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The development of the Red panda *Ailurus fulgens* EEP: from a failing captive population to a stable population that provides effective support to *in situ* conservation

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The Red panda *Ailurus fulgens* is an Endangered small carnivore that occurs in Bhutan, India, Myanmar, Nepal and the People's Republic of China. Wild populations of Red pandas have declined by 50% over the last three generations as a result of habitat loss and fragmentation, hunting and poaching. In 1979 an international studbook was established for the species to monitor the demographically small and unstable population in human care. At that time the breeding results were poor. In 1985 a European Endangered Species Programme (EEP) was initiated and from then onwards the Red panda population started to grow as improved breeding techniques were utilized. As at 31 December 2019 there were 407 Red pandas: 177.228.2 (♂♂.♀♀.??) in the EEP housed at 182 institutions. The EEP developed in stages over four decades, from a small population of Red pandas with low breeding success and high mortality, to a popular breeding programme with high breeding success and direct links to *in situ* conservation. However, there are still challenges that need to be addressed, such as mean kinship and genetic diversity, climate change and its effects on juvenile mortality, and the welfare of individuals housed in long-term bachelor groups. These issues are highlighted to encourage future research into the conservation of this species with some indications given of what zoos can do to find solutions to the most-pressing challenges.

Key-words: breeding; EEP; *in situ* conservation; population management; red panda; studbook.

INTRODUCTION

The Red panda *Ailurus fulgens*, also known as the Lesser panda, is an Endangered member of the Carnivora with herbivorous tendencies (especially the leaves and shoots of bamboo) (IUCN, 2019). Its ancestors once roamed throughout the whole Eurasia region (Mayr, 1986). At the time of writing, two subspecies are recognized, namely *Ailurus fulgens fulgens* and *Ailurus fulgens styani.* Populations of both subspecies are sporadically distributed among bamboo forests; *A. f. fulgens* in Nepal, India and Bhutan, and *A. f. styani* in Myanmar and southwestern China (Su *et al.*, 2001; Li *et al.*, 2005). Wild populations of Red pandas have declined by 50% over the last three generations, mainly as a result of habitat loss and fragmentation, hunting and poaching (Wei *et al.*, 1999; Choudhury, 2001; Jha, 2011). Accordingly, in 2015 the status of the wild population was upgraded from Vulnerable (VU) to Endangered (EN) on the International Union for Conservation of Nature (IUCN) Red List (IUCN, 2019). Because of the critical situation facing wild populations, breeding programmes for Red pandas in human care have to be considered and recognized as appropriate assurance populations (Zhang, L., *et al.*, 2008). At the time of writing, Padmaja Himalayan Zoo in India and the West Bengal Zoo Authority (India) are planning to introduce four captive-bred Red pandas to the Singalila National Park (India) (A. Banerjee, 'Workshop on conservation of red pandas',

Millennium Post, 25 April 2019, http://www.millenniumpost.in/kolkata/workshop-on-conservation-of-red-pandas-350532). The hope is that this will be the first step towards a functional reintroduction programme in cooperation with several zoos.

The Red panda European Endangered Species Programme [EEP: now the European Association of Zoos and Aquaria (EAZA) Ex situ Programme] was established in 1985; however, the international studbook was approved in 1978 and, therefore, the European population of Red pandas was already being monitored. From 1982 onwards, the international studbook was divided into five regions, namely (1) North America, (2) mainland Europe, (3) Great Britain and Scandinavia, (4) Australia and (5) all other countries (Glatston & Princee, 1993). The monitoring of the European Red panda population in the early years of the international studbook (i.e. 1978–1985) revealed that the population was small in size and demographically unstable, and breeding results were poor (Glatston, 1998). From 1985 onwards, the numbers of individuals and holding institutions started to increase in stages and, eventually, the Red panda EEP became a successful breeding programme with direct links to *in situ* conservation programmes and that facilitates research. As at 31 December 2019, the total Red panda EEP population contained 407 individuals: 177.228.2 (♂♂.♀♀.??) housed at 182 institutions (studbook data: Sparks data set updated to 31 December 2019). The increases in the total number of individual Red pandas in human care and the number of participating institutions through the years (1978–2019) is given in Fig. 1. In this article, in order to chronicle the trends in the development of the Red panda EEP population, the authors have divided the timeline into four periods: 1978–1985, 1985–2000, 2000–2009 and 2009–2019.

These time periods make it possible to address various notable occurrences. For example, between 1978 and 1985 the international studbook was under way and the European population was being monitored within those data. However, during that period the total number of Red pandas in the population decreased and the situation became critical. Then between 1985 and 2000 the population of Red pandas started to increase once the EEP was established. This led to measures being taken to reduce the population size again because predicted carrying capacity was going to be reached. The effect of those measures was reflected in the third period (2000–2009) with the EEP recommending breeding, in a controlled way, to ensure that the number of individuals perfectly matched carrying capacity. The final time period brings the information up to the present day (2009–2019).

In this article the authors will describe the important occurrences during the different time periods, including the developments, measures taken and different phases encountered by the Red panda EEP. Finally, the future prospects and suggestions for further research are discussed for this EEP as it becomes even more successful.

RED PANDA EEP

1978–1985: international studbook

Before there was a regional breeding programme (i.e. the EEP) the European population was monitored as part of the international studbook for Red panda that was launched in 1978. Although the European population was not intensively managed in these early years, the international studbook keeper assisted European zoos by identifying appropriate institutions where young zoo-bred Red pandas could be relocated (Glatston & Princee, 1993). The aims of the international studbook were indicated in its first edition. Instead of solely providing an overview of the individual animals comprising the population in human care for the different regions, the international studbook aimed to provide information about husbandry and management techniques, reports on pathological studies, and

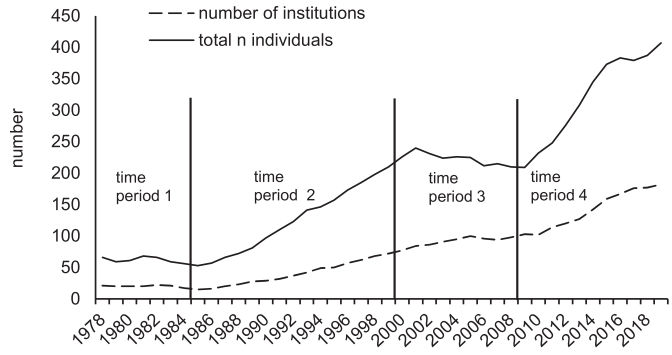

Fig. 1. Number of holding institutions and individuals encompassing the Red panda *Ailurus fulgens* European Endangered Species Programme (EEP) between 1978 and 2019: *n*, number of individuals; time period 1, 1978–1985; time period 2, 1985–2000; time period 3, 2000–2009; time period 4, 2009–2019.

the results from behavioural and other studies (Glatston, 1980).

In the early years it became apparent that the international studbook would work more effectively if some regional breeding programmes were developed. These regional breeding programmes would be semi-autonomous, with each having a regional studbook keeper; however, a loose association between the different breeding programmes would be facilitated by the international studbook (Glatston & Princee, 1993). It was also believed that separating the international population of Red pandas into multiple regional populations would lead to an improved prospect for the preservation of gene diversity. If a population is comprised of several genetically isolated subpopulations, within these smaller subpopulations genetic drift will have a larger influence on the loss of gene diversity than natural selection or inbreeding. Essentially, because genetic drift is a random process, each subpopulation would probably be genetically different. This would mean that the genetic diversity of the whole population would be greater than if the population was managed as a single entity, as long as the different subpopulations are sufficiently large (i.e. number of individuals). In addition, periodic exchanges between the various regions would counteract the increasing inbreeding levels in the different subpopulations. This way of managing populations became known as the 'Single Large or Several Small' debate (SLOSS debate) (Margan *et al.*, 1998).

Regional breeding programmes were proposed during an International Union of Directors of Zoological Gardens [now the World Association of Zoos and Aquariums (WAZA)] meeting held in 1982 in Rotterdam (The Netherlands). Initially the proposal was based on the following regions: North America, Europe, Great Britain and Scandinavia, Australia and the rest of the world (Glatston & Princee, 1993). In 1989, Scandinavia was included in the mainland Europe region (Glatston, 1991). Great Britain remained a separate region because of the restrictions on the free movement of animals between mainland Europe and the British Isles (Glatston & Princee, 1993). At the time of writing, the mainland Europe and British populations are managed as one population, together constituting the EEP population (Janno Weerman, EEP studbook keeper, 2019). Therefore, in this article the European and/or EEP population is considered a combination of the populations of mainland Europe, the Scandinavian region and Great Britain.

In the early years of the international studbook, the European population of Red pandas declined in numbers (Glatston, 1987). Between 1978 and 1985, the total

number of individuals decreased from 66 [28.38 (♂♂.♀♀)] to 53 (27.26). Accordingly, the number of holding institutions decreased from 21 to 15 (studbook data: Sparks data set updated to 31 December 2019). In those first years, zoos were experiencing difficulties with breeding Red pandas, which was reported in the first edition of the international studbook published in 1980. Although the survivorship of the animals was high for both sexes, a low fertility rate was considered the biggest threat for the European population (Glatston, 1980). The decrease in the number of females (from 38 in 1978 to 26 in 1985) only increased the likelihood of a low fertility rate. The other main issue at that time was high juvenile mortality. The third edition of the international studbook reported that juvenile mortality in European zoos ranged between 43% and 75%, with an average of 62% in the period between 1 January 1978 and 1 January 1985. Numbers for the population in Britain and Scandinavia were slightly better but juvenile mortality was still 47% (Glatston, 1984). The main causes for high juvenile mortality were reported as trauma and malnutrition, both of which were probably the result of inappropriate maternal behaviour. The way in which Red pandas were housed was most likely the main contributing factor to inappropriate maternal behaviour. Therefore, it was suggested that improving the housing and management of Red pandas in order to increase breeding success would ensure a future for the European population (Glatston, 1984). Despite low fertility and high juvenile mortality, the percentage of captive-born individuals increased from 31·8% in 1978 to 84·9% in 1985 (studbook data: Sparks data set updated to 31 December 2019).

In the early days of keeping Red pandas there was a lot to be learned about the diet, husbandry and natural behaviour of the species, and there was a bit of trial and error as keepers tried to establish the optimal conditions for the species. For example, it was discovered that the simple act of providing more nestboxes in the enclosure increased reproductive success significantly (Glatston, 1980). Different group compositions were also tried to determine the most favourable; for instance, pairs of one male and one female, trios of one male and two females, or multiple male and female groups. It was concluded that a male–female pair was the most successful group composition in reproductive terms (Glatston, 1980). A lot of research has been carried out to establish the perfect diet for Red pandas, a species that demonstrates the characteristics of both carnivores and herbivores. In the early days there were some indications of diet-related health issues, such as hair loss and dental caries. Consequently, a review of the zoo diet recommended that the quantity of soft, sweet foods in the diet was reduced (Glatston, 1984).

In 1983, these findings were amongst others documented in a first draft of the husbandry and management guidelines for Red pandas, which was sent to all Red panda holders for consultation (Glatston, 1989b). That was the first step towards the publication of the first edition of the husbandry and management guidelines, which marked the start of improvements in the husbandry of Red pandas and, consequently, improved breeding success.

1985–2000: foundation of EEP and population increase

In 1985, the fourth edition of the international studbook introduced the foundation of the different regional breeding programmes. Because mainland Europe and Great Britain were considered two separate regions they each had their own regional breeding programme. The EEP related to the programme in mainland Europe while Great Britain had the United Kingdom Red Panda Species Survival Programme. However, for the purposes of this article, the two regional breeding programmes are considered together as the EEP population. In the first years of the regional programmes most of the already existing issues

remained as threats to the population (i.e. high juvenile mortality and nutrition-related disorders). The first Red panda conference was held in August 1986 at Rotterdam Zoo (The Netherlands), specifically to discuss these issues and find solutions. The conference was attended by Red panda experts working in the field and at universities as well as people from the zoo world. The discussions at the first conference formed the basis of an updated version of the husbandry and management guidelines (Glatston, 1989b). In 1993, a revised version of the husbandry and management guidelines was published in the seventh edition of the studbook (Glatston, 1993).

Although many of the threats remained, the total number of individuals in the EEP population started to increase and continued to do so from 1985 [53 (27.26) individuals] onwards. By 2000 the population was 226 (104.122) individuals (studbook data: Sparks data set updated to 31 December 2019). The breeding success also increased the percentage of zoo-born individuals. For example, in 1985 the percentage of zoo-born Red pandas was *c.* 85% but by 1998 it was 100%, and from then on the whole population was composed of zoo-born individuals (studbook data: Sparks data set updated to 31 December 2019). This was not only the consequence of increased breeding success but also because the Red panda was added to Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1995, which rarely allows imports from the wild (https://www.iucnredlist.org/species/714/110023718#speciesplus; Glatston, 1994). The total number of births per year increased from 12 in 1985 to 45 in 2000, breeding success that was achieved through hard work and much research carried out by holding institutions in order to optimize the husbandry and diet of Red pandas in European zoos. For instance, in 1989, a questionnaire was circulated to all European holders to gather information about the composition of the diets of the Red pandas at their institutions. Through the results of that study it became apparent that the diets used in European zoos were very variable, and more than 80 different foodstuffs were offered to the Red pandas. Some zoos treated the species as a carnivore and provided a diet of meat and fish products. Others considered the species a herbivore and provided a diet of fruit and bamboo. In many zoos a porridge or gruel was the basis of the diet. The general conclusion of the research was that only a few of the offered diets conformed with the dietary norms recommended at that time (Glatston, 1991). Furthermore, that study also highlighted the possible consequences of non-adequate diets for reproductive success. In all breeding institutions where they were fed an adequate diet, the Red pandas bred. However, in most other institutions where the diet was not adequate, breeding failed or infant mortality was high (Glatston, 1991). Although it is difficult to draw robust conclusions from the results of a single study, it would appear that in the early days the diets were still not optimal and they were having a negative effect on breeding success. A lot of research was also carried out to establish the optimal housing conditions that would reduce maternal stress in order to decrease juvenile mortality. These efforts eventually paid off, because in 1993 a juvenile mortality of 26% was reported (Glatston, 1994). Although still unacceptably high, juvenile mortality was much lower than the average of 62% for Mainland Europe and 47% for Great Britain for the period 1978–1985 (Glatston, 1994).

During a workshop in Front Royal (VA, USA) in 1991, the International Red Panda Management Group (I.R.P.M.G) was established. Many members of this group also joined the Captive Breeding Specialist Group [CBSG; now the Conservation Planning Specialist Group (CPSG)] meeting in Antwerp in 1993. At this meeting *A Global Masterplan for the Captive Breeding of the Red Panda* was ratified by I.R.P.M.G. members. In the Global Masterplan the goals for the captive breeding of Red

pandas were listed, with the main goal being: 'to develop a viable population which will retain 90% of the original genetic variation for a period of, at least, 100 but more preferably, 200 years' (Glatston & Princee, 1993). According to the Global Masterplan this goal needed to be achieved without imports of new Red pandas from the wild. Furthermore, the suggestion was made that the EEP should only keep *A. f. fulgens* and not *A. f. styani* to avoid hybridization. This was assumed to be straightforward because all except one or two EEP institutions at that time were keeping *A. f. fulgens*. At the time of writing, the EEP population contains only *A. f. fulgens* individuals. Also during the Antwerp meeting in 1993 it was assumed that in the near future surplus animals would become available, because the carrying capacity was going to be reached. In order to avoid a huge surplus, attempts were being made to reduce breeding by delaying the age at first conception, and placing individuals in a breeding situation at the age of 3–5 years of age instead of at 1–3 years of age as done previously (Glatston, 1995). Because of the anticipated number of surplus animals, the possibility of sending surplus animals to breeding centres in range states was investigated. Establishing breeding centres in range states was integrated into the IUCN Species Survival Commission (SSC) Procyonid and Ailurid Action Plan. India was chosen as a suitable candidate for the project, because at that time there were already some Red pandas in zoos there. In 1994 three animals (two males and a female) were exported from the EEP population to the Padmaja Himalayan Zoo (India) to boost the captive population of Red pandas in India. In 1995, another two animals (one male and one female) were sent to Indian zoos (Glatston, 1995). The EEP also started to support the development of the Red panda programme in India. Two representatives of the EEP went to India in 1995 to participate in the training workshop organized by the Padmaja Himalayan Zoo and the Central Zoo Authority (India). The EEP also offered to support in the drafting of a captive-breeding masterplan for Indian zoos (Glatston, 1995). In this way the EEP, together with other regional breeding programmes, started linking the *ex situ* and *in situ* conservation communities. An I.R.P.M.G. meeting in Dublin in 1995 emphasized this by agreeing that future goals of the Red panda regional breeding programmes should be supporting *in situ* conservation rather than solely increasing breeding success in the EEP (Glatston, 1995).

2000–2009: stabilizing the population

In 2001 financial and time constraints meant that a physical international studbook was no longer published. One of the original aims of the studbook was to publish research articles about Red pandas but over time fewer zoos were sending research articles to the international studbook keeper for publication (Angela R. Glatston, pers. comm.). Since 2001, the studbook data of the EEP population has been published annually on the Rotterdam Zoo website and sent to the EAZA office (Angela R. Glatston, pers. comm.). This means that there is not that much published literature available about the Red panda EEP for the time period 2000–2009. During that time, management of the EEP intensified, because the carrying capacity was far outstripped. In the Global Masterplan the carrying capacity for the EEP population was estimated to be 180 individuals by the year 2003 (Glatston & Princee, 1993). However, the actual total number of individuals in the EEP was 224 by 2003. Many efforts were made to reduce population growth in the Red panda EEP. By 2000 the age of first conception was delayed to 5 years of age. In order to achieve this, all young animals were placed in same-sex groups for 2–3 years on reaching sexual maturity (Glatston, 2011). The policy paid off, because between 2001 and 2009 the total number of individuals decreased from 240 to 209,

respectively (studbook data: Sparks data set updated to 31 December 2019).

2009–2019: working towards modern management

In 2009 it was assumed that the carrying capacity would increase and the restricted-breeding protocol was released. Accordingly, the number of births per year and subsequently the total number of Red pandas increased from then on. The total number of individuals increased from 209 individuals in 2009 to 407 individuals in 2019. Moreover, the number of births per year increased between from 39 in 2009 to 78 in 2014, which was the highest number recorded in the history of the EEP (studbook data: Sparks data set updated to 31 December 2019). Since 2014 the number of births per year decreased, because the initial estimates for increased carrying capacity appeared to be too optimistic. From then on, every year the international studbook keeper determined the actual increase in capacity and adjusted the number of breeding recommendations to that number. In order to control breeding, in 2013 the EEP started to use single-sex pairs and groups to restrict population growth. However, this method of housing does not conform to the natural behaviour of Red pandas, which are predominantly solitary and only associate with another individual for reproductive purposes (Zhang, Z., *et al.*, 2009; Mallick, 2010). Studies of single-sex groups have already been started by numerous EEP participants; for example, at Avifauna (Alphen a/d Rijn, The Netherlands), Parc Zoo du Reynou (France), Mulhouse Zoo (France) and GaiaZOO (Kerkrade, The Netherlands). A study of the single-sex group at GaiaZOO looked at a four-male bachelor group, two of which were siblings. The results showed that there were more agonistic behaviours than affiliative ones between the members of that bachelor group (de Feijter, 2017). Moreover, if affiliative behaviours occurred, most of them took place between the siblings, which suggests that, where possible, it is better to house siblings together to avoid agonistic behaviours (de Feijter, 2017).

In addition to utilizing the single-sex group method, from 2014 the EEP also recommended that only the most genetically valuable Red pandas should breed, in order to stabilize population growth and fit the population to carrying capacity. The EEP has worked with the EAZA Group on Zoo Animal Contraception (EGZAC) on a survey of Red panda holders to obtain more information about the effects, duration and reversibility of Suprelorin implants, which are being used as a contraceptive method for Red pandas. The main findings of the survey were that the number of failures was negligible and that the majority of zoos reported no side effects (EGZAC Red Panda Contraception Survey 2017, published in Weerman, 2019). The total number of individuals in the population continued to increase from 345 (150.193.2) individuals in 2014 to a population of 407 (177.228.2) individuals in 2019 (studbook data: Sparks data set updated to 31 December 2019). This increase in the total number of individuals was in line with the increase in the carrying capacity.

During this time period a direct connection was made between the EEP and Red panda conservation activities in the wild. This link with *in situ* conservation activities was initiated in 2012 at a Red panda workshop at Rotterdam Zoo with all the regional coordinators. During the workshop the international studbook for Red pandas was accepted as a Global Species Management Plan (GSMP). In 2003, GSMPs were initiated by WAZA to encourage more collaboration and cooperation between different regional conservation programmes, thereby improving the long-term viability of populations of threatened species (https://www.waza.org/priorities/conservation/conservation-breeding-programmes/global-species-management-plans/; Princée & Glatston, 2016). At the 2012 workshop the GSMP regions agreed to partner with the Red Panda Network (formerly known as the

Red Panda Project). In 2006 this Network became the first community-based project monitoring the Red pandas in Nepal (McNamara, 2009). As part of this partnership, EEP holders of Red pandas provide financial support for the conservation activities of the Red Panda Network. For example, several EEP institutions finance the EEP Red Panda Forest Guardians Initiative which pays the salaries of sixteen forest guardians. This direct link between the EEP and the Red Panda Network is in line with the new approach that EAZA has developed for their breeding programmes, namely the One Plan approach of the IUCN SSC CPSG (CPSG, 2019; Traylor-Holzer *et al.*, 2019). This approach encourages regional studbook keepers to think about how *ex situ* management can be included in the conservation plan for a threatened species, and the precise form this should take (Traylor-Holzer *et al.*, 2019). To determine this, well-maintained contacts with *in situ* conservation practices are needed. Therefore, the contacts between the Red panda EEP and the Red Panda Network are a first step in the right direction for a One Plan approach. One of the first outcomes of this partnership was camera-trapping research carried out in eastern Nepal. The aim was to establish baseline data on the status of mammals (excluding rodents and bats) along the Panchthar–Ilam–Taplejung corridor, which is also Red panda habitat. At the time of writing, various publications about this research are in preparation. For example, a paper reporting on the first photographic record of a Marbled cat *Pardofelis marmorata* in Nepal has already been published (Tashi Lama *et al.*, 2019). Research into the behavioural and morphological effects of collars on two Red pandas was carried out at Rotterdam Zoo. This research showed that there were no significant, negative effects of the collars on the behaviour of the Red pandas, and it was assumed that these are suitable for field research in Nepal (Van de Bunte, 20192019). In September 2019, the first wild Red panda was fitted with a GPS-collar (Plate 1). This operation was carried out in Nepal by the Red Panda Network and in the presence of Janno Weerman, the current EEP studbook keeper and co-author of this article. In total, ten wild Red pandas in the Panchthar–Ilam–Taplejung corridor were fitted with GPS collars (Red Panda Network, 2020). The data collected with these GPS collars will be used for research into the effects of habitat fragmentation on the viability of the Red panda population in this area.

Such activities demonstrate that the Red panda EEP population can also support the wild population by serving as a research population. Besides collar research, the Red panda EEP population was also used in genome sequencing research carried out by the University of Münster (Germany) to obtain a more accurate interpretation of the position of the Red panda in the Musteloidea tree. This research was part of a project that explored the incomplete lineage sorting in Arctoids (Doronina *et al.*, 2015). By serving as a research population and being a partner to *in situ* conservation organizations the Red panda EEP is fulfilling the aims that were stated at the start of the breeding programme; that is, serving as a research platform. Through the years, a couple of the initial aims of the EEP were

Plate 1. Applying a GPS collar to a wild Red panda *Ailurus fulgens* **in Nepal.** *Sonam Tashi Lama, Red Panda Network***.**

lost, such as publishing a physical studbook annually and publishing research articles. The efforts that have been made in the last 5 years have resulted in the Red panda EEP functioning more as originally envisioned.

However, there are still some issues of concern, such as the increasing mean kinship in the EEP population. At the time of writing, the population mean kinship is 0·0877, which indicates that there is already a level of close relationship between individuals of the EEP population (studbook data: Sparks data set updated to 8 October 2019). Without an influx of individuals from other regional breeding programmes this average mean kinship will continue to increase. Eventually this will make it harder to find genetically distinct pairs to avoid inbreeding and in turn this will be a threat to gene diversity. According to PMx, gene diversity in the Red panda EEP is still 0·9123. Moreover, a study that compared the genetic diversity of the EEP population with the wild population by looking to 19 markers, concluded that the genetic diversity in the EEP population could be summarized as slightly lower than in the wild (Schäfer, 2016). However, according to PMx projections, under current conditions it will not be possible to preserve at least 90% of the gene diversity for the next 100 years. To adhere to this goal new founders need to be added to the population or genetic management needs to be optimized.

First-year mortality is still high at 36%, and it is highest in zoos that are situated in countries with warm and humid climates during the Red panda breeding season (Princée & Glatston, 2016). It has been suggested that this is caused by the mothers leaving their youngsters unattended more frequently in warmer climates because of heat stress (Glatston, 1989a). More research into this high first-year mortality is needed to gain a greater understanding of this problem. This is important for the sustainability of the EEP, because despite the fact that breeding is restricted it is nevertheless important that the offspring of those few recommended breeding pairs survive into adulthood.

There is an unwelcome trend of using Red pandas in animal encounters with visitors, such as Meet and Greet, in some EEP institutions, and concerns about what this will do to the image of the Red panda EEP. Photographs of people handling Red pandas at such encounters are starting to appear on social media. The authors believe this is not in line with the direction that zoos should take to ensure the continued existence of both zoos and threatened species into the future.

FUTURE PROSPECTS

The Red panda EEP has evolved from a small unstable population with low breeding success and high mortality, into a successful breeding programme with high breeding success and direct links to *in situ* conservation. However, some issues and challenges still remain, and these need to be monitored and solutions found. The biggest concern is the genetic integrity and mean kinship of the increasingly large population. At the time of writing, the EEP is working with the EAZA office to investigate which individuals are the best candidates (based on genetics) to be exchanged between the EEP and the Association of Zoos and Aquariums Species Survival Plan Program. Exchanges between the different regional breeding programmes have been carried out sporadically in the past. However, to preserve gene diversity as much as possible, it would be helpful if exchanges between the regions took place structurally and were based on genetic-sequencing data. To be able to base such exchanges on genetic data, research into the genetic diversity of the different populations is required. Furthermore, there are worries about climate change and the effects of rising mean temperatures. Research has identified that with higher temperatures female Red pandas may leave their cubs unattended for longer periods. In theory, rising temperatures could thus increase juvenile mortality

and thereby decrease population viability. Developments in this area need to be followed closely, so interventions can be made when necessary. Another factor that needs further research and monitoring is the welfare of individuals living in bachelor groups, especially for the long term. To date, research in this field has only focused on individuals that were temporarily housed in bachelor groups, and groups were only monitored for short time periods. New research is needed to get more insight into the possible effects on well-being, welfare and behaviour of permanently housing individuals in bachelor groups. Even though the Red panda EEP is connected with the *in situ* conservation world via Red Panda Network, the impact of such collaboration could be further increased by partnering with organizations operating in other range countries of Red pandas. To ensure the sustainability of the Red panda EEP for the future it will be necessary to address these issues; however, looking at the developments that have been made in the recent past, there is no doubt that the zoo community will be able to overcome the problems facing Red pandas.

REFERENCES

Choudhury, A. (2001): An overview of the status and conservation of the red panda *Ailurus fulgens* in India, with reference to its global status. *Oryx* **35**: 250–259.

CPSG (2019): *The One Plan approach to species conservation*. Apple Valley, MN: Conservation Planning Specialist Group (CPSG). Available at https://www.cpsg.org/our-approach/one-plan-approach-conservation

De Feijter, L. (2017): *Social functionality of a zoo-housed bachelor group of red pandas (*Ailurus fulgens fulgens*): match or no match?* Master's thesis, Van Hall Larenstein, University of Applied Sciences, Leeuwarden, Friesland, The Netherlands.

Doronina, L., Churakov, G., Jingjing, S., Brosius, J., Baertsch, R., Clawson, H. & Schmitz, J. (2015): Exploring massive incomplete lineage sorting in arctoids (Laurasiatheria, Carnivora). *Molecular Biology and Evolution* **32**: 3194–3204.

Glatston, A. R. (1980): *The red or lesser panda studbook* number 1 (1978–1979). Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1984): *The red or lesser panda studbook* number 3. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1987): *The red or lesser panda studbook* number 4. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1989a): Planning enclosures for red pandas. In *Zoo design and construction*: 204–211. Stevens, P. M. C. (Ed.). Paignton: Whitley Wildlife Conservation Trust.

Glatston, A. R. (1989b): *The red or lesser panda studbook* number 5. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1991): *The red or lesser panda studbook* number 6. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1993): *The red or lesser panda studbook* number 7. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1994): *The red or lesser panda studbook* number 8. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1995): *The red or lesser panda studbook* number 9. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (1998): *The red or lesser panda studbook* number 10. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

Glatston, A. R. (2011): Red pandas in zoos today: the history of the current captive population. In *Red panda: biology and conservation of the first panda*: 303–321. Glatston, A. R. (Ed.). Oxford: William Andrew Publishing.

Glatston, A. R. & Princee, F. (1993): *A global masterplan for the captive breeding of the red panda*. Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.

IUCN (2019): *The IUCN Red List of Threatened Species*. Gland, Switzerland, and Cambridge, UK: International Union for Conservation of Nature. Available at https://www.iucnredlist.org

Jha, A. K. (2011): Release and reintroduction of captive-bred red pandas into Singalila National Park, Darjeeling, India. In *Red panda: biology and conservation of the first panda*: 435–446. Glatston, A. R. (Ed.). Oxford: William Andrew Publishing.

Li, M., Wei, F., Goossens, B., Feng, Z., Hidetoshi, B. T., Bruford, M. W. & Funk, S. M. (2005): Mitochondrial phylogeography and subspecific variation in the red panda (*Ailurus fulgens*): implications for conservation. *Molecular Phylogenetics and Evolution* **36**: 78–89.

Mallick, J. K. (2010): Status of red panda *Ailurus fulgens* in Neora Valley National Park, Darjeeling District, West Bengal, India. *Small Carnivore Conservation* **43**: 30–36.

Margan, S. H., Nurthen, R. K., Montgomery, M. E., Woodworth, L. M., Lowe, E. H., Briscoe, D. A. & Frankham, R. (1998): Single large or several small? Population fragmentation in the captive management of endangered species. *Zoo Biology* **17**: 467–480.

Mayr, E. (1986): Uncertainty in science: is the giant panda a bear or a raccoon? *Nature* **323**: 769–771.

McNamara, M.-L. (2009): Red panda network: fighting for the firefox. *Earth Island Journal* **23**(4): 18–20.

PRINCÉE, F. P. G. & GLATSTON, A. R. (2016): Influence of climate on the survivorship of neonatal red pandas in captivity. *Zoo Biology* **35**: 104–110.
RED PANDA NETWORK (2020): *Annual report 2019*. Baluwatar, Kathmandu, and Eugene, OR: Red Panda Network. Available at https://www.redpandanetwork.org/public/rpn-2019-annual-report.pdf
SCHÄFER, F. (2016): *Demographic and genetic analysis of red pandas (*Ailurus f. fulgens*) managed through the international studbook with a focus on the European Endangered Species Programme (EEP).* Thesis, Faculty of Biology and Psychology, Georg-August-Universität Göttingen, Germany.
SU, B., FU, Y., WANG, Y., JIN, L. & CHAKRABORTY, R. (2001): Genetic diversity and population history of the red panda (*Ailurus fulgens*) as inferred from mitochondrial DNA sequence variations. *Molecular Biology and Evolution* **18**: 1070–1076.
TASHI LAMA, S., ROSS, J. G., BISTA, D., PHURI SHERPA, A., RAM REGMI, G., KRISHNA SUWAL, M., SHERPA, P., WEERMAN, J., SHRESTHA LAMA, S., THAPA, M., PRASAD POUDYAL, L. & PATERSON, A. M. (2019): First photographic record of marbled cat *Pardofelis marmorata* Martin, 1837 (Mammalia, Carnivora, Felidae) in Nepal. *Nature Conservation* **32**: 19–34.
TRAYLOR-HOLZER, K., LEUS, K. & BAUMAN, K. (2019): Integrated collection assessment and planning (ICAP) workshop: helping zoos move toward the One Plan approach. *Zoo Biology* **38**: 95–105.
VAN DE BUNTE, W. (2019): *The effect of a GPS-collar on the behaviour of the red panda (*Ailurus fulgens*)*. Master's thesis, Wageningen University & Research, The Netherlands.
WEERMAN, J. (2019): *Annual report 2019 and recommendations 2020, Red Panda EEP* (8th edn). Rotterdam: Stichting Koninklijke Rotterdamse Diergaarde.
WEI, F., FENG, Z., WANG, Z. & HU, J. (1999): Current distribution, status and conservation of wild red pandas *Ailurus fulgens* in China. *Biological Conservation* **89**: 285–291.
ZHANG, L., LIANG, X., ZHANG, Z., SHEN, F., ZHANG, W., WEI, K., YANG, Z., HOU, R., YUE, B., KAMATA, H., OKABAYASHI, K., OHBA, S., KIBA, H., TSUMAGARI, S., SATO, T., KANAYAMA, K., PAN, I. & WATANABE, T. (2008): Identification and characterization of ten polymorphic microsatellite loci in the red panda *Ailurus fulgens*. *Conservation Genetics* **9**: 787–790.
ZHANG, Z., HU, J., YANG, J., LI, M. & WEI, F. (2009): Food habits and space-use of red pandas *Ailurus fulgens* in the Fengtongzhai Nature Reserve, China: food effects and behavioural responses. *Acta Theriologica* **54**: 225–234.

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