

**Supplementary Table 1.** Welfare indicators scored within the physical parameter class (adapted from Justice et al. 2017).

Score	General condition	Clinical assessment	Faecal consistency	Activity level, mobility	Not eating/drinking or reported hungry/thirsty
1	Weight within normal range, good body condition and good coat condition	Clinically healthy; no injuries	Formed	Normal	Normal
2	Weight slightly outside normal range and body somewhat over/under condition for <7 days. And/or a minor reduction in coat condition for <7 days.	Mild transient (sub)clinical symptoms (including vomiting) or injury, little effect on welfare and full rapid recovery expected	Soft but formed (below 50% of total or for <3 days)	Slight increase in activity (not caused by normal variation)	Food/water intake reduced
3	Weight slightly outside normal range and body somewhat over/under condition for 7-14 days. And/or a minor reduction in coat condition for 7-14 days.	Mild clinical disease with symptoms and/or minor injury, and some effect on short-term welfare but with full recovery expected	Soft but formed (above 50% of total or for $\geq 3$ days)	Increased activity or slight decrease in activity (possible cause: environmental factors)	Food/water intake reduced for 2-3 days
4	Weight slightly outside normal range and body somewhat over/under condition for >14 days. And/or a minor reduction in coat condition for >14 days.	Mild-to-moderate clinical disease with medium-term effect on welfare but with full expected recovery	Soft (below 50% of total or for <3 days)	Increased or decreased activity	Food/water intake reduced for 4-5 days
5	Weight considerably outside normal range and body over/under condition for <7 days. And/or a clear reduction in coat condition for <7 days.	Moderate clinical disease or injury with moderate or long-term effect on welfare and unknown recovery potential	Soft (above 50% of total or for $\geq 3$ days)	Sizable increase or decrease in activity that shows full recovery (not related to courtship)	Food/water intake reduced for 6-7 days
6	Weight considerably outside normal range and body over/under condition for 7-14 days. And/or a clear reduction in coat condition for 7-14 days.	Moderate clinical disease or injury with severe short-term effect on welfare and unknown recovery potential	Loose (below 50% of total or for <3 days)	Sizable increase or decrease in activity that shows some recovery (not related to courtship)	Food/water intake reduced for 8-9 days
7	Weight considerably outside normal range and body over/under condition for >14 days. And/or a clear reduction in coat condition for >14 days.	Moderate clinical disease or injury with severe or long-term effect on welfare and unknown recovery potential	Loose (above 50% of total or for $\geq 3$ days)	Sizable increase or decrease in activity that is consistent throughout the day	Food/water intake reduced for >10 days
8	Weight severely outside normal range and body heavily over/under condition for <7 days. And/or major reduction in coat condition for <7 days.	Severe disease with clinical symptoms or severe injury with long-term effect on welfare and little chance of full recovery	Very loose (below 50% of total or for <3 days)	Minimal movement or signs of hyperactivity	Animal reported to be very thirsty, dehydrated or anorexic for 1 day
9	Weight severely outside normal range and body heavily over/under condition for 7-14 days. And/or major reduction in coat condition for 7-14 days.	Chronic or acute severe disease(s) with pain, negatively affecting welfare or severe injury with long-term welfare effects and no chance of full recovery	Very loose (below 50% of total or for <3 days)	Lethargy or hyperactivity	Animal reported to be very thirsty, dehydrated or anorexic for 2 days
10	Weight severely outside normal range and body heavily over/under condition for >14 days. And/or major reduction in coat condition for >14 days.	Severe disease with clinical signs and/or severe injury with high long-term welfare impact and no chance of full recovery	Soft to very loose with the presence of blood and/or mucus	Complete lethargy (no movement, possible minimal movement when encouraged)	Animal reported to be very thirsty, dehydrated or anorexic for $\geq 3$ days

**Supplementary Table 2.** Welfare indicators scored within the psychological parameter class (adapted from Justice et al. 2017).

Score	Abnormal behaviours	Hierarchy upset/ dispute, aggression/ bullying	Use of (foraging) enrichments	Reaction to 'normal' events	(Positive reinforcement) training	Anticipatory behaviour
1	None	None	Multiple types of enrichment provided, all used well	Trained/ habituated animal, no stress or fear noted	Animal participated well with session	Slight increase in activity and/or regular presence of contentment indicators preceding scheduled husbandry practices
2	Low frequency, minimal time spend, no damage done	Some present in group, not directly affecting the individual	Multiple types of enrichment provided, some used well	Untrained/ unhabituated animal, no stress or fear noted	No training took place	Considerable increase in activity preceding scheduled husbandry practices
3	Medium frequency, minimal time spend, no damage done	Some present in group, animal was instigator or winner	One type of enrichment provided, used well	Trained/ habituated animal, some stress or fear noted	Animal did not participate well with session	Large increase in activity preceding scheduled husbandry practices
4	Medium frequency, some time spend, no damage done	Some present in group, animal was subject or loser	Multiple types of enrichment provided, some use	Untrained/ unhabituated animal, some stress or fear noted	Some stress or fear noted associated with training session; animal participated well	Change in normal anticipatory behaviour as a result of change in husbandry routine, social situation or other potentially stressful event
5	Higher frequency, some time spend, no damage done	Regular presence in group, not directly affecting the individual, or animal was instigator or winner	One type of enrichment provided, some use	Some stress or fear noted, possible aggression	Some stress or fear noted associated with training session; animal did not participate well	Increase in aggressive behaviours and/or presence of agitation indicators preceding scheduled husbandry practices
6	Higher frequency, considerable time spend, possible damage	Regular presence in group for >2 days, not directly affecting the individual, or animal was instigator or winner	Multiple types of enrichment provided, minimal use	Some stress, fear or aggression	Medium stress or fear noted associated with training session; animal participated well	Large increase in aggressive behaviours and/or agitation indicators preceding scheduled husbandry practices
7	High frequency, considerable time spend, damage noted	Regular presence in group, animal was subject or loser	One type of enrichment provided, minimal use	Some stress, fear and aggression	Medium stress or fear noted associated with training session; animal did not participate well	Change in normal anticipatory behaviour without a clear cause
8	High frequency, considerable time spend, damage (e.g., small wound or bald patch)	Regular presence in group for >2 days, animal was subject or loser	Enrichment(s) provided, but not used	High levels of stress and fear	Medium stress or fear noted associated with training session; animal did not participate	Increase in abnormal behaviours preceding scheduled husbandry practices
9	High frequency, considerable time spend, sizable damage (e.g., wound)	Regular presence in group for >4 days, animal was subject or loser	No enrichments provided	High levels of stress and fear with possible aggression	Stress or fear evident associated with training session; animal did not participate well	Large increase in abnormal behaviours preceding scheduled husbandry practices
10	High frequency, majority of free time spend, severe damage (e.g., large wound or digit damage)	Regular presence in group for >7 days, animal was subject or loser	Enrichment(s) provided, but adverse reaction noted	High levels of stress, fear and aggression	Stress or fear evident associated with training session; animal did not participate	No clear change in behaviour preceding scheduled husbandry practices

Supplementary Table 3. Risk factors scored within the environmental parameter class (adapted from Justice et al. 2017).

Score	Housing	Group size	Furnishing/enclosure design	Nutrition	Space	Introductions	Contingent events	Perceived control
1	Good space provision, lighting, ventilation, available shelter, materials used, temperature, drainage, humidity, UV and low noise levels	Group size in adherence with natural group size; stocking density appropriate for the enclosure; group structure is suitable	Branches/plants/hiding places/shelters/climbing structures and other items are available allowing the expression of natural behaviours	Diet and forage are optimally suited to the species-specific needs (nutritional, and behavioural) as well as that of the individual	Access to all of enclosure	No introduction	None	Access to enclosure. Physical complexity. Temporal complexity. View of visitors. Caretaker-animal relationships.
2	1-2 factors are below standard	Group structure differs slightly from a suitable group structure	Natural behaviours can be expressed however the options provided for this are not optimal	The nutrition has slightly reduced suitability to the species, and/or individual needs and beneficial improvements could be made	Shut in large enclosure for part of the day	New animal introduced into group, positive reactions from group	External interruption (e.g., ongoing building works) taking place with minimal disturbance	1 factor is partly below standard
3	3 factors are below standard	Presence of more or less animals when compared with natural group size range; however, no overstocking	Natural behaviours can be expressed however the options provided for this are minimal	The nutrition provided has reduced suitability to the individual needs which would benefit from review	Shut in large enclosure for 1 day	New animal introduced into group, neutral/no reactions from group	Small change in enclosure furnishing	1 factor is below standard, or 2-3 factors are partly below standard
4	4 factors are below standard	Group structure differs from a suitable group structure	The expression of one type of natural behaviour is limited due to furnishing	The nutrition provided has reduced suitability to the species needs which would benefit from review	Shut in medium sized enclosure for part of the day	New animal introduced into group, some aggressive interactions, no contact-aggression	External interruption with some disturbance	1 factor is below standard and 1-2 factors are partly below standard
5	5 factors are below standard	Stocking density slightly higher than appropriate for the enclosure	A type of natural behaviour cannot be expressed at all due to the option not being provided	The nutrition provided is suited to the species, however not the individual	Shut in medium enclosure for 1 day	New animal introduced into group, several aggressive interactions, no contact-aggression	Enclosure furnishing is taken out and changed	1 factor is below standard and 3 factors are partly below standard, or 2 factors are below standard
6	6 factors are below standard	Presence of more or less animals when compared with natural group size range, with slight overstocking	The options for expressing natural behaviours are minimal, preventing the expression of a few natural behaviours related to furnishing	The nutrition provided lacks behavioural requirements of the species	Shut in large enclosure for 2-7 days	New animal introduced into group, some contact-aggression, no injuries	External interruption with definite disturbance	1 factor is below standard and/or ≥4 factors are partly below standard

Supplementary Table 3 (continued). Risk factors scored within the environmental parameter class (adapted from Justice et al. 2017).

Score	Housing	Group size	Furnishing/enclosure design	Nutrition	Space	Introductions	Contingent events	Perceived control
7	7 factors are below standard	Group structure shows a large difference from a suitable group structure	The options for expressing natural behaviours are minimal, preventing the expression of numerous natural behaviours related to furnishing	The nutrition provided lacks physiological requirements of the species	Shut in medium sized enclosure for 2-7 days	New animal introduced into group, some contact-aggression, possible injuries, introduction possibly terminated	External interruption with definite disturbance for >4 days	2 factors are below standard and 1-3 factors are partly below standard
8	8 factors are below standard	Stocking density higher than appropriate for the enclosure	The options for expressing natural behaviours are minimal, preventing the expression of most natural behaviours related to furnishing	The nutrition provided lacks nutritional requirements of the species	Shut in small enclosure for part of the day	New animal introduced into group, contact-aggression, injuries present, introduction possibly terminated	External interruption with definite disturbance for >7 days	3 factors are below standard
9	9 factors are below standard	Group structure shows a large difference from a suitable group structure combined with overstocking	The options for expressing natural behaviours are very limited, preventing the expression of almost all behaviours related to furnishing	The nutrition provided lacks two of the requirements of the species	Shut in small enclosure for 1 day	New animal introduced into group, severe contact-aggression, injuries present, introduction possibly terminated	External interruption with definite disturbance for >14 days	4 factors are below standard
10	All factors are below standard	Large difference between natural group size and housed group size (e.g., solitary housing); or a large degree of overstocking the enclosure	The options for the animal to express natural behaviours are not provided through furnishing, preventing the expression of behaviours related to furnishing	The nutrition provided is not suited to the requirements of the species and the individual	Shut in small enclosure for 2-7 days	New animal introduced into group, severe contact-aggression, severe injuries present, introduction terminated	External interruption with definite disturbance for >30 days	All factors are below standard

**Supplementary Table 4.** Risk factors scored within the procedural parameter class (adapted from Justice et al. 2017).

Score	Sedation	Medical procedure	Change in routine (as consequence of medical procedure)
1	No sedation	No medical procedure	No change in routine
2	Mild, brief sedation with calm induction and recovery and rapid return to normal feeding and behaviour	Minor veterinary procedure with minimal effect on animal	Starved for <6 hours (minor change in feeding routine)
3	Longer sedation with calm induction and recovery and rapid return to normal feeding and behaviour	Minor veterinary procedure with noticeable short-term effect on animal	Change in housing for the aftermath of the procedure (max. 4 hours)
4	Sedation with stressful induction and/or recovery but rapid return to normal feeding and behaviour after event	Minor veterinary procedure with noticeable medium-term effect on animal	Solitary housed for the aftermath of the procedure (max. 4 hours)
5	Sedation with stressful induction and/or recovery and/or effects on normal feeding and behaviour for a few hours after event	Moderate veterinary procedure with noticeable short-term or medium-term effect on animal	Change in housing for the aftermath of the procedure (max. 12 hours)
6	Sedation with either stressful induction/recovery and/or effects on normal behaviour and short-term effects on integration with the group afterwards	Moderate veterinary procedure with noticeable long-term effect on animal	Solitary housed for the aftermath of the procedure (max. 12 hours)
7	Sedation with either stressful induction/recovery and/or effects on normal behaviour and medium-term effects on integration with the group afterwards	Moderate veterinary procedure with noticeable long-term effect on animal including loss of group status	Starved for 6-12 hours, change in housing for aftermath of the procedure (max. 12 hours)
8	Sedation with stressful induction and/or recovery with effects on normal behaviour afterwards lasting over 24 hours	Severe veterinary procedure with minor short-term or medium-term effect on animal	Change in housing (>12 hours) and starved for <6 hours, possibly solitary housed
9	Prolonged sedation with highly stressful induction and/or recovery and moderate long-term effects on normal behaviour and affecting integration with the group	Extensive veterinary procedure resulting in severe short-term pain despite appropriate treatment and analgesia and a loss of status in the hierarchy	Change in housing (>12 hours) and starved for >12 hours
10	Prolonged sedation with highly stressful induction and/or recovery and prolonged effects on normal behaviour and food intake afterwards and/or preventing integration with the group	Extensive veterinary procedure resulting in severe short-term pain despite appropriate treatment and analgesia and a loss of status in the hierarchy	Solitary housed (>12 hours) and starved for >12 hours

**Supplementary Table 5.** Average parameter scores, parameter class scores and cumulative welfare scores per individual (family group: n=4, 83 welfare assessments; all-male group: n=4, 81 welfare assessments) and group means (m).

Welfare indicators	Family group					All-male group				
	KO	KS	TU	NW	m	UZ	MB	KI	MK	m
General condition	1.00	3.24	1.02	4.00	2.32	1.00	7.04	1.05	4.00	3.27
Clinical assessment	1.00	1.00	1.18	1.01	1.05	1.33	7.04	1.01	1.09	2.62
Faecal consistency	1.11	1.11	1.11	1.13	1.12	1.14	1.13	1.18	1.12	1.14
Activity level, mobility	1.06	1.06	1.16	1.06	1.09	1.10	4.17	1.07	1.10	1.86
Not eating/drinking or reported hungry/thirsty	1.04	1.02	1.07	1.01	1.04	1.02	1.13	1.00	1.00	1.04
Abnormal behaviours	1.00	1.02	3.52	1.05	1.65	1.00	1.11	1.01	1.00	1.03
Hierarchy upset/dispute, aggression/bullying	1.40	1.25	1.20	1.20	1.26	1.49	1.64	1.43	1.51	1.52
Use of (foraging) enrichments	2.65	2.67	2.66	2.66	2.66	2.53	2.98	2.51	2.51	2.63
Reaction to 'normal' events	1.19	2.45	1.22	1.19	1.51	1.02	1.53	1.41	1.05	1.25
(Positive reinforcement) training	1.84	1.84	1.83	1.81	1.83	1.98	1.98	1.99	1.99	1.99
Anticipatory behaviour	1.07	1.04	1.08	1.04	1.06	1.20	1.66	1.34	1.26	1.37
Housing	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Group size	2.00	2.00	2.00	2.00	2.00	5.96	7.00	5.98	5.98	6.23
Furnishing/enclosure design	4.00	4.00	4.00	4.00	4.00	2.00	2.00	2.00	2.00	2.00
Nutrition	1.06	1.06	1.06	1.06	1.06	1.83	1.02	1.79	1.82	1.62
Space	3.00	3.02	3.00	3.00	3.01	2.84	2.70	2.84	2.84	2.81
Introductions	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Contingent events	1.06	1.06	1.06	1.06	1.06	1.09	1.06	1.09	1.09	1.08
Perceived control	3.01	3.04	3.04	3.04	3.03	3.16	3.19	3.17	3.18	3.18
Sedation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medical procedure	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Change in routine	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Physical parameter class	1.04	1.49	1.11	1.64	1.32	1.12	4.10	1.06	1.66	1.99
Psychological parameter class	1.53	1.71	1.92	1.49	1.66	1.54	1.82	1.62	1.55	1.63
Environmental parameter class	2.39	2.40	2.39	2.39	2.39	2.73	2.75	2.73	2.74	2.74
Procedural parameter class	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cumulative welfare assessment score	4.34	5.27	5.11	5.03	4.94	4.89	9.65	4.97	5.61	6.28