Marwell Wildlife

Wildlife Conservation Resource

Wildlife Conservation Booklet

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Introduction

Is there a need for conservation?

Marwell Wildlife is dedicated to the conservation of biodiversity and other resources. We feel that there is a need to conserve the wealth of life on Earth, which includes all living organisms, biological communities and ecosystems. Biodiversity matters as it is essential to all life, including our own. It provides us with food, water and oxygen, and regulates the climate and some forms of pollution. In addition, biodiversity provides us with useful products, such as medicines.

We feel there is a need for conservation as there have been about 800 documented extinctions since 1963[1] and over 60 species have become extinct in the wild[1]. This is an alarming extinction rate, as the fossil record shows us that the natural rate of background extinctions is approximately 1 species every 4 years. This means that the current rate of extinction is much greater than the natural rate and it is very probable that the majority of these are the result of human activities.

Currently we have documented an estimated 1.8 million[2] species; however it is very likely that there are many more species that are undiscovered. In order for us to monitor the species we are aware of, the IUCN (International Union for the Conservation of Nature) evaluates populations and categorises them depending on the health of their numbers and the threats affecting them. As of 2015 IUCN had evaluated over 76,000 species, of which 24,000 and classed as threatened. Species are placed into nine categories ranging from extinct to not evaluated. Of the nine categories, animals which fallen into the categories Endangered, critically endangered and vulnerable are classified as threatened species.

At Marwell Wildlife we have a number of species of conservation concern. The list below shows the IUCN categories from most to least threatened. You can see some of these species at Marwell.

Extinct: Quagga (*Equus quagga quagga*)

Extinct in the wild: Scimitar horned oryx (*Oryx dammah*)

Critically endangered: Cotton-top tamarin (*Saguinus oedipus*)

Endangered: Przewalski's horse (*Equus ferus przewalskii*)

Vulnerable: Humboldt penguin (*Spheniscus humboldti*)

Near Threatened: Southern white rhinoceros (*Ceratotherium simum simum*)

Least concern: Meerkat (*Suricata suricatta*)

Data deficient: Spiny seahorse (*Hippocampus histrix*)

Not evaluated: Estimates for the number of species on Earth range from 3-30 million species meaning this category of those not yet evaluated is the by far the largest of all.

The work of the IUCN enables the implementation of conservation strategies and protection agreements in order to support remaining populations.

CITES is the Convention on International Trade in Endangered Species (flora and fauna) which aims to control the trade of species and their products worldwide. In order to be party to this convention a country must sign up to it. Currently 5,000 species of animal and 29,000 species of plant are protected by CITES under three appendices[3]:-

- **Appendix I:** Lists the most endangered species (plants and animals) on the IUCN Red List. As these species are threatened with extinction their trade is prohibited unless permission has been granted by CITES[3]. An example species is the red panda (*Ailurus fulgens fulgens*).
- **Appendix II:** Lists the species that are not currently threatened with extinction but may become so if their trade is not strictly controlled. Therefore export permits must be acquired before specimens can be traded internationally[3]. Hartmann's mountain zebra (*Equus zebra hartmannae*) is one sub-species listed in this appendix.
- **Appendix III:** This refers to lists that have been requested by Parties (signatories to CITES) that already control the trade of certain species to prevent unsustainable or illegal exploitation[3]. For example, the ring-necked parakeet (*Psittacula krameri*) is listed in Appendix III under the request of Ghana, as trade of this bird from Ghana is prohibited and therefore certification of origin is required.

Value of biodiversity

Biodiversity includes all living organisms together with their genetic variation and the variety of habitats in which they are found. Biodiversity matters for a number of reasons as it is essential for all life, especially our own.

We place an intrinsic value upon the diversity of life as it provides us with aesthetic pleasure and thereby enhances our own recreation and leisure activities. This intrinsic value ranges from the grass on which to play sports and sunbathe on to breath-taking views and wildlife watching.

We utilise a wide range of products including food items and medicinal products, which helps to support the global economy. Examples of these products grow in our tropical house and include plants such as *Ananas sativa*, which produces pineapples, and the rosy periwinkle (*Catharanthus roseus*) which contains alkaloids used in the treatment of cancers such as childhood leukaemia. These products are not only beneficial to individuals today but also to individuals in the future as we learn more about how they can be used.

On an ecosystem level, biodiversity not only provides food for species at all trophic levels but also supplies oxygen, fresh water and assists in climate regulation.

Loss of biodiversity

Unfortunately, many of the species that form the world's biodiversity are under threat from extinction. This is largely down to human activities that are causing problems such as habitat loss, pollution and climate change. Whilst some species are affected by one main threat, many are threatened by a combination of human impacts.

There are 5 main reasons/threats that are currently causing the loss of biodiversity, especially in terms of species diversity, the genetic diversity of a species and their habitats.

5 main threats to biodiversity:-

1. Habitat loss

Habitat loss occurs in all habitats and can be linked to a number of human activities. Many are aware of the loss of rainforest due to logging however few think about the loss of the frozen pack-ice in the Arctic which is reducing the area over which species, such as the polar bear, can hunt. Examples of species threatened by habitat loss include:-

- **Cotton-top tamarin** (*Saguinus oedipus*) – now classed as critically endangered since publications from 2008 highlight that the population of this species had decreased by more than 80% over 18 years due to habitat destruction[4]. This has resulted from colonisation by a growing human population and clearance of forest for agricultural activities. More than 70% of the tamarins' natural habitat had been lost by 1966 and the remainder has become severely fragmented[5].

- **Hula painted frog** (*Discoglossus nigriventer*) – was thought to be extinct as a result of marsh drainage in the 1950's to eradicate malaria and provide land for agriculture[6]. However, this species has since been rediscovered and is now classed as critically endangered[7]. A small remnant population must have survived and as a result of conservation work to restore the habitat of the Hula Valley this species has made a comeback[8]. This provides an example of a conservation success story.

2. Pollution and nutrient loading

Pollution is the result of any contaminant (pollutant) that affects the natural biotic and abiotic environment. This includes air pollution, light pollution, thermal pollution, soil contamination, littering, water pollution, space pollution and radioactive pollution. Any form of pollution can affect the environment in which it is initially released and also those further afield. For example pesticides and other toxic contaminants are released into the environment in one place yet can still affect species that are not found in the local area. Contaminants can be carried along water currents and in the air. Once they enter the food chain they bioaccumulate which affects all species, particularly the top carnivores

as these contaminants build up in the tissues at each trophic level. Examples of species threatened by pollution include:-

- **Polar bears** – research has revealed the presence of high levels of contaminants such as DDT and PBDE, to which their environment has never been directly exposed, in their tissues[9]. These contaminants can affect the endocrine system thereby reducing fertility, decreasing the strength of immune systems and interrupting neural pathways[9]

- **Boreal felt lichen** (*Erioderma pedicellatum*) – like many lichens, this species is extremely sensitive to air pollution. The global population of this lichen, found mostly in Canada, has decreased by more than 80% thereby making this species critically endangered[10].

- **White-rumped vulture** (*Gyps bengalensis*) – critically endangered as the result of feeding on carcasses that had been treated with a veterinary drug which is toxic to this bird species[11].

3. Over-exploitation

The over-exploitation of species occurs due to their usefulness to us for a wide variety of purposes including as food sources, manufacturing products, medicinal aids, agricultural uses, industrial uses, entertainment/media exploitation, the pet trade, as ornaments and as energy sources. The ways in which we exploit the world's biodiversity are endless and whilst some use is sustainable, most is not thereby impacting upon the diversity of the biotic and abiotic environment.

Unfortunately, human choices tend to determine the future of some species as despite our understanding surrounding the threats to these species, we continue as if there was no issue at all. Examples of species threatened by over-exploitation are:-

- **North Sea cod and blue fin tuna** – Our wish to eat specific fish species such as North Sea cod (vulnerable) and blue fin tuna (critically endangered) had led to these species becoming threatened. We continue to harvest these species even though we know that it is unsustainable just because we want to eat them.

4. Climate change

The extent to which human activities have influenced the natural change in climatic conditions is debatable however it is clear that a number of forms of pollution have influenced changes within our climate. These changes include temperature rises and alterations to weather patterns. Human populations can be dramatically impacted by some of these changes; however other species are far more sensitive to the more

delicate changes such as those of temperature. An example of an animal threatened by climate change is:-

- **Coral** – global climate change is a major threat to all coral species as it leads to bleaching and therefore increases the susceptibility of these species to disease. Coral bleaching refers to the loss or reduction of the symbiotic zooxanthellae (microscopic organisms) that reside within the coral and can be caused by variations in sea temperature and solar irradiance.

5. Alien species

Any species that is introduced into a country or habitat from which it does not originate is an alien species. The impact of these species varies greatly as they could affect food webs, the diversity of species or even influence the genetic diversity of a species if they can interbreed.

Some species are introduced into environments in order to act as biological controls, others have escaped into the wild from captivity, and some have been released without understanding of the potential consequences, for example unwanted pets. Examples of species that have been threatened by the introduction of alien species are:-

- **Partula snails** – The most notable example of an attempt at biological control which has adversely affected an entire genus is that of the Partula snails. 72% of the *Partula* species in Polynesia have become extinct due to the introduction of the carnivorous wolf snail (*Euglandina rosea*) in 1975[12]. The wolf snail was introduced as a control measure to reduce the spread of the African giant snail (*Achatina fulica*) that had been brought to the islands as a food species. Unfortunately, the wolf snails prefer to eat the Partula snails and so many species of Partula snails have become extinct and many others are now threatened[12].

- **Indigenous wildlife** – Unwanted exotic pets can directly or indirectly impact upon the biodiversity of a habitat. For example the red-eared terrapins, *Trachemys scripta elegans*, from Central America became very popular pets due to the cartoon Teenage Mutant Ninja Turtles. However, they demonstrate a common problem - many exotic pet owners do not find out enough information about their chosen pet before they buy it. Sooner or later they realise that for a variety of reasons their chosen pet is not suitable and they no longer want it, so many red-eared terrapins have been indiscriminately released into ponds and lakes throughout Britain.

They are voracious carnivores and have proceeded to decimate the numbers of indigenous wildlife. As a result of this the EU has banned the import of these animals.

The biodiversity concept model

The concept model below shows what we mean by biodiversity and all the elements that come together to provide a strategy for conservation.

Marwell's Role in Conservation

Marwell Wildlife is dedicated to the conservation of biodiversity and other natural resources. Our vision is to live in balance with nature and to achieve this we have four aims:

1. Conserve species and their habitats, locally and globally

The best way to conserve biodiversity is to maintain existing habitats. However, many places have already been damaged by human activities and need to be restored and managed to enhance their value to wildlife.

Through our British Wildlife programme we seek to make a significant contribution to the conservation of biodiversity on our doorstep in Hampshire and the surrounding counties of southern England. Eelmoor Marsh is a site close to Farnborough, which includes a variety of habitats such as lowland heath, grassland and bog/mire; therefore this site is both nationally and internationally important. Lowland heath is currently a priority for nature conservation because it is a rare and threatened habitat, as over 80% has been lost in Britain since the 1800s[13].

Eelmoor Marsh is protected under National and European legislation. It has been designated a **SSSI** (Site of Special Scientific Interest), originally due to the mixture of habitats but now also due to the variety of invertebrates, especially the dragonflies, butterflies and beetles, that have returned due to the restoration. It is a **SPA** (Special Protected Area) for birds due to the presence of breeding pairs of nightjar, Dartford warbler and woodlark. As it is a refuge for over 360 species of conservation concern it has been designated a **SINC** (Site of Importance for Nature Conservation).

Marwell has been working with the Eelmoor Marsh site owner for over 10 years on the restoration of habitat and management of the site. The habitat management and restoration programme includes the use of particular species. Highland cattle are used on a range of habitats, as they graze to a certain height and also keep the birch and scrub below seed-bearing height, thereby keeping them under control. The Przewalski's horses graze specific species to a lower height so they are used to manage the grassland.

Physical and mechanical management is also needed in balance with the grazers. This management involves the clearance of scrub areas, clear-felling of the pines and also, as the animals are at a low stocking density, grassland areas are mown.

This management allows the botanical species to diversify in the grassland to include herbs and orchids. An increase in rare species such as the previously absent yellow bartsia, early marsh orchid and pale heath violet has been seen.

Populations of many species have become so small that they need a lot of help to secure their future.

Marwell has participated in the breeding and release of sand lizards (*Lacerta agilis*) since 1989. Sand lizards are the UK's largest and rarest lizard, and are protected under National and European Law. We aim to breed between 50 and 100 sand lizards each year. Marwell bred sand lizards are released into protected heathland sites in local counties. This is done in partnership with Amphibian and Reptile Conservation[14] who coordinate the releases as sand lizards from a range of breeding facilities are used at release sites in order to maximise genetic diversity.

The once abundant scimitar-horned oryx was declared as extinct in the wild by the IUCN in 2000 due to over-hunting, competition with domestic livestock and fragmentation of their habitat; therefore they only exist today due to breeding programmes such as the one Marwell is involved in. Due to the success of the captive breeding programme there are now approximately 200 captive bred scimitar-horned oryx in protected areas in Tunisia. The reintroductions began in 1985 with 10 oryx from Marwell and Edinburgh Zoo (co-ordinated by ZSL). These were released into Bou Hedma National Park. In 1999 and 2007 Marwell co-ordinated the release of scimitar-horned oryx into protected areas within their former historic range. The oryx chosen for the project were from various collections in Europe and the US and placed into 3 areas in Tunisia. These populations are currently being monitored. Reintroductions involve various organisations, are costly, complex and require a lot of expertise along with global collaboration. For further details on the scimitar horned oryx please refer to the conservation pages on our website[15].

Although difficult, re-introductions involving Marwell have also been successful for cheer pheasants (to the Himalayan foothills in Pakistan), golden lion tamarins (to a reserve in the Brazilian rainforest), Przewalski's horses (to a reserve in Hungary), natterjack toads and reddish buff moths (to sites in the south of England).

2. Inspire care for the natural world

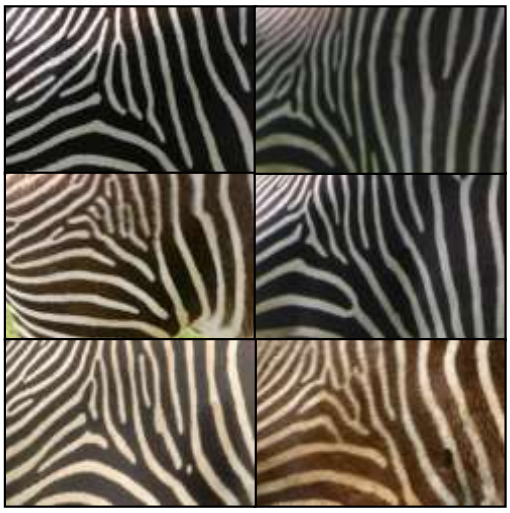
Education is vital if we are to succeed in conserving the natural world as without interest or understanding, conservation work cannot be self-sustaining.

Here at Marwell we are very fortunate as we have a fantastic range of resources that allow us to offer first hand learning experiences. We have the Science & Learning Centre where teaching sessions use confiscated animal artefacts and live animal contact. Currently we cater for ages 3 up through to higher education. Out in the park, visitors are able to experience a range of familiar and unfamiliar animals first hand and learn more about them from our interpretation signs. We also have a public engagement team who deliver talks to the public as well as run bookable keeper experiences and animal encounters. In addition, we run activities and events during the school holidays as we have around half a million visitors each year.

In 2010 the Education team was awarded the Learning Outside the Classroom Quality Badge, which we were re-awarded in 2012. This is a nationally recognised benchmark that helps teachers to identify organisations providing high quality education provision. We have also seen a steady growth in the numbers of students visiting us with around 30-35,000 visiting a year.

3. Undertake and share our results of scientific studies

In Northern Kenya, we work with communities who have traditionally made a living through their livestock, but who also recognise the importance of biodiversity for their livelihood. Many have set aside areas of their land for conservation with the aim of deriving benefits from activities such as wildlife tourism. Our field biologists help communities to set up practical, long term monitoring programmes to evaluate the success of their conservation initiatives. This includes designing surveys and providing training for people to monitor vegetation and large mammals.



Marwell works closely with Kenyan conservation partners through a joint conservation programme for Grevy's zebra[16]. Marwell helped design, plan and carry out a new aerial survey of Grevy's zebra in 2008. This included training partners and local people in the use of software to identify and store individual stripe patterns (similar to human fingerprints) of Grevy's zebra from digital photos.

In 2009, we trialled the use of digital camera traps, to identify which would be the most suitable to survey Grevy's zebra and other species in remote locations.

Storing striped patterns for individual zebra enables more accurate counting of the zebra and also offers the opportunity to track individual zebra to help us better

understand zebra movements and the wildlife corridors they use. This enables us to apply appropriate conservation strategies and focus conservation efforts on areas used frequently by the zebra. Population surveys also enable us to measure conservation success, by providing information on whether the population is continuing to decline, stabilised or starting to increase[17].

In addition to using camera traps to monitor Grevy's zebra in the field we also deploy the use of GPS radio collars, which report the positions of individual collared zebra directly to the internet on an hourly basis. This allows us to keep track of the zebra in real time and we can analyse the data to determine how the zebra move through the landscape, where they spend the majority of their time, which water resources are important to them and where they find their food. We can use this information to advance our conservation efforts as it provides valuable information on which areas zebra use and it is only by protecting these scarce patches of habitat that we can hope to conserve this species for future generations.

We have conducted surveys interviewing local nomadic herdsmen in the far north of Kenya about their attitudes towards the Grevy's zebra. The herdsmen have a very good knowledge about wildlife and interviewing them is a very efficient means of collecting information over a vast and inaccessible area. By improving our insight into herders' attitudes through the surveys, and combining this with information from aerial surveys, camera traps and radio collars on the zebras, we now have a more detailed understanding of the issues surrounding the zebra and are therefore able to understand the main threats facing this species, which allows limited conservation resources to be focused towards these areas. For example, one of the reasons for hunting Grevy's zebra is to produce traditional medicines from their body fat. If herding communities were able to access modern medicines then the need for hunting would be much reduced. Therefore funding is currently being sought to provide reliable medical services to mitigate this threat. This is an example of how research findings can be turned into conservation actions, and therefore highlights the importance of carrying out research for successful conservation[17].

In Zimbabwe we are helping to understand more about behaviour and distribution of cheetah, which are sometimes blamed for killing livestock.

This includes promoting ways of protecting livestock without harming cheetah. See pages 20-21 for more information on cheetah conservation.

4. Improve our environmental performance and promote sustainable living

Our sustainability manager has created environmental management systems so that we have policies and procedures in place for effective environmental management, which include the prevention of pollution, improvement in our environmental performance and ensuring compliance with legal requirements. We have recycling facilities throughout the park for both visitors and staff and in 2011 we recycled approximately 88% of our waste.

As part of our ethical purchasing code we consider where we purchase items from and also consider local sourcing. Our policy is based on the following principles and actions:

- Seek to reduce consumption of materials by:
  - reusing rather than disposing of materials, whenever possible
  - promoting recycling and the use of recycled materials
  - repairing existing products
- Use of the least environmentally damaging products should be promoted.
- When new products are obtained, every effort should be made to purchase products made of recycled and recyclable materials.
- Products at the end of their useful life should be recycled wherever possible, and as a last resort should be disposed of in the most environmentally responsible manner possible.
- Market products that are safe to use, which make efficient use of resources and which can be reused, recycled, or disposed of safely.
- Work with our suppliers to minimise the impact of their operations on the environment.
- Monitor progress and publish an environmental performance report on an annual basis.
- Develop staff awareness of the environmental issues directing procurement, through the provision of appropriate information and training.
- Integrate environmental factors into our buying decisions, including taking account of environmental costs and benefits as part of total life cost assessment.

The construction of buildings must also be environmentally friendly. For example, Café Graze has lots of natural light, insulation, use of low energy materials and rainwater collection systems (used in our toilets).

We also have a travel plan so we encourage car sharing and the use of public transport.

Due to our sustainable management practice we achieved the ISO14001, which is the international standard for environmental management systems, in 2009. We were also presented with the Sustainable Business Award for the medium business category at the 2009-10 Hampshire and Isle of Wight Sustainable Business Partnership awards[18].

Investment in individuals and communities

These 4 aims are further achieved by our investment in individuals and communities.

In Kenya there is a delicate balance between the wildlife and the livestock that are reared by the nomadic pastoralists. Marwell is currently involved in the training of the pastoralists, within conservancies, in a range of methods for gathering and recording data from vegetation, bird and mammal surveys in order to gain a better understanding of the impact that livestock have. Marwell also provides laptops and electronic equipment to help gather and analyse the data.

Marwell also sponsors MSc students, mostly from the less affluent north Kenya region, in their research projects. The information gained from these studies is used to help conservancies and develop our understanding.

Involving local communities and listening to their views and opinions is vital for successful conservation and is something we endeavour to do where possible.

Can zoological collections play an active role in conservation?

Many zoological parks once envisaged their animals as only visitor attractions but now many have followed the path taken by conservation charities such as Marwell and now aim to act as arks for threatened species. Many, like Marwell, have also played a vital role in the breeding and reintroduction of species that are extinct in the wild. There are difficult questions that we need to consider: If we have species in zoological parks that, for whatever reason, we cannot put back into the wild then what is their value? Do they then not just become a living museum specimen? Do we breed endangered species because they have a great importance within the biodiversity of their natural habitat or do we do it because it fulfils our pleasure?

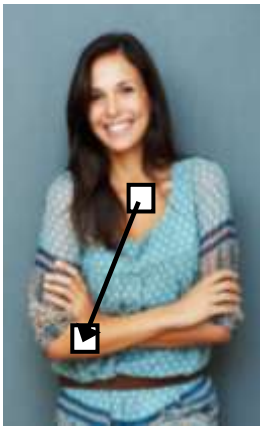
We now know that to conserve a species in our arks we need more than one male and one female, not just to secure genetic diversity but to also recreate environments that stimulate natural social behaviour as many species have complex social systems that influence their reproductive success. If we were to conserve a species initially with only one male and one female we would end up with inbreeding.

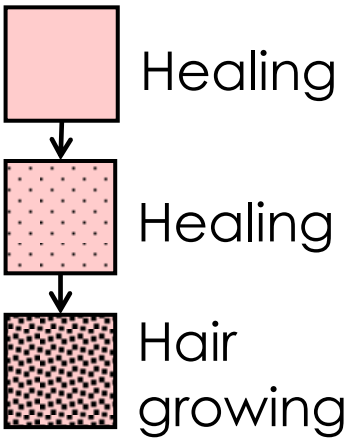
Nowadays zoological parks rarely take individuals from the wild and therefore the captive populations come from the original individuals that were taken from the larger wild population. This is known as the founder effect as a new population has been established within the zoological community and consequently only a small amount of the overall genetic variation is available. Therefore we must ensure that this variation is maintained and maximised through captive breeding programmes.

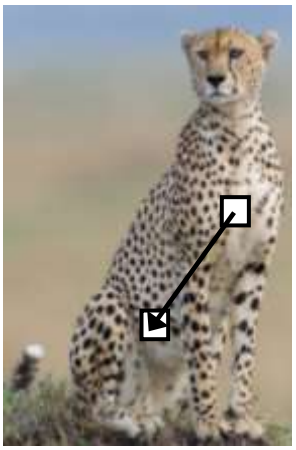
The aim of a captive breeding programme is to maintain a healthy, self-sustaining population of each chosen threatened species. The key to this is to preserve as much of the initial genetic variation for as long as possible. The genetic variation of a captive population comes from its founders (animals taken from a wild population). It is essential that as many as possible of the founders' genes are passed on to future generations if a breeding programme is to succeed.

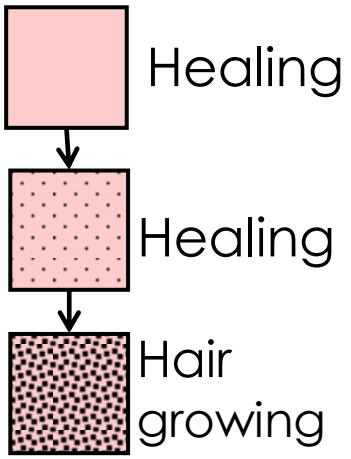
Ideally animals should not breed with their close relatives and where possible, matings should be between entirely unrelated animals. This ensures that the species remains as healthy and as varied as possible.

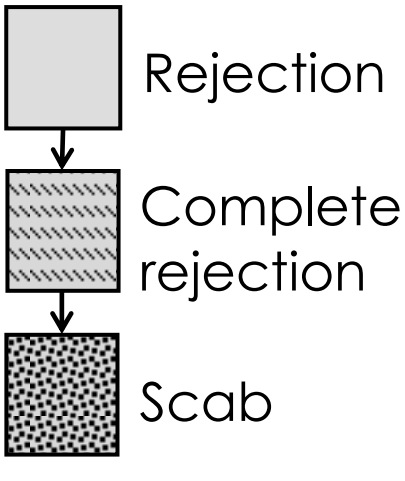
Case study: Cheetah Alongside issues with captive populations resulting from the founder effect, some of the original wild populations from which captive individuals were taken were already subject to reductions in genetic diversity, due to genetic bottlenecks. The cheetah you see today, *Acinonyx jubatus*, are the sole remaining member of its genus much like ourselves. Around 20,000 years ago, different species of cheetah roamed across the savannas and plains of Africa, Asia, North America and Europe. Then around 10,000 years ago all but one species became extinct. This was probably the result of extreme climate changes. With the drastic reduction in their numbers, close relatives interbred, and the cheetah became genetically inbred, meaning all cheetahs are now very closely related. Inbreeding occurs when members of the same family or close relatives breed only among themselves. When geneticists looked at the amount of variation within the genes of the cheetah, they found that they exhibit much lower levels of variation than other mammals. In most species, related individuals share about 80% of the same genes but this rises to approx. 99% with the cheetah. An experiment used to illustrate this monomorphism (reduced variety of alleles) involves the use of skin grafts. If you take a skin graft from a person and place in it onto

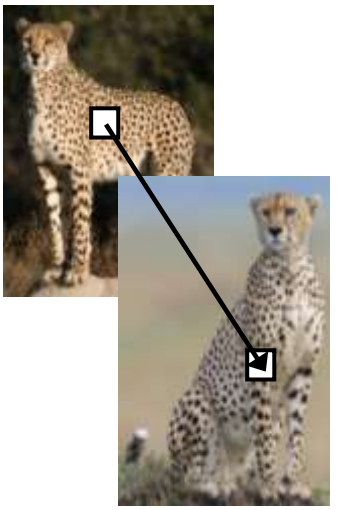


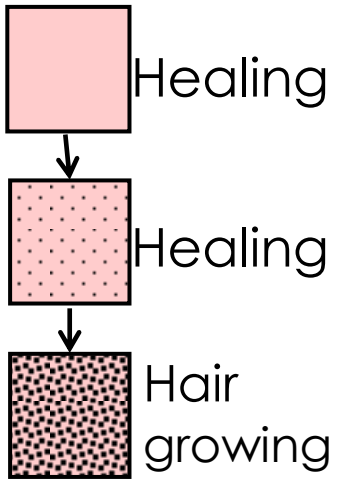












another area of their body it will accept the graft. However, if you graft a piece of skin taken from another unrelated person the genetic differences, and hence differences in

antigens, result in the graft being rejected. Similarly, if you take a skin graft from a cheetah and place in it onto another area of their body it will accept the graft. However, the genetic similarity between individual cheetah is so close that a skin graft from one individual can be placed onto another individual and be accepted, not rejected as you would expect.

This inbreeding with cheetah could cause the population to be more susceptible to certain diseases due to the reduction in the diversity of alleles. Issues such as low quality sperm production in males were believed to cause low reproductive success, however, cheetah in the wild show no issues with reproductive success. Therefore the low quality sperm appears to only be an issue with captive bred populations so it is likely that husbandry can affect breeding success. This example shows that in order to protect a species we must not only look at the genetics of a population but also the way that we manage them and the husbandry techniques used.

International cooperation

Individual captive populations are so small that on their own they are of little conservation value. However with large scale cooperation, all the small populations can be considered as one larger, more genetically viable, population.

In order for this cooperation to occur there are a number of different organisations involved. The mission of these organisations is to guide and support a community of zoological parks to develop education, research and global conservation. EAZA is a regional organisation enabling effective coordination between European zoos and aquaria. EAZA was formed in 1992 and their "mission is to facilitate cooperation within the European zoo and aquarium community towards the goals of education, research and conservation"[20]. There are two parts to their breeding programme, the European endangered species breeding programme (EEP) and the European studbook (record system for individuals of each species). Through this programme individuals are matched together to produce the highest genetic diversity and the European captive populations are managed as a sub population of the overall larger global captive population. This management is the most effective and promotes genetic diversity. On a more local level we also have BIAZA[21] who are a similar umbrella organisation to EAZA for British zoos and aquaria.

Endangered species breeding programme

Studbooks allow captive populations to be managed cooperatively through programmes such as EEPs. A studbook keeper is responsible for the collation of data on individuals within a specific species. This information contained in studbooks includes their sex, date of birth, who their parents are and where they are geographically. This studbook data is then used for population management (for example EEPs) to make recommendations on the selection of breeding partners and the movement of animals between collections in order to maximise the genetic diversity within the captive population. Marwell co-ordinates international studbooks for; scimitar-horned oryx, Grevy's zebra, Hartmann's zebra and Arabian oryx. Studbook reports are available to view on the conservation pages of our website[18].

As technology has developed the information available to the studbook keeper, and the analysis they can carry out, has progressed.

Genetic analysis allows relationships between individuals to be determined. This has been necessary for some species as records dating back to when the founders were first taken from the wild are missing or non-existent. The analysis is carried out on captive groups that are reintroduced to their natural habitat in order to ensure that they have the greatest genetic diversity and are not closely related.

PM2000 is a software programme used by studbook keepers to analyse the demographic and genetic data of a captive population. This analysis helps the keeper know which animals to breed, how many to breed and where to move animals within EAZA member zoos.

Selective breeding

Selective breeding is the process which has been used for centuries by humans to select individuals with characteristics that we desire. This mostly relates to livestock and pet breeds including sheep, cattle, snakes, rats, cats and dogs.

The allele responsible for the white colouration of white tigers originates, like many variations, from a mutation, but many collectors preferred this colouration. The white tigers were subjected to a selective breeding process to accentuate the allele responsible for the phenotypic white colouration. Selective breeding has resulted in them becoming inbred and having a very low genetic diversity. This has led to problems such as individuals being cross-eyed and having bone problems.

There can also be some advantages to selective breeding. As this process leads to individuals being very closely genetically related it is perfect for producing animals such as laboratory rats that need to be as genetically similar as possible for research purposes.

Benefits and disadvantages to artificial selection of captive breeding

The artificial selection of individuals through the captive breeding programme is different to the selective breeding described above; captive breeding programmes aim to maximise genetic diversity rather than to breed animals to obtain a particular characteristic. However, the selection of breeding partners through the captive breeding programme does have its own problems.
Sometimes breeding is unsuccessful either due to the animals' not cooperating or being infertile.A lack of cooperation can sometimes be attributed to husbandry and their captive environment. Also, the captive environment may not be able to sustain the population just like a natural environment. If too many males are produced in groups where the social ratio is one male to many females then housing of the surplus males may become an issue.

One example of where the artificial environment influenced mating to the detriment of a species was that of the giant panda. They are currently listed as endangered and there have been some issues with a lack of interest in mating and poor reproductive success; therefore artificial insemination was used to increase the captive population. More recently, possibly with a greater understanding of the giant panda and their husbandry, they have begun to increase their interest in mating in captivity.

Ideally, we would have a greater number of founders who would produce offspring with an equal ratio of males to females. This would then lead to a captive population with an ideal demographic with an equal sex ratio and an even spread of ages. The reality of what we have is very different to the ideal. We have animals that don't want to cooperate with breeding which could be due to the husbandry conditions and social set-up. There was a lack of understanding regarding the importance of records on the founders which has led to incomplete pedigrees, although this no longer causes major problems due to the development of better genetic analysis which enables us to determine how related individuals are. Despite these issues many conservation breeding programmes are proving successful.

For more information on the population management programmes that Marwell is involved in please visit our website[22, 23].

Conservation case study: Cheetah (*Acinonyx jubatus*)

Acinonyx jubatus was the only species of cheetah to survive the last ice age 10,000 years ago.

This species has over time evolved into several separate sub-species due to geographical isolation either through natural barriers or due to human influences. Today the largest populations are found in South and East Africa, the main stronghold being in South Africa as the East African populations are fragmented[24].

Cheetah have very large ranges within which they hunt, which is one of the reasons why the populations have been affected by human settlements.

Interestingly, the meta-populations of cheetah are found in areas bordering National Parks as cheetah do not do well in protected areas due to interspecific competition.

Factors affecting cheetah populations

Habitat loss

Habitat loss has occurred in many areas with cheetah ranges becoming enclosed or divided due to human settlements. This means that humans have placed obstructions within the cheetah ranges thereby reducing the area in which they can hunt for food and live. Cheetah need a large open space for running down their prey and if buildings are constructed or areas are enclosed then they are unable to hunt successfully.

Decline in prey species

Cheetah prey species and their populations have themselves experienced declines in recent years. This could be due to a number of factors including poaching. This raises a larger problem for the cheetah as they are also experiencing a lot of pressure through interspecific competition.

Interspecific competition

Cheetah are often unsuccessful within protected areas, such as National Parks, due to the large populations of other large carnivores such as lions, leopards and hyenas. The cheetah are capable of catching their own prey but will often be bullied away from their prey by these species. This means they are much more successful in areas fringing around national parks. Unfortunately this does mean that they are in areas in which they are not as protected.

Direct persecution

Cheetah are mostly hunted as they are considered to be a threat to livestock by both pastoralists such as the Masai and the more wealthy livestock ranch owners. Trophy hunting is permitted in some countries such as Namibia. The most vulnerable population

in Iran is still persecuted by illegal trophy hunting even though the current population is believed to be less than 100 and is consequently listed on the IUCN Red List as critically endangered. The threat of direct persecution is considered to be the easiest of the threats to deal with and resolution of this threat would also have the greatest impact on the populations.

Low genetic diversity

It was previously thought that the cheetah genetic monomorphism would influence survival especially as there have been problems with cheetah in captive breeding programmes. However, there is no evidence that the low genetic diversity negatively impacts cheetah populations in the wild and in fact most of the populations that are not disturbed have had no issues with breeding and do not seem to have an increased susceptibility to disease as was previously thought.

Current protection

Currently cheetah are listed on Appendix I of CITES so the trade in products, like pelts, and live individuals is strictly regulated; although trophy hunting is currently permitted in Namibia, Zimbabwe and Botswana. Each country has a quota for the number of animals that they are allowed to hunt in this way; annual quotas are 150 for Namibia, 50 for Zimbabwe and 5 for Botswana[24].

Cheetah are listed as Vulnerable overall on the IUCN Red List. However there are fragmented populations such as the Saharan and Iranian cheetah that are listed as Critically Endangered due to their extremely low numbers.

Marwell and cheetah conservation

In 2009 we held the Sprint campaign here at Marwell which allowed us to raise funds for our cheetah project in Kenya and to revamp our cheetah enclosure. The work being carried out in Kenya involves surveying cheetah populations through spoor counts (that is counting their trails or tracks) and with the use of camera traps.

Our work in Kenya also involves working with local communities and listening to their thoughts on the cheetah. To address their worries about their livestock a simple strategy that can be used to protect livestock from large cats, including cheetah, is to keep dogs with livestock herds to deter predators. However, it is important that the dogs are vaccinated against diseases such as rabies and canine distemper, otherwise the dogs pose a major threat to wildlife as they can spread these diseases to other animals.

The Milgis Trust in northern Kenya (which Marwell contributes funds and expertise to) has started to run a vaccination campaign through which they provide annual vaccinations to dogs in the area.

Classification and Marwell

Carl Linnaeus

Carl Linnaeus was a Swedish naturalist in the 18th Century and is considered by many to be the father of the modern classification system. He devised a system for grouping organisms which he proposed in his work "Systema Naturae". You may have come across this system of grouping things as either animal, vegetable or mineral. His work is still the basis of the system that we use today.

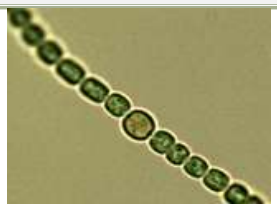
Classification

We need to place organisms into an ordered system as there are so many different types of species in the world today. There could possibly be up to 30 million, however we have only named around 1.8 million. When we study living organisms we find that there are many differences and similarities between them and classification helps us to learn more about the relationships between them. Classification is essentially the placing of organisms into groups based on similarities and differences in their characteristics. However, in recent years it has become far more developed and also considers genetic comparisons as well. This has meant that many species that were once put into particular groups have now been placed into separate ones as we have found that even though they have similar physical features they are actually very different genetically. The branch of science that specifically looks at the classification of organisms is known as taxonomy.

Throughout your time in school you will have learnt different ways of grouping living things. The simplest way of separating organisms is to group them into animals and plants. To be an animal you need to be made up of many cells, have cells that have specific jobs, have some means of ingesting food and also have some form of locomotion (be able to move from one place to another), whereas to be a plant you need to fulfil the same first two criteria but you also need to be able to photosynthesise food and have no form of locomotion. These criteria are very simplified in order to give a broad spectrum; however there are some animals and plants that do not fulfil all of these requirements and yet are placed within these categories. For example, there are around 3000 species of non-photosynthetic plants that are nearly all parasitic meaning they get what they need from their host instead of photosynthesising.

Hierarchical system

Organisms are classified within a hierarchical system. Linnaeus originally proposed a 3 **kingdom** system with everything being an animal, a vegetable or a mineral. As scientists learn more about organisms classification systems change. Therefore a 5 kingdom system evolved, with the kingdoms at the top of the hierarchy:-

Prokaryotae	Protoctista	Plantae	Animalia	Fungi
				

Essentially in this division, all the organisms within a kingdom will work in similar ways. However, advances in technology mean that we are now able to classify organisms to an even finer level and consequently a 3 **domain** system has been developed, with the 3 domains now forming the top of the hierarchy and 6 (instead of 5) kingdoms coming underneath these domains. The taxa found in each domain share some similar characteristics and share an evolutionary history so that at some point they have descended from a common ancestor. These 3 domains and the kingdoms they are represented by are summarised below:-

- **Bacteria** (Kingdoms = Eubacteria)
- **Archaea** (Kingdoms = Archaebacteria)
- **Eukarya** (Kingdoms = Protista, Fungi, Plantae, Animalia)

However, there is still some discussion as to which is currently the accepted version (5 kingdoms or 3 domain/6 kingdom system).

The taxonomic rank below kingdom is **phylum**. Some examples of the phyla within the Animalia kingdom include:
• Cnidaria – means 'stinging nettle' so animals in this phylum are ones with stinging cells such as jellyfish.
• Chordata – means 'chord' so this is the phylum we belong to as we have a chord or spine. All organisms within the Chordata phylum have a chord or spine for all or part of their lifecycle. All vertebrates belong to this category along with some invertebrates that share many characteristics with vertebrates but lack a bony skeleton. Examples of Chordata invertebrates are tunicates and lancelets.

The taxonomic rank below phylum is called **class**. Within the Chordata phylum there are the following classes: birds, amphibians, mammals and reptiles. Due to the diverse physiology of fish species there are currently four classes of living fish; hagfishes, lampreys,

cartilaginous fish and bony fish. There are also two classes of extinct fish which are subject to regular changes.

As there are so many different species within each class, these categories are subdivided further, however taxonomists rarely agree in which subdivisions organisms should be placed. **Genus** and **species** on the other hand are **universally accepted**, which means that we can identify specific living things by their unique scientific name (which is made up from the genus and species). This is very important for scientists so that studies of certain organisms can be shared and our understanding can be developed. For example, when pieces of scientific research are published in journals, the names used for the species they refer to are given in both their common name, for that country, and their scientific name. This means that someone wanting to research that same organism can find the work of another scientist as there is a universal agreement on their scientific name.

Example of classification: Ocelot

- Firstly, the **kingdom** in which the ocelot belongs is **Animalia** as it is multicellular, it has specialised cells, ingests food and has a means of locomotion.
- It has a spine so it is in the **phylum Chordata**.
- It is warm-blooded, has hair, suckles its young and gives birth to live young so it fits into the **class Mammalia**.
- The ocelot has specialised teeth for biting and shearing, and lives primarily on a diet of meat so they belong in the **order Carnivora**.
- As they are a carnivore with a short skull and well developed claws they are in the **family Felidae**.
- They are a small cat weighing a maximum of around 16kg so they fit into the **genus *Felis***.
- Their **species name is *pardalis*** which refers to its appearance (painted/spots).
- This means that the **scientific name for the ocelot is *Felis pardalis*.**

Scientific name

This is the only part of classification that the majority of scientists agree (made up of the genus and species for an organism) and is extremely important to organisations such as Marwell. We need to correctly identify all of our species, not just for the management of our collection, but also to ensure that the correct animals are put together for breeding.
It is also important for studbooks as they refer to species by their scientific names to ensure that there is no confusion as one species can have many common names. This universal language is also important for research purposes. Sometimes a third name is added such as in the case of our Amur leopards. The Amur leopard is *Panthera pardus orientalis* as it is a subspecies of the species *Panthera pardus* (leopard).

The importance of classification to Marwell

So why exactly is classification so important to zoological parks like Marwell? Firstly we are involved in a number of breeding programmes and with them the keeping of studbooks. For breeding programmes to be successful pure species need to be involved and not hybrids as this will adversely alter the genetics of the population, so accurate identification of individuals is needed. Commonly, genetic testing is used to determine the purity of an individual's breed so that they can participate within the breeding programmes and be registered within a studbook.
In terms of our animal collection, we need to ensure that we correctly identify all the individual animals that we have here in the park and keep accurate records. They are all registered with ISIS, the International Species Information System.

The following are examples of where correct classification has been essential for the protection of an endangered species. Many years ago we had a group of Asiatic lions that were involved in a breeding programme. Asiatic lions are an endangered species so it would have been ideal to have had our female, Tara, included as part of a breeding programme. However it was found that genetically she had some African lion in her so therefore she was not a pure breed and could not contribute to the programme.

Currently we have two sub-species of giraffe here at Marwell but we would like to breed pure Rothschild's giraffes. Before the separate sub-species were recognised, individuals were allowed to breed producing hybrids, particularly individuals of the Masai and Rothschild's sub-species. This has produced a 'mongrel' population which poses major issues for conservationists trying to protect the sub-species.

Irsula is a pure Rothschild giraffe, as is Ruby, who was born to Irsula in February 2012, which is excellent news in terms of conservation of this subspecies.

Issues with classification

Many species are being reclassified due to more detailed information being collected through genetic screening. Also it has been found that in many cases when individuals have initially been classified and given a scientific name they have been considered to be a separate species when actually they are the adult/juvenile stage of another organism.
Essentially classification is a very fluid model that constantly changes, but for the majority of the time the genus and species names remain universal.

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