

BPRC's

ENRICHMENT
MANUAL

for Macaques & Marmosets

Edited by M.K. Vernes and A.L. Louwerse



BPRC

Publication of the Biomedical Primate Research Centre

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for
MACAQUES & MARMOSETS

Preface

This enrichment manual is a compilation of the different environmental enrichment items used at the Biomedical Primate Research Centre (BPRC) in Rijswijk, The Netherlands. At the BPRC, we keep long-tailed macaques (*Macaca fascicularis*), rhesus macaques (*Macaca mulatta*) and common marmosets (*Callithrix jacchus*). As most 'rhesus' enrichment is also suitable for long-tailed macaques, this manual will use 'macaque' enrichment to discuss possible enrichment items for both species.

The first chapter of this enrichment manual deals with macaque enrichment items. This chapter itself will be divided into two parts: first non-food enrichment items, for both pair- and group-housed macaques. The second part demonstrates possibilities for food enrichment for both pair- and group-housed macaques.

The second chapter of this enrichment manual deals with enrichment items we provide to our marmosets. This chapter will again be divided into two parts: first non-food enrichment items for both pair- and group-housed marmosets. The second part deals with food enrichment items for both pair- and group-housed marmosets.

The description of each enrichment item includes why the device is important, how animals use it, how to construct and how to clean it. In the food enrichment part of each section, recipes have been composed describing the materials and preparation as well as nutritional information and storing suggestions.

Although these enrichment devices have only been used with our two species of macaques and with our marmosets, it is probable that they can also be used as environmental enrichment for other non-human primates. The designs discussed in this manual may not be usable in all facilities, so small modifications might be needed. While using environmental enrichment, always keep safety considerations in mind to prevent conflicts and injuries.

We would like to thank our sponsors, who donate money and/or materials to help us provide our animals with as much enrichment as possible. Thanks are due as well to the BPRC animal care staff for contributing to this manual by devising new enrichment ideas.

Last but not least, we thank our macaques and marmosets for trying out the new types of enrichment and showing us how to obtain suitable and durable enrichment possibilities.

We hope you will find this manual helpful, inspirational and stimulating to set up your own environmental enrichment programme.

On behalf of BPRC's Animal Science Department,

Marit Vernes

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This handbook provides guidelines for enrichment for macaques and marmosets. Every reasonable effort has been made to ensure that the information provided is current, safe and accurate. However, users are responsible for the application in their own facilities. Without limitation, the authors shall not be deemed negligent or liable for any damage whatsoever either indirect or consequential which may arise from the use of these guidelines.

Special thanks are due to the animal caretakers and veterinarians who have invented, developed and tried out the enrichment items in this book. We gratefully acknowledge Henk van Westbroek, who has created this book's lay-out.

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Chapter 1: Macaque enrichment

Part 1: Non-food enrichment

Non-food enrichment is used to stimulate animals to express natural and species specific behaviours.

Through providing animals with non-food enrichment items like toys, mirrors and climbing possibilities, the development of unwanted abnormal and stereotypical behaviour is slowed down or even prevented.

By offering our macaques a challenging enclosure, which renews regularly, they are physically and psychologically stimulated and boredom is prevented.

1.1.1 Non-food enrichment for group-housed macaques

All macaques in our breeding facility are housed in family-groups, each group consisting of 20-30 members. To provide the animals with a challenging and enriched environment, the following non-food enrichment items are used at the BPRC:

- Perches
- Windows
- Rings mounted in walls and ceilings
- Ladders
- Car tires
- Fire hoses
- Sawdust in inside enclosure
- Hammocks
- Swinging crates
- Rope ladders
- Climbing frames
- Tree trunks and branches
- Swimming pools
- Telephone directories

Each family-group in our breeding-facility has as many of these enrichment items included in their enclosure as possible. Furthermore, the animals in our breeding facility have access to both an inside and an outside enclosure, which they can access by choice.

To prevent disturbing the groups too often to provide non-food enrichment, items are mostly supplied, replaced or repaired while cleaning the inside enclosure. This cleaning of the inside enclosures happens once every three weeks, and the animals are sent to the outside enclosure, so work can be done calmly.



Furthermore, non-food enrichment in the outside enclosures is supplied, replaced or repaired when needed. Good observation of the use of non-food enrichment and checking the enrichment items regularly for fraying or sharp edges is important.

Perches

Perches open up the vertical dimension of an enclosure, thereby increasing the usable cage space. In addition, perches increase species specific behaviour such as climbing, balancing and surveying the environment.

The perches used in our group-housing facilities are made of three composite plastic round beams, mounted together on a supporting frame using bolts. Each beam has a circumference of 33 centimetres and can be cut to any desired length. The perches can be placed at various heights, but the perches on each wall should overlap to ensure that animals can reach them. By placing the perches at strategical points in the enclosure, a route is designed for the macaques to follow while moving around.

Windows

In nature, primates are exposed to a complex and shifting visual landscape. To provide similar fluctuating visual scenes, windows are mounted in the outside walls of all inside enclosures. The windows also allow sunlight to enter and to illuminate the building.

The windows are 80 centimetres tall, 85 centimetres wide and are countersunk in the walls. As a result, a seat is created which enables animals to reach the window easily and to sit and look outside. These characteristics make the windows a favorite place for the macaques to sit and enjoy the view.

Rings

Rings are mounted on all walls and ceilings of our inside enclosures to help the animals move around. Macaques use rings for playing and climbing. Furthermore, all sorts of environmental enrichment devices can be hung from them. The rings are made of stainless steel, measure 10 centimetres in diameter and are mounted on the walls by drilling a hole and screwing them in, securing them with Loctite®. In each of the three compartments of the inside enclosure, 24 rings are mounted on the ceiling, while each wall has 10 rings.



Ladders

Ladders are installed to help macaques reaching perches. When members of a family-group get older, ladders get more important in order to reach perches. Furthermore, ladders improve the accessibility of the enclosure, enabling all animals to move easily from the floor to a higher position or the other way around.

Ladders are made of bar-shaped composite plastic beams and consist of two long beams (2.45 metres) with seven rungs, each 50 centimetres wide. The seven rungs are mounted 20-25 centimetres apart. Attached to the perches by means of bolts, the ladders are not fixed to the floor. This enables the ladder to be lifted from the floor while cleaning the enclosure.



Car tires

The animals use car tires for climbing, playing, swinging and seating. In addition, the car tires make the enclosure more accessible to the animals and they open up the vertical dimension. The car tires can be hung from fire hoses as well as placed individually in the enclosure. Car tires of all sizes can be used for hanging. In the outside enclosure, large car tires can also be dug in the soil. Always drill several small holes in the tire to make sure water caught inside can be diverted.



Fire hoses

Fire hoses are mounted on the ceiling by means of rings, bolts and nuts. The animals use the fire hoses for climbing, playing and seating. Moreover, fire hoses make the enclosure more accessible to the animals and open up the vertical dimension. Fire fighters generally donate the hoses, but they can also be purchased from a wholesale trade.

When using fire hoses, it is important to ensure that the hoses are checked regularly for fraying, as an animal could easily catch and injure a finger or toe during play. To prevent this, replace worn fire hoses at regular intervals and cut off frayed edges.

Fire hoses can easily be used to create other enrichment items to fit in the (outdoor) enclosures. Examples are hammocks and swinging crates (see page 19).



Sawdust in inside enclosure

Sawdust is spread on the floors in all inside enclosures. Before we began to use sawdust, the inside enclosures had no bedding and had to be cleaned every day. This also meant disturbing the family-groups every day while cleaning. To obtain a more stable and calmer breeding colony, sawdust was introduced to cover the floors and absorb urine and faeces. Depending on the size of the group and the type of enclosure, the use of sawdust as bedding means that an inside enclosure now only needs to be cleaned once every three weeks.



With the use of sawdust as bedding, new possibilities for providing environmental enrichment emerged. Sawdust is an excellent material to provide animals with foraging enrichment and it allows them to develop and maintain this very important species specific behaviour. To promote the expression of foraging behaviour, an enrichment mix (see page 32) can be scattered in the sawdust. This keeps animals busy for the rest of the day while foraging for the small seeds.

Hammocks

The animals use hammocks for climbing, playing and seating. The best hammock is made using longer fire hoses on the outer sides, so it can easily be suspended inside the enclosure. Hammocks can easily be created by using at least 6 fire hoses with a minimum length of 2,5 metres. Make a hammock by weaving the fire hoses. Use bolts, nuts and rings to suspend it in the enclosure, to secure the ends of each fire hose and to prevent fraying.

Swinging crates

Swinging crates provide a lot of fun for our macaques as they can be used both actively and passively. Active use of the device results in wild swinging and making lots of noise. Passive use results in animals climbing inside the crate and lay down while resting and sunbathing.

To create a swinging crate, use two fire hoses (each about two metres long), a crate, two sheer connectors to suspend the swinging crate and some bolts, nuts and rings to secure the fire hoses.

Attach a fire hose to each handle of the crate using bolts, nuts and rings. After this, the swinging crate can be suspended in both the inside and the outside enclosure by using more bolts, nuts and rings.



Rope ladders, climbing frames, slides and tree trunks

To provide the animals with climbing facilities, rope ladders, climbing frames, slides and tree trunks are placed in the outside enclosures.

These items have been made available by various donators. The devices have all been placed securely in the ground to prevent them from falling over. Rope ladders have also been attached to the ceiling, using bolts and nuts of appropriate dimensions.

The tree trunks and branches, mostly from willows, are most popular when they have just been placed into the ground or handed out, as the animals find the bark very interesting and quickly peel it off. After this, the tree trunk is used for climbing, playing and hiding.

The climbing frames are usually made of metal but can also be wooden and are mainly used by young animals for playing, climbing and sliding down.



Swimming pools

Swimming pools are provided to promote species specific behaviour such as swimming and playing, and they help the animals to cool down in hot weather. The pools are also used when the temperature is below freezing, as the ice is a real treat for the animals.

The swimming pool should be shallow to prevent animals from drowning, and made of firm plastic that is resistant to chewing. Every breeding group has its own swimming pool, which is placed in the outside enclosure.

When used regularly, the swimming pool should be cleaned weekly to maintain the quality of the water.



Telephone directories

Telephone directories, generally six per enclosure, are a short-term type of non-food enrichment. After they are provided with the directories, the animals will begin to play and shred. This will keep them busy for up to 4 days.

If no telephone directories are available, other types of directories and magazines can be used as long as there are no staples inside. If there are staples, simply remove them and hand the paper out to the animals.

1.1.2 Non-food enrichment for pair-housed macaques

At the BPRC, we strive after an experimental set-up in which we can provide our macaques with social enrichment by means of pair-housing. In some cases however, it might be necessary to keep some macaques in single-housing enclosures. In these single- and pair-housing conditions, we find it very important that the macaques have some form of non-food enrichment every day. The following enrichment items can be distributed amongst animals that are housed singly or in pairs:

- Kong toys
- Mirrors
- Nylabone rings and tug toys
- Triangle rattles
- Swimming pools
- Shakers
- Food puzzles
- Perches
- Sounds through music

The food puzzle allows you to offer the daily amount of food in an alternative way. Music is played during the time that the caretakers are present in the building. Perches and music are being used as permanent enrichment. Swimming pools are a type of non-food enrichment, which can be used as an extra treat for your animals.

To keep the other types of non-food enrichment interesting, we have created a rotating schedule for each animal-room. For example, when 20 cages in an animal room are keeping macaques a rotating schedule can look as follows:

		Cage																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Week	1	Nylabone ring			Mirror					Kong toy			Triangle rattle								Shaker
	2	Shaker			Nylabone ring					Mirror			Kong toy								Triangle rattle
	3	Triangle rattle			Shaker					Nylabone ring			Mirror								Kong toy
	4	Kong toy			Triangle rattle					Shaker			Nylabone ring								Mirror
	5	Mirror			Kong toy					Triangle rattle			Shaker								Nylabone ring

When the non-food enrichment items are rotated according to the schedule, all animals will have a different type of environmental enrichment each week for a period of 5 weeks. After 5 weeks, this rotating schedule is repeated.

Kong toys

Macaques are naturally curious animals and they explore and manipulate the various kinds of objects they encounter. To help compensate for the comparatively sparse environment, toys can be provided to give the animals opportunities for manipulation and exploration. An example of such a toy is a kong toy.



Kong toys are made from durable, natural rubber and can be purchased in four sizes, from 'small' to 'extra large'. For macaques, kongs in size 'large' are preferred. These toys are 8 centimetres high and 6 centimetres wide.

Next to kong toys, there are rhinos. These are toys with large nubs on the outside, which clean teeth and massage gums. Both kong toys and rhinos can be purchased from distributors of primate products or enrichment specialists.

The kong toy can be attached to the cage using a snap hook, which is attached to the toy by a 20 centimetres long, stainless steel, chain. The kong toy should be placed on the outside of the cage, in a place where it can easily be reached and manipulated by the animal.

Kong toys can also be used in food enrichment (see page 45).

Clean kong toys and rhinos using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush. They can then be dried and handed out to other animals.



Mirrors

A mirror fixed to the cage of a macaque has a two-sided effect: it enables the animal to see areas, which are normally invisible, and makes it possible for them to see other macaques. Mostly, however, the animal sees its own reflection in the mirror. Because macaques are not capable of self-recognition, the reflection appears to be another macaque. The presence of a mirror on the cage of a single- or pair-housed macaque increases the animal's communicative behaviour.

A mirror consists of a circular-shaped piece of stainless steel 16 centimetres in diameter. A small hole is drilled into the stainless steel and a chain 25 centimetres long is connected. A snap-hook at the end of the chain ensures the mirror can readily be attached to the outside of the cage, in a place where it can easily be reached and manipulated. These mirrors can be purchased from distributors of products for primates or enrichment specialists, or can be homemade. When making mirrors yourself, make sure sharp edges are absent and the device is safe to use.

Interest in the mirror can be preserved if it does not remain too long in one place at the cage. After several days, the mirror should be placed at another side of the cage. This 'new toy' will regain the interest of the animal, and the next time this animal is given a mirror it will be interesting again.

It is possible the mirror will lose its shine after a certain period. To bring back the shine, the mirror should be cleaned using water and detergent and then polished with a cloth.

In some cases, however, an animal will react opposite to the above and will become aggressive towards its roommates or towards the mirror. In these cases, immediately remove the mirror and provide the animal with another type of non-food enrichment. Make a note of the animal disliking mirrors, so it will not be provided again.



Nylabone rings and tug toys

The nylabone ring consists of a durable exterior and a softer interior, which encourages chewing. The ring is ideal for promoting play, while at the same time the chewing helps to remove plaque and tartar from the animals' teeth.



The nylabone rings are made of 100% nylon and can be ordered in two sizes: 9 centimetres and 15 centimetres in diameter. The tug toy is also made of 100% nylon and is 33 centimetres long and 13 centimetres wide. Tug toys and nylabone rings can be purchased from distributors of primate products or enrichment specialists.



Both the bigger tug toys as well as the nylabone rings can be placed inside the cage. The animal will quickly start to play and chew. Usually, when the macaque is done playing, it will throw the toy out of the cage. Both the nylabone ring and the tug toy can easily be cleaned and placed in the cages of other animals.

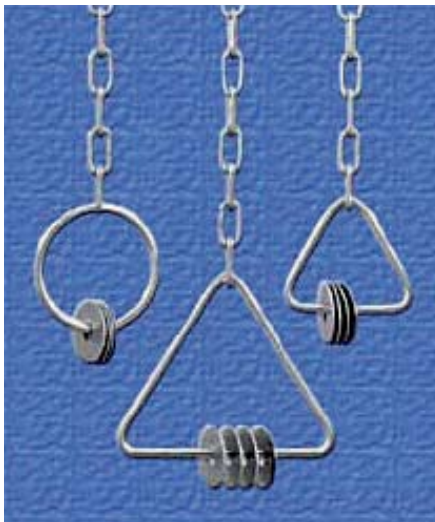
Clean nylabone rings and tug toys using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush.

Triangle rattles

The rattle was developed to stimulate a macaques' natural instinct to manipulate objects. Because the rattle produces noise while it is being used, the animals become increasingly interested in the device. Rattles can be purchased from distributors of primate products or enrichment specialists.

The rattle is made of stainless steel in the shape of a triangle, though they can also be purchased in the shape of a ring. The animals can manipulate and shake this device to make noise. Four washers run along the bottom rod and the tip of the triangle runs through a chain 18 centimetres long; the chain is connected to a snap hook used to fasten the device to the outside of the cage. The rattle should be placed on the outside of the cage, in a place where it can easily be reached and manipulated.

Clean the rattles using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush. Finally, they can be dried and handed out to other animals.



Shakers

The shaker was developed to meet the animals' natural need to manipulate objects. Noise is produced when the shaker is used, which increasingly stimulates a macaque to further manipulate and examine the object.

Shakers are created using a pvc-tube without holes. A screw thread is created at both ends of the tube where the caps can be screwed on. A chain for hanging is attached to one cap by means of a screw.

Before making a shaker, ensure that the pvc-tubes are clean and empty. Open the tube by unscrewing one cap and drop about 5 small pebbles into the tube. After this, screw the cap back on and agglutinate the cap, with the chain attached, to the pvc-tube. Give the shaker to the animals by hanging it on the outside of the cage in a place where it can easily be reached and manipulated.

Clean the outside of the shakers regularly using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush. Finally, they can be dried and handed out to other animals.

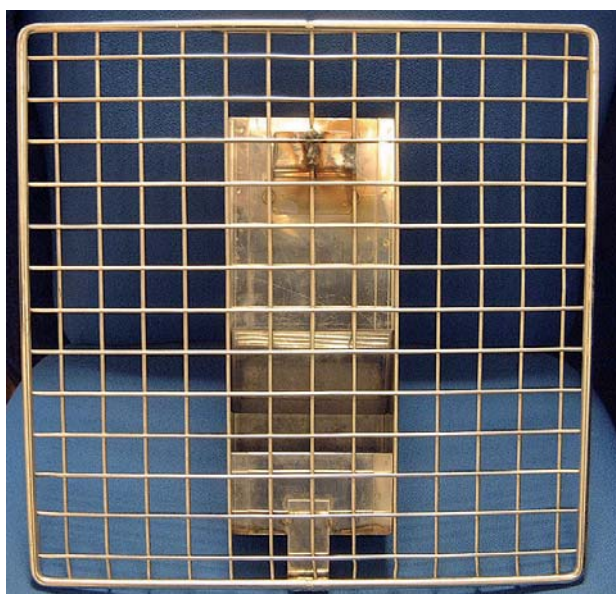


Food puzzles

Food puzzles are created to encourage the animals to work at obtaining their food. Normally, the food is offered in such a way that little or no effort is required to collect and process it.

Offering the daily biscuits in a food puzzle instead of the ordinary feeder results in a huge increase in time needed to collect the biscuits. Moreover, using a food puzzle results in fewer biscuits being spilled and dropped on the floor. Because the animals have to work to finally reach their food, they handle their food with more care. This makes the food puzzle a useful type of enrichment.

Remounting the feeder box in a place on the mesh where there is no large opening through which the biscuits could easily be reached can simply create a food puzzle. Another way to make a food puzzle is to place the ordinary feeder box on a loose piece of small-wired mesh and weld it together. The food puzzle can be placed on the front of the cage in an easy-to-reach location: for example near a perch. The puzzle can be secured to the cage using chains or cable ties.



Perches

For captive macaques, a perch is more important than a toy or a mirror, as it opens up the vertical dimension, thereby increasing the usable cage space. Perches lead to an increase in species specific behaviour like climbing, balancing and surveying the environment.

Perches can be made from several types of wood, preferably the hard kind. They can also be metallic. The perches are as long as the cages are deep, 5 centimetres high and 10 centimetres wide, and are placed in the cage by means of a wood-screw at the front. A hole the size of the perch can be made at the back of the cage so that the squeeze part of the cage can still be used.



Music

Under free-ranging conditions, primates are continuously exposed to a variety of sounds, they normally do not encounter in a laboratory environment. Thus, to maintain the animals' auditory stimulation, music can be played in the animal facilities. Little research has been conducted on what type of music is most appropriate or desirable, so the choice is mostly based on the preference of the caretaker. Our experience shows that slower music, like jazz, is more likely to relax the animals while rockmusic makes the animals active and sometimes aggressive. Music can be played during the day while the caretakers are present, but it should be turned off in the evening to allow the animals to rest and sleep.

Part 2:

Food enrichment

Food enrichment is provided to stimulate the expression of foraging behaviour. It stimulates animals to work for their food and gives them some distraction from their daily routine.

Nutritional values are included with each item of food enrichment, thus allowing sound decisions to be made regarding what products to use. In addition, referring to the nutritional values makes it easier to implement food enrichment in an animals' diet.

When supplying food enrichment, keep in mind that food enrichment can only be kept fresh for about 4 days after preparation. Furthermore, make sure to always keep prepared food enrichment in cold storage.

Enrichment mix

Ingredients for one bucket:

1 kilogram of pigeon seed
 500 grams (1 bag) of cornflakes
 100 grams (1 bag) of crumbled
 Rice waffles



NUTRITIONAL VALUE (kJ)

Per mix	
1 bucket: (1.6 kilo)	22,125
1 kilo:	13,828

To create food enrichment, an enrichment mix has been developed. This enrichment mix is used in most food-enrichment items.

The pigeon seed consists of 15 different types of seeds, being:

- | | | |
|----------------|----------------|------------------|
| - buckwheat | - barley | - paddy rice |
| - beans | - green peas | - red dari |
| - dun peas | - cabbage seed | - safflower seed |
| - french maize | - linseed | - wheat |
| - yellow peas | - maple peas | - white dari |

By adding 1 bag (500 grams) of regular corn flakes and 1 pack (100 grams) of rice waffles to 1 kilo of pigeon seed, one bucket of enrichment mix is created. Break the rice waffles into small pieces and also crumble the cornflakes. Mix well to promote an equal mixture.

If larger amounts than one bucket of enrichment mix are needed, the portions can always be doubled. However, to prevent the mix from drying out or getting tough, do not make too much enrichment mix at once.

Store the enrichment mix in buckets that can be vacuum-closed to keep it fresh. Before using, scoop through the mix a few times to spread the different ingredients equally.

1.2.1 Food enrichment for group-housed macaques

Foraging for enrichment mix

Materials needed for each
 family group (30 macaques):
 300 grams of mix

NUTRITIONAL VALUE (kJ)

Per enclosure	
Mix:	4,148
Popcorn:	5,265
Sunflower seeds:	7,926



After an inside enclosure in our group-housing facility has been cleaned, 10 grams of enrichment mix per macaque can be scattered in the clean sawdust. This promotes the use of species-typical behaviour like foraging and will encourage the animals into active use and searching through the enclosure.

- The enrichment mix can be replaced with plain popcorn or sunflower seeds. For this, use 10 grams of popcorn or 10 grams of sunflower seeds for each macaque.
- Foraging for enrichment mix, in this shape, is only applicable for group-housed animals. The animals will quickly begin to forage for the mix and will find and eat everything, so there is no increased danger of attracting vermin. Foraging-enrichment for pair-housed animals is described on page 42 of this manual.

Paper bags with enrichment mix

Materials needed for each family group (30 macaques):
8 empty paper pellet bags
80 grams of mix
Some handfuls of straw



NUTRITIONAL VALUE (kJ)

Per bag	
Mix:	138

Open up all bags and make sure they are empty. Place a handful of enrichment mix (10 grams) in each bag, and add a handful of straw. Roll the bags up very tightly. When placing the bags inside the enclosure, hide them between the tires and place them at a hard-to-reach location, so the animals really have to work to get a bag and reach for the food hidden inside.

- Instead of straw, shredded paper can be used to fill up the bag.
- The bags will be completely shredded after the animals are done. Hence, removal will be no problem.
- Instead of putting enrichment mix inside the bags, the daily pellets or fruits can also be spread out in these bags.
- For pair-housed animals, smaller bags with some other ingredients are used (see page 43 of this manual).

Cardboard boxes with honey, mix and shredded paper

Materials needed for 10 macaques:
5 small boxes
25 ml of honey
25 ml of hot water
25 grams of enrichment mix
A clean 60 ml syringe
An empty honey jar
Some handfuls of shredded paper



NUTRITIONAL VALUE (kJ)

Per cardboard box	
Yoghurt:	86
Applesauce:	99
Marmalade:	120
Apple syrup:	186
Honey:	205

Pour honey into the empty honey jar and dilute it with the hot water. Fill each small cardboard box with 5 grams of enrichment mix and use the syringe to drop 10 ml of diluted honey on top of this. To finish, fill the boxes up with some handfuls of shredded paper.

- Any small cardboard box can be used for this type of enrichment: for instance, glove boxes, syringe boxes or biscuit boxes.
- The animals will completely shred the cardboard, so removal will be no problem.
- For variation, honey can be replaced with low-fat yoghurt, applesauce, low-fat strawberry marmalade or diluted apple syrup.
- To obtain diluted apple syrup, mix one tablespoon (20 grams) of apple syrup with 100 ml hot water. Stir briskly to remove any lumps. After this, use the same recipe as above. The yoghurt (100 ml), applesauce (100 grams) and low-fat marmalade (100 grams) are used undiluted.

Popsicle-buckets for group-housed macaques

Materials needed for each family group (30 macaques, 3 popsicle-buckets):

3 oranges
3 apples
2 cucumbers
300 ml of syrup
24 litres of water
3 big buckets (10 L)
3 connection tubes



NUTRITIONAL VALUE (kJ)

Per popsicle-bucket	
Yoghurt & fruit:	1,363
Syrup & fruit:	2,150

For each popsicle-bucket, cut one orange, one apple and 2/3 cucumber into small pieces (about 5x5 centimetres). Put these fruits in a clean, empty bucket and add 100 ml of syrup. Add 8 litres of water and stir well. Next, put the connection tube into the bucket and place the popsicle in the freezer. Make sure the suspension hook does not fall into the water; otherwise the popsicle cannot be suspended.

- The colours of the fruits in these popsicle-buckets are important, as they attract the animals and give them a better view of what is inside. In addition to oranges, apples and cucumbers, any other type of fruit can be used.
- The syrup can be replaced with low-fat yoghurt; for this, use 0.5 litres of yoghurt in each popsicle-bucket. However, yoghurt does not freeze as well as syrup, so the popsicles will melt faster when yoghurt is used. Syrup-based popsicles will take 6 hours to melt, while those with yoghurt will take about 4 hours (depending on the outside temperature).
- The prepared popsicles can be kept in the freezer for about a month without losing quality.
- Popsicles in this shape can only be used for group-housed animals. Provide one popsicle-bucket for every 10 animals. And remove the bucket from the posicle before suspending. If multiple popsicles are suspended, put them as far away from each other as possible, because competition for such a treat is fierce. For smaller groups, suitable popsicles can be created by using smaller buckets (5 L) and half the ingredients.
- After the animals have finished the popsicle, the connection tubes should be removed from the enclosure as soon as possible. Clean the tubes using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush. Finally, they can be dried and used for another popsicle.

Straw-filled egg cartons with honey and enrichment mix

Materials needed for 10 animals:

5 egg cartons with 6 cups
(or 3 egg cartons with 10 cups)
50 grams of honey
25 grams of mix
A brush
Some handfuls of straw

NUTRITIONAL VALUE (kJ)

Per egg carton	
Yoghurt:	86
Applesauce:	99
Marmalade:	120
Apple syrup:	186
Honey:	205



Prepare the egg cartons by opening them. Use the brush to smear a thin layer of honey in each cup. Scatter one handful (5 grams) of enrichment mix on top of the honey and finish with a handful of straw on top of the mix. Close the egg carton so that this enrichment-item is ready to hand out.

- The straw can be replaced with shredded paper.
- The cardboard egg cartons will be completely shredded by the animals, so removal will be no problem.
- For variation, honey can be replaced with low-fat strawberry marmalade, low-fat yoghurt, applesauce or apple syrup. All these products are used undiluted and in accordance with the above recipe.
- Because applesauce and yoghurt dry out when put on cardboard, the egg cartons with these ingredients should be filled on the day they are handed out to the animals.

PVC tube with enrichment mix and straw

Materials needed for each family-group (30 macaques):

One PVC tube (\pm 1 metre)
with holes
50 grams of mix
Some straw
A broomstick



NUTRITIONAL VALUE (kJ)

Per tube

Enrichment mix:	691
Popcorn:	878
Sunflower seeds:	1,321

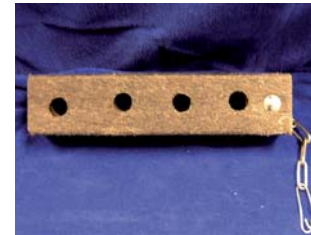
Fill half the tube with straw, then tamp it down using the end of the broomstick. Scatter 10 grams of enrichment mix on top of the straw. Repeat this procedure until the tube is filled and firmly tamped down. The tube is then ready to suspend on the outside of the cage, using the snap hooks which are mounted on the tube.

- The enrichment mix can be replaced with raisins or sunflower seeds. Use 50 grams of popcorn or 50 grams of sunflower seeds.
- The tube must be removed after the animals have taken out all the straw and enrichment mix, which is usually after 1-2 days.
- For pair-housed animals, a smaller version of the PVC tube can be created, using a fruit-tube and 10 grams of enrichment mix.
- Clean the tube using hot water and detergent. After this, it needs to be rinsed with hot water and scrubbed clean using a brush. It can then be dried and used for another group of animals.

Logs with honey cake and enrichment mix

Materials needed for each family-group (30 macaques):

Two composite plastic logs
(about 40 centimetres in length)
with holes
100 grams of honey cake
50 ml water
10 grams of mix



NUTRITIONAL VALUE (kJ)

Per log

Honey cake & mix:	1,428
Peanut butter & mix:	2,768

Mix the honey cake with the water until a smooth pulp is created. Smear this pulp into the holes until they are filled halfway. Next, scatter enrichment mix inside the holes and top off with some more of the honey cake-water mixture. Repeat this until each hole is filled. The log can now be suspended on the outside of the cage, in a place where it can easily be reached and manipulated. Use at least two logs per family-group to reduce monopolisation by high-ranking animals.

- For variation, the honey cake and water-mix can be replaced with 50 grams of peanut butter. Use the same recipe as described above.
- The log must be removed after the animals have emptied all the holes, which is usually after 1 day.
- Clean the log with hot water and detergent. After this, it needs to be rinsed with hot water and scrubbed clean with a brush. Finally, it can be dried and used for another family-group of macaques.

1.2.2 Food enrichment for pair-housed macaques

Fruit-tube filled with pear and endive

Materials needed for each macaque:
1 fruit-tube
1 pear
Several leafs of endive

NUTRITIONAL VALUE (kJ)

Per fruit-tube
Pear & endive: 226



Make sure the fruit-tube is clean before use. Cut the pear into pieces large enough not to fall out the tube. Remove the lid and fill up the tube with pieces of pear and leafs of endive. Close the fruit-tube by placing the lid back on. The tube should be placed on the outside of the cage, in a place where it can easily be reached and manipulated.

- The pear and endive can be replaced with all sorts of vegetables and fruits, depending on what is available at your facility. Use the fruit-tube to provide the daily amount of fruits, vegetables or bread and to make some variations in your daily feeding routine.
- When the fruit tube is empty, it can be removed from the cage, cleaned and refilled.
- Clean the fruit tube using hot water and detergent. After this, the fruit tube needs to be rinsed with hot water and scrubbed clean using a brush. Afterwards, it can be dried and used for another macaque.

Jerrycans with enrichment mix and straw

Materials needed for each family group (30 macaques):
6 clean and empty jerrycans
120 grams of mix
Straw

NUTRITIONAL VALUE (kJ)

Per jerrycan
Rice waffles: 252
Enrichment mix: 277
Cornflakes: 318



Make sure the jerrycans are clean and empty. Fill each jerrycan with 20 grams of enrichment mix and top off with lots of straw. After this, the jerrycans can be spread throughout the enclosure.

- The enrichment mix can be replaced with cornflakes, crumbled rice waffles or popcorn. Use 20 grams of cornflakes, 2 crumbled rice waffles or 20 grams of popcorn in each jerrycan.
- The jerrycans can be replaced with smaller cans, for example milk cans. For each enclosure, use 10 clean and empty milk cans and fill each of them with 10 grams of enrichment mix and top off with straw.
- The jerrycans can easily be removed from the enclosure and disposed off during the next cleaning session.

Bran-tub with sawdust and enrichment mix

Materials needed for each macaque:

1 bran-tub
10 grams of mix
Sawdust



NUTRITIONAL VALUE (kJ)

Per bran-tub	
Enrichment mix:	138
Rice waffle:	163
Popcorn:	175
Sunflower seeds:	260
Raisins:	380

Fill the bran-tub with about 5 centimetres of sawdust. Next, suspend the bran-tub on the outside of the cage by means of snap hooks. Make sure the bran-tub cannot be knocked over by the animals. While the animals observe you, add 10 grams of enrichment mix into the sawdust. In this way they will know what is in the tub, and they will soon start their search for the enrichment mix.

- To create a bran-tub, cut off the top of a jerrycan, creating a bucket with a depth of about 20 centimetres. Attach four chains with snap hooks by means of some nuts and bolts, two on each short side of the bucket.
- The enrichment mix can be replaced with 10 raisins, one crumbled rice waffle, a handful of popcorn or 10 sunflower seeds.
- Instead of a foraging item, the bran-tub can also be used as a small swimming pool by filling it with water. To encourage the animals to use this device, scatter some enrichment mix onto the water. The macaques will love to play with the water inside the tub.
- Clean the bran-tub using hot water and detergent. After this, it needs to be rinsed with hot water and scrubbed clean using a brush. It can then be dried and used for other animals.

Lunch bags with applesauce and enrichment mix

Materials needed for 10 macaques:

10 lunch bags
100 grams of applesauce
50 grams of mix
A knife



NUTRITIONAL VALUE (kJ)

Per lunch bag	
Yoghurt:	86
Applesauce:	99
Marmalade:	120
Apple syrup:	186
Honey:	205
Peanut butter:	332

Open the lunch bags and smear two knife-tips of applesauce on the inside of the bag. Try smearing as much to the bottom as possible. Next, sprinkle 5 grams of enrichment mix into each lunch bag, on top of the applesauce. To finish, fold the bags and distribute them amongst the animals.

- To make the bags more appealing, add shredded paper or straw.
- The bags with applesauce should be handed out on the same day that they are prepared, otherwise the applesauce will soak through the paper.
- The animals will shred the bags completely to pieces, so removal will not be a problem.
- For variation, the applesauce can be replaced with peanut butter, low-fat yoghurt, apple syrup, low-fat marmalade or honey. Use the same recipe as described above. The bags with peanut butter, apple syrup and honey can be kept longer (about 3 days) without losing quality than can the bags with applesauce, yoghurt or marmalade.

Cap puzzle with raisins

Materials needed for each macaque:

1 cap puzzle
10 raisins



NUTRITIONAL VALUE (kJ)

Per cap-puzzle	
Enrichment mix:	138
Sunflower seeds:	260
Raisins:	380

Fill the cap puzzle with 10 raisins, 5 in the upper cap and 5 in the lower. After filling, the cap puzzle should be placed on the outside of the cage, in a place where it can easily be reached and manipulated.

- The cap puzzle is created using 3 PVC caps (from broken fruit tubes) and an eyebolt. Holes are drilled in the caps, just off-centre. The caps are placed on the eyebolt and attached to the bolt with nuts. The cap puzzle has a snap hook on top, so it can be hung on the outside of the cage.
- After being given the cap puzzle, the animals will start foraging. When the puzzle is empty, a toy is left behind to play with. The cap puzzle should be removed from the cage and cleaned within one day.
- The raisins can be replaced with enrichment mix (10 grams) or sunflower seeds (10 pieces).
- Clean the cap puzzle with hot water and detergent. After this, it needs to be rinsed with hot water and scrubbed clean with a brush. Finally, it can be dried and used for another macaque.

Kong toys with honey and enrichment mix

Materials needed for each macaque:

1 kong toy on a chain
10 grams of honey
5 grams of mix
A pair of gloves
A brush



NUTRITIONAL VALUE (kJ)

Per kong toy	
Apple syrup:	186
Honey:	332

Using a gloved finger or a brush, smear the honey on the outside of the kong toy. Roll the kong through a bucket of enrichment mix; about 5 grams of mix will stick to the kong. The kong with honey and enrichment mix can be handed out directly, but can also be frozen beforehand. The kong should be placed on the outside of the cage, in a place where it can easily be reached and manipulated.

- Instead of smearing honey on the outside of the kong, the honey can be smeared on the inside. This will make it more challenging for the animals to reach the food.
- After the honey and enrichment mix are eaten, a toy remains for the animals to play with.
- Instead of honey, the kong toy can be smeared with apple syrup. Use 10 grams of apple syrup and the same recipe as before.
- Clean the kong toy with hot water and detergent. After this, it needs to be rinsed with hot water and scrubbed clean with a brush. Finally, it can be dried and used for another macaque.

1.2.3 Food enrichment for group- and pair- housed macaques

Tennis ball soaked in syrup

Materials needed for each macaque:

1 tennis ball
5 ml of syrup
A small bucket



NUTRITIONAL VALUE (kJ)

Per tennis ball

Honey:	34
Syrup:	59

Pour a thin layer of syrup into a small bucket and drop in a tennis ball. Roll the ball around so that the syrup can be absorbed. Keep the tennis ball in the bucket for about 5 minutes and rotate regularly. After this, the tennis balls can be given to the animals by placing them inside the cage. Hand out one soaked tennis ball per animal.

- The tennis balls provide the animals with manipulable enrichment, which they can groom and play with.
- Of course, tennis balls can also be handed out to the animals without being soaked in syrup.
- The tennis balls should be removed from the cage as soon as they begin to disintegrate after being chewed. Otherwise, the animals can swallow pieces of the ball or keep pieces in their cheek pouches.
- Instead of syrup, the tennis balls can also be soaked in diluted honey. For 10 tennis balls, dilute 25 ml of honey with 25 ml of hot water. Use the same recipe as above.
- It is also possible to drill a hole in the tennis ball and put some other food (like peanuts or raisins) inside the tennis ball.

Puzzle ball with raisins and rice waffles

Materials needed for each family-group:

3 puzzle balls
30 raisins (135 grams)
3 rice waffles



NUTRITIONAL VALUE (kJ)

Per puzzle ball

Raisins & rice waffle:	506
Sunflower seeds & rice waffle:	516

Crumble the rice waffles into large pieces so that they will not fall out of the ball easily. Put one crumbled rice waffle and 10 raisins in each ball. After this, the balls can be placed inside the enclosure.

- For variation, the raisins can be replaced with 15 sunflower seeds.
- The balls can be removed from the enclosure the next time it is cleaned.
- Clean the puzzle balls using hot water and detergent. After this, they need to be rinsed with hot water and scrubbed clean using a brush. Finally, they can be dried and used for another macaque.

Paper cups smeared with marmalade and enrichment mix

Materials needed for

100 macaques:

100 paper cups
1 jar of low-fat marmalade
750 grams of mix
A knife



NUTRITIONAL VALUE (kJ)

Per paper cup	
Yoghurt:	115
Applesauce:	115
Marmalade:	120
Apple syrup:	133
Honey:	145
Peanut butter:	183

Smear 1 to 2 knife-tips of marmalade on the inside of the cup. Scoop the cup through a bucket of enrichment mix so that the mix will stick to the marmalade. Close the paper cup by folding the top sides inwards.

- The cups with marmalade should be prepared on the day they are handed out to the animals, otherwise the marmalade will dry out and lose its flavour.
- The cups can be frozen and stored in the freezer for about three weeks without losing quality.
- After being smeared and filled with enrichment mix, the cup can be filled with shredded paper or straw to make consumption more challenging for the animals.
- The cups will be completely shredded by the animals, so removal will be no problem.
- The marmalade can be replaced with honey (300 grams), peanut butter (300 grams), low-fat yoghurt (500 ml), apple syrup (125 grams) or applesauce (360 grams). Cups with yoghurt and applesauce can be kept as long as those with marmalade. The other cups can be kept for about four days without losing quality.

Bottles with honey and enrichment mix

Materials needed for

10 macaques:

10 plastic bottles (0,5 litres)
without a cap
50 grams of honey
50 ml hot water
50 grams of mix
A clean 60 ml syringe
An empty honey jar
Some handfuls of shredded paper



NUTRITIONAL VALUE (kJ)

Per bottle	
Yoghurt:	86
Apple sauce:	100
Honey:	137

Use the empty jar in which to dilute honey with the hot water. Using the syringe, drop 10 ml of diluted honey in each bottle and add one handful (5 grams) of enrichment mix. Top off by cramming the bottle with shredded paper. The bottles should be supplied to the animals inside their cage.

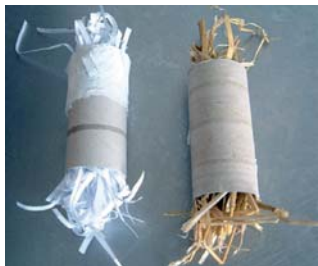
- Frozen bottles can be kept in the freezer for three weeks without the ingredients losing quality. Non-frozen bottles can be kept for a week.
- The bottle should be removed out of the cage as soon as they begin to disintegrate after being chewed. Otherwise, the animals can swallow pieces of the bottle or keep pieces in their cheek pouches.
- For variation, the honey can be replaced with applesauce or low-fat yoghurt. Use 100 ml yoghurt or 100 grams of applesauce without diluting. Use the same recipe as described above.
- For safety, do not put the caps back on the bottles before handing out, as the animals sometimes collect the caps in their cheek pouches. When caps stay in cheek pouches too long, there is a risk of infection or injury.

Toilet-paper rolls with apple syrup and enrichment mix

Materials needed for

10 macaques:

10 toilet-paper rolls
30 grams of apple syrup
50 grams of mix
A knife



NUTRITIONAL VALUE (kJ)

Per toilet-paper roll	
Yoghurt:	78
Applesauce:	87
Marmalade:	94
Apple syrup:	104
Honey:	109
Peanut butter:	148

Smear a thin layer of apple syrup on the inside of the toilet-paper rolls. Next, scoop the roll through a bucket of enrichment mix so that the mix will stick to the apple syrup. To close the rolls, folds both ends inwards.

- Instead of closing the rolls by folding the ends inwards, they can also be closed off using shredded paper or straw. This increases the difficulty and makes sure the animals will take longer to finish the roll.
- After preparation, the rolls with apple syrup can be kept for three days without losing quality. To keep the rolls for a longer period, they can be frozen. After freezing, they can be kept for three weeks without losing quality.
- The rolls will be completely shredded by the animals, so removal and cleaning will be no problem.
- For variation, apple syrup can be replaced with low-fat yoghurt, applesauce, low-fat marmalade, peanut butter or honey. Apply thin layers of these products, and use the same recipe as previously described. Toilet-paper rolls with yoghurt, marmalade and applesauce should be prepared on the same day as they are handed out to the animals. The other rolls can be kept for about 4 days without losing quality.

Yoghurt and peanut ice creams

Materials needed for

100 macaques:

100 paper cups
A 10 litre plastic jug
1 litre of yoghurt
6 litres of water
100 peanuts



NUTRITIONAL VALUE (kJ)

Per ice cream	
Yoghurt and fruit:	56
Yoghurt and mix:	58
Yoghurt and peanuts:	80
Yoghurt and sunflower seeds:	95

Use the large jug in which to dilute the yoghurt with the water. Fill the cups one-third full with the diluted yoghurt and add one peanut per cup. Freeze the cups for 1-2 days, after which the ice creams are ready to hand out.

- Instead of peanuts, enrichment mix, sunflower seeds and fruits can be added to the yoghurt ice cream. Use a small handful (3 grams) of enrichment mix, three sunflower seeds or three small pieces of fruit in each ice cream.
- The cups are only one-third filled because this size fits more easily through the mesh of the cage.
- The cups will be completely shredded by the animals, so removal will be no problem.

Ice cream variations

Materials needed for

100 macaques:

100 paper cups

A 10 litre plastic jug

7 litres of water

100 peanuts

140 grams of apple syrup

or

250 ml of syrup

or

640 grams of low-fat marmalade

or

720 grams of applesauce



For more variation on the yoghurt and peanut ice cream, the yoghurt can be replaced with syrup (250 ml per 7 L water), applesauce (720 grams per 7 L water), low-fat marmalade (640 grams per 7 L water) or apple syrup (7 tablespoons per 7 L water).

Instead of a peanut, enrichment mix, sunflower seeds and fruits can be added to the ice cream. Use a small handful (3 grams) of enrichment mix, three sunflower seeds or three small pieces of fruit in each ice cream.

NUTRITIONAL VALUE (kJ)

Per ice cream

Apple syrup & fruit:	55
Apple syrup & mix:	57
Apple syrup & peanut:	79
Apple syrup & sunflower seeds:	94
Syrup & fruit:	68
Syrup & mix:	70
Syrup & peanut:	92
Syrup & sunflower seeds:	107
Yoghurt & fruit:	56
Yoghurt & mix:	58
Yoghurt & peanut:	80
Yoghurt & sunflower seeds:	95
Marmalade & fruit:	72
Marmalade & mix:	74
Marmalade & peanut:	96
Marmalade & sunflower seed:	111
Apple sauce & fruit:	61
Apple sauce & mix:	63
Apple sauce & peanut:	85
Apple sauce & sunflower seed:	100

Herbal tea

Materials needed for

100 macaques:

100 paper cups

A large cooking pot (minimal 10L)

10 litres of water

3 stalks of fennel

Primate drinking bottles



Cut the three stalks of fennel into four pieces each. Put the pieces of fennel into a large pot and add 10 litres of water. Boil the water with fennel for about 5 minutes. After this, remove the fennel and let the water cool down. The tea can be handed to the animals as liquid in drinking bottles or frozen as ice treats.

- If there is no fresh fennel available, seeds, dried herbs or tea leaves can also be used to make tea with.
- Other herbs that can be used include stinging nettle, camomile, sage, anise and liquorice.



Chapter 2: Marmoset enrichment

Part 1: Non-food enrichment

Non-food enrichment is used to provide the marmosets with an environment in which natural behaviours are stimulated to occur and they can be displayed freely.

Some very important natural behaviours for marmosets are scent marking, fleeing for conflicts or 'danger' and group-wise resting or sleeping. Enclosures should be equipped with enough facilities to provide the animals with an environment in which they can express these natural behaviours.

Furthermore, non-food enrichment helps reducing the development of unwanted abnormal and stereotypical behaviour by preventing boredom.

2.1.1 Non-food enrichment for group-housed marmosets

All marmosets in BPRC's breeding colony are housed in family-groups, consisting of one adult male and one adult female and their offspring. These family-groups have access to both an inside and an outside enclosure. The outside enclosure provides the animals with other sounds and views compared to the inside enclosure. Furthermore, also weather influences are being experienced in the outside enclosure. Each breeding group has two tunnels to by choice migrate from the inside to the outside enclosure and vice versa.

To provide the animals with an enriched environment, the following non-food items are used at the BPRC:

- Biofloor in inside enclosure
- Windows
- Small trees and willow branches
- Perches and fire fighters' helmets
- Garden hoses, rope ladders and rope netting
- Rope bridges
- Plastic hammocks and plastic hanging baskets
- Plastic seatings, small tires and trapeziums

Each breeding group has as many of these enrichment items included in their enclosure as possible.

Besides the enrichment items mentioned above, rings are mounted on all walls and ceilings of our inside enclosures to help the animals move around. The animals use the rings while playing and climbing. All sorts of environmental enrichment devices can be hung from them as well. The rings are made of stainless steel, measure 10 centimetres in diameter and are mounted in the walls by drilling a hole and screwing them in, securing them with Loctite®.

Biofloor in inside enclosure

In all inside enclosures in our breeding colony, a biofloor has been realised as bedding. The high temperature and humidity in the enclosure provides an excellent environment for bacteria and moulds to grow in the biofloor. Furthermore, animals drop food-items and faeces onto the biofloor, which attracts insects. These insects also nest in the biofloor. Altogether, the biofloor breaks down and consumes dropped food items and faeces, but is also considered an enrichment item because of all the insects living in it. Marmosets practice their hunting skills by chasing after these insects.

Because of the use of this biofloor, the enclosures only have to be cleaned once each week. Furthermore, during cleaning sessions, only the training corridor, window-frames and perches need to be cleaned using water. When necessary, the top layer of the biofloor can be spaded to promote the diffusion of waste-products. The frequency of spading depends on group-size, humidity and the temperature of the enclosure.



Windows

Wild roaming marmosets are being exposed to a complex and shifting visual landscape. To provide similar fluctuating visual scenes, windows are constructed in the outside walls of the inside enclosures. The windows allow sunlight to enter and illuminate the building. The windows are 54 centimetres tall and 57 centimetres wide. Each enclosure has four windows, allowing views towards the outside enclosure and its surroundings. The window-ledges are very popular amongst the animals for sunbathing.



Rope bridges

Originally, rope bridges are commonly used as environmental enrichment in rats. However, it can also be involved in a marmoset enrichment programme as our marmosets love to use the rope bridges while resting and observing the surroundings. Rope bridges are made out of cotton ropes, which are weaved into each other. Caps with screw thread are attached on the end of each cotton rope, making it possible to attach the rope bridge to the cage. Attach the rope bridge at a high location in the cage, so the animals will have a resting place at a preferred location, high in the enclosure.



Small trees and willow-branches

Both in the inside as well as in the outside enclosures, willow-branches are available to the marmosets. In the inside enclosures, willow branches have been hung from the ceiling to open up the vertical dimension and increase the usable cage space. Furthermore, the branches are used as a surface to engage in scent marking and tree gouging.

Willow branches can be placed inside the enclosure by clinging them between rings, which are mounted on the walls and ceiling. Furthermore, willow branches may also be hung horizontally, vertically or diagonal from the ceiling by means of a plastic or metallic linked chain. When branches are hung by means of a (metallic) rope, the animals have to face another challenge as the branches will be very unstable while using.

The branches need to be replaced when animals have gnawed them to the point of breaking. Furthermore, by regularly (ex. monthly) rearranging willow branches, the enclosure will keep interesting the animals and decorating rearrangements will furthermore prevent habituation to the enclosure.

In the outside enclosure, willow branches have been planted in the ground. These willow branches will soon grow into small willow trees. The trees provide a naturalistic type of enrichment in which the animals use the leaves and branches as hiding-place, climbing attribute and for resting. When the trees grow too large, they can be clipped. The cut off branches can afterwards be used as enrichment in any inside enclosure



When branches or trees wear out and die, they can be replaced with some new ones.

Plastic perches

By fastening plastic beams on the enclosure's walls, plastic perches can be created. These open up the vertical dimension of the room, thereby increasing the usable cage space. These perches provide the animals with an environment in which they can express species specific behaviours such as climbing, resting, observing and scent marking. In addition, the perches are of use while expressing social behaviours like grooming other animals.



Each inside enclosure is equipped with perches, each perch being made out of two composite plastic round beams, mounted together on a supporting frame using bolts. The supporting frame is attached to the enclosure's wall using screws. Each beam has a circumference of 14 centimetres, and can be cut to any desired length. The perches can easily be cleaned by hosing them off with water.

Fire fighter's helmets

Fire fighter's helmets can be used as a place for hiding, resting, sunbathing and sleeping. A helmet can be hung in both inside and outside enclosures, by suspending the helmets' neckband to a branch. Helmets can also be hung from a ring in the wall by means of a plastic chain.

After the animals have used the helmet for a longer period, the helmet might be in need of cleaning. If you want to keep the helmet inside the enclosure, simply hose the helmet off with water. If you can easily remove the helmet from the cage, you can also give the helmet a machine wash. After cleaning, the helmet can be re-suspended in the enclosure.



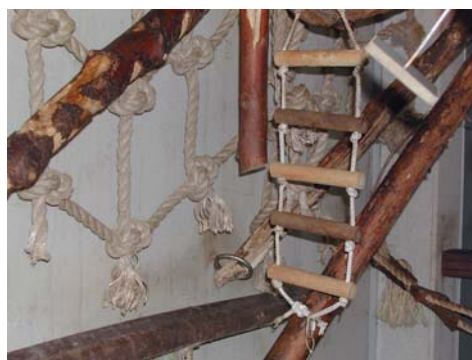
Garden hoses, rope ladders and rope nets

Garden hoses, rope ladders and rope nets are used by the marmosets for climbing, resting, observing and seating. Moreover, these devices make the enclosure more accessible to the animals and they open up the vertical dimension.

Garden hoses are hung high in the enclosure, at about 2.5 metres from the ground. They are hung in a zigzag pattern between the rings in the walls. Because of these garden hoses, the upper cage space can be optimally used.



Rope ladders are created using wired rope and wooden poles. At the end of each pole, a small hole is drilled to thread the wired rope trough. Secure every pole with a knot in the rope.



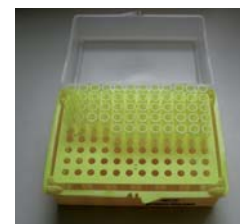
Rope nets improve the accessibility of the enclosure, enabling all animals to move easily from the floor to a higher position or the other way around. They have been created by knotting wired rope in squares. The nets are hung vertically in the indoor enclosure from the rings in the ceiling.

These types of enrichment can be attached to the rings inside the enclosure by means of tie-wraps but they can also be tied up to the rings using knots.

When using garden hoses, rope ladders and rope nets, make sure the animals' safety is kept in mind. Old materials can start fraying and could trap an animals' finger or toe. To prevent injuries like these, regularly check the enrichment items and replace them in time.

Plastic hammocks and hanging baskets

We create our own plastic hammocks and hanging baskets to supply our animals with. The animals use these enrichment items for resting, sleeping and observing.



To create these hammocks and hanging baskets, we collect inserts of boxes for micropipette-tips. Inserts are attached to each other by means of tie-wraps. By putting together multiple inserts and combining the inserts in different ways, hammocks and hanging baskets of each size and shape can be created.

The hanging baskets can be used to provide the animals with both food and non-food enrichment. A discription of the use of hanging baskets as food enrichment is given on page 79.

Hammocks and hanging baskets can be hung from plastic chains by attaching a minimum of two small metal rings (for instance key-rings) in the upper two corners of the enrichment device. One end of the chain is attached to the key-ring in the enrichment item, while the other end is attached to one of the enclosure's stainless steel rings.



After using and when needed, the hammocks and hanging baskets can be cleaned by rinsing them off using water. After rinsing, the enrichment items can be re-used in another enclosure.



For some variation, these hammocks and hanging baskets can also be replaced by hanging jerrycans. To create this type of enrichment, two big holes need to be cut in clean and empty jerrycans. After making these holes, the jerrycan can be filled for about half with straw. After filling, suspend the jerrycan inside the enclosure by means of a plastic chain. The plastic chain should be attached to the jerrycan by fastening to the handle. By suspending this enrichment item at a high location, it will become even more attractive.

Plastic seatings, trapeziums and small tires

The animals make use of plastic seatings, trapeziums and small tires to move through the enclosure and as a seating accommodation to observe the surroundings. Furthermore, these enrichment items enlarge the usable cage space by enlarging the three dimensional space. It is important to place these types of enrichment at high locations, so the animals can easily make use of it.



Plastic seatings are created by connecting three inserts of boxes for micropipette-tips to each other by means of tie-wraps. Attaching the plastic seating to the lattice-work of the enclosure makes it approachable to the animals and enables them to observe the outside of their enclosure even better.

Trapeziums are originally used as enrichment for birds like parakeets, but they are also very useful as enrichment item for marmosets. The animals make lots of use of the trapezium as it is unstable and fun to swing around. Trapeziums are hung from the enclosures' rings by means of a plastic linked chain.



Small tires are hung inside the enclosure by attaching plastic chains to it. To be able to attach the chain, several small holes need to be drilled on the inside of the small tire. Attach the chain by cutting one link and pulling it through the fresh-drilled hole. After attaching the chain, the tire can be hung inside the enclosure, preferably from one of the rings in the ceiling.

When needed, these types of enrichment can be cleaned by rinsing them off with water. After rinsing, the items can be hung in another enclosure.

2.1.2 Non-food enrichment for pair-housed marmosets

Animals which are part of an experimental protocol are no longer housed in family-groups but in pairs. However the animals are still able to express their social behaviour, the number of different interactions decrease as there are less animals to interact with. Preferably, pairs are created by same-sex twins. By doing so, stress and aggression of introduction and group-formation is decreased because the animals already are used to each other.

In pair-housing facilities, animals are kept in smaller enclosures and being part of an experimental protocol means undergoing different types of experimental procedures. To promote welfare and to reduce stress, the animals will not only need to be provided with the previous mentioned social enrichment, but also with non-food enrichment. Not all items used in group-housing enclosures are fit for pair-housing enclosures. The items which are previously used and described in group-housing are not copied, but there will be a reference to the page in this manual where the description is.

Non-food enrichment can be divided into fixed enrichment items and circulative enrichment items. Circulative enrichment provides the animals with new cage-items to explore each time, providing the animals with new and various activities. The following fixed enrichment items can be provided to pair-housed marmosets:

- Wooden perches and willow branches
- Metallic perches and night-boxes
- Garden hoses, rope ladders and rope nets (see page 64)
- Plastic hammocks and hanging baskets (see page 65)
- Rope bridges (see page 61)
- Plastic seatings and small tires (see page 66)

The following circulative enrichment items can be provided, following a rotating schedule.

- Wrapped-up paper towels
- Rope-rings
- Squared rope ladders
- Trapeziums (see page 66)
- Mirrors

This rotating schedule should be set up in such a way that each enrichment item is available to each pair of marmosets for a week. After this week, the old item should be taken out and the next item can be introduced.

Wooden perches and willow branches

The smaller housing conditions make it more challenging to equip the cage with a regular horizontal perch. Because of this, we make perches that exactly fit each cage. Horizontal perches are important as environmental enrichment to create a larger floor surface. The perches are fitted in the cage at different heights by means of metallic supporting frames.

Wooden perches can be created out of any kind of wood, as long as it is a hard kind. We use circular pieces of wood with a diameter of 3 centimetres. Most marmosets love to gnaw on their perch, so these need to be regularly checked and, when necessary, replaced with another one to prevent breaking. Perches are cleaned once every two weeks by rinsing them off with water. Furthermore, when animals leave the cage permanently, the entire cage, including perches, needs to be cleaned using detergent and water to lose the old animals' scent.

Besides the wooden perches, willow branches are placed in the cage slanting to promote accessibility of the cage.

By replacing the willow branches regularly, the enclosure will keep the interest of the animals. Removing the old, dried out wood and replacing it with fresh and flexible new branches is stimulating to the animals and increases their use of the branches. Furthermore, new branches stimulate the animals in their natural curiosity as it promotes exploration and scent marking.



Wrapped-up paper towels

To promote foraging behaviour, paper towels can be wrapped up and placed on top of the animals' enclosure. Soon, they will start pulling the paper through the mesh and play with the 'conquered' paper. We usually offer this type of enrichment after cleaning the cages, to promote activity and to diminish after-cleaning stress.

After the animals have pulled the paper inside their cage and are done playing, the left-overs will be dropped to the bottom of the cage. By removing the left-overs in the next cleaning session, the animals do not need to be disturbed and they can choose to play with the left-overs, even when it has been on the floor for a couple of days.



Metallic perches and night boxes

Being an arboreal species, marmosets prefer to rest and sleep together at an elevated location. By fixing metallic perches and night boxes at a high location inside the cage, these species specific behaviours will be promoted.

To fasten the metallic perches and night boxes inside the cage, grooves have been designed in the cage. By means of these grooves, the enrichment items can easily be slid in. Cleaning metallic perches and night boxes is easy, just rinse them with water and use a small brush and some detergent to clean the extra dirty spots.



Rope-rings, trapeziums and squared rope ladders



These types of enrichment are used to renew the cage environment and to stimulate the animals in their natural curiosity for novel objects. After examination of the items, the animals will use them for resting and sleeping and as a location to observe the environment.

By rotating these enrichment items weekly, the animals will every time be stimulated again in actively investigating novel objects and later on using the objects while expressing their natural behaviours as described above. Rope-rings, trapeziums and squared rope ladders can be bought from pet-stores or from distributors of primate products or enrichment specialists.



Mirrors



A mirror fixed to the cage of a marmoset has a two-sided effect: it enables the animal to see areas that are normally invisible and makes it possible for them to see other marmosets. The presence of a mirror on the cage of pair-housed marmosets increases the animal's activity and communicative behaviour towards other animals. The mirror consists of a circular-shaped piece of stainless steel 5 centimetres in diameter. A small hole is drilled into the stainless steel and a chain 15 centimetres long is connected. A snap-hook at the end of the chain ensures the mirror can readily be attached to the outside of the cage, in a place where it can easily be reached and manipulated.

Interest in the mirror can be preserved if it does not remain too long in one place on the cage. After two to three days, interest will decrease and the animals' use of the mirror will rapidly decline. When the mirror is no longer used, you can remove it from the cage and use the mirror for another pair of marmosets. When the mirror is used again after a few weeks, this 'new toy' will again gain the interest of the animal.

It is possible the mirror will lose its shine after a long period of use. To bring back the shine, the mirror should be cleaned using water and detergent and then polished with a cloth.

Note that for some animals, the mirror will provoke aggressive behaviour towards what they see in the mirror. When animals react aggressive, immediately remove the mirror from the cage and make a note not to supply a mirror to that animal in order to prevent this reaction from happening again.

Part 2: Food enrichment

After implementing various types of non-food enrichment in the marmoset enclosure, the animals are stimulated to perform their natural and species specific behaviour.

Further environmental enrichment can be provided by means of food enrichment.

This type of enrichment is provided to stimulate foraging behaviour.

Furthermore, it gives the animals some activity during the day.

As a result, the development of unwanted abnormal and stereotypical behaviour is reduced, slowed down or even stopped.

2.2.1 Food enrichment for group- and pair-housed marmosets

Free-roaming marmosets spend a large amount of their time foraging for food. By offering food enrichment, the expression of foraging behaviour is stimulated.

The following types of food enrichment can be offered to both group- and pair-housed marmosets:

- Gum-cups
- Fruit on a chain
- Sunflowers
- Mealworms from a mealworm dispenser
- Cardboard boxes with shredded paper and gum arabic bits
- Plastic hanging basket with raisins and straw

To keep these types of non-food enrichment interesting, we have created a rotating schedule. This rotating schedule is created with the assumption that the diet allows the addition of one food enrichment item each week.

By creating a rotating schedule for these food enrichment items, animals will receive each enrichment item once every six weeks.

Nutritional values are included with each item of food enrichment, thus allowing sound decisions to be made regarding what products to use. In addition, referring to the nutritional values makes it easier to implement food enrichment in an animals' diet. Gum arabic has no nutritional value in terms of kilo joules. However, marmosets need gum arabic in their diet in order to obtain proper minerals.

Gum-cups

Materials needed for 10 small or 10 large gum-cups:

600 grams of gum arabic-bits or
1 000 grams of gum arabic-bits
1 00 ml boiling water
10 large cardboard cups
10 plastic linked chains, 20 cms
A clean 60 ml syringe



Start off by hanging the plastic linked chain inside the cardboard cups. Fill up the cups with a layer of gum arabic bits (for a small cup, use 60 grams per cup and use 100 grams of gum arabic to make large gum-cups). Make sure the linked chain is well covered with gum arabic. After this, pour 10 ml of boiling water over each gum-cup using a large 60 ml syringe. Try to hit as much of the gum as possible. Because of the water and the high temperature of the water, the gum will slightly melt and stick together. Wait for about 5 minutes and then pour out all redundant water.

Let the gum-cup rest for about a day before handing it out to the marmosets, so the bits can stick together and harden out properly. When handing out the gum-cups, make sure to hang them at an high location inside the enclosure, so the animals will have to work hard to reach the gum. The amount of gum-cups which is offered to the animals depends on the group size.

For single or pair-housed marmosets, one small gum-cup is supplied. One large gum-cup is handed out to small groups which consist of about four animals. Larger groups receive an amount of gum-cups consistent with this division. A group of 10 marmosets thus will receive two large and one small gum-cup. The animals will be busy for about a week to consume the gum-cup.

After handing out, the cups will be shredded by the animals in their attempt to reach for the gum arabic. The cardboard will drop to the floor and can easily be removed while cleaning the cage. When there is a biofloor inside the enclosure, the cardboard shavings can be left inside.

When the gum-cups are consumed, the plastic linking chains should be placed in a bucket with hot water, so the left-over gum can be removed easily. As all gum has been removed, the chains can be cleaned a final time by using hot water with detergent. After this, they can be re-used for making the next load of gum-cups.

Fruit on a chain

Materials needed for each pair of marmosets:

One fruit chain
20 grams of fruit
(for example oranges)



NUTRITIONAL VALUE (kJ)

Per fruit chain

Orange:	37
Pear:	46
Apple:	46

Placing fruit on a chain gives you an alternative way to offer fruit to the marmosets. Mostly, fruit is chopped into small bits and placed in a bowl, which is offered to the animals. To promote foraging behaviour, this enrichment-device makes use of large particles being placed at an hard-to-reach area.

The fruit chain consists of a piece of wire which is 45 centimetres long. At the top, an hook has been created by bending the wire. This hook provides you with the opportunity to hang the chain inside the enclosure. At the bottom, a small sheet of Trespas™ is fastened to prevent the threaded food from dropping down. Fruit can be threaded on the fruit chain from the top.

After the animals have eaten all fruit off the fruit chain, the wire can be take out, cleaned by rinsing it off with hot water with detergent, and re-used.

Sunflowers

Materials needed for each family group (10 marmosets):

One head of a sunflower which is out of blossom
Two tie-wraps



At the BPRC, we grow our own sunflowers in our kitchen garden. At the end of the summer, the sunflowers' heads are out of blossom and can be taken off the plant by chopping off. Keep a small piece of the stalk on the sunflowers' head, so you can suspend the head inside the enclosure from the stalk.

These heads are perfect to promote foraging behaviour, as the animals love to eat the sunflower seeds. However, they can not easily take them out, as they are firmly held by the sunflowers' head.

The sunflowers can be hung inside the enclosure by means of two tie-wraps. Make a hole in the small piece of stalk you have left on while chopping it off the plant. Run the tie-wrap through this hole and attach the sunflower to one of the enclosures' rings.

By hanging the sunflowers at an high location inside the enclosure, the animals will make a lot of use of it and will also have to do some work to reach the sunflowers' head.

After all seeds have been peeled out of the sunflowers' head, the enrichment item can be removed from the enclosure and can be disposed.

NUTRITIONAL VALUE (kJ)

Per sunflower (depending on size)	
Small:	1317
Medium:	2634
Large:	5268

Mealworms from a dispenser

Materials needed for each pair of marmosets:

One mealworm dispenser
10 living mealworms



NUTRITIONAL VALUE (kJ)

Per dispenser	
Mealworms:	270
Raisins:	380

In addition to the marmosets' regular diet, living mealworms can be provided. As the mealworms are alive while being handed out by the caretaker, the animals' foraging- and hunting techniques are stimulated to catch the food. An alternative to the hand-feeding of mealworms can be found in the use of a dispenser for mealworms. This dispenser is created by using a 0.5 liter PET-bottle, two tie-wraps, a pair of scissors and about 40 centimetres of plastic linked chain. First off, use the scissors to make four little holes in the side of the bottle, two small holes at the top and two at the bottom of the same side. Lace the tie-wraps through these holes and attach the plastic chain to the bottle by means of this tie-wraps.

After attaching the plastic chain to the bottle, use the scissors to cut two oval-shaped holes, 1.5 centimetres in diameter, in the bottle. The holes should be cut in such a manner that when you hang the bottle inside the enclosure, the holes are at the top of the horizontal bottle.

Finally, the mealworms (about 5 for each animal) can be put inside the dispenser, which can afterwards be hung inside the enclosure.

For some variation, the meal worms can be replaced with the same amount of raisins or gum arabic-bits. Furthermore when the animals become clever in getting the treat out the dispenser, you can make dispensers with smaller holes. When doing so, make sure the animals' hands cannot get caught in the smaller holes.

After emptying the contents, the dispenser can be removed from the enclosure. Cleaning is simple as rinsing with hot water is enough. After cleaning, the dispenser can be handed out to the next pair of animals.

Cardboard box with shredded paper and gum arabic

Materials needed for each pair of marmosets:

1 cardboard box
10 grams of gum arabic-bits
Some handfuls of shredded paper



NUTRITIONAL VALUE (kJ)

Per box	
Mealworms:	270
Raisins:	380

Fill up the cardboard boxes with shredded paper and hide about 10 grams of gum arabic-bits inside each box. After this, the boxes are all ready to hand out to the animals. They will, soon after handing out, start searching for the gum arabic-bits.

While the animals search through the boxes, the shredded paper will fall to the floor. This should be removed during the next cleaning-session.

After the animals are done with the boxes, they can be removed from the enclosure. Simply throw the used boxes away. For each pair of marmosets, one cardboard box is supplied.

For some variation, the gum arabic-bits can be replaced with the same amount of raisins or living mealworms. When using mealworms, you cannot make the enrichment items a day ahead, as the mealworms will gnaw their way out of the box.

Plastic hanging basket with raisins and straw

Materials needed for each pair of marmosets:

1 hanging basket
About 10 raisins
Some handfuls of straw



NUTRITIONAL VALUE (kJ)

Per basket	
Raisins:	380

As described on page 65, hanging baskets can be created by using inserts of boxes for micropipette-tips. Fill the hanging baskets with a handful of straw and add about 10 raisins per basket. After suspending the basket inside the enclosure, the animals will soon start their search for the raisins.

While the animals search through the baskets, the straw will fall to the floor. This should be removed during the next cleaning-session. When using a biofloor, this removal is not necessary.

After the animals are done with the baskets, they can be removed from the enclosure. Cleaning is simple as rinsing with hot water is enough. After cleaning, the dispenser can be handed out to the next pair of animals.

For each pair of marmosets, one hanging basket is provided. By suspending the basket at an high location in the cage, climbing and foraging is stimulated.



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