca fascicularis)	Autologous cell therapy	Parthenogenetic embryos	The parthenogenetic stem cells with ability to induced differentiation into various lineages such as functional neurons, and epithelial morphologies could serve as potential source of stem cells autologous cell therapy (Vrana et al. 2003)
Mammalian carnivores/omnivores			
African wild cat (*Felis silvestris lybica*)	Conservation	Using iSCNT to produce cloned embryos	Transfer of cloned embryos to domestic cat, birth of kitten proves use of the technique to produce cloned carnivore (Gomez et al. 2004)
African wild dog (*Lycaon pictus*)	Conservation	Cryopreservation	Improving sperm cryopreservation by manipulating semen extenders (Van den Berghee et al. (2018)
Coyotes (*Canis latrans*)	Conservation	Using iSCNT to produce cloned embryos	Births of eight live offspring from transfer of embryos to dogs, indicating that despite limitations the technique can be used to conserve and multiply endangered wild canines (Hwang et al. 2013)
Gray wolf (*Canis lupus*)	Conservation	Using iSCNT to produce cloned embryos	The ability of cells collected from a dead wolf to form cloned embryos when fused with cytoplasts developed from dog oocytes, implies that iSCNT could be strategy to resurrect the endangered wild canine after death (Oh et al. 2008)
Grey wolf (*Canis lupus*)	Conservation	Using iSCNT to produce cloned embryos	The dogs used as source of oocytes, and surrogate mothers to produce cloned grey wolves implying that SCNT might be a practical approach for repopulating the endangered wild canines (Kim et al. 2007)
Jaguar (*Panthera onca*)	Collection and semen evaluation	Chemical restraining of animals and semen collection	Collecting semen by uretheral catherization found to be promising method for collecting semen from wild and captive carnivores (Araujo et al. 2017)
Jungle cat (*Felis chaos*)	Semen collection and evaluation	Chemical restraining of animals and semen collection	Collecting semen by uretheral catherization found to be promising method for collecting semen from collection by restraining wild and captive carnivores (Kheirkhah et al. 2017)

(continued)

Table 46.1 (continued)

Species	Targets	Technological interventions	Inferences and recommendations (references)
Leopard cat (*Prionailurus bengalensis*)	Feasibility of SCNT is the species	iSCNT	Development interspecies cloned nuclei from fibroblasts of *P. bengalensis* and cytoplasts from domestic cat oocytes, the cloned embryos could be used for establishing pregnancies indicating the feasibility of use of the SCNT as alternative strategy for producing offspring (Yin et al. 2006)
Black lion tamarin (*Leontopithecus chrysopygus*)	Genetic assessment and diversity species	Microsatellite-based polymorphism in different	The data envisaged to provide insights into genetic diversity in different species that could support breeding programs and prevent inbreeding depression, and conserving genetic biodiversity (Ayala-Burbano et al. 2017)
Lion (*Panthera leo*))	Diversity conservation	In vitro embryo production	Production of embryos from oocytes retrieved from lioness after death, and embryos produced through ICSI, by using homologous frozen-thawed sperm. The technique explores the feasibility of producing blastocysts in lions from IVM of oocytes and ICSI frozen-thawed sperm (Fernandez-Gonzalez et al. 2015)
Snow leopard (*Panthera uncia*)	Conservation	Inducing pluripotency in fibroblasts	The pluripotency induced by retroviral transfection with Moloney-based retroviral vectors (pMXs) encoding four factors (OCT4, SOX2, KLF4 and cMYC), led to development of iPSCs. The iPSCs might have applications in NT cloning, genetic conservation, and deriving games in vitro (Verma et al. 2012)
Tammar wallaby (*Macropus eugenii*)	Conservation	ARTs	Birth of young ones after AI (Paris et al. 2005)

Abbreviations eFSH—equine follicle stimulating hormone; ICSI—intercytoplasmic sperm injection; IVF—in vitro fertilization, IVM—in vitro maturation, IVEP—in vitro embryo production, SCNT—somatic cell nuclear transfer, iSCNT—interspecies somatic cell nuclear transfer, SRY—sex-determining region Y

cryopreservation of sperm, improving quality of semen, understanding ovarian functions, IVF, and embryo biotechnology.

A study on investigating the effects of sex-sorting and cryopreservation on post-thaw characteristics and fertility of red deer (*Cervus elaphus*) semen collected by electroejaculation from 10 mature stags during breeding season shows that Y-chromosome bearing sperm possessed adequately acceptable post-thaw sperm parameters (viz., sperm motility, chromatin stability, and fertility) and expected offspring sex ratio. It was inferred that technique has potential in wild animals though further studies should be carried out to resolve the sperm damage (Anel-Lopez et al. 2017a, b).

46.6 Conserving Felids and Other Carnivores

Reproductive biotechnological interventions are expected to conserve or repopulate wild felids (Holt et al. 2004; Yin et al. 2006; Gomez and Pope 2015; Angrimani et al. 2017). In 2003, for the first time, SCNT cloned African Wildcat (*Felis silvestris lybica*) kitten were reported from domestic cat as surrogate mothers. Embryos were developed from fusion of fibroblasts from *F. silvestris lybica* to cytoplasts from oocytes obtained of domestic cat (Gómez et al. 2004). Since then other species are also cloned.

Similarly, SCNT is used to produce clones of wild canids (Table 46.1). Other ARTs, such as sperm cryopreservation (Anel-Lopez et al. 2017), oocyte and embryo biotechniques (Singh et al. 2009), and ICSI (Salamone et al. 2017) are used to conserve and increase the population of domestic and wild mammals. It is necessary to be acquainted with fundamentals of reproductive biotechniques for their successful implementation in wild mammalian fauna (Jewgenow et al. 2017).

One of the most important benefits of freeze-drying and storage is that lyophilized sperm can be preserved when liquid nitrogen supply is interrupted in natural calamities such as Hurricane, floods or other natural or man-mediated disasters (Dickey et al. 2006). It is envisaged that semen of some wild species including chimpanzee, giraffe, jaguar, weasel, and the long-haired rat can withstand freeze-drying. Their sperm is found to remain viable after lyophilization. As pronuclei were formed after the injection of freeze-dried sperm into the mouse oocytes, the technique has potential in micro-insemination techniques, and for establishing "freeze-drying zoo" to conserve and repopulate endangered wild animals when semen availability is less (Takehito Kaneko et al. 2014).

46.7 Genomics Advances in Wildlife Conservation Management

A large number of studies are carried out in studying wild animals. Prime objective studying genomics in wild animals is assessing their genetic make-up, and diversity, comparing genetic diversity parameters between wild populations and captive groups and developing molecular markers as parameters of preventing genetic diversity and inbreeding depression. In addition, the molecular markers are indicators of their evolutionary adaptation to harsh climate.

Currently, the data is equivocal livestock domestication was a multiple or singular process. Early animal populations have contributed in a different ways to modern animal rearing and human nutrition and welfare. Wildlife genomics includes analysis of genetic materials using large-scale genome analysis tools. In addition, "omics" tools have provided a lot of valuable information on physiological adaptations, population history, behavioral aspects, health, and dynamics of wild animals. Transcriptomics studies have provided insights into molecular biological and biochemical mechanisms regulating hibernation in dwarf lemurs (*Cheirogaleus crossleyi*) (Faherty et al. 2018).

Genomics has important role in conservation of endangered species and studying endangered animal populations. More specifically, the conservation genetics has facilitated empirical insights into the effect of inbreeding and increased genetic drift leading to minimal genetic diversity in isolated populations of wild animals. The genetic information obtained on wildlife is valuable for wildlife managers and conservationists, calculating harvest rates, and managing the migration or translocation of wild animals.

Koala, the only extant species of the marsupial family Phascolarctidae, is classified as "vulnerable" due to shrinking habitat, scarcity of dietary forage, and outbreak of infectious diseases. Genome of koala is sequenced recently. Koala feeds exclusively on eucalyptus leaves that are known to contain anti-nutritional hydrolysable tannins (HTs). Genome sequence data revealed that koala's ability to detoxify eucalypt HTs might be due to expansions within a cytochrome P450 gene family, and its ability to smell, taste, and regulate intake of phytometabolites owing to expansions in the vomeronasal and taste receptors (Johnson et al. 2018). Genetically diverse population's studies require habitat corridors and translocation strategies to assist the survival of koala in its natural habitat (Johnson et al. 2018).

Metagenomic analysis of gut ecosystem of bamboo-eating giant panda (*Ailuropoda melanoleuca*) and red panda (*Ailurus fulgens*) has shown abundance of cyanide-degrading bacteria (Zhu et al. 2018). It is envisioned that gut ecosystem of other herbivores adapted to unconventional diets might yield valuable microbial resources. Integrated transcriptome sequencing, proteomics, phenotypic, and biochemical studies revealed presence of highly fibrolytic fungi from the herbivores gut and found that enzyme synthesis is triggered in response to substrate, i.e. lignocelluloses ingested by the host (Solomon et al. 2016).

Characterization and analysis of phylogenetically conserved and derived transcripts (55,910 expressed sequence tag or ESTs) contigs in *Loxodonta Africana*, the African elephant, has revealed evolution and variation of eutherian placentation showing that some candidate genes might be important for normal development and functioning of human placenta. A total of 2963 genes were found to be expressed commonly in the placentas of some eutherian mammals (mouse, cattle, and humans) studied. Further, it was inferred that dysfunction these genes might lead to complications to human fetal development (Hou et al. 2012).

46.8 Negative Impact of Wildlife

There are negative aspects of wild animals that need attention of biologists, microbiologists, and personnel involved in veterinary-public health management. Many wild animals serve as natural hosts or reservoirs of deadly viruses, pathogens, food-borne pathogens, pests, and parasites. Diseases spread from animals to humans are called zoonotic diseases.

It is noted that of the 37 new infectious diseases encountered during past 30 years, more than two-thirds are zoonotic in nature (http://needtoknow.nas.edu/id/threats/animal-carriers/, accessed August 7, 2018). Around 48 human diseases spread from pests that bite animals. Water infected with animal feces and urine is the source of several infections in humans. Wild boar is reservoir of numerous zoonotic diseases.

Some of the remarkable diseases caused by wild animals include protozoal infections (toxoplasmosis), bacterial (leptospirosis), and viral (encephalitis caused by Nipah virus).

While some wild birds are natural reservoirs of West Nile virus, fatal bird flu, the bats spread Nipah viruses, and severe acute respiratory syndrome (SARS), the rodents are carriers of deadly plague. In addition, wild animals pose threats to domestic animals by preying on them, attack occasionally humans, and devastate crops and horticulture.

46.9 Outlook and Challenges

Protecting and conserving wildlife is a major issue across the globe. The threats from smugglers and poachers are of paramount concerns. Technologies are developed to monitor wildlife and prevent unauthorized exploitation of the wildlife. However, technology and data developed for protecting endangered feral species can also be utilized by the hunters and poachers.

Reproductive techniques are used to clone many livestock species and have also been found promising to increase population of wild animals. Somatic cell banking, semen, oocyte, and embryo banking are explicitly useful to conserve wild animals. Nuclear transfer cloning has limited success when used in wild animals. The underlying technical causes should be resolved. NT cloning of endangered mammals presents practical problems, many of which stem from the paucity of knowledge about their basic reproductive biology.

In endangered species, research should focus on characterizing reproductive traits, reproductive behavior, and species-specific endocrine principals. The knowledge acquired will be useful in manipulating female reproductive cycle of females intended for use surrogate mothers. Efforts should also be made to study molecular and cellular mechanisms of gamete development, their cryopreservation, and optimizing applications of ARTs at larger scale in wild species. Also, efforts should be made for scientific control of overpopulating wild and feral animals that have posed threats to humans, crops, gardens, and domestic animals.

46.10 Conclusions

Wild animals and plants are of immense importance to humans, ecological balance, and agriculture. Regrettably, our planet is losing wild animals rapidly, many have become extinct. More than half of the total wild animals have decimated during past four decades due to habitat loss, climate change, pollution, diseases, and hunting. Clearly, protecting wildlife has become an environmental and security concern. Modern ARTs tested in domestic livestock should be optimized for use in conserving and disseminating valuable wild animals. Also strategies should be evolved for preventing reproduction in wild animals that are harmful to agriculture and humans.

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