



What Works in Conservation



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EDITED BY

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9. MANAGEMENT OF CAPTIVE ANIMALS

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Husbandry interventions for captive breeding amphibians

Expert assessors

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Jeff Dawson, Durrell Wildlife Conservation Trust, UK

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Jay Redbond, Wildfowl & Wetlands Trust, UK

Rebecca K. Smith, Cambridge University, UK

Benjamin Tapley, Herpetology Section, Zoological Society of London, UK

Scope of assessment: for husbandry interventions for captive breeding amphibians.

Assessed: 2017.

Promoting health and welfare in captive carnivores (felids, canids and ursids) through feeding practices

Expert assessors

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Marcus Clauss, University of Zurich, Switzerland

Ellen Dierenfeld, Independent comparative nutrition consultant, USA

Thomas Quirke, University College Cork, Republic of Ireland

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Scope of assessment: for promoting health and welfare in captive carnivores (felids, canids and ursids) through feeding practices.

Assessed: 2018.

Promoting natural feeding behaviours in primates in captivity

Expert assessors

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Scope of assessment: for promoting natural feeding behaviours in captive primates.

Assessed: 2017.

Effectiveness measure is the median % score for effectiveness.

Certainty measure is the median % certainty of evidence for effectiveness, determined by the quantity and quality of the evidence in the synopsis.

Harm measure is the median % score for negative side-effects on the species included.

This book is meant as a guide to the evidence available for different conservation interventions and as a starting point in assessing their effectiveness. The assessments are based on the available evidence for the target group of species for each intervention. The assessment may therefore refer to different species or habitat to the one(s) you are considering. Before making any decisions about implementing interventions it is vital that you read the more detailed accounts of the evidence in order to assess their relevance for your study species or system.

Full details of the evidence are available at
www.conservationevidence.com

There may also be significant negative side-effects on the target groups or other species or communities that have not been identified in this assessment.

A lack of evidence means that we have been unable to assess whether or not an intervention is effective or has any harmful impacts.

9.1 *Ex-situ* conservation – breeding amphibians

9.1.1 Refining techniques using less threatened species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for refining techniques using less threatened species?	
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none">• Identify and breed a similar species to refine husbandry techniques prior to working with target species

Unknown effectiveness (limited evidence)

- **Identify and breed a similar species to refine husbandry techniques prior to working with target species**

Two small, replicated interlinked studies in Brazil found that working with a less threatened surrogate species of frog first to establish husbandry interventions promoted successful breeding of a critically endangered species of frog. *Assessment: unknown effectiveness (effectiveness 68%; certainty 30%; harms 15%).*

<https://www.conservationevidence.com/actions/1862>

9.1.2 Changing environmental conditions/microclimate

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for changing environmental conditions/microclimate?	
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Vary enclosure temperature to simulate seasonal changes in the wild • Vary quality or quantity (UV% or gradients) of enclosure lighting to simulate seasonal changes in the wild • Provide artificial aquifers for species which breed in upwelling springs • Vary artificial rainfall to simulate seasonal changes in the wild
No evidence found (no assessment)	<ul style="list-style-type: none"> • Vary enclosure humidity to simulate seasonal changes in the wild using humidifiers, foggers/misters or artificial rain • Vary duration of enclosure lighting to simulate seasonal changes in the wild • Simulate rainfall using sound recordings of rain and/or thunderstorms • Allow temperate amphibians to hibernate • Allow amphibians from highly seasonal environments to have a period of dormancy during a simulated drought period • Vary water flow/speed of artificial streams in enclosures for torrent breeding species

Unknown effectiveness (limited evidence)

● **Vary enclosure temperature to simulate seasonal changes in the wild**

One small, replicated study in Italy found that one of six females bred following a drop in temperature from 20-24 to 17°C, and filling of an egg laying pond. One replicated, before-and-after study in 2006-2012 in Australia found that providing a pre-breeding cooling period, alongside allowing

females to gain weight before the breeding period, along with separating sexes during the non-breeding period, providing mate choice for females and playing recorded mating calls, increased breeding success. *Assessment: unknown effectiveness (effectiveness 50%; certainty 35%; harms 0%).*

<https://www.conservationevidence.com/actions/1864>

● **Vary quality or quantity (UV% or gradients) of enclosure lighting to simulate seasonal changes in the wild**

One replicated study in the UK found that there was no difference in clutch size between frogs given an ultraviolet (UV) boost compared with those that only received background levels. However, frogs given the UV boost had a significantly greater fungal load than frogs that were not UV-boosted. *Assessment: unknown effectiveness (effectiveness 0%; certainty 33%; harms 20%).*

<https://www.conservationevidence.com/actions/1865>

● **Provide artificial aquifers for species which breed in upwelling springs**

One small study in the USA found that salamanders bred in an aquarium fitted with an artificial aquifer. *Assessment: unknown effectiveness (effectiveness 50%; certainty 15%; harms 0%).*

<https://www.conservationevidence.com/actions/1871>

● **Vary artificial rainfall to simulate seasonal changes in the wild**

Two replicated, before-and-after studies in Germany and Austria found that simulating a wet and dry season, as well as being moved to an enclosure with more egg laying sites and flowing water in Austria, stimulated breeding and egg deposition. In Germany, no toadlets survived past 142 days old. *Assessment: unknown effectiveness (effectiveness 78%; certainty 33%; harms 0%).*

<https://www.conservationevidence.com/actions/1872>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Vary enclosure humidity to simulate seasonal changes in the wild using humidifiers, foggers/misters or artificial rain

- Vary duration of enclosure lighting to simulate seasonal changes in the wild
- Simulate rainfall using sound recordings of rain and/or thunderstorms
- Allow temperate amphibians to hibernate
- Allow amphibians from highly seasonal environments to have a period of dormancy
- Vary water flow/speed of artificial streams in enclosures for torrent breeding species

9.1.3 Changing enclosure design for spawning or egg laying sites

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for changing enclosure design for spawning or egg laying sites?	
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none">• Provide multiple egg laying sites within an enclosure• Provide natural substrate for species which do not breed in water (e.g. burrowing/tunnel breeders)• Provide particular plants as breeding areas or egg laying sites

Unknown effectiveness (limited evidence)

● **Provide multiple egg laying sites within an enclosure**

One replicated study in Australia found that frogs only bred once moved into an indoor enclosure which had various types of organic substrate, allowed temporary flooding, and enabled sex ratios to be manipulated along with playing recorded mating calls. One small, replicated, before-and-after study in Fiji found that adding rotting logs and hollow bamboo pipes to an enclosure, as well as a variety of substrates, promoted egg laying in frogs. *Assessment: unknown effectiveness (effectiveness 50%; certainty 25%; harms 0%).*

<https://www.conservationevidence.com/actions/1873>

● **Provide natural substrate for species which do not breed in water (e.g. burrowing/tunnel breeders)**

Two replicated studies in Australia and Fiji found that adding a variety of substrates to an enclosure, as well as rotting logs and hollow bamboo pipes in one case, promoted egg laying of frogs. The Australian study also temporarily flooded enclosures, manipulated sex ratios and played recorded mating calls. *Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 0%).*

<https://www.conservationevidence.com/actions/1874>

● **Provide particular plants as breeding areas or egg laying sites**

One small, controlled study in the USA found that salamanders bred in an aquarium heavily planted with java moss and swamp-weed. *Assessment: unknown effectiveness (effectiveness 75%; certainty 20%; harms 0%).*

<https://www.conservationevidence.com/actions/1875>

9.1.4 Manipulate social conditions

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for manipulating social conditions?	
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Manipulate sex ratio within the enclosure • Separate sexes in non-breeding periods • Play recordings of breeding calls to simulate breeding season in the wild • Allow female mate choice
No evidence found (no assessment)	<ul style="list-style-type: none"> • Provide visual barriers for territorial species • Manipulate adult density within the enclosure

Unknown effectiveness (limited evidence)

● **Manipulate sex ratio within the enclosure**

One replicated study in Australia found that frogs only bred once sex ratios were manipulated, along with playing recorded mating calls and moving

frogs into an indoor enclosure which allowed temporary flooding, and had various types of organic substrate. *Assessment: unknown effectiveness (effectiveness 35%; certainty 15%; harms 0%).*

<https://www.conservationevidence.com/actions/1879>

● **Separate sexes in non-breeding periods**

One replicated, before-and-after study in Australia found that clutch size of frogs increased when sexes were separated in the non-breeding periods, alongside providing female mate choice, playing recorded mating calls and allowing females to increase in weight before breeding. *Assessment: unknown effectiveness (effectiveness 65%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1880>

● **Play recordings of breeding calls to simulate breeding season in the wild**

One replicated study in Australia found that frogs only bred when recorded mating calls were played, as well as manipulating the sex ratio after frogs were moved into an indoor enclosure that allowed temporary flooding and had various types of organic substrates. One replicated, before-and-after study in Australia found that clutch size of frogs increased when playing recorded mating calls, along with the sexes being separated in the non-breeding periods, providing female mate choice, and allowing females to increase in weight before breeding. *Assessment: unknown effectiveness (effectiveness 35%; certainty 28%; harms 0%).*

<https://www.conservationevidence.com/actions/1881>

● **Allow female mate choice**

One replicated study in Australia found that frogs only bred after females carrying eggs were introduced to males, sex ratios were manipulated, recorded mating calls were played, and after being moved to an indoor enclosure which allowed temporary flooding and had various types of organic substrates. One replicated, before-and-after study in Australia found that clutch size of frogs increased when female mate choice was provided, alongside playing recorded mating calls, sexes being separated in the non-breeding periods, and allowing females to increase in weight before breeding. *Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 0%).*

<https://www.conservationevidence.com/actions/1882>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Provide visual barriers for territorial species
- Manipulate adult density within the enclosure.

9.1.5 Changing the diet of adults

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for changing the diet of adults?	
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Supplement diets with carotenoids (including for colouration) • Increase caloric intake of females in preparation for breeding
No evidence found (no assessment)	<ul style="list-style-type: none"> • Vary food provision to reflect seasonal availability in the wild • Formulate adult diet to reflect nutritional composition of wild foods • Supplement diets with vitamins/calcium fed to prey (e.g. prey gut loading) • Supplement diets with vitamins/calcium applied to food (e.g. dusting prey)

Unknown effectiveness (limited evidence)

● **Supplement diets with carotenoids (including for colouration)**

One study in the USA found that adding carotenoids to fruit flies fed to frogs reduced the number of clutches, but increased the number of tadpoles and successful metamorphs. *Assessment: unknown effectiveness (effectiveness 70%; certainty 28%; harms 0%).*

<https://www.conservationevidence.com/actions/1887>

● **Increase caloric intake of females in preparation for breeding**

One replicated, before-and-after study in Australia found that clutch size of frogs increased when females increased in weight before breeding, as well as having mate choice, recorded mating calls, and sexes being separated during the non-breeding periods. *Assessment: unknown effectiveness (effectiveness 60%; certainty 23%; harms 0%).*

<https://www.conservationevidence.com/actions/1888>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Vary food provision to reflect seasonal availability in the wild
- Formulate adult diet to reflect nutritional composition of wild foods
- Supplement diets with vitamins/calcium fed to prey (e.g. prey gut loading)
- Supplement diets with vitamins/calcium applied to food (e.g. dusting prey).

9.1.6 Manipulate rearing conditions for young

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for manipulating rearing conditions for the young	
Trade-off between benefit and harms	<ul style="list-style-type: none"> • Manipulate temperature of enclosure to improve development or survival to adulthood
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Formulate larval diets to improve development or survival to adulthood • Manipulate larval density within the enclosure
No evidence found (no assessment)	<ul style="list-style-type: none"> • Leave infertile eggs at spawn site as food for egg-eating larvae • Manipulate humidity to improve development or survival to adulthood • Manipulate quality and quantity of enclosure lighting to improve development or survival to adulthood • Allow adults to attend their eggs

Trade-off between benefit and harms

● **Manipulate temperature of enclosure to improve development or survival to adulthood**

One replicated study in Spain found that salamander larvae had higher survival rates when reared at lower temperatures. One replicated study in Germany found that the growth rate and development stage reached by harlequin toad tadpoles was faster at a higher constant temperature rather than a lower and varied water temperature. One replicated study in Australia found that frog tadpoles took longer to reach metamorphosis when reared at lower temperatures. One replicated, controlled study in Iran found that developing eggs reared within a temperature range of 12-25°C had higher survival rates, higher growth rates and lower abnormalities than those raised outside of that range. *Assessment: trade-offs between benefits and harms (effectiveness 80%; certainty 58%; harms 20%).*

<https://www.conservationevidence.com/actions/1893>

Unknown effectiveness (limited evidence)

● **Formulate larval diets to improve development or survival to adulthood**

One randomized, replicated, controlled study in the USA found that tadpoles had higher body mass and reached a more advanced developmental stage when fed a control diet (rabbit chow and fish food) or freshwater algae, compared to those fed pine or oak pollen. One randomized, replicated study in Portugal found that tadpoles reared on a diet containing 46% protein had higher growth rates, survival and body weights at metamorphosis compared to diets containing less protein. *Assessment: unknown effectiveness (effectiveness 65%; certainty 35%; harms 0%).*

<https://www.conservationevidence.com/actions/1889>

● **Manipulate larval density within the enclosure**

One randomized study in the USA found that decreasing larval density of salamanders increased larvae survival and body mass. *Assessment: unknown effectiveness (effectiveness 88%; certainty 28%; harms 0%).*

<https://www.conservationevidence.com/actions/1894>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Leave infertile eggs at spawn site as food for egg-eating larvae
- Manipulate humidity to improve development or survival to adulthood
- Manipulate quality and quantity of enclosure lighting to improve development or survival to adulthood
- Allow adults to attend their eggs.

9.1.7 Artificial reproduction

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for artificial reproduction?	
No evidence found (no assessment)	• Use artificial cloning from frozen or fresh tissue

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Use artificial cloning from frozen or fresh tissue

For summarised evidence for

Use hormone treatment to induce sperm and egg release

Use artificial fertilization in captive breeding

See Smith, R.K. and Sutherland, W.J. (2014) *Amphibian Conservation: Global Evidence for the Effects of Interventions*. Exeter, Pelagic Publishing.

Key messages and summaries are available here:

<https://www.conservationevidence.com/actions/834>

<https://www.conservationevidence.com/actions/883>

9.2 Promoting health and welfare in captive carnivores (felids, canids and ursids) through feeding practices

9.2.1 Diet and food type

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for diet and food type?	
Likely to be beneficial	<ul style="list-style-type: none"> • Provide bones, hides or partial carcasses
Trade-off between benefit and harms	<ul style="list-style-type: none"> • Feed whole carcasses (with or without organs/ gastrointestinal tract)
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Feed commercially prepared diets • Feed plant-derived protein • Supplement meat-based diets with prebiotic plant material to facilitate digestion • Supplement meat-based diet with amino acids
No evidence found (no assessment)	<ul style="list-style-type: none"> • Supplement meat-based diet with vitamins or minerals • Supplement meat-based diet with fatty acids • Increase variety of food items

Likely to be beneficial

● Provide bones, hides or partial carcasses

One replicated, before-and-after study in the USA and one replicated, controlled study in Finland found that the provision of bones decreased the frequency of stereotypic behaviours in lions, tigers and Arctic foxes. Two replicated, before-and-after studies of felids and red foxes in the USA and Norway found that the provision of bones increased activity and manipulation time. *Assessment: likely to be beneficial (effectiveness 80%; certainty 60%; harms 0%).*

<https://www.conservationevidence.com/actions/1902>

Trade-off between benefit and harms

● Feed whole carcasses (with or without organs/gastrointestinal tract)

Two replicated, before-and-after studies in the USA found that feeding whole carcasses reduced pacing levels in lions, leopards, snow leopards and cougars. However, it increased pacing in tigers. One replicated, randomized, controlled study in Denmark found that when fed whole rabbit, cheetahs had lower blood protein urea, zinc and vitamin A levels compared to supplemented beef. One replicated before-and-after study in Denmark found that feeding whole rabbit showed lower levels of inflammatory bowel indicators in cheetahs. One replicated, randomized study and one controlled study in the USA found that when fed whole 1 to 3 day old chickens, ocelots had lower digestible energy and fat compared to a commercial diet and African wildcats had had lower organic matter digestibility compared to a ground-chicken diet. *Assessment: trade-offs between benefits and harms (effectiveness 80%; certainty 70%; harms 25%).*

<https://www.conservationevidence.com/actions/1901>

Unknown effectiveness (limited evidence)

● Feed commercially prepared diets

One replicated, before-and-after study in the USA found that providing a commercial diet to maned wolves led to similar dry matter intake and digestibility despite having a lower protein content. One replicated, controlled study in South Africa found that cheetahs fed a commercial diet had a similar likelihood of developing gastritis as those fed horse meat, lower levels of

blood protein urea but higher levels of creatine. One study in USA found that cheetahs fed a commercial meat diet or whole chicken carcasses had plasma a-tocopherol, retinol and taurine concentrations within the ranges recommended for domestic cats. *Assessment: unknown effectiveness (effectiveness 40%; certainty 35%; harms 50%).*

<https://www.conservationevidence.com/actions/1900>

● **Feed plant-derived protein**

One replicated, randomized, controlled study and one replicated, controlled study in the USA found that a plant-derived protein diet increased digestible energy and dry matter digestibility but decreased mineral retention and plasma taurine levels in maned wolves compared to a (supplemented) animal-based protein diet. *Assessment: unknown effectiveness (effectiveness 10%; certainty 25%; harms 70%).*

<https://www.conservationevidence.com/actions/1903>

● **Supplement meat-based diets with prebiotic plant material to facilitate digestion**

One replicated, before-and-after study in India found that providing Jerusalem artichoke as a supplement increased two types of gut microbiota, faecal scores and faecal moisture content in leopards. *Assessment: unknown effectiveness (effectiveness 50%; certainty 25%; harms 0%).*

<https://www.conservationevidence.com/actions/1905>

● **Supplement meat-based diet with amino acid**

One replicated, before-and-after study in the USA found that supplementing an animal-protein diet with taurine, increased plasma taurine levels in maned wolves. *Assessment: unknown effectiveness (effectiveness 90%; certainty 25%; harms 0%).*

<https://www.conservationevidence.com/actions/1908>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Supplement meat-based diet with vitamins or minerals
- Supplement meat-based diet with fatty acids
- Increase variety of food items.

9.2.2 Food presentation and enrichment

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for food presentation and enrichment?	
Beneficial	<ul style="list-style-type: none"> • Hide food around enclosure
Likely to be beneficial	<ul style="list-style-type: none"> • Present food frozen in ice • Present food inside objects (e.g. Boomer balls)
Trade-off between benefit and harms	<ul style="list-style-type: none"> • Provide devices to simulate live prey, including sounds, lures, pulleys and bungees
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Change location of food around enclosure • Scatter food around enclosure • Provide live vertebrate prey • Provide live invertebrate prey
No evidence found (no assessment)	<ul style="list-style-type: none"> • Present food in/on water • Use food as a reward in animal training

Beneficial

● Hide food around enclosure

Four replicated, before-and-after studies in the USA, UK and Germany and one before-and-after study of a black bear, leopard cats, bush dogs, maned wolves and Malayan sun bears found that hiding food increased exploring and foraging behaviours. One replicated, before-and-after study and one before-and-after study in the USA found a decrease in stereotypical pacing in leopard cats and black bear. One before-and-after study in the USA found that hiding food reduced the time Canadian lynx spent sleeping during the day. *Assessment: beneficial (effectiveness 90%; certainty 70%; harms 10%).*

<https://www.conservationevidence.com/actions/1915>

Likely to be beneficial

● Present food frozen in ice

Two replicated, before-and-after studies in the USA found that when presented with food frozen in ice, abnormal or stereotypic behaviours decreased and activity levels increased in bears and felids. One replicated, before-and-after

study in the USA found that manipulation behaviours increased in lions, whereas a replicated study in the USA found that manipulation behaviours decreased in grizzly bears. *Assessment: likely to be beneficial (effectiveness 70%; certainty 52%; harms 10%).*

<https://www.conservationevidence.com/actions/1923>

● Present food inside objects (e.g. Boomer balls)

Two before-and-after studies in Germany and India found that exploratory and foraging behaviours increased and stereotypic behaviours decreased in sloth bears and spectacled bears when presented with food inside objects. One before-and-after study in the USA found that exploring/foraging behaviours decreased in a sloth bear when presented with food inside objects. One replicated study in the USA found that grizzly bears spent a similar time manipulating food in a box and freely available food. *Assessment: likely to be beneficial (effectiveness 60%; certainty 70%; harms 10%).*

<https://www.conservationevidence.com/actions/1924>

Trade-off between benefit and harms

● Provide devices to simulate live prey, including sounds, lures, pulleys and bungees

Two before-and-after studies in the USA and the UK found that activity levels and behavioural diversity increased in felids when presented with a lure or pulley system. One replicated, before-and-after study in the USA found that pacing behaviour decreased and walking increased in cougars, but pacing initially increased in tigers, when provided with a carcass on a bungee. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 50%; harms 25%).*

<https://www.conservationevidence.com/actions/1927>

Unknown effectiveness (limited evidence)

● Change location of food around enclosure

One replicated, before-and-after study in Ireland found that altering the location of food decreased pacing behaviours in cheetahs. *Assessment: unknown effectiveness (effectiveness 90%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1918>

● Scatter food around enclosure

One replicated, before-and-after study in Brazil found that scattered feeding increased locomotion in maned wolves. One replicated study in Brazil found that maned wolves spent more time in the section of their enclosure with scattered food than in a section with food on a tray. *Assessment: unknown effectiveness (effectiveness 70%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1921>

● Provide live vertebrate prey

One small before-and-after study in the USA found that hunting behaviour increased and sleeping decreased when a fishing cat was provided with live fish. One replicated, before-and-after study in the USA found that there was no change in the occurrence of stereotypical behaviours in tigers when provided with live fish. *Assessment: unknown effectiveness (effectiveness 50%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1925>

● Provide live invertebrate prey

One replicated study in the USA found that provision of live prey increased explorative behaviours in fennec foxes compared to other types of enrichment. *Assessment: unknown effectiveness (effectiveness 80%; certainty 20%; harms 0%).*

<https://www.conservationevidence.com/actions/1926>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Present food in/on water
- Use food as a reward in animal training.

9.2.3 Feeding schedule

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for feeding schedule?	
Trade-off between benefit and harms	• Provide food on a random temporal schedule

Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Allocate fast days
No evidence found (no assessment)	<ul style="list-style-type: none"> • Alter food abundance or type seasonally • Provide food during natural active periods • Use automated feeders • Alter feeding schedule according to visitor activity • Provide food during visitor experiences

Trade-off between benefit and harms

● Provide food on a random temporal schedule

Three replicated, before-and-after studies and one replicated, controlled study found that an unpredictable feeding schedule reduced the frequency of stereotypic pacing behaviours in tigers and cheetahs. One replicated, before-and-after controlled study in the USA found that an unpredictable feeding schedule increased territorial behaviour in coyotes but did not affect travelling or foraging. One before-and-after study in Switzerland found that an unpredictable feeding schedule increased behavioural diversity in red foxes. *Assessment: trade-offs between benefits and harms (effectiveness 100%; certainty 80%; harms 20%).*

<https://www.conservationevidence.com/actions/1904>

Unknown effectiveness (limited evidence)

● Allocate fast days

One replicated, before-and-after study in the UK found that large felids fed once every three days paced more frequently on non-feeding days. *Assessment: unknown effectiveness (effectiveness 6%; certainty 25%; harms 50%).*

<https://www.conservationevidence.com/actions/1906>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Alter food abundance or type seasonally

- Provide food during natural active periods
- Use automated feeders
- Alter feeding schedule according to visitor activity
- Provide food during visitor experiences.

9.2.4 Social feeding

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for social feeding?	
No evidence found (no assessment)	<ul style="list-style-type: none">• Feed individuals separately• Feed individuals within a social group• Hand-feed

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Feed individuals separately
- Feed individuals within a social group
- Hand-feed.

9.3 Promoting natural feeding behaviours in primates in captivity

9.3.1 Food Presentation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for food presentation?	
Beneficial	<ul style="list-style-type: none"> • Scatter food throughout enclosure
Likely to be beneficial	<ul style="list-style-type: none"> • Hide food in containers (including boxes and bags) • Present food frozen in ice • Present food items whole instead of processed • Present feeds at different crowd levels • Maximise both vertical and horizontal presentation locations
Trade-off between benefit and harms	<ul style="list-style-type: none"> • Present food in puzzle feeders
Unknown effectiveness (limited evidence)	<ul style="list-style-type: none"> • Present food in water (including dishes and ponds) • Present food dipped in food colouring • Provide live vegetation in planters for foraging
No evidence found (no assessment)	<ul style="list-style-type: none"> • Present food which required the use (or modification) of tools • Paint gum solutions on rough bark • Add gum solutions to drilled hollow feeders

Beneficial

● Scatter food throughout enclosure

Four studies, including one replicated study, in the USA, found that scattering food throughout enclosures increased overall activity, feeding and exploration and decreased abnormal behaviours and aggression. *Assessment: beneficial (effectiveness 80%; certainty 80%; harms 0%).*

<https://www.conservationevidence.com/actions/1315>

Likely to be beneficial

● Hide food in containers (including boxes and bags)

Three studies including two before-and-after studies in the USA and Ireland found that the addition of food in boxes, baskets or tubes increased activity levels in lemurs and foraging levels in gibbons. *Assessment: likely to be beneficial (effectiveness 75%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1316>

● Present food frozen in ice

Two studies in the USA and Ireland found that when frozen food was presented, feeding time increased and inactivity decreased. *Assessment: likely to be beneficial (effectiveness 60%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1321>

● Present food items whole instead of processed

One before-and-after study in the USA found that when food items were presented whole instead of chopped, the amount of food consumed and feeding time increased in macaques. *Assessment: likely to be beneficial (effectiveness 80%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1323>

● Present feeds at different crowd levels

One before-and-after study in the USA found that when smaller crowds were present foraging and object use in chimpanzees increased. *Assessment: likely to be beneficial (effectiveness 60%; certainty 40%; harms 0%).*

<https://www.conservationevidence.com/actions/1324>

● Maximise both vertical and horizontal presentation locations

One controlled study in the UK and Madagascar found that less time was spent feeding on provisioned food in the indoor enclosure when food was hung in trees in an outdoor enclosure. One replicated, before-and-after study in the UK reported that when vertical and horizontal food locations were increased feeding time increased. *Assessment: likely to be beneficial (effectiveness 65%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1328>

Trade-off between benefit and harms

● Present food in puzzle feeders

Three studies including two before-and-after studies in the USA and UK found that presenting food in puzzle feeders, increased foraging behaviour, time spent feeding and tool use but also aggression. *Assessment: trade-offs between benefits and harms (effectiveness 55%; certainty 80%; harms 60%).*

<https://www.conservationevidence.com/actions/1318>

Unknown effectiveness (limited evidence)

● Present food in water (including dishes and ponds)

One replicated, before-and-after study in the USA found that when exposed to water filled troughs, rhesus monkeys were more active and increased their use of tools. *Assessment: unknown effectiveness (effectiveness 60%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1320>

● Present food dipped in food colouring

One before-and-after study in the USA found that when food was presented after being dipped in food colouring, orangutans ate more and spent less time feeding. *Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 20%).*

<https://www.conservationevidence.com/actions/1322>

● Provide live vegetation in planters for foraging

One replicated, before-and-after study in the USA reported that chimpanzees spent more time foraging when provided with planted rye grass and scattered sunflower seeds compared to browse and grass added to the enclosure with their normal diet. *Assessment: unknown effectiveness (effectiveness 80%; certainty 30%; harms 0%).*

<https://www.conservationevidence.com/actions/1327>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Present food which required the use (or modification) of tools
- Paint gum solutions on rough bark
- Add gum solutions to drilled hollow feeders.

9.3.2 Diet manipulation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for diet manipulation?	
Likely to be beneficial	<ul style="list-style-type: none">• Formulate diet to reflect nutritional composition of wild foods (including removal of domestic fruits)• Provide cut branches (browse)• Provide live invertebrates• Provide fresh produce
No evidence found (no assessment)	<ul style="list-style-type: none">• Provide gum (including artificial gum)• Provide nectar (including artificial nectar)• Provide herbs or other plants for self-medication• Modify ingredients/nutrient composition seasonally (not daily) to reflect natural variability

Likely to be beneficial

- **Formulate diet to reflect nutritional composition of wild foods (including removal of domestic fruits)**

Two replicated, before-and-after studies in the USA and UK found that when changing the diet of captive primates to reflect nutritional compositions of wild foods, there was a decrease in regurgitation and reingestion, aggression and self-directed behaviours. *Assessment: likely to be beneficial (effectiveness 70%; certainty 60%; harms 0%).*

<https://www.conservationevidence.com/actions/1329>

● Provide cut branches (browse)

One replicated, before-and-after study in the Netherlands and Germany found that captive gorillas when presented with stinging nettles use the same processing skills as wild gorillas to forage. *Assessment: likely to be beneficial (effectiveness 70%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1332>

● Provide live invertebrates

One before-and-after study in the UK found that providing live invertebrates to captive lorises increased foraging levels and reduced inactivity. *Assessment: likely to be beneficial (effectiveness 85%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1333>

● Provide fresh produce

One replicated, before-and-after study in the USA found that when fresh produce was offered feeding time increased and inactivity decreased in rhesus macaques. *Assessment: likely to be beneficial (effectiveness 60%; certainty 40%; harms 1%).*

<https://www.conservationevidence.com/actions/1335>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Provide gum (including artificial gum)
- Provide nectar (including artificial nectar)
- Provide herbs or other plants for self-medication

- Modify ingredients/nutrient composition seasonally (not daily) to reflect natural variability.

9.3.3 Feeding Schedule

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for feeding schedule?	
Likely to be beneficial	<ul style="list-style-type: none">• Change feeding times
Trade-off between benefit and harms	<ul style="list-style-type: none">• Change the number of feeds per day
No evidence found (no assessment)	<ul style="list-style-type: none">• Provide food at natural (wild) feeding times• Provide access to food at all times (day and night)• Use of automated feeders

Likely to be beneficial

● Change feeding times

One controlled study in the USA found that changing feeding times decreased inactivity and abnormal behaviours in chimpanzees. *Assessment: likely to be beneficial (effectiveness 70%; certainty 50%; harms 0%).*

<https://www.conservationevidence.com/actions/1338>

Trade-off between benefit and harms

● Change the number of feeds per day

Two before-and-after studies in Japan and the USA found that changing the number of feeds per day increased time spent feeding in chimpanzees but also increased hair eating in baboons. *Assessment: trade-offs between benefits and harms (effectiveness 70%; certainty 50%; harms 50%).*

<https://www.conservationevidence.com/actions/1337>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Provide food at natural (wild) feeding times
- Provide access to food at all times (day and night)
- Use of automated feeders.

9.3.4 Social group manipulation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for social group manipulation?	
Trade-off between benefit and harms	<ul style="list-style-type: none"> • Feed individuals in social groups
No evidence found (no assessment)	<ul style="list-style-type: none"> • Feed individuals separately • Feed individuals in subgroups

Trade-off between benefit and harms

● Feed individuals in social groups

One replicated, controlled study in the USA found that an enrichment task took less time to complete when monkeys were in social groups than when feeding alone. One before-and-after study in Italy found that in the presence of their groupmates monkeys ate more unfamiliar foods during the first encounter. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 50%; harms 25%).*

<https://www.conservationevidence.com/actions/1343>

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Feed individuals separately
- Feed individuals in subgroups.

