

## **Draft Terms of Reference – Bat-eared Fox**

- **1. Provide information on the taxonomy of the species**

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia (mammals)

Order: Carnivora (Carnivores)

Suborder: Caniformia (dogs, bears, mustelids, procyonids, and pinnipeds)

Family: Canidae (dogs)

Genus: *Otocyon*

Species: *megalotis*

Synonyms: *Canis megalotis* Desmarest 1822; *Canis lalandii* Desmoulins 1823; *Otocyon caffer* Mueller 1836; *Agriodus auritus* Smith 1840; *Otocyon virgatus* Miller 1909; *Otocyon canescens* Cabrera 1910; *Otocyon steinhardti* Zukowsy 1924.<sup>1,2</sup>

None of these synonyms are in current use, other than *Otocyon virgatus* and *Otocyon canescens* being retained as subspecies (*Otocyon megalotis virgatus* and *Otocyon megalotis canescens* respectively).

Common name: Bat-eared Fox

Alternative common names: none in general use, although Clark Jr. (2005) notes the alternative names of Big-eared Fox, Black-eared Fox, Delalande's Fox, and Cape Fox.<sup>3</sup> Note that Cape Fox is the common name for a true fox from South Africa, *Vulpes chama*.

Scientific binomen: The Bat-eared Fox was first described by Desmarest in 1822, under the name *Canis megalotis*. The genus *Otocyon* was erected by Mueller in 1836.<sup>4,5</sup>

Subspecies: Two or three subspecies are recognised. The nominate *Otocyon megalotis megalotis* is found in southern Africa (this subspecies includes the synonyms *auritus*, *caffer*, *lalandii* and *steinhardti*). The second subspecies is *Otocyon megalotis virgatus* of eastern Africa. Some authors separate a third subspecies, *Otocyon megalotis canescens* of Ethiopia and Somalia, although this is normally included within *Otocyon megalotis virgatus*.<sup>6,7</sup>

The majority of Bat-eared Foxes kept in zoos are treated as being "non-subspecific", probably due to most founder stock being of unknown origin. ZIMS has additional listings of the nominate subspecies, mostly from within range countries, although these are few in comparison to "unknown" animals.<sup>8</sup>

<sup>1</sup> Wilson, D.E., and D.M. Reeder (eds) (2005) "*Mammal Species of the World: a taxonomic and geographic reference*" (3rd edition), John Hopkins University Press

<sup>2</sup> Clark Jr., H. O. (2005) "Otocyon megalotis" in *Mammalian Species* no.766, pp. 1-5

<sup>3</sup> Clark Jr. (2005), *op. cit.*

<sup>4</sup> Wilson and Reeder (2005), *op. cit.*

<sup>5</sup> Clark Jr. (2005), *op. cit.*

<sup>6</sup> Castello, J. R. (2018) "*Canids of the World*" Princeton University Press

<sup>7</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>8</sup> *Species360* Zoo Aquarium Animal Management Software (ZIMS)

- **2. Provide information on the status of the species under CITES**

**CITES Listing:** not listed

**IUCN Red List Status:** LC (Least Concern)

The Bat-eared Fox is not included in the CITES Appendices.<sup>9,10</sup>

The species is listed by the IUCN as LC (Least Concern).<sup>11</sup>

The Bat-eared Fox has a large distribution covering at least twelve countries in eastern and southern Africa.<sup>12,13</sup> The IUCN states "Subspecies *O. m. virgatus* ranges from southern Sudan, Ethiopia and Somalia down through Uganda and Kenya to south-western Tanzania; *O. m. megalotis* occurs from Angola through Namibia and Botswana to Mozambique and South Africa", and further notes that they are considered to be "common" and that there have been range extensions in some countries due to changes in climate.<sup>14</sup>

<sup>9</sup> CITES home page: <https://cites.org/eng>

<sup>10</sup> IUCN page for "Otocyon megalotis": <https://www.iucnredlist.org/species/15642/46123809>

<sup>11</sup> IUCN page for "Otocyon megalotis" as above

<sup>12</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>13</sup> Castello, J. R. (2018) "*Canids of the World*" Princeton University Press

<sup>14</sup> IUCN page for "Otocyon megalotis" as above

- **3. Provide information about the ecology of the species.**

A) Longevity: what is the average lifespan of the species in the wild and in captivity?

The lifespan of the Bat-eared Fox is given by most sources as being nine years in the wild, and 13 or 14 years in captivity (e.g. in Castello (2018)<sup>15</sup> and Hunter (2018)<sup>16</sup>). The wild-longevity of nine years comes from a 2006 paper by Kamler and Macdonald<sup>17</sup> regarding what they term "an unusually old" female fox, from which an age of nine years and one month was determined via tooth study after the animal's natural death. The authors note that up to that point "longevity in wild bat-eared foxes has never been reported" (and apart for this one paper, this still appears to be the case). This particular animal was considered to be exceptionally old for a wild animal based on the condition of the teeth (worn to nubs), and a suggestion for the attaining of this age was the lack of larger predators in the area (the study area was a sheep farm). For captive animals, the record for a captive

lifespan is given as 13 years and 9 months in Jones (1982).<sup>18</sup> However Weigl (2005) gives a record for a wild-caught animal dying in captivity at an estimated 17 years of age.<sup>19</sup>

B) What is the maximum length and weight that the species attains?

The Bat-eared Fox is a small canid. Nowak and Paradiso<sup>20</sup> and Clark Jr.<sup>21</sup> give a head-body length of 46-66cm and tail-length of 23-34cm. In contrast, Hunter<sup>22</sup> gives a reduced head-body range of 46.2-60.7cm, while Castello<sup>23</sup> gives a wider range of 40-66cm. Weight in all sources is given as 3.0-5.4kg.<sup>24,25,26,27</sup> As a comparison with familiar species in Australia, the Tasmanian Devil (*Sarcophilus harrisi*) has a head-body length of 55-65cm and a weight of 7-9kg; the domestic Cat (*Felis catus*) has a head-body length of 38-60cm and weight of 2.5-6.5kg; and the Red Fox (*Vulpes vulpes*) has a head-body length of 60-74cm and weight of 3.5-8kg (all measurements taken from Menkhorst and Knight<sup>28</sup>). Castello<sup>29</sup> says that female Bat-eared Foxes are "slightly larger" than males, while Kingdon<sup>30</sup> says that "females may weigh more than males", however this does not seem to be a constant. In wild studies, a sample of 25 males and 29 females from Botswana appeared to show that the females averaged heavier, but in a series of specimens from the Limpopo Valley in southern Africa there were no discernable differences between sexes.<sup>31</sup>

C) Discuss the identification of the individuals in this species, including if the sexes of the species are readily distinguishable, and if the species is difficult to distinguish from other species.

The Bat-eared Fox is a very small canid with a fluffy pelage, relatively long and slender legs, and extremely large ears, giving it a distinctive appearance. It is much smaller than most canid species (dogs, wolves, jackals, etc). It may fall within the size range of several other fox species, but the body proportions (long legs, narrow pointed snout, disproportionately large ears, and short bushy tail) coupled with colouration (grizzled greyish or buffy body, black legs, and raccoon-like facial mask) make it impossible to confuse with other species. Colouration is the same between males and females. Females may be larger than males but this cannot be considered accurate for sexing. However in zoo animals the sexes can be determined easily by the presence of teats in the female and a scrotum in the male.<sup>32,33,34,35,36</sup>

D) Natural geographic range.

The Bat-eared Fox has a large distribution covering at least twelve countries in eastern and southern Africa (South Sudan, Ethiopia, Somalia, Uganda, Kenya, Tanzania, Angola, Botswana, Mozambique, Namibia, South Africa, Zimbabwe).<sup>37,38</sup> The two subspecies, *O. m. megalotis* in southern Africa and *O. m. virgatus* in eastern Africa, have discrete distributions with about 1000km separating them, although they are thought to have been continuous until the Pleistocene.<sup>39</sup> The species is restricted to arid and semi-arid grassland environments, and the distribution appears to be tied to that of termites of the genera *Hodotermes* and *Microhodotermes* which form the basis of the species' diet.<sup>40</sup> Wild populations can fluctuate locally depending on rainfall and season (probably connected to changes in invertebrate prey availability).<sup>41</sup> The presence of larger predators such as large Carnivores, raptors and pythons also impacts on the population levels of Bat-eared Foxes, with Black-backed Jackals (*Canis mesomelas*) in particular being a dominant predator as well as being an agent for diseases such as rabies, canine distemper, and canine parvovirus which can decimate Bat-eared Fox populations locally.<sup>42</sup>

E) Is the species migratory?

Bat-eared Foxes are not migratory. Pairs or family groups occupy territories year-round, although the size of the territory can vary through the course of a year or between years depending on factors such as number of individual group members, prey availability, and predator levels.<sup>43,44</sup>

F) Does the species have the ability to hibernate in winter or aestivate (go into stasis or torpor) in the summer months?

Bat-eared Foxes do not hibernate or aestivate. They are active year-round, although activity patterns can change between being diurnal and nocturnal depending on the time of year (largely relating to night-time temperatures in some parts of their range).<sup>45,46,47</sup>

G) Does the species have the ability to breathe atmospheric air i.e. has accessory breathing organs? (fish and other mobile aquatic animals)

Not applicable.

H) Outline the habitat requirements for all life stages of the species.

Bat-eared Foxes are restricted to arid and semi-arid (xeric) environments, comprising grasslands, scrublands, and shrublands. Their predominant environment is short grassland, being less common in shrublands. They are not found in true desert or in forest.<sup>48,49</sup> Habitats may be extremely hot by day and below freezing at night (in winter). They seek shade either below ground or under trees to escape high day-time temperatures, and huddle in groups to combat cold temperatures.<sup>50</sup> In some parts of their range (in southern Africa) they are active mainly by day during the winter to avoid freezing night-time temperatures, although this is thought to be more related to the activity of the temperature-sensitive termites upon which they feed than due to their own temperature restrictions.<sup>51</sup> They use burrows as dens, either digging them or utilising existing burrows of other animals. Burrows may be up to three metres in length, and contain multiple chambers and exits. Several dens may be used within a family group's range.<sup>52</sup> The species lives in xeric environments, does not live in or near water-bodies, and wild animals have not been observed to drink from free-standing water sources.<sup>53</sup>

I) Social behaviour or groupings.

Bat-eared Foxes typically form monogamous pairs, and live either in these pairs or as family groups (especially before the dispersal of the offspring).<sup>54,55</sup> Larger groups are normally composed of the pair plus grown young before dispersal, however female offspring may remain with the pair once mature and breed with the male (their father) to form multi-female groups.<sup>56,57</sup> Territories of pairs/family groups may be discrete or overlapping depending on food sources and season.<sup>58</sup> Interactions between pairs/groups from different territories is described as "usually amicable".<sup>59</sup> In some areas high availability of insect prey means that polygyny, allo-suckling, and communal breeding may occur more frequently than monogamous breeding.<sup>60</sup> Bat-eared Foxes typically ignore large herbivores (ungulates).<sup>61</sup> They avoid larger Carnivores because, due to their own small size, they are a prey item for most predatory species. However they are reported to ignore mongooses, except during breeding when they mob the mongooses to drive them away from den areas.<sup>62</sup>

J) Is this species ever territorial or does it exhibit aggressive behaviour?

Bat-eared Fox pairs and family groups maintain loose territories using olfactory cues (i.e. urine-marking).<sup>63</sup> Interaction between different groups is usually "amicable"<sup>64</sup> although contact between members of the same sex may be aggressive.<sup>65</sup> The size of territories varies through the year, mostly

according to prey availability which in turn is affected by rainfall and season.<sup>66,67</sup> Clark Jr.<sup>68</sup> states that reported home-ranges vary between 0.3 and 3.5km<sup>2</sup> while Hunter<sup>69</sup> gives a figure of 1-8km<sup>2</sup> and Castello<sup>70</sup> giving 2-8km<sup>2</sup>. Varying territory size also affects how separate groups interact with one another. During periods of abundant termite availability, territories become much smaller and overlap considerably.<sup>71,72</sup> Groups may also merge peacefully together at this time.<sup>73</sup> Unrelated pairs will also breed in close proximity to one another during such periods; for example Kingdon<sup>74</sup> notes an instance of six pairs breeding within separate dens in an area covering just 0.5km<sup>2</sup> in the Kalahari. Bat-eared Foxes typically either ignore or avoid non-prey species (depending on whether the animal is herbivorous or predatory), but have been recorded as mobbing small predators such as mongooses when these may be a threat to pups.<sup>75</sup>

K) Characteristics that may cause harm to humans or any other species.

Bat-eared Foxes are very small and inoffensive canids. They have the most reduced tooth-size of any canid (although possessing the most individual teeth of any canid due to the presence of additional molars).<sup>76,77</sup> The teeth also have less shearing surfaces than is typical for canids and an undeveloped carnassial blade, due to the adaptations for an insectivorous diet.<sup>78,79</sup> They do retain larger incisors and can bite effectively, but because of their small muzzle size the length of each tooth-row, exclusive of the incisors, measures only 4-5cm.<sup>80</sup> They also have long blunt claws on the front paws, for digging, which project 1.8cm beyond the pad.<sup>81</sup> Their teeth and claws could cause minor injuries to a person, in the same manner as bites or scratches from a domestic Cat or other small Carnivore.

<sup>15</sup> Castello, J. R. (2018) "*Canids of the World*" Princeton University Press

<sup>16</sup> Hunter, L. (2018) "*Carnivores of the World*" (2nd edition) Princeton University Press

<sup>17</sup> Kamler, J. F., and D. W. Macdonald (2006) "Longevity in a wild bat-eared fox" in *African Journal of Wildlife Research*, vol. 36, pp. 199-200

<sup>18</sup> Jones, M. L. (1982) "Longevity of Captive Mammals" in *Der Zoologische Garten Neue Folge Jena* vol. 52, pp. 113-128

<sup>19</sup> Weigl, R (2005) "*Longevity of Mammals in Captivity; from the living collections of the world*" Kleine Senckenberg-Reihe 48

<sup>20</sup> Nowak, R.M., and J.L. Paradiso (1999) "*Walker's Mammals of the World*" John Hopkins University Press

<sup>21</sup> Clark Jr., H. O. (2005) "Otocyon megalotis" in *Mammalian Species* no.766, pp. 1-5

<sup>22</sup> Hunter (2018), *op. cit.*

<sup>23</sup> Castello (2018), *op. cit.*

<sup>24</sup> Nowak and Paradiso (1999), *op. cit.*

<sup>25</sup> Clark Jr. (2005), *op. cit.*

<sup>26</sup> Hunter (2018), *op. cit.*

<sup>27</sup> Castello (2018), *op. cit.*

<sup>28</sup> Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

<sup>29</sup> Castello (2018), *op. cit.*

<sup>30</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>31</sup> Berry, M. P. S. (1978) "*Aspects of the ecology and behaviour of the bat-eared fox, (Otocyon megalotis Desmarest, 1822) in the Upper Limpopo Valley*" University of Pretoria

<sup>32</sup> Nowak and Paradiso (1999), *op. cit.*

<sup>33</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>34</sup> Hunter (2018), *op. cit.*

<sup>35</sup> Castello (2018), *op. cit.*

<sup>36</sup> Clark Jr. (2005), *op. cit.*

- <sup>37</sup> IUCN page for "Otocyon megalotis": <https://www.iucnredlist.org/species/15642/46123809>
- <sup>38</sup> Castello (2018), *op. cit.*
- <sup>39</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>40</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>41</sup> Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals of South Africa, Swaziland and Lesotho*" South African National Biodiversity Institute and Endangered Wildlife Trust
- <sup>42</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>43</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>44</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>45</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>46</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>47</sup> Pauw, A. (2000) "Parental care in a polygynous group of bat-eared foxes, *Otocyon megalotis* (Carnivora, Canidae)" *African Zoology*, vol. 35 (1), pp. 139-145
- <sup>48</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>49</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>50</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>51</sup> Pauw (2000), *op. cit.*
- <sup>52</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>53</sup> Clark Jr. (2005), *op. cit.*
- <sup>54</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>55</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>56</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>57</sup> Clark Jr. (2005), *op. cit.*
- <sup>58</sup> Clark Jr. (2005), *op. cit.*
- <sup>59</sup> Malcolm, J. R. (1986) "Socio-Ecology of Bat-eared Foxes (*Otocyon megalotis*)" *Journal of Zoology*, vol. 208 (3), pp. 457-469
- <sup>60</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>61</sup> Clark Jr. (2005), *op. cit.*
- <sup>62</sup> Clark Jr. (2005), *op. cit.*
- <sup>63</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>64</sup> Malcolm (1986), *op. cit.*
- <sup>65</sup> Nowak and Paradiso (1999), *op. cit.*
- <sup>66</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>67</sup> Clark Jr. (2005), *op. cit.*
- <sup>68</sup> Clark Jr. (2005), *op. cit.*
- <sup>69</sup> Hunter (2018), *op. cit.*
- <sup>70</sup> Castello (2018), *op. cit.*
- <sup>71</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>72</sup> Clark Jr. (2005), *op. cit.*
- <sup>73</sup> Clark Jr. (2005), *op. cit.*
- <sup>74</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>75</sup> Clark Jr. (2005), *op. cit.*
- <sup>76</sup> Nowak and Paradiso (1999), *op. cit.*
- <sup>77</sup> Clark Jr. (2005), *op. cit.*
- <sup>78</sup> Keiser, J. A. (1995) "Gnathomandibular Morphology and Character Displacement in the Bat-eared Fox" *Journal of Mammalogy*, vol. 76 (2), pp. 542-550
- <sup>79</sup> Asahara, M. (2016) "The origin of the fourth lower molar in canids, inferred by individual variation" *Peer J*, vol. 4

<sup>80</sup> Clark Jr. (2005), *op. cit.*

<sup>81</sup> Stuart, C. (2013) "*Field Guide to Tracks & Signs of Southern, Central & East African Wildlife*" Penguin Random House

- **4. Provide information on the reproductive biology of the species**

Bat-eared Foxes typically form monogamous pairs, and live either in these pairs or as family groups.<sup>82,83</sup> Larger groups are normally composed of the pair plus grown young before dispersal, however female offspring may remain with the pair once mature and breed with the male (their father) to form multi-female groups.<sup>84,85</sup> In some areas high availability of insect prey means that polygyny, allo-suckling, and communal breeding may also occur.<sup>86</sup>

Pairs breed annually (once per year),<sup>87</sup> with births being timed to coincide with the rainy season when insects are most abundant.<sup>88,89</sup> Clark gives varying months for births, depending on location: August to October in East Africa, September to November in the Kalahari, and October to December in Botswana.<sup>90</sup>

Denning sites are burrows, either dug by the foxes themselves or utilising the abandoned burrows of other animals.<sup>91,92</sup> Unrelated pairs may breed in close proximity to one another - for example Kingdon<sup>93</sup> notes an instance of six pairs breeding within separate dens in an area covering just 0.5km<sup>2</sup> in the Kalahari. A pair maintains multiple dens and moves regularly between them with the pups; Pauw records time spent at individual dens being between two days and two weeks.<sup>94</sup>

The gestation period is 60-75 days.<sup>95,96</sup> Litters contain from one to six pups; Dalerum *et al* additionally says "usually five" pups,<sup>97</sup> while Pauw gives an average of three per litter.<sup>98</sup> Pups rely almost entirely on milk, with the parents rarely bringing food to the den.<sup>99</sup> The male remains almost constantly at the den site to guard the pups. Pauw notes that even when foraging for food himself, the male remains within close proximity to the den.<sup>100</sup>

The pups are weaned at 14-15 weeks of age, and disperse from the group at about five to six months old.<sup>101</sup> They attain sexual maturity at eight to nine months of age.<sup>102</sup>

As in all canid species, males and females are distinct sexes (i.e. not hermaphroditic; and parthenogenetic births are not possible), and they cannot change sex.<sup>103,104</sup>

Members of the family Canidae are renowned for hybridisation, although this occurs almost exclusively within the genus *Canis* (wolves and jackals).<sup>105</sup> Probably all members of *Canis* can produce fertile hybrids with one another as this has been demonstrated in almost all species, and based on their genetics some species are regarded as being the product of hybridisation events (e.g. the African Golden Wolf *Canis lupaster*).<sup>106,107,108,109,110</sup> A 2018 study on the genetics of the genus *Canis* by Gopalakrishnan *et al* produced an additional surprising result of past hybridisation between the Asiatic Dhole (*Cuon alpinus*) and the African Hunting Dog (*Lycaon pictus*), the ranges of which do not meet today but in pre-human times may have done so in the Middle East.<sup>111</sup> It seems probable that foxes of the genus *Vulpes* can also hybridise with other members of their own genus, although reports on this are usually only suggestions of hybridisation (e.g. Thornton 1971<sup>112</sup>) rather than confirmations. However hybrids between Arctic Foxes (*Vulpes lagopus*) and Red Foxes (*Vulpes vulpes*) are produced intentionally on fur farms via artificial insemination.<sup>113,114</sup>

Apart for the ancient hybridisation event between *Cuon* and *Lycaon* inferred from the genetic studies by Gopalakrishnan *et al*, there are no records of hybridisation between canid genera.<sup>115</sup> The Arctic Fox was formerly placed in the genus *Alopex*, in which case hybrids between that species and the Red Fox (*Vulpes vulpes*) would be considered intergeneric, but the genetics show conclusively that the Arctic Fox is in fact a member of the genus *Vulpes*.<sup>116</sup>

The chromosome counts for canids are extremely variable, which probably accounts for the high incidences of hybridisation amongst *Canis* (all species of *Canis*, as well as *Cuon* and *Lycaon*, have counts of 78) but few or no cases amongst other canids (which, depending on genus and species, have chromosome counts varying from as low as 34 up to 76).<sup>117</sup> The Bat-eared Fox has a chromosome count of 72 which appears to be unique amongst the Canidae,<sup>118</sup> and it is the sole member of the genus *Otocyon* which is basal to all other Canidae genera,<sup>119</sup> so hybridisation would not be expected to occur with other canid species. It is also considerably smaller than any member of the genus *Canis* and in the wild the larger canids (e.g. Black-backed Jackals *Canis mesomelas* and African Hunting Dogs *Lycaon pictus*) are active predators of Bat-eared Foxes, rather than perceiving the foxes as potential mates.<sup>120</sup>

The only native mammal in Australia with which there could be a possibility of Bat-eared Foxes hybridising, is the Dingo (variously *Canis dingo* or *Canis lupus dingo* or *Canis familiaris dingo*). All other native placental mammals in Australia are rodents, bats, pinnipeds and cetaceans.<sup>121</sup> Although introduced to Australia by humans at some point in the past few thousand years, the Dingo is generally treated as a native species due to the length of time it has been in the country. Given that intergeneric canid hybrids have not been recorded, that the two species have different chromosome counts, the physical size difference between the two species (i.e. roughly cat-sized versus dog-sized), and that Dingos would be more likely to consider Bat-eared Foxes as prey than mates, the chance of hybridisation seems remote.

<sup>82</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>83</sup> Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals of South Africa, Swaziland and Lesotho*" South African National Biodiversity Institute and Endangered Wildlife Trust

<sup>84</sup> Clark Jr., H. O. (2005) "*Otocyon megalotis*" in *Mammalian Species* no.766, pp. 1-5

<sup>85</sup> Dalerum *et al* (2016), *op. cit.*

<sup>86</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>87</sup> Dalerum *et al* (2016), *op. cit.*

<sup>88</sup> Clark Jr. (2005), *op. cit.*

<sup>89</sup> Dalerum *et al* (2016), *op. cit.*

<sup>90</sup> Clark Jr. (2005), *op. cit.*

<sup>91</sup> Nowak, R.M., and J.L. Paradiso (1999) "*Walker's Mammals of the World*" John Hopkins University Press

<sup>92</sup> Clark Jr. (2005), *op. cit.*

<sup>93</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>94</sup> Pauw, A. (2000) "Parental care in a polygynous group of bat-eared foxes, *Otocyon megalotis* (Carnivora, Canidae)" *African Zoology*, vol. 35 (1), pp. 139-145

<sup>95</sup> Dalerum *et al* (2016), *op. cit.*

<sup>96</sup> Nowak and Paradiso (1999), *op. cit.*

<sup>97</sup> Dalerum *et al* (2016), *op. cit.*

<sup>98</sup> Pauw (2000), *op. cit.*



- <sup>99</sup> Clark Jr. (2005), *op. cit.*
- <sup>100</sup> Pauw (2000), *op. cit.*
- <sup>101</sup> Clark Jr. (2005), *op. cit.*
- <sup>102</sup> Clark Jr. (2005), *op. cit.*
- <sup>103</sup> Castello, J. R. (2018) "*Canids of the World*" Princeton University Press
- <sup>104</sup> Nowak and Paradiso (1999), *op. cit.*
- <sup>105</sup> Castello (2018), *op. cit.*
- <sup>106</sup> Gopalakrishnan, S., M. S. Sinding, J. Ramos-Madrigal, J. Niemann, J. A. S. Castruita, F. G. Vieira, C. Caroe, M. de Manuel Montero, L. Kuderna, A. Serres, V. M. Gonzalez-Basallote, Y. Liu, G. Wang, T. Marques-Bonet, S. Mirarab, C. Fernandes, P. Gaubert, K. Koepfli, J. Budd, E. K. Rueness, C. Sillero, M. P. Heide-Jorgensen, B. Petersen, T. Sicheritz-Ponten, L. Bachmann, O. Wiig, A. J. Hansen, M. Thomas, and P. Gilbert (2018) "Interspecific Gene Flow Shaped the Evolution of the Genus *Canis*" *Current Biology*, vol. 28 (21), pp. 3441-3449
- <sup>107</sup> Stronen, A. V., N. Tessier, H. Jolicoeur, P. C. Paquet, M. Henault, M. Villemure, B. R. Patterson, T. Sallows, G. Goulet, F. Lapointe (2012) "Canid hybridization: contemporary evolution in human-modified landscapes" *Ecology and Evolution*, vol. 2 (9), pp. 2128-2140
- <sup>108</sup> Hailer, F., and J. A. Leonard (2008) "Hybridization among Three Native North American *Canis* Species in a Region of Natural Sympatry" *PloS One*, vol. 3 (10)
- <sup>109</sup> Gotelli, D., C. Sillero, G. D. Applebaum, and M. S. Roy (1994) "Molecular genetics of the most endangered canid: The Ethiopian Wolf *Canis simensis*" *Molecular Ecology*, vol. 3 (4), pp. 301-312
- <sup>110</sup> Galov, A., E. Fabbri, R. Caniglia, H. Arbanasic, S. Lapalombella, T. Florijancic, I. Boskovic, M. Galaverni, and E. Randi (2015) "First evidence of hybridization between golden jackal (*Canis aureus*) and domestic dog (*Canis familiaris*) as revealed by genetic markers" *Royal Society Open Science*, vol 2 (12)
- <sup>111</sup> Gopalakrishnan *et al* (2018), *op. cit.*
- <sup>112</sup> Thornton, W. A. (1971) "Hybridization in the Fox Genus *Vulpes* in West Texas" *The Southwestern Naturalist*, vol. 15 (4), pp. 473-484
- <sup>113</sup> Makinen, A. and I. Gustavsson (1982) "A comparative chromosome-banding study in the Silver Fox, the Blue Fox, and their hybrids" *Hereditas*, vol. 9, pp. 289-297
- <sup>114</sup> Serov O.L. , S. M. Sakijam, and V. A. Kulichkov (1978) "Allelic expression in intergeneric fox hybrids (*Alopex lagopus* x *Vulpes vulpes*)" *Biochemical Genetics*, vol. 16 (1-2), pp. 145-57
- <sup>115</sup> Gopalakrishnan *et al* (2018), *op. cit.*
- <sup>116</sup> Bininda-Emonds, O. R. P., J. L. Gittleman, and A. Purvis (1999) "Building large trees by combining phylogenetic information: a complete phylogeny of the extant Carnivora (Mammalia)" *Biological Reviews*, vol. 74 (2), pp. 143-175
- <sup>117</sup> Graphodatsky, A. S., P. L. Perelman, N. V. Sokolovskaya, V. R. Beklemisheva, N. A. Serdukova, G. Dobigny, S. O'Brien, M. A. Ferguson-Smith, and F. Yang (2008) "Phylogenomics of the dog and fox family (Canidae, Carnivora) revealed by chromosome painting", *Chromosome Research*, vol. 16 (1), pp. 129-143
- <sup>118</sup> Wayne, R. K., W. G. Nash, and S. J. O'Brien (1987) "Chromosomal evolution of the Canidae", *Cytogenetics and Cell Genetics*, vol. 44 (2-3), pp. 123-133
- <sup>119</sup> Westbury, M., F. Dalerum, K. Noren, and M. Hofreiter (2017) "Complete mitochondrial genome of a bat-eared fox (*Otocyon megalotis*), along with phylogenetic considerations", *Mitochondrial DNA Part B Resources*, vol. 2 (1), pp. 298-299
- <sup>120</sup> Clark Jr. (2005), *op. cit.*
- <sup>121</sup> Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

- **5. Provide information on whether the species has established feral populations**

The Bat-eared Fox has never established wild populations outside of its natural range, and it has never been deliberately introduced to the wild in countries outside of its natural range. There is no mention of the species in Lever (1985),<sup>122</sup> and the only account in Long (2003) regarding artificial movements of animals is of a reintroduction to the Mountain Zebra National Park in South Africa (within the species' natural range).<sup>123</sup>

The Bat-eared Fox is largely insectivorous and is not considered to be a pest of livestock or agriculture, but it is persecuted by farmers in some parts of its natural range such as South Africa<sup>124</sup> and Namibia.<sup>125</sup> Generally this is stated to be due to a mistaken belief that the foxes kill livestock (through observation of the foxes feeding on insects from animal carcasses),<sup>126</sup> or simply through ignorance of / confusion with other canid species (notably the Black-backed Jackal *Canis mesomelas*).<sup>127,128</sup>

<sup>122</sup> Lever, C. (1985) "*Naturalized Mammals of the World*" Longman

<sup>123</sup> Long, J.L. (2003) "*Introduced Mammals of the World*" CSIRO

<sup>124</sup> Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals of South Africa, Swaziland and Lesotho*" South African National Biodiversity Institute and Endangered Wildlife Trust

<sup>125</sup> Kurberg, L. (2005) "The effect of grazing on Bat-eared foxes, and how farmers in Namibia perceive Bat-eared foxes" *Uppsala Universitet*

<sup>126</sup> Hunter, L. (2018) "*Carnivores of the World*" (2nd edition) Princeton University Press

<sup>127</sup> Dalerum *et al* (2016), *op. cit.*

<sup>128</sup> Kurberg (2005), *op. cit.*

## • 6. Environmental risk assessments of the species

The Bat-eared Fox is not listed in the Vertebrate Pests Committee's "List of Exotic Vertebrate Animals in Australia" and hence has no assessment in that document.<sup>129</sup>

Importation and quarantine requirements for live exotic Canidae to Australia have been covered in the "Interim Quarantine Requirements For The Importation Of Zoo Carnivores", and would cover Bat-eared Foxes if these were allowed to be imported.<sup>130</sup>

Five species of Canidae are already included on the list of exotic zoo animals allowed to be imported into Australia, namely Dingo (*Canis lupus dingo*), Maned Wolf (*Chrysocyon brachyurus*), Dhole (*Cuon alpinus*), African Hunting Dog (*Lycaon pictus*), and Fennec Fox (*Vulpes zerda*).<sup>131</sup>

<sup>129</sup> Vertebrate Pests Committee "List of Exotic Vertebrate Animals in Australia":

<https://www.pestsmart.org.au/wp-content/uploads/2010/03/VPCListJuly2007.pdf>

<sup>130</sup> Australian Government "Interim Quarantine Requirements for the Importation of Zoo Carnivores":

<https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/ba/memos/2003/animal/2003-20a.pdf>

<sup>131</sup> Australian Government "List of Specimens Taken to be Suitable for Live Import":  
<https://www.legislation.gov.au/Series/F2006B01053>

- **7. Assess the likelihood that the species could establish a breeding population in Australia**

The likelihood of Bat-eared Foxes establishing a breeding population in Australia outside effective human control is low if based on historical and global data. Despite the species being held in zoos throughout the world there are no wild populations of Bat-eared Foxes established outside their natural range, via accidental or deliberate releases, and the only record of a deliberate re-introduction to any area of former range appears to be to the Mountain Zebra National Park in South Africa.<sup>132,133</sup>

Fennec Foxes (*Vulpes zerda*), a canid of similar size to Bat-eared Foxes and likewise adapted to arid environments, have been kept in Australian zoos for most of the 20th Century, and are still kept in Australian zoos today,<sup>134</sup> and this species has never established wild populations in the country.<sup>135,136,137</sup> The Red Fox (*Vulpes vulpes*), a larger species and one which is much more versatile in habitat use and diet than the Bat-eared Fox,<sup>138</sup> is established in the wild in Australia but only through deliberate releases with the specific aim of creating a wild population.<sup>139,140</sup>

A) Ability to find food sources. Is the species a generalist feeder or does it have specific food needs? What is the likelihood of it finding food in Australia if it was released or escaped? Describe the feeding characteristics of the species, including whether it has a similar diet to any Australian native species.

The Bat-eared Fox is typically described in books and on websites as being a specialist termite-feeder, although results from studies on the diets of wild animals are rather variable. Partly this is due to differing methods of measuring the contents of the diet of study animals, partly due to varying importance or availability of food items through the year, and partly to the location and habitat of study animals.<sup>141</sup>

The distribution of the Bat-eared Fox overlaps almost exactly (95%) with that of harvester termites of the genera *Hodotermes* and *Microhodotermes*, which form the basis of the species' diet according to most sources.<sup>142,143,144,145</sup> Clark Jr. states that 80-90% of the species' diet is composed of these termites,<sup>146</sup> while Malcolm gives a total of 90% of the species' diet being composed of termites for his specific Kenyan study-site.<sup>147</sup> A two-year study in the Kalahari by Jumban *et al* found that termites formed 69.79% of the diet across the year, being most important in autumn (81.5%) and least important in summer (57.33%).<sup>148</sup>

A wide range of other invertebrates are also taken, although mostly in low quantity.<sup>149,150</sup> The study by Jumban *et al* found that after termites (69.79% of the diet across the year), the next highest prey items were beetles (10.64% of the diet), ants (8.16%), and grasshoppers (4.72%). The very high ratio of termites to other invertebrate groups within the diet of these study animals led Jumban *et al* to state "Our data support bat-eared foxes as obligate termite specialists but highlight that they appear to have the ability to show dietary flexibility based on both temporal and spatial variations in food abundance".<sup>151</sup>

In contrast to studies which show a dependence on termites, others have shown a marked preference for fruit. One study in South Africa found that while termites were found in 90% of scats,

they composed only 12-40% of the total mass of the diet - in this study fruit formed the bulk of the diet's mass, with 63% in summer and 74% in autumn.<sup>152</sup> A separate study in the Karoo found that at a natural site (a national park) fruit formed 64% of the diet in winter and 36% in the summer, and in a human-influenced site (farmland, which had a greater abundance of termites) fruit formed 38% of the diet in the winter and 16% in the summer.<sup>153</sup>

Bat-eared Foxes are also recorded as feeding on carrion and small vertebrates, although this appears to be relatively rare and taken opportunistically rather than by preference.<sup>154</sup> In the two-year study by Jumban *et al*, vertebrates (reptiles, frogs, rodents) formed only 0.4% of the diet over the course of a year.<sup>155</sup> In the Kalahari, the male fox of a polygynous breeding group brought lizards to the den for the pups, although the adults of this group rarely ate lizards themselves.<sup>156</sup>

Most (but not all) studies show that termites form a large to predominant part of the diet of Bat-eared Foxes. The termite species they feed upon belong to the genera *Hodotermes* and *Microhodotermes*, of the African family Hodotermitidae.<sup>157</sup> These termites are grass-feeding "harvester termites" which forage for food above ground, and live in underground tunnel systems rather than in concremented mounds.<sup>158</sup> Bat-eared Foxes are largely nocturnal in the wild and use their extremely large ears to find their prey by sound while walking - they do not excavate termite mounds as do, for example, anteaters or aardvarks.<sup>159</sup>

The termite family Hodotermitidae does not occur in Australia, but there are five other termite families here (Mastotermitidae, Termopsidae, Kalotermitidae, Rhinotermitidae, and Termitidae), containing about thirty genera collectively and at least 350 species. These include species which are mound-builders and species which are groundtunnel-nesters.<sup>160</sup> It is likely that Bat-eared Foxes could feed on the ground-dwelling Australian termites although, as a possible opposition to this likelihood, it has been shown that captive animals refuse to eat African termites of the genus *Trinervitermes* (of the family Termitidae), probably due to their chemical defences.<sup>161</sup>

Wild studies also show that Bat-eared Foxes feed on a wide variety of other invertebrates (albeit, generally to a much lesser extent than on termites) and on fruit, so would easily be able to find additional food sources in the wild in Australia.

In Australia, Numbats (*Myrmecobius fasciatus*) and Short-beaked Echidnas (*Tachyglossus aculeatus*) feed entirely or largely on termites. Various species of small marsupials such as bandicoots and dasyurids may occur in similar habitats (arid or semi-arid country) and feed on the same non-termite food items (invertebrates and small vertebrates).<sup>162</sup>

B) Ability to survive and adapt to climatic conditions. Describe the characteristics or behaviour that would enhance its ability to survive extreme climatic conditions (e.g. drought) and its ability to adapt to different environments.

In the wild Bat-eared Foxes are restricted to arid and semi-arid (xeric) environments, predominantly in areas of short grassland. They are not found in true desert or in forest.<sup>163,164</sup> Temperatures may vary through the seasons from extremely hot by day to below freezing at night; Pauw gives extremes of temperature in his study area (in the Kalahari) of 39°C by day in summer and -7°C at night in winter.<sup>165</sup> Bat-eared Foxes seek shade either below ground in their dens or under trees to escape high day-time temperatures, and huddle in groups to combat cold temperatures.<sup>166</sup> Their large ears are suggested to aid in thermoregulation (cooling the fox during high temperatures).<sup>167,168</sup> In eastern Africa the species is largely nocturnal and/or crepuscular year-round, but in southern Africa they are

active mainly by day during the winter to avoid freezing night-time temperatures.<sup>169,170</sup> Lourens and Nel recorded effective temperatures of between 1.5°C and 27°C during the daytime in winter at their study site in South Africa, during which the foxes were less active at the low temperatures and more active at the higher temperatures.<sup>171</sup> The species lives in xeric environments and wild animals have not been observed to drink from free-standing water sources, instead obtaining all necessary moisture from their diet.<sup>172</sup>

C) Ability to find shelter. Can the species live in modified habitats? Identify if this species can live in habitats that have been modified by humans, either directly or indirectly.

Bat-eared Foxes are notable for being able to survive well in human-modified landscapes if they are not persecuted, and - most importantly - so long as the environment is suited to their requirements (i.e. dry farmland where livestock keep the grass heavily-grazed, and where termites and other invertebrates are abundant).<sup>173,174</sup> Within these landscapes they shelter in burrows which are either dug themselves or are the abandoned burrows of other animals.<sup>175</sup> Dalerum *et al* suggest that ranching has a positive effect on Bat-eared Fox populations because moderate to heavy grazing increases termite populations: "Because this species focuses on termite consumption, it is compatible with a broad range of habitats and management strategies".<sup>176</sup> Kurberg notes various opposing studies where Bat-eared Foxes are negatively or positively affected by livestock ranching, with the results likely to be related to how intensely the landscape is grazed.<sup>177</sup>

There appear to be no situations within their natural range where Bat-eared Foxes occur in other forms of cultivation than ranching (e.g. in gardens, orchards, plantations, etc): e.g. in Dalerum *et al* which covers the IUCN conservation assessment of the species for South Africa,<sup>178</sup> there is no mention of interaction in any human-dominated habitats other than livestock farming. This is most likely due to the species being naturally restricted to arid and semi-arid environments which are not suited for crops or fruit production.

D) Reproduction. Could factors such as longevity, birth rates and numbers of offspring increase the likelihood of the species to establish?

Bat-eared Foxes form monogamous pair-bonds and breed only once per year. Litters consist of 1-6 pups which remain with the parents until they are about five to six months old. They attain sexual maturity at eight to nine months of age.<sup>179,180,181,182</sup>

Wild animals have fairly short lifespans, probably in the average range of five or six years although there seem to be no proper studies on wild lifespan. A nine-year-old wild animal recorded by Kamler and Macdonald was regarded by them as being "unusually old".<sup>183</sup>

If a pair lived to six years of age and had a maximum number of pups per litter, they would produce only thirty pups over the course of their life. However the young mature at a relatively young age (8-9 months) and have a high dispersal ability.<sup>184</sup>

Mortality is also quite high in wild animals due to predation by larger Carnivores such as Black-backed Jackals (*Canis mesomelas*) and disease. Hunter quotes a percentage of 25-30% adult mortality in South Africa.<sup>185</sup> In Australia an equivalent predator would be the Dingo.

E) Are there any limiting influences on the species' natural range? Predator/prey relationships, competition, availability of resources etc. Assess what similar population constraints might exist in Australia.

Bat-eared Foxes are naturally restricted to arid and semi-arid (xeric) landscapes in eastern and southern Africa, a distribution which is generally regarded as having a direct connection to that of the Hodotermitidae termites upon which they feed (although they are known to also feed on a wide range of additional invertebrate species).<sup>186,187</sup> Their particular foraging behaviour of walking across open ground, nose down, while listening for active insects (as opposed to finding hidden prey by sight or smell) also requires habitats that are open.<sup>188</sup>

Large areas of inland Australia would probably be suitable habitat for Bat-eared Foxes.

Hodotermitidae termites are not found in Australia which may be a limiting factor for the species; however there are at least 350 species of termites in other families within the country<sup>189</sup> and it is likely that some of these would be suitable prey for Bat-eared Foxes.

Larger species of Carnivores kill or prey on Bat-eared Foxes in the wild in Africa, with the most important one being the Black-backed Jackal (*Canis mesomelas*).<sup>190,191</sup> In some studies up to 32% of monitored Bat-eared Foxes were killed by jackals, and others by domestic Dogs (*Canis familiaris*).<sup>192,193</sup> In Australia the Dingo (*Canis dingo*), a similar large canid, would be an equivalent wild predator. Bat-eared Foxes are also preyed upon by eagles and pythons,<sup>194</sup> of which there are equivalent native species in Australia.

F) Address the issue of increased potential for feral population establishment if more individuals of the species were present in Australia.

Bat-eared Foxes in Australia would be legally restricted to licenced holders (i.e. zoos) and thus the importation of additional animals past an initial import would likely not result in any increase in risk as the containment requirements of all individuals would be the same.

<sup>132</sup> Lever, C. (1985) "*Naturalized Mammals of the World*" Longman

<sup>133</sup> Long, J.L. (2003) "*Introduced Mammals of the World*" CSIRO

<sup>134</sup> Australian zoo census data from Zoo and Aquarium Association (ZAA)

<sup>135</sup> Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

<sup>136</sup> Lever (1985), *op. cit.*

<sup>137</sup> Long (2003), *op. cit.*

<sup>138</sup> Menkhorst and Knight (2010), *op. cit.*

<sup>139</sup> Lever (1985), *op. cit.*

<sup>140</sup> Long (2003), *op. cit.*

<sup>141</sup> Jumban, K. R., S. Periquet, F. Dalerum, and A. Le Roux (2019) "Spatial and temporal variation in the use of supplementary food in an obligate termite specialist, the bat-eared fox" *African Zoology*, vol. 54 (1), pp. 63-71

<sup>142</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>143</sup> Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals*"

of South Africa, Swaziland and Lesotho" South African National Biodiversity Institute and Endangered Wildlife Trust

<sup>144</sup> Clark Jr., H. O. (2005) "Otocyon megalotis" in *Mammalian Species* no.766, pp. 1-5

<sup>145</sup> Nowak, R.M., and J.L. Paradiso (1999) "*Walker's Mammals of the World*" John Hopkins University Press

<sup>146</sup> Clark Jr. (2005), *op. cit.*

<sup>147</sup> Malcolm, J. R. (1986) "Socio-Ecology of Bat-eared Foxes (*Otocyon megalotis*)" *Journal of Zoology*, vol. 208 (3), pp. 457-469

<sup>148</sup> Jumban *et al* (2019), *op. cit.*

<sup>149</sup> Clark Jr. (2005), *op. cit.*

<sup>150</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>151</sup> Jumban *et al* (2019), *op. cit.*

<sup>152</sup> Klare, U., J. F. Kamler, and D. W. Macdonald (2011) "The bat-eared fox: A dietary specialist?" *Mammalian Biology*, vol. 76 (5), pp. 646-650

<sup>153</sup> Kuntzsch, V., and J. A. J. Nel (1992) "Diet of bat-eared foxes *Otocyon megalotis* in the Karoo" *Koedoe - African Protected Area Conservation and Science*, vol 35 (2), pp. 37-48

<sup>154</sup> Clark Jr. (2005), *op. cit.*

<sup>155</sup> Jumban *et al* (2019), *op. cit.*

<sup>156</sup> Pauw, A. (2000) "Parental care in a polygynous group of bat-eared foxes, *Otocyon megalotis* (Carnivora, Canidae)" *African Zoology*, vol. 35 (1), pp. 139-145

<sup>157</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>158</sup> Abe, T., D. E. Bignell, and M. Higashi (eds.) (2000) "*Termites: Evolution, Sociality, Symbioses, Ecology*" Springer

<sup>159</sup> Grant, P. B. C. and M. J. Samways (2015) "Acoustic prey and a listening predator: interaction between calling katydids and the bat-eared fox" *Bioacoustics*, vol. 24 (1), pp. 49-61

<sup>160</sup> Australian Department of Agriculture and Fisheries, "Subterranean Termites in Queensland": [https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fd9df/fs\\_download/subterranean-termites-in-queensland\\_2019.pdf](https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fd9df/fs_download/subterranean-termites-in-queensland_2019.pdf)

<sup>161</sup> Clark Jr. (2005), *op. cit.*

<sup>162</sup> Menkhorst and Knight (2010), *op. cit.*

<sup>163</sup> Clark Jr. (2005), *op. cit.*

<sup>164</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>165</sup> Pauw (2000), *op. cit.*

<sup>166</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>167</sup> Castello, J. R. (2018) "*Canids of the World*" Princeton University Press

<sup>168</sup> Clark Jr. (2005), *op. cit.*

<sup>169</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>170</sup> Clark Jr. (2005), *op. cit.*

<sup>171</sup> Lourens, S., and J. A. J. Nel (1990) "Winter activity of bat-eared foxes *Otocyon megalotis* on the Cape West coast" *South African Journal of Zoology*, vol. 25 (2), pp. 124-132

<sup>172</sup> Clark Jr. (2005), *op. cit.*

<sup>173</sup> Dalerum *et al* (2016), *op. cit.*

<sup>174</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>175</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>176</sup> Dalerum *et al* (2016), *op. cit.*

<sup>177</sup> Kurberg, L. (2005) "The effect of grazing on Bat-eared foxes, and how farmers in Namibia perceive Bat-eared foxes" *Uppsala Universitet*

<sup>178</sup> Dalerum *et al* (2016), *op. cit.*

<sup>179</sup> Clark Jr. (2005), *op. cit.*

<sup>180</sup> Dalerum *et al* (2016), *op. cit.*

- <sup>181</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>182</sup> Castello (2018), *op. cit.*
- <sup>183</sup> Kamler, J. F., and D. W. Macdonald (2006) "Longevity in a wild bat-eared fox" in *African Journal of Wildlife Research*, vol. 36, pp. 199-200
- <sup>184</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>185</sup> Hunter, L. (2018) "*Carnivores of the World*" (2nd edition) Princeton University Press
- <sup>186</sup> Clark Jr. (2005), *op. cit.*
- <sup>187</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>188</sup> Grant and Samways (2015), *op. cit.*
- <sup>189</sup> Australian Department of Agriculture and Fisheries, "Subterranean Termites in Queensland": [https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fd9df/fs\\_download/subterranean-termites-in-queensland\\_2019.pdf](https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fd9df/fs_download/subterranean-termites-in-queensland_2019.pdf)
- <sup>190</sup> Clark Jr. (2005), *op. cit.*
- <sup>191</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>192</sup> Kamler, J. F., N. F. Jacobsen, D. W. Macdonald, U. Stenkewitz, and U. Klare (2012) "Resource partitioning among Cape Foxes, Bat-eared Foxes, and Black-backed Jackals in South Africa" *Journal of Wildlife Management*, vol. 76 (6), pp. 1241-1253
- <sup>193</sup> Kamler, J. F., S. Rostro-Garcia, and D. W. Macdonald (2017) "Seasonal changes in social behaviour and movements of bat-eared foxes in South Africa: disease implications" *Journal of Mammalogy*, vol. 98 (5), pp. 1426-1433
- <sup>194</sup> Clark Jr. (2005), *op. cit.*

- **8. Provide a comprehensive assessment of the potential impact of the species should it become established in Australia**

A. Does the species have similar niche/living requirements to native species?

The diet of Bat-eared Foxes is composed primarily of insects and fruit, with termites making up a larger part of the diet. In this regard they may compete with certain native mammals, in particular the endangered Numbat (*Myrmecobius fasciatus*) and the widespread Short-beaked Echidna (*Tachyglossus aculeatus*) which also feed primarily on termites and other soil-dwelling insects.<sup>195,196</sup>

While these species all feed predominantly on termites there may be a low probability of actual competition because they have contrasting feeding behaviours, with the two native mammals finding termites by digging into either the ground or into termite nests (e.g. within logs)<sup>197,198</sup> whereas the Bat-eared Fox locates termites on the surface. The feeding behaviours are relative to the specific foraging techniques of the different species of termite - Bat-eared Foxes feed on harvester termites which are active above ground,<sup>199</sup> while the Numbat and Echidna feed on subterranean termite species.

Bat-eared Foxes also feed on other invertebrates, especially on beetles. In this respect they may compete with arid-dwelling bandicoot species of which there are several species, some of which are endangered and localised.<sup>200</sup>

Bat-eared Foxes shelter in burrows, but they either dig their own burrows or utilise the abandoned burrows of other animals; they are not known to evict other animals in order to make use of a burrow.<sup>201,202</sup> (In an Australian context, an example might be an abandoned wombat burrow as this is probably the only native mammal which would construct a burrow large enough to accommodate the foxes). Bat-eared Foxes live in arid habitats which may include shrubland or the edges of arid woodland, but they are entirely terrestrial and do not climb trees.<sup>203, 204</sup>



B. Is the species susceptible to, or capable of transmitting any pests or diseases?

Bat-eared Foxes can be carriers of external parasites such as ticks and fleas, and internal parasites such as nematodes, all of which can be easily and effectively treated/removed before undergoing quarantine.

There are a number of zoonoses (including protozoal, fungal, bacterial, and viral species) which can be carried by and transferred between Bat-eared Foxes and other carnivore species (including the domestic dog). Some of these are also transferrable to humans, notably (in the case of Bat-eared Foxes) rabies. All diseases which affect domestic dogs will also affect Bat-eared Foxes. In wild Bat-eared Foxes the most dangerous diseases are rabies, canine distemper, and canine parvovirus. These three diseases are transmitted from and to other canid species (including the domestic dog) and are responsible for regular population crashes in Bat-eared Foxes.<sup>205,206</sup>

A study by Murray *et al* (1999), covering the research of diseases in large carnivores, found 52 diseases, of which 44% were viral, 31% bacterial, and the rest fungal or protozoal.<sup>207</sup>

Zoonoses can be tested for, and generally be effectively treated, before undergoing quarantine.

Quarantine requirements for live exotic Canidae to Australia have been covered in the "Interim Quarantine Requirements For The Importation Of Zoo Carnivores".<sup>208</sup> Five species of Canidae are already included on the list of exotic zoo animals allowed to be imported into Australia, namely Dingo (*Canis lupus dingo*), Maned Wolf (*Chrysocyon brachyurus*), Dhole (*Cuon alpinus*), African Hunting Dog (*Lycaon pictus*), and Fennec Fox (*Vulpes zerda*).<sup>209</sup>

C. Probable prey/food sources.

The distribution of the Bat-eared Fox in the wild overlaps almost exactly (95%) with that of harvester termites of the genera *Hodotermes* and *Microhodotermes*, which form the basis of the species' diet according to most sources.<sup>210,211,212,213</sup>

A wide range of other invertebrates are also taken, although mostly in low quantity.<sup>214,215</sup> A study by Jumban *et al* found that after termites (69.79% of the diet across the year), the next highest prey items were beetles (10.64% of the diet), ants (8.16%), and grasshoppers (4.72%). The very high ratio of termites to other invertebrate groups within the diet of these study animals led Jumban *et al* to state "Our data support bat-eared foxes as obligate termite specialists but highlight that they appear to have the ability to show dietary flexibility based on both temporal and spatial variations in food abundance".<sup>216</sup>

Fruit from wild plants also forms a part of the diet in some areas.<sup>217,218</sup>

Bat-eared Foxes are also recorded as feeding on carrion and small vertebrates, although this appears to be relatively rare and taken opportunistically rather than by preference.<sup>219</sup> In the two-year study by Jumban *et al*, vertebrates (reptiles, frogs, rodents) formed only 0.4% of the diet over the course of a year.<sup>220</sup> In the Kalahari, the male fox of a polygynous breeding group brought lizards to the den for the pups, although the adults of this group rarely ate lizards themselves.<sup>221</sup>

Within Australia, vertebrate animals which may be prey items for Bat-eared Foxes would be frogs, small lizards, and rodent-sized mammals (e.g. native and introduced rodents, and native mouse-sized dasyurids). However, as noted above, the wild diet is predominantly composed of insects.

Bat-eared Foxes have not been recorded as preying on domestic animals.<sup>222</sup>

#### D. Impacts on habitat and local environments.

If a wild population should become established there would be little or no physical impact on the habitats in which they live. Bat-eared Foxes dig burrows as shelters, and typically have several such shelters in separate locations within their home-ranges, but these are individual burrows (i.e. the species does not have subterranean habits or create extensive tunnel systems).<sup>223</sup> They do not dig to obtain food, but rather use auditory signals to find prey on the surface as they walk.<sup>224, 225</sup> They do not live or dig burrows near waterways as they are adapted for life in arid environments.<sup>226</sup>

There appear to be no reports of damage caused by Bat-eared Foxes to wildlife or habitats within their native range. In southern Africa they are commonly found on livestock ranches where their presence causes no damage.<sup>227</sup>

The species inhabits arid or semi-arid environments and avoids well-treed areas such as woodlands and plantations.<sup>228</sup>

Bat-eared Foxes could transport plant seeds attached to their fur, and also in their droppings as fruit from wild plants forms part of their natural diet. In one study in South Africa fruit formed the bulk of the diet's mass, with 63% in summer and 74% in autumn.<sup>229</sup> A separate study in the Karoo found that at a natural site (a national park) fruit formed 64% of the diet in winter and 36% in the summer, and in a human-influenced site (farmland, which had a greater abundance of termites) fruit formed 38% of the diet in the winter and 16% in the summer.<sup>230</sup>

#### E. Discuss any control/eradication programs that could be applied in Australia if the species escaped or were released.

Bat-eared Foxes typically inhabit open country with little to no ground-cover.<sup>231</sup> In cases where they are active diurnally (in the wild, during winter in some parts of their range<sup>232</sup>) they are readily visible. When active nocturnally they would be much more difficult to detect individually, however they have regular home burrows at which they could be trapped.<sup>233</sup> They live in monogamous pairs or in larger family groups,<sup>234</sup> which would make eradication from the wild more attainable than for solitary species. In the event that a wild population became established it would most likely be in an area of low human activity (given the species' habitat of arid or semi-arid country) and so control programmes as used for the introduced Red Fox (*Vulpes vulpes*) and feral dogs (*Canis familiaris*) could be used for Bat-eared Foxes. In Australia foxes and dogs are most commonly controlled using poison baits and trapping, as well as by shooting.<sup>235</sup> Poison baits would likely not be very effective for Bat-eared Foxes as carrion is a minimal part of their diet.<sup>236</sup> Trapping at home-burrows would probably be the more effective strategy.

#### F. Behaviours that cause environmental degradation.

Bat-eared Foxes do not cause any environmental damage other than by digging individual burrows for shelter. They typically have several such shelters in separate locations within their home-ranges, but the species does not have subterranean habits or create extensive tunnel systems.<sup>237</sup> They do not dig to obtain food, but rather use auditory signals to find prey on the surface as they walk.<sup>238</sup> They do not live in or near waterways as they are adapted for life in arid environments.<sup>239</sup>

#### G. Impacts on primary industries.

Bat-eared Foxes are notable for being able to survive well on livestock ranches so long as the environment is suited to their requirements (i.e. dry farmland where livestock keep the grass heavily-grazed, and where termites and other invertebrates are abundant).<sup>240</sup> They have not been recorded as causing damage to or competing with livestock in these situations.<sup>241</sup>

There appear to be no situations within their natural range where Bat-eared Foxes occur in any other forms of cultivation than ranching (e.g. they do not occur in gardens, orchards, plantations, etc): e.g. in Dalerum *et al* which covers the IUCN conservation assessment of the species for South Africa, there is no mention of interaction in any human-dominated habitats other than livestock farming.<sup>242</sup> This is most likely due to the species being naturally restricted to arid and semi-arid environments which are not suited for crops or fruit production.

Bat-eared Foxes do feed on fruit from wild arid-adapted plants,<sup>243,244</sup> and so potentially could also affect commercial fruit production, although this seems unlikely given that the habitat of the foxes does not align with that of commercial orchards. They do not feed on other plant material (e.g. seedlings, leaves, etc).

#### H. Damage to property.

Bat-eared Foxes have not been recorded as causing damage to physical properties. In their native range they do inhabit farmland and ranches, where they do not cause issues for humans.<sup>245</sup>

#### I. Is the species a social nuisance or danger?

Bat-eared Foxes have not been recorded as being a danger to or creating a nuisance for humans. In their native range they do inhabit farmland and ranches, where they do not cause issues for humans.<sup>246</sup>

#### J. Describe any potentially harmful characteristics of the species.

Bat-eared Foxes are very small and inoffensive canids. They have the most reduced tooth-size of any canid (although possessing the most individual teeth of any canid due to the presence of additional molars).<sup>247</sup> The teeth also have less shearing surfaces than is typical for canids and an undeveloped carnassial blade, due to the adaptations for an insectivorous diet.<sup>248, 249</sup> They do retain larger incisors and can bite effectively, but because of their small muzzle size the length of each tooth-row, exclusive of the incisors, measures only 4-5cm.<sup>250</sup> They also have long blunt claws on the front paws, for digging, which project 1.8cm beyond the pad.<sup>251</sup> Their teeth and claws could cause minor injuries to a person, in the same manner as bites or scratches from a domestic Cat or other small carnivorous mammal.

In captivity they should be treated with the same safety measures as other small carnivorous mammals (e.g foxes, small felids, the larger dasyurids, etc).

Bat-eared Foxes can carry and transmit the same zoonoses as domestic dogs or any other wild canid, including rabies. Wild Health Australia lists the zoonoses of canids and felids which have been recorded within Australia.<sup>252</sup>

Biosecurity Australia has existing quarantine requirements for the importation of live exotic Carnivora for zoos, which covers disease control.

<sup>195</sup> Van Dyck, S., and R. Strahan (2008) "*The Mammals of Australia*" Reed New Holland

<sup>196</sup> Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

<sup>197</sup> Van Dyck and Strahan (2008), *op. cit.*

<sup>198</sup> Menkhorst and Knight (2010), *op. cit.*

<sup>199</sup> Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

<sup>200</sup> Menkhorst and Knight (2010), *op. cit.*

<sup>201</sup> Clark Jr., H. O. (2005) "Otocyon megalotis" in *Mammalian Species* no.766, pp. 1-5

<sup>202</sup> Nowak, R.M., and J.L. Paradiso (1999) "*Walker's Mammals of the World*" John Hopkins University Press

<sup>203</sup> Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals of South Africa, Swaziland and Lesotho*" South African National Biodiversity Institute and Endangered Wildlife Trust

<sup>204</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>205</sup> King, A. A., C. D. Meredith, and G. R. Thomson (1993) "Canid and viverrid viruses in South Africa" *Onderstepoort Journal of Veterinary Research*, vol. 60, pp. 295-299

<sup>206</sup> Dalerum *et al* (2016), *op. cit.*

<sup>207</sup> Murray, D.L., C.A. Kapke, J.F. Evermann, and T.K. Fuller (1999) "Infectious disease and the conservation of free-ranging large carnivores" *Animal Conservation Forum*, vol. 2 (4), pp. 241-254

<sup>208</sup> Australian Government "Interim Quarantine Requirements for the Importation of Zoo Carnivores":

<https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/ba/memos/2003/animal/2003-20a.pdf>

<sup>209</sup> Australian Government "List of Specimens Taken to be Suitable for Live Import":

<https://www.legislation.gov.au/Series/F2006B01053>

<sup>210</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>211</sup> Dalerum *et al* (2016), *op. cit.*

<sup>212</sup> Clark Jr. (2005), *op. cit.*

<sup>213</sup> Nowak and Paradiso (1999), *op. cit.*

<sup>214</sup> Clark Jr. (2005), *op. cit.*

<sup>215</sup> Kingdon and Hoffman (2013), *op. cit.*

<sup>216</sup> Jumban, K. R., S. Periquet, F. Dalerum, and A. Le Roux (2019) "Spatial and temporal variation in the use of supplementary food in an obligate termite specialist, the bat-eared fox" *African Zoology*, vol. 54 (1), pp. 63-71

<sup>217</sup> Klare, U., J. F. Kamler, and D. W. Macdonald (2011) "The bat-eared fox: A dietary specialist?" *Mammalian Biology*, vol. 76 (5), pp. 646-650

- <sup>218</sup> Kuntzsch, V., and J. A. J. Nel (1992) "Diet of bat-eared foxes *Otocyon megalotis* in the Karoo" *Koedoe - African Protected Area Conservation and Science*, vol 35 (2), pp. 37-48
- <sup>219</sup> Clark Jr. (2005), *op. cit.*
- <sup>220</sup> Jumban *et al* (2019), *op. cit.*
- <sup>221</sup> Pauw, A. (2000) "Parental care in a polygynous group of bat-eared foxes, *Otocyon megalotis* (Carnivora, Canidae)" *African Zoology*, vol. 35 (1), pp. 139-145
- <sup>222</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>223</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>224</sup> Grant, P. B. C. and M. J. Samways (2015) "Acoustic prey and a listening predator: interaction between calling katydids and the bat-eared fox" *Bioacoustics*, vol. 24 (1), pp. 49-61
- <sup>225</sup> Renda, S., and A. Le Roux (2017) "Sensory ecology of prey detection in the bat-eared fox (*Otocyon megalotis*)" *Behaviour*, vol. 154, pp. 227-240
- <sup>226</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>227</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>228</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>229</sup> Klare *et al* (2011), *op. cit.*
- <sup>230</sup> Kuntzsch and Nel (1992), *op. cit.*
- <sup>231</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>232</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>233</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>234</sup> Malcolm, J. R. (1986) "Socio-Ecology of Bat-eared Foxes (*Otocyon megalotis*)" *Journal of Zoology*, vol. 208 (3), pp. 457-469
- <sup>235</sup> PestSmart, European Fox: <https://pestsmart.org.au/pest-animal-species/european-fox/>
- <sup>236</sup> Clark Jr. (2005), *op. cit.*
- <sup>237</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>238</sup> Renda and Le Roux (2017), *op. cit.*
- <sup>239</sup> Kingdon and Hoffman (2013), *op. cit.*
- <sup>240</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>241</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>242</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>243</sup> Klare *et al* (2011), *op. cit.*
- <sup>244</sup> Kuntzsch and Nel (1992), *op. cit.*
- <sup>245</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>246</sup> Dalerum *et al* (2016), *op. cit.*
- <sup>247</sup> Clark Jr. (2005), *op. cit.*
- <sup>248</sup> Keiser, J. A. (1995) "Gnathomandibular Morphology and Character Displacement in the Bat-eared Fox" *Journal of Mammalogy*, vol. 76 (2), pp. 542-550
- <sup>249</sup> Asahara, M. (2016) "The origin of the fourth lower molar in canids, inferred by individual variation" *Peer J*, vol. 4
- <sup>250</sup> Clark Jr. (2005), *op. cit.*
- <sup>251</sup> Stuart, C. (2013) "*Field Guide to Tracks & Signs of Southern, Central & East African Wildlife*" Penguin Random House
- <sup>252</sup> Wild Health Australia, "Infectious agents of feral and wild Canids and Felids in Australia": <https://www.wildlifehealthaustralia.com.au/Portals/0/Documents/FactSheets/Mammals/Infectious%20agents%20in%20feral%20and%20wild%20Canids%20and%20Felids%20in%20Australia.pdf>

- **9. What conditions or restrictions could be applied to reduce any potential for negative impacts of the species?**

Importation and transfer of Bat-eared Foxes would be limited exclusively to recognised zoological facilities as licensed by their respective states and territories. As a containment species, Bat-eared Foxes would be specifically excluded from import by or transfer to private individuals to keep as private pets.

Measures to prevent breeding such as limiting importation to a single sex or to de-sexed individuals would prevent imported specimens being used to conserve the species in Australian zoos in the future.

- **10. Summary of proposed activity**

The Bat-eared Fox application is to import a unique species for:

- 1) captive breeding [ultimately in collaboration with other licensed zoos] to further the conservation of this species in captivity.
- 2) public display as an ambassador for this species.
- 3) facilitating the education of zoo visitors about different members of this taxa.

The Darling Downs Zoo initially intends to import two unrelated males and two unrelated females to establish the nucleus of a genetically diverse breeding population.

All of these animals will be held at the Darling Downs Zoo.

Further animals will need to be imported in the future to ensure the genetic diversity of the Australian population.

All imported animals will be from licensed overseas zoos which are eligible to export zoo animals to zoos in Australia.

Males will need to be separated to avoid negative conspecific interaction and to ensure sound genetic management.

Canids such as Bat-eared Foxes are capable of producing annual litters. Thus, breeding will be controlled by periodically contracepting the females to manage the frequency of litters.

Facilities for this species will be provided to permit the separate holding of two adult pairs plus nursing bitches and any progeny awaiting dispersal to other zoos.

Genetic viability will be maintained by the careful management of the original pairs and then the management of subsequent progeny. At some time in the future it will be necessary to import unrelated bloodlines.

This species will only be used for display, education and breeding to institutional and industry requirement in licensed zoos.

It has no pet potential nor are there any research projects designed for this species.

Only captive-bred animals, or rehab animals deemed to be unreleaseable in their range state, will be obtained from licensed zoos.

- **11. Guidelines on how species should be kept**

Transport of imported Bat-eared Foxes will comply with current IATA Live Animal Regulations.

The proposed enclosure size has been determined following the applicant's study tour of captive facilities in Europe. The proposed size of each enclosure, and the number of enclosures provided, conform with the information gleaned during that tour and comply with the Standards for Keeping Carnivores in NSW.

The Standards for Keeping Carnivores in NSW provide for a minimum size enclosure of 200 square metres for a pair of canids of similar size to Bat-eared Foxes.

Each Bat-eared Fox enclosure at the Darling Downs Zoo will, at the least equal that size.

Each enclosure is to be 2.5 metres high and have an in-hang of 700mm at 45 degrees to the perpendicular.

Enclosures are to be constructed of 50 x 50 x 3mm galvanised wire mesh. The enclosures will be locked at all times.

Each enclosure will have a 900mm-wide apron of wire mesh, buried beneath the substrate, internally around the complete perimeter fence of the enclosure.

This species will be kept in pairs or in groups of compatible juveniles awaiting dispersal.

Each enclosure for this species will have adequate shade – either from existing surrounding vegetation or artificially provided by shade cloth.

Enclosure furniture such as large logs and rocks will provide shelter in the enclosure from prevailing bad weather. Additionally, all animals will have full time access to their dens.

Keeper access to the enclosure will be through a lockable air-lock.

There will be no visitor access to these enclosures.

Visitor viewing will be from one side of the enclosure only, and visitors will be kept back from the enclosure by a 1200mm stand-off fence.

The zoo premises have 24 hour live-in security presence and, at night, guard dogs patrol the grounds.

The entire zoo property is enclosed with a security fence with lockable access gates.

These enclosures will be sufficiently large enough for the humane containment of the animals, and provide sufficient depth and length.

This is a social canid species not suited to holding as singletons. Progeny may be held as single sex groups awaiting dispersal to other zoos. Breeding will be controlled by contracepting females when required.

The Standards for Keeping Carnivores in NSW are the best Standards worldwide that we have found. In Australia the Standards are applied by State Governments: in the case of Darling Downs Zoo, the Queensland Government department – Biosecurity Queensland Exhibited Animals division applies these Standards as secondary legislation.

The environmental welfare for this species will be addressed by the provision of suitable substrate, non-toxic plants, logs, rocks and areas in which to hide from conspecifics as well as zoo visitors.

The nutritional welfare of this species will be catered for by the provision of a wide variety of small carcass meat items, fruit, invertebrates and termite replacement formula such as Wombaroo® Echidna formula.

The social and behavioural welfare of this species will be catered for by the keeping of them in socially appropriate pairs, dam with offspring, or single sex groups of juveniles awaiting dispersal.

The health of this species will be managed by veterinary professionals with canid experience and will include regular vet checks, worming, body scoring and weighing.

If all the foregoing are positive then the Five Domains Animal Welfare model guarantees that the animals' affective state will also be positive.

- **12. State/Territory controls**

\*The Australian Government's "List of Specimens Taken to be Suitable for Live Import" does not currently include Bat-eared Fox. Five other species of wild Canidae are currently on the list as being allowed to be imported into Australia, namely Dingo (*Canis lupus dingo*), Maned Wolf (*Chrysocyon brachyurus*), Dhole (*Cuon alpinus*), African Hunting Dog (*Lycaon pictus*), and Fennec Fox (*Vulpes zerda*).

<https://www.legislation.gov.au/Series/F2006B01053>

Because Bat-eared Foxes have not been kept in Australian zoos before, they are not specifically covered by state legislations. A total of eleven other Canidae species are covered by the laws of the combined states, inclusive of Red Fox (*Vulpes vulpes*), Dingo (*Canis lupus / familiaris / dingo*) and



Domestic Dog (*Canis familiaris*). The eight exotic canid species restricted to zoos in the state legislations are Wolf (*Canis lupus*), Coyote (*Canis latrans*), Black-backed Jackal (*Canis mesomelas*), Maned Wolf (*Chrysocyon brachyurus*), Dhole (*Cuon alpinus*), African Hunting Dog (*Lycaon pictus*), Raccoon Dog (*Nyctereutes procyonoides*), and Fennec Fox (*Vulpes zerda*).

\*In Queensland the *Exhibited Animals Act 2015* does not cover the Bat-eared Fox (or any species specifically) but allows a licence holder to "Exhibit and deal with animals listed on this authority in accordance with information assessed and approved in deciding the application and details listed on this authority".

<https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-2015-005>

\*In New South Wales the *Non-Indigenous Animals Regulation 2012* does not list the Bat-eared Fox but does currently list eight other species of wild Canidae under Categories 2 and 3a (species which are restricted to licenced facilities). This regulation allows these species to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

<https://www.legislation.nsw.gov.au/regulations/2012-405.pdf>

\*In Victoria the *Catchment and Land Protection Act 1994* does not list the Bat-eared Fox but does currently list four other species of wild Canidae under Schedule 2 as Controlled Pest Animals. Species listed in Schedule 2 are allowed to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

<http://www.gazette.vic.gov.au/gazette/Gazettes2010/GG2010S399.pdf>

\*In South Australia the *Natural Resources Management Act 2004* does not list the Bat-eared Fox but does currently list eight other species of wild Canidae under Category 1 of Schedule 1. Species listed as such are allowed to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

[https://www.pir.sa.gov.au/\\_data/assets/pdf\\_file/0003/137460/Declaration\\_of\\_Animals\\_and\\_Plants\\_Jan\\_2015.pdf](https://www.pir.sa.gov.au/_data/assets/pdf_file/0003/137460/Declaration_of_Animals_and_Plants_Jan_2015.pdf)

\*In Western Australia the *Biosecurity and Agricultural Management Act 2007* does not list the Bat-eared Fox as a species allowed to be kept in that state.

The *Biosecurity and Agricultural Management (Prohibited Organisms) Declaration 2013* is available at the following link (species arranged alphabetically by genus rather than taxonomically):  
<https://www.agric.wa.gov.au/sites/gateway/files/BAM%20Decl%20s22%20%28Prohibited%20Organisms%29.pdf>

The Western Australian Organism List is searchable online at the following link for the most current results: <https://www.agric.wa.gov.au/organisms>

\*In Tasmania the Bat-eared Fox has not been risk-assessed for the State.

<https://www.legislation.tas.gov.au/view/html/inforce/current/act-2002-063>

List of species which have been risk-assessed for Tasmania, which currently includes only one species of wild canid: <http://dpiw.tas.gov.au/wildlife-management/management-of-wildlife/wildlife-imports/species-risk-assessments>

\*In the Northern Territory all non-native wildlife is classed as a "Prohibited Entrant" and applications for keeping these species (which would include the Bat-eared Fox) are assessed on a case-by-case basis.

<https://nt.gov.au/environment/animals/wildlife-permits/prohibited-wildlife>

\*In the Australian Capital Territory there doesn't appear to be any specific legislative status of exotic zoo species.

Importation and quarantine requirements for live exotic Canidae to Australia have been covered in the "Interim Quarantine Requirements For The Importation Of Zoo Carnivores", and would cover Bat-eared Foxes if these were allowed to be imported.

<https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/ba/memos/2003/animal/2003-20a.pdf>

## **LIST OF REFERENCES**

Abe, T., D. E. Bignell, and M. Higashi (eds.) (2000) "*Termites: Evolution, Sociality, Symbioses, Ecology*" Springer

Asahara, M. (2016) "The origin of the fourth lower molar in canids, inferred by individual variation" *Peer J*, vol. 4

Berry, M. P. S. (1978) "*Aspects of the ecology and behaviour of the bat-eared fox, (Otocyon megalotis Desmarest, 1822) in the Upper Limpopo Valley*" University of Pretoria

Bininda-Emonds, O. R. P., J. L. Gittleman, and A. Purvis (1999) "Building large trees by combining phylogenetic information: a complete phylogeny of the extant Carnivora (Mammalia)" *Biological Reviews*, vol. 74 (2), pp. 143-175

Clark Jr., H. O. (2005) "Otocyon megalotis" in *Mammalian Species* no.766, pp. 1-5

Castello, J. R. (2018) "*Canids of the World*" Princeton University Press

Dalerum F., A. Le Roux, J. L. de Vries, J. F. Kamler, S. Page-Nicholson, C. Stuart, M. Stuart, B. Wilson, and E. Do Linh San (2016) "A conservation assessment of *Otocyon megalotis*", in Child, M. F., L. Roxburgh, E. Do Linh San, D. Raimondo, and H. T. Davies-Mostert (eds) "*The Red List of Mammals of South Africa, Swaziland and Lesotho*" South African National Biodiversity Institute and Endangered Wildlife Trust

Galov, A., E. Fabbri, R. Caniglia, H. Arbanasic, S. Lapalombella, T. Florijancic, I. Boskovic, M. Galaverni, and E. Randi (2015) "First evidence of hybridization between golden jackal (*Canis aureus*) and domestic dog (*Canis familiaris*) as revealed by genetic markers" *Royal Society Open Science*, vol 2 (12)

Graphodatsky, A. S., P. L. Perelman, N. V. Sokolovskaya, V. R. Beklemisheva, N. A. Serdukova, G. Dobigny, S. O'Brien, M. A. Ferguson-Smith, and F. Yang (2008) "Phylogenomics of the dog and fox family (Canidae, Carnivora) revealed by chromosome painting", *Chromosome Research*, vol. 16 (1), pp. 129-143

Gopalakrishnan, S., M. S. Sinding, J. Ramos-Madrugal, J. Niemann, J. A. S. Castruita, F. G. Vieira, C. Caroe, M. de Manuel Montero, L. Kuderna, A. Serres, V. M. Gonzalez-Basallote, Y. Liu, G. Wang, T. Marques-Bonet, S. Mirarab, C. Fernandes, P. Gaubert, K. Koepfli, J. Budd, E. K. Rueness, C. Sillero, M. P. Heide-Jorgensen, B. Petersen, T. Sicheritz-Ponten, L. Bachmann, O. Wiig, A. J. Hansen, M. Thomas, and P. Gilbert (2018) "Interspecific Gene Flow Shaped the Evolution of the Genus *Canis*" *Current Biology*, vol. 28 (21), pp. 3441-3449

Gotelli, D., C. Sillero, G. D. Applebaum, and M. S. Roy (1994) "Molecular genetics of the most endangered canid: The Ethiopian Wolf *Canis simensis*" *Molecular Ecology*, vol. 3 (4), pp. 301-312

Grant, P. B. C. and M. J. Samways (2015) "Acoustic prey and a listening predator: interaction between calling katydids and the bat-eared fox" *Bioacoustics*, vol. 24 (1), pp. 49-61

Hailer, F., and J. A. Leonard (2008) "Hybridization among Three Native North American *Canis* Species in a Region of Natural Sympatry" *PloS One*, vol. 3 (10)

Hunter, L. (2018) "*Carnivores of the World*" (2nd edition) Princeton University Press

Jones, M. L. (1982) "Longevity of Captive Mammals" in *Der Zoologische Garten Neue Folge Jena* vol. 52, pp. 113-128

Jumban, K. R., S. Periquet, F. Dalerum, and A. Le Roux (2019) "Spatial and temporal variation in the use of supplementary food in an obligate termite specialist, the bat-eared fox" *African Zoology*, vol. 54 (1), pp. 63-71

Kamler, J. F., and D. W. Macdonald (2006) "Longevity in a wild bat-eared fox" in *African Journal of Wildlife Research*, vol. 36, pp. 199-200

Kamler, J. F., N. F. Jacobsen, D. W. Macdonald, U. Stenkewitz, and U. Klare (2012) "Resource partitioning among Cape Foxes, Bat-eared Foxes, and Black-backed Jackals in South Africa" *Journal of Wildlife Management*, vol. 76 (6), pp. 1241-1253

Kamler, J. F., S. Rostro-Garcia, and D. W. Macdonald (2017) "Seasonal changes in social behaviour and movements of bat-eared foxes in South Africa: disease implications" *Journal of Mammalogy*, vol. 98 (5), pp. 1426-1433

Keiser, J. A. (1995) "Gnathomandibular Morphology and Character Displacement in the Bat-eared Fox" *Journal of Mammalogy*, vol. 76 (2), pp. 542-550

King, A. A., C. D. Meredith, and G. R. Thomson (1993) "Canid and viverrid viruses in South Africa" *Onderstepoort Journal of Veterinary Research*, vol. 60, pp. 295-299

Kingdon, J., and M. Hoffman (eds) (2013) "*Mammals of Africa*" (Volume 5), A & C Black

Klare, U., J. F. Kamler, and D. W. Macdonald (2011) "The bat-eared fox: A dietary specialist?" *Mammalian Biology*, vol. 76 (5), pp. 646-650

Kuntzsch, V., and J. A. J. Nel (1992) "Diet of bat-eared foxes *Otocyon megalotis* in the Karoo" *Koedoe - African Protected Area Conservation and Science*, vol 35 (2), pp. 37-48

Kurberg, L. (2005) "The effect of grazing on Bat-eared foxes, and how farmers in Namibia perceive Bat-eared foxes" *Uppsala Universitet*

Lever, C. (1985) "*Naturalized Mammals of the World*" Longman

Long, J.L. (2003) "*Introduced Mammals of the World*" CSIRO

Lourens, S., and J. A. J. Nel (1990) "Winter activity of bat-eared foxes *Otocyon megalotis* on the Cape West coast" *South African Journal of Zoology*, vol. 25 (2), pp. 124-132

Makinen, A. and I. Gustavsson (1982) "A comparative chromosome-banding study in the Silver Fox, the Blue Fox, and their hybrids" *Hereditas*, vol. 9, pp. 289-297

Malcolm, J. R. (1986) "Socio-Ecology of Bat-eared Foxes (*Otocyon megalotis*)" *Journal of Zoology*, vol. 208 (3), pp. 457-469

Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

Murray, D.L., C.A. Kapke, J.F. Evermann, and T.K. Fuller (1999) "Infectious disease and the conservation of free-ranging large carnivores" *Animal Conservation Forum*, vol. 2 (4), pp. 241-254

Nowak, R.M., and J.L. Paradiso (1999) "*Walker's Mammals of the World*" John Hopkins University Press

Pauw, A. (2000) "Parental care in a polygynous group of bat-eared foxes, *Otocyon megalotis* (Carnivora, Canidae)" *African Zoology*, vol. 35 (1), pp. 139-145

Renda, S., and A. Le Roux (2017) "Sensory ecology of prey detection in the bat-eared fox (*Otocyon megalotis*)" *Behaviour*, vol. 154, pp. 227-240

Serov O.L. , S. M. Sakijam, and V. A. Kulichkov (1978) "Allelic expression in intergeneric fox hybrids (Alopex lagopus x Vulpes vulpes)" *Biochemical Genetics*, vol. 16 (1-2), pp. 145-57

Stronen, A. V., N. Tessier, H. Jolicoeur, P. C. Paquet, M. Henault, M. Villemure, B. R. Patterson, T. Sallows, G. Goulet, F. Lapointe (2012) "Canid hybridization: contemporary evolution in human-modified landscapes" *Ecology and Evolution*, vol. 2 (9), pp. 2128-2140

Stuart, C. (2013) "*Field Guide to Tracks & Signs of Southern, Central & East African Wildlife*" Penguin Random House

Thornton, W. A. (1971) "Hybridization in the Fox Genus *Vulpes* in West Texas" *The Southwestern Naturalist*, vol. 15 (4), pp. 473-484

Van Dyck, S., and R. Strahan (2008) "*The Mammals of Australia*" Reed New Holland

Wayne, R. K., W. G. Nash, and S. J. O'Brien (1987) "Chromosomal evolution of the Canidae", *Cytogenetics and Cell Genetics*, vol. 44 (2-3), pp. 123-133

Weigl, R (2005) "*Longevity of Mammals in Captivity; from the living collections of the world*" Kleine Senckenberg-Reihe 48

Westbury, M., F. Dalerum, K. Noren, and M. Hofreiter (2017) "Complete mitochondrial genome of a bat-eared fox (*Otocyon megalotis*), along with phylogenetic considerations", *Mitochondrial DNA Part B Resources*, vol. 2 (1), pp. 298-299

Wilson, D.E., and D.M. Reeder (eds) (2005) "*Mammal Species of the World: a taxonomic and geographic reference*" (3rd edition), John Hopkins University Press

## **OTHER**

Species360 Zoo Aquarium Animal Management Software (ZIMS)

CITES home page: <https://cites.org/eng>

IUCN page for "Otocyon megalotis": <https://www.iucnredlist.org/species/15642/46123809>

Vertebrate Pests Committee "List of Exotic Vertebrate Animals in Australia":  
<https://www.pestsmart.org.au/wp-content/uploads/2010/03/VPCListJuly2007.pdf>

Australian Government "List of Specimens Taken to be Suitable for Live Import":  
<https://www.legislation.gov.au/Series/F2006B01053>

Australian Department of Agriculture and Fisheries, "Subterranean Termites in Queensland":  
[https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fdfdf/fs\\_download/subterranean-termites-in-queensland\\_2019.pdf](https://www.publications.qld.gov.au/dataset/53ac3a6d-ae93-4a4d-9461-a629ab60f797/resource/34a952d1-dc8e-4755-beca-96f9ae0fdfdf/fs_download/subterranean-termites-in-queensland_2019.pdf)

PestSmart, European Fox: <https://pestsmart.org.au/pest-animal-species/european-fox/>

Wild Health Australia, "Infectious agents of feral and wild Canids and Felids in Australia":  
<https://www.wildlifehealthaustralia.com.au/Portals/0/Documents/FactSheets/Mammals/Infectious%20agents%20in%20feral%20and%20wild%20Canids%20and%20Felids%20in%20Australia.pdf>

