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Keeping and breeding the North-Atlantic puffin (*Fratercula arctica* Linnaeus, 1758) in the Animal Park Berne

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Abstract

In 2009 and 2010, the Animal Park Berne acquired a total of 33 young puffins from a breeder in Germany. The facilities provided to these puffins are described as are the challenges faced in managing this species. Adults and young puffins are fed with 'Lundi' pellets all year round; nutritional supplements are used to protect the birds from diseases. The eggs are maintained in an incubator and the young birds raised individually by hand. After around 60 days, the pufflings are put together with a few adult birds in a small breeding basin, so that the chicks can acclimate to adults. The aim is to make the chicks later integration into the full group less stressful. Thirteen of the 33 young birds acquired eight years ago are still alive. The first birds reached sexual maturity at the age of three. In 2011, we raised the first chick, followed by 22 offspring. Twenty of them lived beyond 30 days. Young birds reach their adult weight after about 50 days. Our biggest breeding successes were in 2013 and 2015, when six young were produced. Since this time, there have been no offspring as the eggs, as well as a newly-hatched chick, became infected. The most common cause of death among our birds is aspergillosis, the treatment of which has led to minimal success. We prepose that social stress during the integration of young birds into the group is a pre-condition for aspergillosis. The aim for the future will be to bolster the puffins' immune system and reduce their susceptibility to disease; potentially by minimising social stress.

Background

Puffins (*Fratercula arctica*) are very common along the North Atlantic coast. In Europe, puffins are found along rocky shores and cliffs from northwest Greenland to Denmark and from Norway to the Canary Islands (Birdlife International 2017). It is rare, however, to find puffins in captivity despite them being attractive. The birds are very active during the daytime. With their large, triangular, black, yellow and red, laterally compressed beak, they are photogenic; they are playful and entertaining so it is easy to understand how they got the name, the "clowns of the seas". Public feeding sessions are a lively affair, because they demonstrate how they can "fly under water", using their wings and not their feet for propulsion while diving.

Puffins are commonly found in the wild, but they are increasingly under threat (Breton and Diamond 2014) due to marine pollution, global warming, over-fishing, deterioration of basic food resources as well as invasive predators at the nesting sites. Populations have for the most part diminished considerably and since 2016, the IUCN has classified the species as 'vulnerable' (Birdlife International 2017). Thus puffins in zoos are well suited for conveying educational messages about ecology and conservation.

Among ZIMS affiliated institutions, only eight zoos in Europe and one in Singapore, are recorded to keep puffins (September 2018), as well as six institutions in North America (Huettner 2017b). According to ZIMS (September 2018), 178 puffins are kept in zoos. The reproductive rate in captivity is very low, and mortality rates among young birds high (Tocidlowski et al.

Figure 1: Exterior of the Puffin Hall, facing east (Photograph M. Rosset).

Figure 3: Puffin enclosure: Shot from the platform towards the west (Photograph M. Rosset).

1997). In the last 12 months only 3 births have been recorded. Of the European zoos, Lisbon has kept the species since 1997, Rotterdam since 2000, Tenerife since 2006, Berne since 2009, Copenhagen since 2011, the National Aquarium of Denmark since 2013, Hamburg since 2016 and Düsseldorf since 2017.

In 2009, the Animal Park Berne opened a puffin hall with 30 young birds, raised by a private breeder. In 2010, the Park acquired three further birds from the same breeder. Since the animals originated from Iceland, it is assumed that they are *Fratercula arctica arctica*. In 2011, the first chick hatched - it survived for five months. Since the first chick at Animal Park Berne, the breeding rate has improved, notwithstanding the loss of all young birds in 2016 and no chicks in 2017.

In nature, a puffin captures its food in the light-flooded layer of the sea (0–20 m), eating small shoal fish measuring 7–15 cm in length, for example sand eels, sprats, herring in the summer months, and crustaceans, molluscs and bristle worms in the winter. In captivity, pellets mostly replace live fish. Nutrition has been improved, as has breeding and disease prevention, but some critical issues in integrating the chicks into the group have been identified.

Action

In February 2009, 30 (14 male and16 female) juvenile puffins were acquired from Ludger Bremehr in Verl, Germany. The birds had been raised from eggs originating in Iceland. In March 2010, three more pufflings were acquired from the same source and transferred directly into the group/enclosure on their arrival. Puffin hall was constructed to support breeding in puffins.

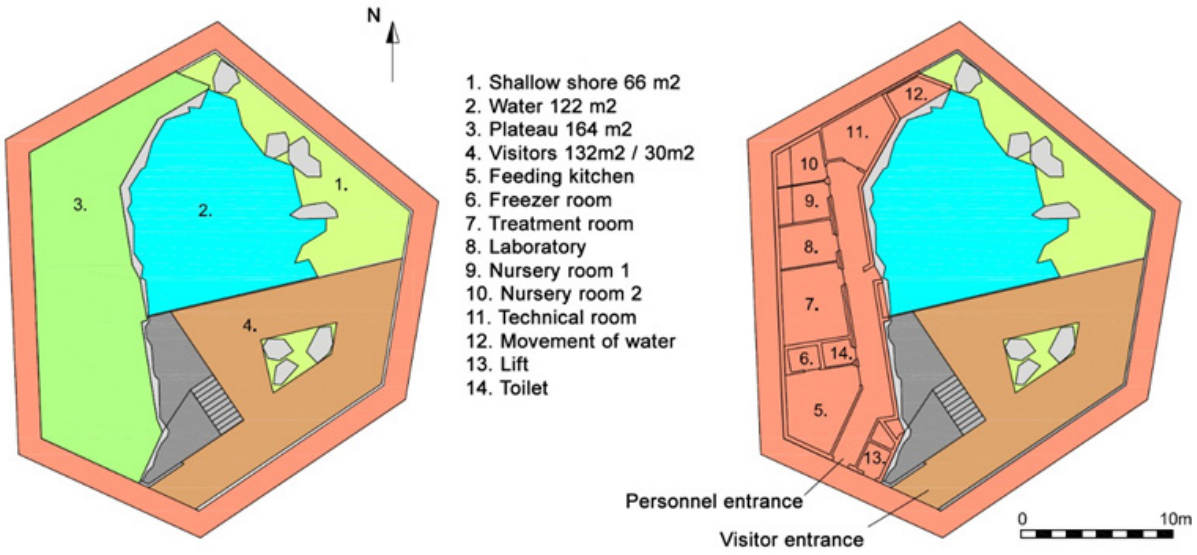

Figure 2: Floor plan of the puffin hall: left - from on top of the plateau, right - plateau, transparent so that the spaces underneath are visible. In the plan on the left, the 'cliff' correlates to the transition from the water (2) to the plateau (3).

Figure 4: Puffin enclosure: Picture taken from the shallow shore towards the west (Photograph B. Schildger).

Figure 5: Puffin enclosure: Underwater view (Photograph M. Rosset).

Hall construction

Puffin hall is hexagonal in layout (Figure 1). The building has an unsupported roof: two diamond-shaped tube supports hold a chromium steel net over the water part of the enclosure, and a translucent plastic membrane above the visitor area. The flight space above the water reaches a height of 8 m. As the cover is primarily translucent the interior is supplied with natural light. The building is roughly divided into two parts, the Puffin Hall (accessible by guests) and the non-public area (Figure 2).

Guest Viewing Area

Guests enter Puffin Hall through a double automatic glass door, pass through a curtain of suspended metal chains and stand on a guest platform 132 m^2 which is adjacent to the 122 m^2 water area and its 66 m^2 expanse of shallow shore (Figure 2). Two thirds of the water surface is an arc shape encircled by 3 m high vertical cliffs spanning 15 m. At the top, the cliff merges into a plateau, a roughly 164 m^2 large, planted, flat area behind the "slope edge". The passage from the plateau to the shore is designed to be an accessible, rocky ramp (Figures 3 and 4).

The guest platform is separated from the water area by a railing of vertical steel bars, so that they stand 30 cm above the water surface and can observe the birds close up. From the guest platform, a staircase leads to a basement where a 7.5 m long and 2 to 3 m high diamond-shaped glass panel provides a view of the underwater area (Figure 5). Underwater viewing also enables guests to see how the birds use their wings to chase dead fish thrown into the water from above, during keeper talks provided once daily when the puffins are fed. A touch screen in the wall informs guests about the biology and habitat of the puffin.

In the non-public area of the enclosure, below the plateau are the kitchen, a cold storage cell, a toilet, the veterinary treatment room and laboratory, two nursery rooms and a technical room. At the rear of the corridor, 8 PVC cylinders have been mounted (50 cm wide and 70 cm high) to serve as nesting cavities for the puffins (Figure 6). Each nesting cavity is accessible to the birds via a separate tube in the cliff. Six further nesting cavities, which are concrete half-shells 60 cm long, 30 cm wide and 30 cm high, with 10 x 15 cm edgewise openings, are distributed around the plateau area and on the shallow shore (Figure 6).

Animal facilities

The cliff was preshaped as a steel structure against a concrete wall, covered with a fine metal net (Aluminium Mesh 20 x 8 0.5mm, Streckmetall NATCON, Nature Construction, Sima GmbH & Co KG, A-9500 Villach, A), then covered with sprayed concrete (KaGo & Hammerschmidt GmbH, D-95632 Wunsiedel/Schönbrunn) and modelled while still wet. Rock ledges, niches and cave entrances had already been provided for in the steel framework. The shallow shore and plateau in the land area are also concrete with inset 80 cm deep tubs, filled with a light mineral substrate as used for the greening of flat roofs (Alfred Forster AG, CH-3207 Golaten). In the shallow shore area, the soil substrate is 5 cm thick, and covered with a layer of shell meal (Muschelbruch 10 mm, Trafor AG, CH-4057 Basel).

The body of fresh water occupies a surface of 120 m^2 and is on average 2.5 m deep. The approximately 360 m3 of water is not filtered, but renewed daily. In a 'grotto' under the cliff, a 40×50 cm steel plate is moved up and down by 50 cm by an eccentric tappet, displacing 90 litres of water per stroke and creating a constant swell over the entire water surface (self-construction). A steel net encases the grotto in open water.

Air conditioning

The air conditioning system runs over the roof allowing direct air exchange with the environment. Direct sunlight is deliberately screened by the roof foil, enclosure walls and surrounding trees, to keep the air cool within the enclosure. A ventilation system (Weger Airhandling units, I-39030 Kiens / Ehrenburg) ensures a constant breeze across the water surface: air is blown through 13 openings onto the east wall and sucked into the cliff at 15 openings (wind speed 50 cm above the water surface: approx. 8 m/s). The draft should keep the air temperature low, but also keep mosquitoes away from the birds as they could transmit bird malaria.

Mixed species management

Over time different species have been managed alongside the puffins, including six Arctic terns (*Sterna paradisea)*, golden plovers (*Pluvialis apricaria*), common barbels (*Barbus barbus)* and nine chubs (*Leuciscus cephals*). Fish which were at least 30 cm long were introduced to the exhibit and in March 2017, two 1.5 m long Beluga sturgeons (*Huso huso*) were also added to the enclosure. The Arctic terns did not successfully reproduce and only one of three potential golden plover pairs successfully bred; though of three chicks produced, two were attacked by the Arctic terns, and the third male was ultimately hand-reared.

Figure 6: Nesting site of the puffins. Left: Inside view of a PVC cylinder, which the puffins use as a nesting box. Right: Artificial nesting hole on the plateau. Under this concrete half-shell, the birds have dug about 80 cm diagonally downwards (Photograph M. Rosset).

Figure. 7: Beak colouration of two birds in 2017: Left: born in 2008, right: born in 2013. The latter has been fed with shrimp remains for the past 1.5 years (Photograph M. Rosset).

Consequences

Feeding the adult birds

The puffins are consistently fed throughout the year with pellets ['Lundi Ibis-See- (Eis-) Ente-Spezial', Lundi Deutschland, D-33415 Verl], size 5, 25–30 g per animal per day. The following were added to the pellets: frozen shrimps (in November to June); and dried shrimp meal (in June to November). More recently, since November 2015, about 15 g per animal per day of frozen shrimp remains (heads and shells) have been mixed in with the pellets. Pellets are offered fresh twice a day in four food trays (diameter 20 cm, height 2 cm). Feeding with fresh shrimp remnants is an experiment; we suspect that shrimp products promote the red colouration of the beak (Figure 7). The pellets are doused with water in which different additives have already been dissolved; these products work in a similar way to homeopathic remedies. The following products are dissolved in water: 'Anti-Malaria' and 'Anti-Aspergillosis' ('Tiere spezial, Wasservögel Island, Papageitaucher POC and HEP', 'Plocher® integral-technik', Zeller Umweltsysteme, D-29339 Wathlingen). Once a day, at 2:30 pm, dead saltwater fish, measuring about 15 cm in length (Capelin, Mallotus villosus) are offered as part of a public feeding. The number of fish is roughly based on the amount of pellets eaten the previous days, on average 1.5 fish per bird per day.

Incubation of eggs, hatching

Eggs are taken from the puffins five to seven days after being laid and placed in an incubator (Grumbach, ProCon automatic systems GmbH & Co. KG, D-35325 Mücke / Sellnrod). Incubation takes place without cooling at 37.2°C and 68% relative humidity. The eggs are turned six times a day. Five days before hatching, the chick starts to peck at its egg.

Puffin chicks cannot tolerate each other so must be reared individually. After hatching, chicks are left to dry in the incubator and are briefly rubbed down by hand, so that their down unfurls. Dry chicks are placed in boxes in a rearing room, which consists of open-top plastic frames (W 30 cm, L 40 cm, H 30 cm; nursery boxes) with a 5mm mesh PVC net bottom. Five nursery boxes stand side by side on a table frame (Figure 8). A piece of black rubber matting measuring 15 x 10 cm and 5 mm thick is laid in each bird's box. The room temperature is 20°C and kept dark. For the first six days young birds are provided a heat lamp (surface temperature of the rubber mat under the lamp reaches a maximum of 35°C). Six days after entering the nursery box, the heat lamp is removed, as the young bird is now able to maintain its own body temperature. The bird stays in the rearing box until it jumps out on its own, which happens after about 50 days.

Feeding the chick

Young birds are reared from their first day with the same Lundi pellets and additives provided to the adults minus supplements. During the first two days, the birds are offered pellets one at a time with tweezers. Normally, by the second day birds will take the pellets independently from a food dish. Pellets provided are counted in and out, and food consumed per day calculated. For young birds, the pellets are placed in water for approx. 45 minutes with the additives. After each pellet feed, the birds receive two big-scale sand smelts measuring about 6 cm (Atherina boyeri, also known in the trade as 'stints') fed by hand. From the second day on, the young birds each receive a fresh, small trout in the morning feed, which has been kept in the adult birds water; this practice enables the trout to absorb components of the adult birds intestinal flora.

Rearing and Introduction to adults

Young birds are moved to a rearing tank, in a second breeding room which is lit and includes a water body maintained at 15°C the surface of which is 2×2 m and 30 cm deep. At this point pufflings are introduced to one another, if other successful births have taken place. When the young pufflings are weaned, one or two adult birds are placed in the rearing tank, to familiarise the young puffins with adult company (Conway et al. 1977, Douma and Carlson 1994). It is thought this adult contact will significantly reduce stress and thus susceptibility to disease ahead of integration into the group. Young birds spend around 30 days in the rearing tank and are fed as adult birds.

Breeding success

While puffins in the wild usually reproduce at five years old (Nettleship 1996), in 2011, 3 year old puffins at Bern produced two eggs which is considered early but not unusual for captive puffins (Huettner 2017a). Of these two eggs, one was unfertilised the other produced a successful hatchling. Figure 9 illustrates the breeding successes from 2011 to 2017; a breeding success requires the bird survive for 30 days.

After the initial rearing success in 2011, three more followed in 2012, six more in 2013 and 2015, and five in 2014. In 2016, three of nine eggs were unfertilised, two embryos died early in the egg,

Figure 8: Nursery boxes, chick from 2017 (Photograph M. Rosset).

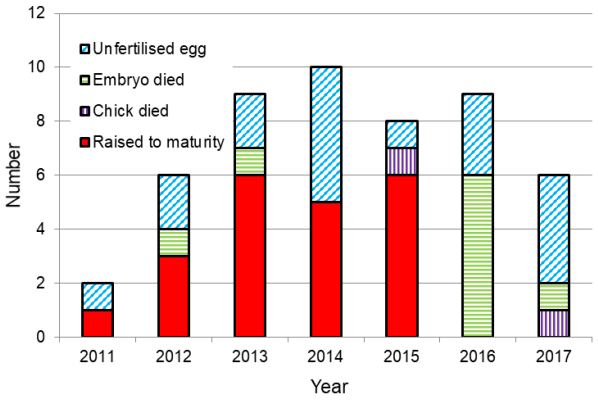

Figure 9: Breeding success of puffins in the Animal Park Berne from 2011 to 2017, or losses incurred at the egg, embryo or chick stage.

and four individuals died immediately before hatching. E. coli and Pseudomonas flavescens was found to have infected the embryos and lead to the four deaths. In 2017, four of the six eggs laid were unfertilised, one embryo died, and the only chick produced died after 25 days.

Mortality

Of the 33 (15 males and 18 females) puffins initially acquired 13 are still alive eight years later (6 males and 7 females); three birds died within the first two months after arrival: one from cranial trauma, one from a tumour and the third from aspergillosis. Conway et al. (1977) described the high susceptibility of the species to transport stress; however, attempts were made to minimise this by transporting the puffins in the dark, with guaranteed ventilation. Of the 23 (11 males and 12 females) young puffins hatched in this population since 2011, seven have survived (3 males and 4 females).

Weight history of the juveniles

Within less than 50 days, all juvenile birds reached the weight of an adult puffin (Figure 10), but following considerable variation: after 40 days, the lightest bird raised weighed 249 g, the heaviest 403 g (M=332, SD=47 g). This average value is higher than the data for fledgling juveniles in the wild: the young birds weighed by Harris (1979) on the Isle of May weighed on average 291.1 g (n=142, SE=2.52 g), those on St. Kilda an average of 259.7 g (n=1391, SE=0.68 g).

Figure 11 shows the weight profile of selected individuals, expressed by the number of pellets consumed: 1 pellet weighs on average 0.122 g, based on 500 pieces weighing a total of 61 g. The first bird raised reached adult weight after more than 40 days but he ate only about 3500 pellets, while other birds attaining this weight ate more than 5000 pellets. This first bird seemed to use the food more efficiently, which likely can be explained by a combination of two factors. The bird was always alone in the

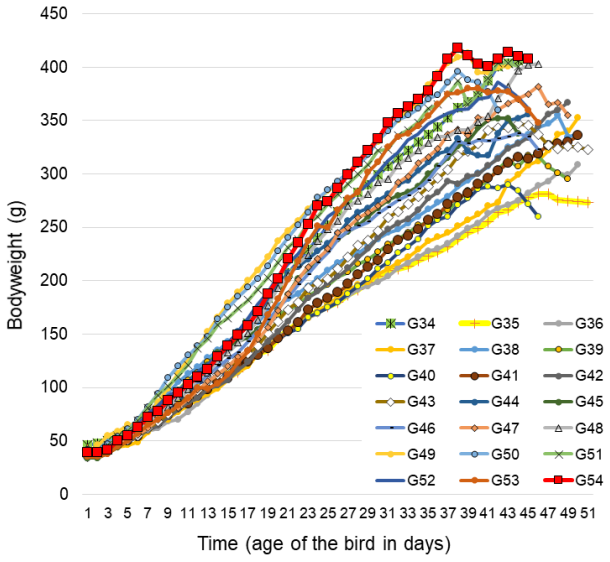

Figure. 10: Weight history of the 21 young puffins during the first 51 days of their lives.

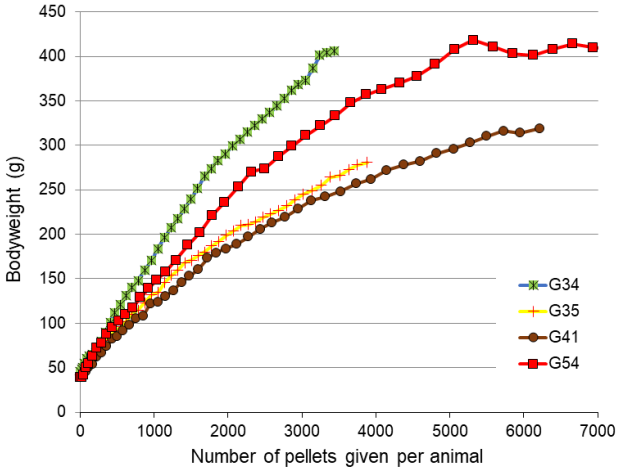

Figure. 11: Weight history of selected individuals depending on the number of feed pellets ingested.

breeding room, where the air temperature was raised by 2.5°C as the bird was kept alone. It is likely that, the higher temperature meant the bird used less energy to maintain its body temperature and was able to invest more in building up its body substances. The second factor was that other birds always lived with their peers in the breeding room, though in their own box, they could always hear neighbouring birds. This relative disturbance for chicks born from 2012 onwards might have led to more activity in the nesting period demanding greater energy expenditure.

Medical problems

The most common cause of death among the puffins was aspergillosis, followed by avian malaria. The Animal Park Berne is located in a forest, so mushroom spores are always present and unavoidable. Diseased birds are treated with Sporanox (2×5 mg per day in a fish), if detected early enough i.e. displaying symptoms of less activity, lean, sternum visible, laboured breathing. This treatment however only led to one bird surviving; whether he really suffered from aspergillosis is not known the others evidently died of aspergillosis despite the treatment mentioned. Three puffins died from avian malaria which led to the development of a food additive to reduce the risk of malaria which was produced by the Plocher company and fed daily. One puffin died of amyloidosis and chick born in 2017 died of coccidiosis. Unfortunately, these latter losses were due to husbandry errors. In 2016, impurities in the incubator led to an *E. coli* and *Pseudomonas flavescens* infection, and the only chick produced in 2017 came in contact with coccidia in the breeding box. Both incidents underline the need for strict hygiene standards when handling eggs and rearing young birds.

Other threats to the overall health of the puffins include the stress generated from integrating the young birds to the adults, which we propose might make them susceptibility to disease. Introducing adults to the young birds in the rearing tank early is hoped to reduce this stress. Foreign bodies are also a great threat; a piece of a metal chain measuring 84 cm was found in dead bird's body.

Discussion

The concept and construction of this enclosure requires neither artificial air conditioning nor complex water treatment. The accelerated air ventilation system limits the numbers of mosquitoes coming in, however, it blows extra spores of Aspergillus into the system. Maintenance of the ventilation system, which requires professional cleaning and disinfection of the pipes, is expensive as air extraction pipes are partially routed through artificial rock and are therefore difficult to access. The cliff, with its steep incline into the water requires the keepers clean the rocks from a boat. This could be improved upon by including a narrow band of rock serving as a walkway above the water surface, which would simplify cleaning and benefit the birds at feeding time providing them with a wider shallow shore to feed from (Figure 2).

The puffins are important for zoo education lessons and included within teaching aids designed and distributed for schools (Mainini and Slezak 2010). Topics focus on the movement of the birds under water, their plumage and beaks during the breeding season, the threat to the species posed by climate change, pollution and overfishing of the oceans. There have been some complaints that no other bird species are kept alongside the puffins, for example common guillemots (*Uria aalge*) and black guillemots (*Cepphus grylle*). A limiting factor on bird numbers and species housed are the number of hatcheries, but equally the aim to maintain the puffins with minimal social stress, to reduce their susceptibility to disease. Presently, it is estimated that this enclosure can hold 25 puffins.

As with all animal species, it is desirable that the puffins raise their own young. Our current food provision limits parent rearing as puffins do not want to feed their chicks pellets, but fish. Establishing appropriate fish species is not considered realistic, as the birds have to adapt to eating pellets after the nursing period.

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References

BirdLife International (2017) *Fratercula arctica*. (amended version published in 2016) *The IUCN Red List of Threatened Species 2017*: e.T22694927A110638141. http://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22694927A110638141.en. Downloaded on 02 November 2017.

Breton A.R., Diamond A.W. (2014) Annual survival of adult Atlantic Puffins Fratercula arctica is positively correlated with Herring *Clupea harengus* availability. *Ibis* 156, pp. 35–47.

Conway W.G., Bell J., Bruning D., Dolensek E. (1977) Care and breeding of puffins and mures. *International Zoo Yearbook* 17: 173–176.

Douma D., Carlson M. (1994) Breeding alcids at the Seattle Aquarium. *International Zoo Yearbook* 33: 142–147.

Harris M.P. (1979) Measurements and weights of British Puffins, *Bird Study* 26(3): 179–186,
DOI: 10.1080/00063657909476636

Huettner S. (2017a) *Population Analysis and Breeding and Transfer Plan. Atlantic Puffin (Fratercula arctica)*. AZA Population Management Center. 34 pp.

Huettner S. (2017b) *AZA Regional Studbook. Atlantic puffin (Fratercula arctica).* Omaha's Henry Doorly Zoo and Aquarium. pp. 131.

Nettleship D.N. (1996) Family Alcidae (Auks). Pp. 678-722 in: J. del Hoyo, A. Elliot, J. Sargatal (eds.) (1996). *Handbook of the birds of the world*. Vol. 3. Hoatzin to Auks. Lynx Edicions, Barcelona.

Mainini C., Slezak D. (2010) *Vögel im Frack und der Klimawandel. Unterrichtshilfe zur Artenvielfalt am Beispiel von Papageitaucher und Pinguin für Unter- und Mittelstufe*. Herausgeber: Tierpark Bern.

Tocidlowski M.E., Cornish T.E., Loomis M.R., Stoskopf M.K. (1997) Mortality in captive wild caught horned puffin chicks (*Fratercula corniculata*). *Journal of Zoo and Wildlife Medicine* 28(3): 298–306.