Supplementary material

What We (Don't) Know about Parrot Welfare: finding welfare indicators through a systematic literature review

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Materials and methods

Search Query creation

A search query was created using the terms reported in Table S1 and additional terms included in the thesaurus of the databases. Filters related to language, publication type and terms to exclude from the results of the systematic search (e.g. "wild birds") were also included in the search queries.

Table S1. Terms used to create the search queries for the systematic literature search to identify valid and feasible outcome measures to assess the welfare of companion parrots.

Search components	Terms
Population	parrot, psittacines, *Psittacids*, cockatoo, macaw, parakeet, budgerigar, cockatiel, *Ara*, *Cacatua*, *Psittacus*, african grey parrot, "grey parrot", amazon parrot, lovebirds, *Poicephalus, Agapornis*, *Psittaccula*, *Eclectus*, conure, caique.
Intervention	enrichment, environmental enrichment, social enrichment, nutritional enrichment, physical enrichment, sensory enrichment, deprivation, diet, nutrition, malnutrition, play, toy, puzzle, play activity, foraging, foraging toy, foraging activity, social activity, activity, stimulation, social bond, social relation, cognitive stimulation, attachment, hand rearing, parent rearing, co-parenting
Outcomes	feather picking, feather plucking, feather damaging, self-damaging, self-mutilation, pododermatitis, atherosclerosis, metabolic bone disease, body condition, obesity, nutritional deficiency, injuries, disease, stereotypes, stereotypical behaviours, abnormal behaviours, behavioural disorders, destructive behaviour, egg laying, reproduction, fertility, biting, screaming, excessive vocalisation, natural behaviours, aggressive, emotion, emotional state, positive state, negative state, stress, distress, hormones, corticosterone, lifespan, life expectancy, longevity, aging

For each database, we applied filters in order to exclude irrelevant studies and optimise the results of the systematic search. These filters included the language restriction (only English), the exclusion of studies focused on wild parrots and reviews or case studies. From a preliminary systematic search, we identified irrelevant studies (e.g. studies focused on bacteria, plants, mammals etc), and therefore added online filters offered by the databases. This included filters related to the topic, authors name (e.g. Parrot *et al*) and studies category (e.g. Fishery, Marine Freshwater Biology, Sport Sciences etc). In addition, on PubMed we applied relevant MeSH terms and the filter "Title/Abstract", on CAB direct relevant organism descriptors and topic terms.

Systematic Search Queries

Below are the search queries used on the 3 databases.

PubMed

((((((((((((((((((((((((((((((Parrot[Title/Abstract]) OR (Psittacines[Title/Abstract])) OR (Psittacids[Title/Abstract])) OR (Psittacidae[Title/Abstract])) OR (Psittacinae[Title/Abstract])) OR (Cacatuidae[Title/Abstract])) OR (Cockatoo[Title/Abstract])) OR (Macaw[Title/Abstract])) OR (Parakeet[Title/Abstract])) OR (Budgerigar[Title/Abstract])) OR (Cockatiel[Title/Abstract])) OR) OR (Cacatua[Title/Abstract])) OR (Psittacus[Title/Abstract])) OR (Grey parrot[Title/Abstract])) OR (Amazona[Title/Abstract])) OR (lovebird[Title/Abstract])) OR (Agapornis[Title/Abstract]))) OR (Psittacula[Title/Abstract])) OR (Conure[Title/Abstract])) OR (Caique[Title/Abstract])) OR (Ecletus[Title/Abstract])*) OR (Poichephalus[Title/Abstract])*) OR ("Parrots"[MAJR])) OR ("Cockatoos"[MAJR])) AND ((("Feather picking") OR ("feather plucking")) OR ("feather damaging")) OR ("feather destruction")) OR (self-

damaging)) OR (self-mutilation)) OR (automutilation)) OR (pododermatitis)) OR (atherosclerosis)) OR ("metabolic bone desease")*) OR ("Body condition")) OR (obesity)) OR (injury)) OR (disease)) OR ("nutritional deficiency")) OR (Stereotypes)) OR ("stereotypical behaviour")) OR ("abnormal behaviour")) OR ("repetitive behaviour")*) OR ("behavioural disorder")) OR ("destructive behaviour")) OR ("natural behaviour")) OR ("egg laying")) OR (reproduction)) OR (fertility)) OR (aggression)) OR (emotion)) OR ("emotional state")) OR (biting)) OR (screaming)) OR ("excessive vocalization")) OR ("positive state")) OR ("negative state")) OR (Stress)) OR (distress)) OR (hormones)) OR (corticosterone)) OR (Lifespan)) OR ("life expectancy")) OR (longevity)) OR (aging)) OR ("Bird Diseases/diagnosis"[MeSH])) OR ("Cognition"[MeSH])) OR ("Emotions"[MAJR])) OR ("Parrots/physiology"[MAJR])) OR ("Vocalization, Animal"[MAJR])) OR ("Feathers/injuries"[MAJR])) OR ("Corticosterone/blood"[MeSH])) OR ("Diagnosis, Differential"[MeSH])) OR ("Aggression/physiology"[MAJR])) OR ("Stereotyped Behavior"[MAJR])) OR ("Impulsive Behavior"[MeSH])) OR ("Behavior, Animal"[MeSH])) OR ("Feeding Behavior/physiology"[MAJR])) OR ("Amazona/metabolism"[MAJR])) OR ("Amazona/physiology"[MAJR])) OR ("Amazona/growth and development"[MAJR])) OR ("Animal Feed/analysis"[MAJR]))) OR ((((((((((((((((((((((((((Parrot[Title/Abstract]) OR (Psittacines[Title/Abstract])) OR (Psittacids[Title/Abstract])) OR (Psittacidae[Title/Abstract])) OR (Psittacinae[Title/Abstract])) OR (Cacatuidae[Title/Abstract])) OR (Cockatoo[Title/Abstract])) OR (Macaw[Title/Abstract])) OR (Parakeet[Title/Abstract])) OR (Budgerigar[Title/Abstract])) OR (Cockatiel[Title/Abstract])) OR) OR (Cacatua[Title/Abstract])) OR (Psittacus[Title/Abstract])) OR (Grey parrot[Title/Abstract])) OR (Amazona[Title/Abstract])) OR (lovebird[Title/Abstract])) OR (Agapornis[Title/Abstract]))) OR (Psittacula[Title/Abstract])) OR (Conure[Title/Abstract])) OR (Caique[Title/Abstract])) OR (Ecletus[Title/Abstract])*) OR (Poichephalus[Title/Abstract])*) OR ("Parrots"[MAJR])) OR ("Cockatoos"[MAJR])) AND ((((((((((((((((((((((((((((Enrichment) OR ("Environmental Enrichment")) OR ("Social Enrichment")) OR ("Nutritional Enrichment")) OR ("Physical Enrichment")) OR ("sensory enrichment")) OR (Deprivation)) OR (Diet)) OR (Nutrition)) OR (Malnutrition)) OR (Play)) OR (Toy)) OR (Puzzle)) OR ("Play activity")) OR (Foraging)) OR ("Foraging toy")) OR ("foraging activity")) OR ("social activity")) OR (activity)) OR (stimulation)) OR ("social bond")) OR ("social relation")) OR ("cognitive stimulation")) OR (attachment)) OR ("Hand rearing")) OR ("parent rearing")) OR (co-parenting)) OR ("Behavior, Animal/drug effects"[MeSH])) OR ("Animal Nutritional Physiological Phenomena/physiology"[MeSH])) OR ("Acoustic Stimulation"[MeSH])) OR ("Social Isolation/psychology"[MAJR])) OR ("Play and Playthings"[MAJR]))) AND (english[Filter] OR french[Filter] OR italian[Filter])) NOT (Review[Publication Type])) NOT (Case Reports[Publication Type])) NOT ("wild birds") AND (english[Filter] OR french[Filter] OR italian[Filter])

*Misspelled terms

CAB direct

(((((((((up:("Cacatuidae" or "Psittacidae")) OR ((up:("Psittaciformes" or "Psittacus")) OR (((((((Parrot) OR (Psittacines) OR (Psittacids) OR (Psittacidae) OR (Psittacinae) OR (Cacatuidae) OR (Cockatoo) OR (Macaw) OR (Parakeet) OR (Budgerigar) OR (Cockatiel) OR (Ara) OR (Cacatua) OR (Psittacus) OR (Grey parrot) OR (lovebird) OR (Agapornis) OR (Psittacula) OR (Conure) OR (Caique) OR (Ecletus)* OR (Poichephalus)*))) OR (od:("Ara" or "Amazona" or "Cacatua" or "Eclectus roratus" or "Nymphicus hollandicus" or "Psittacula" or "Myiopsitta monachus" or "Cacatuidae" or "Nymphicus" or "Pionites" or "Psittacus" or "Eclectus" or "Aratinga")))) OR (od:("Cacatua" or "Agapornis" or "budgerigars"))))) AND ((de:("behaviour problems")) OR (((id:("chewing")) OR ((((((((("Feather picking") OR ("feather plucking") OR ("feather damaging") OR ("feather destruction") OR (self-damaging) OR (self-mutilation) OR ("automutilation") OR (pododermatitis) OR (atherosclerosis) OR ("Body condition") OR (obesity) OR (injury) OR (disease) OR ("nutritional deficiency") OR (Stereotypes) OR ("stereotypical behaviour") OR ("abnormal behaviour") OR ("repetetive behaviour")* OR ("behavioural disorder") OR ("destructive behaviour") OR ("natural behaviour") OR ("egg laying") OR (reproduction) OR (fertility) OR (aggression) OR (emotion) OR ("emotional state") OR (biting) OR (screaming) OR ("excessive vocalization") OR ("positive state") OR ("negative state") OR (Stress) OR (distress) OR (hormones) OR (corticosterone) OR (Lifespan) OR ("life expectancy") OR (longevity) OR (aging))) OR (de:("corticosterone" or "behaviour" or "feather pecking" or "animal behaviour" or "egg production")))) OR (id:("pterotillomania" or "cage birds" or "feather damaging behaviour" or "captive animals")))) OR (id:("deviant behaviour" or "abnormal behavior")))) OR (id:("chewing"))))) OR (((((((Enrichment) OR ("Environmental Enrichment") OR ("Social Enrichment") OR ("Nutritional Enrichment") OR ("Physical Enrichment") OR ("sensory enrichment") OR (Deprivation) OR (Diet) OR (Nutrition) OR (Malnutrition) OR (Play) OR (Toy) OR (Puzzle) OR (Play activity) OR (Foraging) OR (Foraging toy) OR (foraging activity) OR (social) OR (activity) OR (stimulation) OR (social bond) OR (social relation) OR (cognitive stimulation) OR (attachment) OR (Hand rearing) OR (parent rearing) OR (co-parenting))) OR (de:("enrichment" and "physical activity" and "quality of life" and "ornamental birds" and "toys" and "animal welfare" and "foraging")))) OR (de:("exercise" or "animal nutrition" or "diets" or "ontogeny"))) AND ((up:("Cacatuidae" or "Psittacidae")) OR ((up:("Psittaciformes" or "Psittacus")) OR (((((((Parrot) OR (Psittacines) OR (Psittacids) OR (Psittacidae) OR (Psittacinae) OR (Cacatuidae) OR (Cockatoo) OR (Macaw) OR (Parakeet) OR (Budgerigar) OR (Cockatiel) OR (Ara) OR (Cacatua) OR (Psittacus) OR (Grey parrot) OR (Amazona) OR (lovebird) OR (Agapornis) OR (Psittacula) OR (Conure) OR (Caique) OR (Ecletus)* OR (Poichephalus)*))) OR (od:("Ara" or "Amazona" or "Cacatua" or "Eclectus roratus" or "Nymphicus hollandicus" or "Psittacula" or "Myiopsitta monachus" or "Cacatuidae" or "Nymphicus" or "Pionites" or "Psittacus" or "Eclectus" or "Aratinga")))) OR (od:("Cacatua" or "Agapornis" or "budgerigars")))))) NOT (Review)) NOT (de:("wild birds"))) NOT ("Case Study")) NOT (de:("DNA cloning" or "interferon-gamma"))) NOT (de:("guided tours" or "cultural tourism" or "ecotourism"))) AND (((NOT (organism-descriptor:(("Protozoa" OR "mice" OR "fowls" OR "fishes" OR "plants")))) (NOT (topic:(("aquatic organisms" OR "aquatic species" OR "aquatic animals" OR "case reports" OR "forests" OR "bacterium")))) (NOT (broader-term:(("mammals" OR "Spermatophyta" OR "angiosperms" OR "plants"))))))) AND (((topic:(("cage birds" OR "aviary birds" OR "behavior" OR "behaviour" OR "animal behavior" OR "pet animals" OR "pets" OR "animal behaviour"))) (NOT (topic:(("Viral diseases" OR "viral infections")))) (language:(("English" OR "French" OR "Italian")))))

*Misspelled terms

Web of Science

Web of Science did not allow to create a search query containing more than 100 terms, for this reason terms related to the intervention and the outcomes were reduced.

((((((((((((((((((((((((ALL=(Parrot)) OR ALL=(Psittacines)) OR ALL=(Psittacids)) OR ALL=(Psittacidae)) OR ALL=(Psittacinae)) OR ALL=(Cacatuidae)) OR ALL=(Cockatoo)) OR ALL=(Macaw)) OR ALL=(Parakeet)) OR ALL=(Budgerigar)) OR ALL=(Cockatiel)) OR ALL=(Ara)) OR ALL=(Cacatua)) OR ALL=(Psittacus)) OR ALL=("Grey parrot")) OR ALL=(Amazona)) OR ALL=(lovebird)) OR ALL=(Agapornis)) OR ALL=(Psittacula)) OR ALL=(Conure)) OR ALL=(Caique)) OR ALL=(Ecletus)*) OR ALL=(Poichephalus)* AND ((((((((((((((((ALL=(Enrichment)) OR ALL=("sensory enrichment")) OR ALL=(Deprivation)) OR ALL=(Diet)) OR ALL=(Nutrition)) OR ALL=(Malnutrition)) OR ALL=(Play)) OR ALL=(Toy)) OR ALL=(Puzzle)) OR ALL=(Foraging)) OR ALL=("social")) OR ALL=(activity)) OR ALL=(stimulation)) OR ALL=("social bond")) OR ALL=("cognitive stimulation")) OR ALL=("attachment")) OR ALL=(rearing)) OR ALL=(co-parenting) AND ((((((((((((((((((((((((((((((ALL=(Feather)) OR ALL=(damage)) OR ALL=(destruction)) OR ALL=(mutilation)) OR ALL=(pododermatitis)) OR ALL=(atherosclerosis)) OR ALL=("metabolic bone desease")*) OR ALL=("Body condition")) OR ALL=(obesity)) OR ALL=(injury)) OR ALL=(disease)) OR ALL=("nutritional deficiency")) OR ALL=(Stereotypes)) OR ALL=("stereotypical behaviour")) OR ALL=("abnormal behaviour")) OR ALL=("repetitive behaviour")*) OR ALL=("behavioural disorder")) OR ALL=("natural behaviour")) OR ALL=("egg laying")) OR ALL=("reproduction")) OR ALL=(fertility)) OR ALL=(aggression)) OR ALL=("emotional state")) OR ALL=(biting)) OR ALL=(screaming)) OR ALL=("excessive vocalization")) OR ALL=("positive state")) OR ALL=("negative state")) OR ALL=(Stress)) OR ALL=(distress)) OR ALL=(hormones)) OR ALL=(corticosterone)) OR ALL=(Lifespan)) OR ALL=("life expectancy")) OR ALL=(longevity)) OR ALL=(aging)

*Misspelled terms

Inclusion and Exclusion Criteria

To select articles that fit with the research questions, we applied the eligibility criteria described in Table S2.

Table S2. Inclusion and exclusion criteria used to select relevant articles identified during the systematic literature review for possible welfare parameters useful to assess parrot welfare through an initial title/abstract screening and subsequent full-text evaluation.

Population	Inclusion criteria	Species: all species belonging to the order Psittaciformes
		Parrots living as companion animals or laboratory animals, in zoos, shelters or breeding centres
		Demographic factors: all ages, both sexes
	Exclusion criteria	Wild parrots
Intervention	Inclusion criteria	Enrichment: enriched parrot vs not enriched (between or within subject designs) Social enrichment (e.g. intra-interspecific interactions, hand-raised vs parent raise), physical enrichment (e.g. foraging toys, changes in the aviary/cage/room), cognitive enrichment (problem solving activities, training etc.), nutritional enrichment (vegetable and/or fruits as well as seeds), etc.
		Vet Treatments: treated vs not treated
		Examination: In vivo, Post mortem
		Diet manipulation: increased/decreased levels of cholesterol/fibres/fat etc.
		Questionnaires
		Behavioural tests: novel object, open field, flight training, etc.
		Personality tests: only when result are related to the outcomes described below
Outcomes measures	Inclusion criteria	Problematic behaviours: aggressiveness (e.g. bites), fear-related behaviour (avoidance behaviour), abnormal behaviours (self-mutilation, feather plucking, stereotypies, incessant screaming).
		Activity level: resting, exploratory behaviour, foraging behaviour
		Social behaviours: play, allopreening, interspecific interactions, human interactions
		Vocal behaviours
		"Body language": feather ruffling, body posture
		Health measures: body weight, plumage quality, presence of diseases, mortality
		Behaviour related to basic needs: eating, drinking, resting
		Chick mortality only when related to aggressive interactions
	Exclusion criteria	Reproductive parameters: egg hatchability, num. of eggs laid
		Chicks-related: development parameters and nutritional requirements
General	Inclusion criteria	Only English
		Publication date restriction: none
	Exclusion criteria	Methodological details: studies that lacked statistical analysis
		Publication type: reviews, conference abstracts, book chapters
		Irretrievable studies
		Study design: case studies, studies with less than 5 subjects

Full-text screening

Two different reviewers (AP and J-LR) screened the 140 articles. The reviewers, using the exclusion and the exclusion criteria, independently select the papers that considered eligible. After the full-text screening, the reviewers compared their two lists of eligible studies and decide which ones to exclude or include. In case of disagreement between the reviewers a study was considered not eligible.

Data collection

Descriptions of the validity measures

Table S2. Definitions of the validity parameters used to assess the risk of bias of possible outcome measures related to parrot welfare as identified during the systematic literature review.

Validity parameters	Description	**Levels**
Inter-observer reliability	Were the outcomes tested for inter-reliability?	**Yes**: authors reported in the main text that the outcome was tested for inter-observer reliability **No**: authors reported in the main text that the outcome was not tested for inter-observer reliability **Not specified**: authors did not report the information in the main text **Not Possible**: the experimental set up did not allow to test for inter-observer reliability
Intra-observer reliability	Were the outcomes tested for intra-reliability?	**Yes**: authors reported in the main text that the outcome was tested for intra-observer reliability **No**: authors reported in the main text that the outcome was not tested for intra-observer reliability **Not specified**: authors did not report the information in the main text **Not Possible**: the experimental set up did not allow to test for intra-observer reliability
Random group assignment	Were the subjects randomly assigned to experimental and control groups?	**Yes**: authors reported random group assignments of the subjects in the main text **No**: authors reported in the main text that the subjects were not randomly assigned to groups **Not specified**: authors did not report the information in the main text **Not Possible**: the experimental set up did not allow to randomly assign subjects to groups
Condition balancing	Were conditions balanced between subjects and/or groups?	**Yes**: authors reported in the main text that experimental conditions were balanced between subjects and/or groups **No**: authors reported in the main text that experimental conditions were not balanced between subjects and/or groups **Not specified**: authors did not report the information in the main text **Not Possible**: the experimental set up did not allow to balance conditions between subjects and/or groups
Observer blindness	Was the outcome assessor blinded during data collection?	**Yes**: authors reported in the main text that the assessor was blinded **No**: authors reported in the main text that the assessor was not blinded **Not specified**: authors did not report the information in the main text **Not Possible**: the experimental set up did not allow to blind the assessor

Welfare dimensions and outcome categories

Table S3. Welfare dimensions and corresponding outcome categories which were used to group the outcome measures related to parrot welfare as identified during the systematic literature review.

Welfare Dimensions	Outcome Categories
Body measurements	Indirect measures of feather-damaging behaviours, body condition, feather colour
Physiological parameters	Stress-related, metabolic, vitamin D-related, lipid-related, immune system-related, body temperatures, others
Abnormal and fear-related behaviour	Feather-damaging behaviours, fear-related, stereotypies, incessant screaming
Maintenance behaviour	Feeding, drinking, resting, self-care
Locomotor behaviour	Fly, position occupied in the cage, locomotion, inactivity
Exploratory and foraging behaviour	Cognitive stimulation, enrichment interaction, foraging, environment/object preference, reaction to new environment, reaction to novel objects
Diseases and pathologic conditions	-
Social behaviour	Allopreening, aggressive behaviours, human-animal interaction, facial and body displays, sexual behaviours, social dynamics, vocalizations

Subjects' living conditions

Table S4. Description of the various living conditions that would apply to the parrots included in the eligible studies that identified potential welfare parameters to assess parrot welfare.

Living condition	Definition
Breeding facility	Parrots living in private or public breeding facilities
Companion animals	Parrots that live with humans or within human social structures where they are provided with some, or all, of their needs. They are considered to play a primarily social role within the household or community (1)
Laboratory animals	Parrot kept for research purposes at universities or laboratories
Multiple	Studies focused on parrots kept in multiple living conditions
Rehabilitation centre	Parrots kept in rehabilitation centres
Shelter	Parrots, previously kept as companion, that lives in shelters
Zoo	Parrots living in zoo with public or private aviaries

Results

Table S5. Total number of studies and number of studies per parrot genus (in parentheses) on welfare-related outcome parameters, grouped according to the parrots' living conditions.

Living condition	Number of Studies	Genera (number of studies)
Breeding facility	6	*Amazona* (n = 1), *Ara* (n = 1), *Nymphicus* (n = 3), *Guaruba* (n = 1)
Companion animals	21	*Agapornis* (n = 1), *Cacatua* (n = 2), Multiple (n = 11), Nymphicus (n = 1), *Psittacus* (n = 7)
Laboratory-kept animals	48	*Amazona* (n = 22), *Melopsittacus* (n = 14), Multiple (n = 1), *Myiopsitta* (n = 2), *Nymphicus* (n=7), *Platycercus* (n=1), *Psittacus* (n=1)
Multiple	1	*Amazona* (n = 1)
Rehabilitation centre	3	*Amazona* (n = 3)
Shelter	2	*Psittacus* (n = 2)
Unknown	7	*Amazona* (n = 1), *Ara* (n = 1), *Myiopsitta* (n = 1), Multiple (n = 2), *Loriculus* (n = 1), *Psittacus* (n = 1)
Zoo	10	*Amazona* (n = 1), *Ara* (n = 4), *Cacatua* (n = 1), *Calyptorhynchus* (n = 1), Multiple (n = 2), *Pyrrhura* (n = 1)

Genera and living conditions represented in the studies

Eligible studies covered 13 genera, of which 10 belonged to the superfamily *Psittaccoidea* and 3 to the superfamily *Cacatuoidea.* None of the studies investigated the welfare of species belonging to the superfamily *Strigopoidea*. *Amazona* was the genus most investigated, representing 29 studies (29.6%), followed by the genera *Melopsittacus*, *Nymphicus*, and *Psittacus* with 14 (14.3%), 11 (11.2%), and 10 studies (10.2%) respectively (Figure S1, Table S8). A lesser number of studies focused on the genera *Ara* (n = 6; 6.1%), *Cacatua* (n = 3; 3.1%), and *Myiopsitta* (n = 3; 3.1%), while six other genera were represented by only one study each (Figure S1, Table S8). Sixteen studies (16.3%) investigated parrot welfare in multiple genera, including those as previously mentioned, as well as the *Eclectus* (6 studies) and *Poicephalus* (6 studies) genera (Figure S1, Table S7 for a full list of species included in the category 'multiple', Table S8).

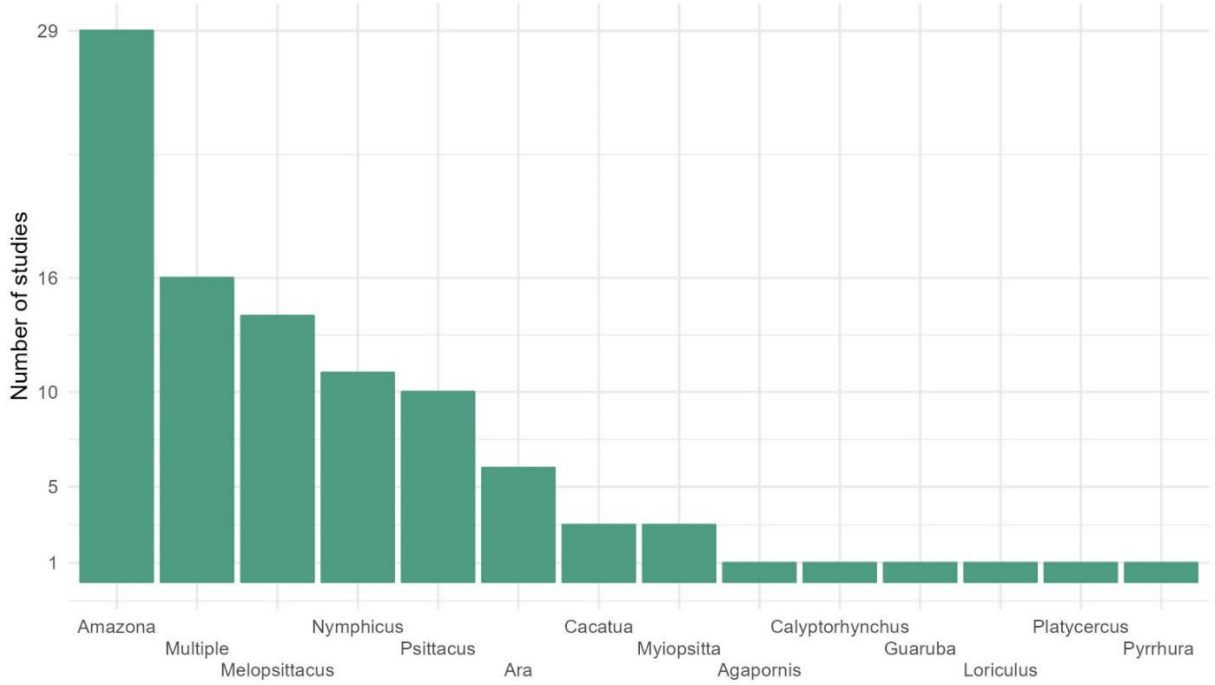

Figure S1. Number of studies identified in the systematic literature search that report on welfare-related outcome measures in parrots, grouped by parrots' genera. The y-axis corresponds to the number of studies reporting on welfare-related outcomes for each parrot genera listed.

Table S6. Number of studies reporting on welfare-related outcome measures for each parrot genus as identified during the systematic literature search. As some studies did not specify the species or genus involved, additional groups were created such as 'cockatoo', 'conure', 'macaw', and 'parakeet' as authors listed the common instead of the scientific name, hindering the ability to attribute the study to a particular genus. Additionally, few studies involving multiple species failed to report on a particular species investigated, classifying these as 'other', 'undetermined' or 'unknown'.

Genus	Number of Studies	Genus	Number of Studies	Genus	Number of Studies	Genus	Number of Studies
Agapornis	6	*Cyanoramphus*	3	*Nadayus*	1	*Psittacara*	1
Alisterus	1	*Deroptyus*	1	*Neophema*	2	*Psittacula*	4
Amazona	10	*Diopsittaca*	2	*Neopsittacus*	1	*Psittaculorostris*	1
Anodorhynchus	2	*Eclectus*	6	*Northiella*	1	*Psittacus*	10
Aprosmictus	1	*Enicognathus*	1	*Nymphicus*	7	*Psitteuteles*	2
Ara	8	*Eolophus*	2	*Opopsitta*	1	*Psittaculorostris*	1
Aratinga	3	*Eos*	2	*Orthopsittaca*	1	*Psittinus*	1
Barnadius	2	*Eupsittula*	1	Other[1]	1	*Purpureicephalus*	1
Bolborhynchus	3	*Forpus*	4	Parakeet[2]	2	*Pyrrhura*	2
Brotogeris	1	*Glossopsitta*	1	*Pionites*	3	*Tanygnathus*	2
Cacatua	6	*Guaruba*	1	*Pionopsitta*	1	*Trichoglossus*	3
Callocephalon	1	*Lathamus*	1	*Pionus*	3	*Triclaria*	1
Chalcopsitta	2	*Lorie*	1	*Platycercus*	3	Undetermined[1]	2
Charmosyna	1	*Lorius*	2	*Poicephalus*	7	Unknown[1]	1
Cockatoo[2]	3	Macaw[2]	2	*Primolius*	1		
Conure[2]	3	*Melopsittacus*	4	*Probosciger*	1		
Coracopsis	1	*Myiopsitta*	4	*Psephotus*	2		
Cyanoliseus	2	*Neopsephotus*	1	*Pseudeos*	2		

[1] *Description reported by the authors.*
[2] *Authors reported common name instead of scientific name.*

Table S7. Absolute and relative (in percentage) number of studies and number of welfare-related outcome measures identified for each parrot genus during the literature search. In addition to the total number of outcome measures, the (absolute and relative) number of significant ($P < 0.05$) and feasible (i.e. not requiring specific skills, expertise or equipment) outcome measures, number of outcome measures specifically studies in companion parrots, and number of significant and feasible outcome measures identified in companion parrots are also presented.

Genera	**Studies (%)**	**Outcomes (%)**	**Significant and feasible outcomes (%)**	***Outcomes (%); only companion***	***Significant and feasible outcomes (%); only companion***
	Total = 98	**Total = 1512**	**Total = 572**	**Total = 340**	**Total = 68**
Agapornis	1 (1.2%)	21 (1.39%)	3 (0.52%)	21 (6.18%)	3 (4.41%)
Amazona	29 (29.59%)	320 (21.16%)	128 (22.34%)	12 (3.53%)	/
Ara	6 (6.12%)	142 (9.39%)	72 (12.57%)	/	/
Cacatua	3 (3.06%)	69 (4.56%)	12 (2.09%)	65 (19.12%)	9 (13.24%)
Calyptorhynchus	1 (1.02%)	6 (0.4%)	4 (0.7%)	/	/
Guaruba	1 (1.02%)	3 (0.2%)	1 (0.17%)	/	/
Loriculus	1 (1.02%)	3 (0.2%)	3 (0.52%)	/	/
Melopsittacus	14 (14.28%)	287 (20.63%)	150 (26.22%)	/	/
Multiple	16 (16.32%)	287 (18.98%)	54 (9.42%)	150 (44.12%)	32 (47.06%)
Myiopsitta	3 (3.06%)	48 (3.17%)	9 (1.57%)	/	/
Nymphicus	11 (11.22%)	148 (9.79%)	65 (11.34%)	4 (1.18%)	/
Platycercus	1 (1.02%)	26 (1.72%)	/	/	/
Psittacus	10 (10.20%)	133 (8.80%)	54 (9.44%)	88 (25.88%)	24 (35.29%)
Pyrrhura	1 (1.02%)	19 (1.26%)	17 (2.97%)	/	/

Welfare dimensions represented in the studies

The most common welfare dimensions investigated across all studies, in decreasing order, were 'body measurements' (35 studies), followed by 'social behaviours' (34 studies), 'physiological parameters' (31 studies), 'maintenance behaviours' (29 studies), 'exploratory and foraging behaviours' (28 studies), 'locomotor behaviours' (20 studies), 'abnormal and fear-related behaviours' (16 studies), and 'diseases and pathologic conditions' (11 studies) (Figure S2 and Table S9).

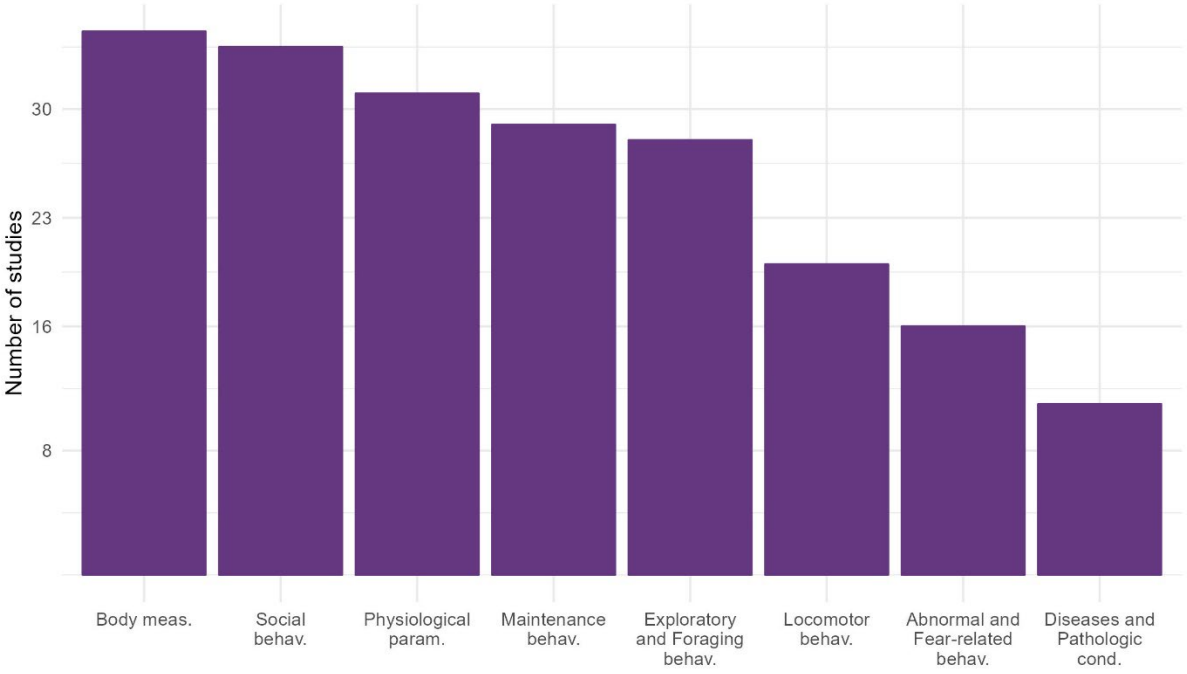

Figure S2. Number of studies reporting on parrot welfare outcome measures as identified during the systematic literature search, grouped by welfare dimension. The y-axis corresponds to the number of studies reporting on at least one welfare-related outcome measures. Behav.=behaviour, meas.=measurements, param.=parameters, cond.=conditions.

Table S8. Absolute and relative (in percentage) number of studies and number of welfare-related outcome measures identified for each welfare dimension identified during the literature search. In addition to the total number of outcome measures, the (absolute and relative) number of significant ($P < 0.05$) and feasible (i.e. not requiring specific skills, expertise or equipment) outcome measures, number of outcome measures specifically studies in companion parrots, and number of significant and feasible outcome measures identified in companion parrots are also presented.

Welfare Dimensions	**Studies (%)**	**Outcomes (%)**	**Significant and feasible outcomes (%)**	***Outcomes (%); only companion***	***Significant and feasible outcomes (%); only companion***
	Total = 1,512		**Total = 572**	**Total = 340**	**Total = 68**
Abnormal and fear-related behaviours	16 (7.84%)	157 (10.38%)	87 (15.18%)	34 (10%)	8 (11.76%)
Locomotor behaviours	20 (9.80%)	149 (9.85%)	83 (14.51%)	/	/
Exploratory and foraging behaviours	28 (13.72%)	212 (14.02%)	93 (16.26%)	1 (0.29%)	1 (1.47%)
Diseases and pathologic conditions	11 (5.39%)	61 (4.03%)	/	17 (5%)	/
Maintenance behaviours	29 (14.21%)	185 (12.24%)	87 (15.21%)	6 (1.76%)	2 (2.94%)
Body measurements	35 (17.15%)	316 (20.90%)	80 (13.99%)	231 (67.94%)	51 (75%)
Physiological parameters	31 (15.19%)	192 (12.70%)	/	45 (13.24%)	/
Social behaviours	34 (16.66%)	240 (15.87%)	142 (24.78%)	6 (1.76%)	6 (8.82%)

Welfare categories represented in the studies

The outcome measures were grouped in 35 different welfare categories (Table S4). Of these, 'indirect measures of feather-damaging behaviour' and 'feeding' were covered by the highest number of studies (n = 19), followed by 'self-care' (n = 18) and 'stereotypies' (n = 16) (Table S10). Most other categories were covered by 2 to 9 studies. Of all categories, 'body surface temperature' was the least studied with only one study (Table S10).

Table S10. Significant and feasible outcome measures related to parrot welfare as identified during the systematic literature search, categorised by welfare dimensions and welfare categories. The table includes the number of outcomes associated with each welfare category, the types of outcomes measured, and the parrot genera investigated, along with corresponding studies. The types of outcomes are detailed using abbreviations to denote different measurement methods: D (duration), L (latency), F (frequency), P (percentage), PP (proportion of parrots), and U (unknown type of measurement). In addition to these details, the table includes the feasible risk factors associated with each welfare category, providing insight into potential causes and influences on welfare across various parrot species. For detailed associations between outcomes, risk factors, and their effects, refer to the dataset.

Welfare dimensions	Welfare Categories	Number of Outcomes	Types of outcomes	Feasible risk factors	Genera	Studies
Abnormal and fear-related behaviours	Fear-related	3 (0.2%)	Phobic behaviours (U)	small cage (max. 80 cm 100 cm 120 cm), highest perch lower than eye level, being wild caught	*Psittacus*	(2)
	Incessant screaming	8 (1.40%)	Incessant screaming (D, F)	being pair-housed, small cage	*Melopsittacus*	(3, 4)
	Stereotypies	76 (13.26%)	Oral stereotypies (P), total stereotypies (F, D, P), whole body stereotypies, self-biting, , sham/wire chewing (F, D), biting (F), pacing (D, F, PP), route tracing (D, F, PP), spot pecking (D, F)	, < 5 weeks when removed from the nest, brain volume (species), small cage, lack of enrichment, being pair-housed), bird sex, number of birds, unbalanced diet (no fruit or few, no protein supply, inappropriate seed mix, etc), being hand-reared, perches' material (only manufactured), being single-housed	*Amazona*, *Ara*, *Calyptorhynchus, Melopsittacus*, "Multiple", *Psittacus*	(2-13)
Exploratory and foraging behaviours	Cognitive	6 (1.05%)	Proactive response towards novel objects**,** latency to reward during attention bias test, problem-solving skills, responsiveness during discrimination task	Correlation with feather-damaging behaviours, presence of unfamiliar humans˙, personality	*Amazona*, *Melopsittacus*, *Psittacus*	(14-16)
	Enrichment interaction	24 (4.19%)	Environment interaction (F, P, PP), object destruction, visit enriched area (F, D), enrichment interaction (F, D, P)	Lack of offered choices, being single-housed, bird sex, lack of enrichments, being hand reared, manual restraint, personality (being explorative)	*Amazona*, *Ara*, "Multiple", *Nymphicus*	(5, 6, 9, 10, 13, 17-21)
	Foraging	16 (2.79%)	Foraging (F, D, P), interaction with food (D), contrafreeloading	Lack of enrichment, personality (individual differences)	*Ara*, *Calyptorhynchus*, *Psittacus*	(11, 13, 22-24)
	Preference	18 (3.14%)	Choice for pellet size or objects colour/size/material, perch diameter/position	Lack of offered choices	*Amazona*, *Loriculus*	(25-28)
	Reaction to new environment	7 (1.22%)	Exploration (D, L), pattern of exploration, total distance/amount squares covered, number of visits of new environments˙ explorative tendency PCA axis ‡Results obtained running a Principal Component Analysis)	Correlation with neophobic behaviours, correlation with feather-damaging behaviours, being single-housed	*Melopsittacus*, *Psittacus*	(14, 16, 29)
	Reaction to novel objects	22 (3.84%)	Novel object interaction (D, L), latency to feed in presence of novel object, latency to touch novel object	Being hand-reared, lack of enrichment (physical + foraging), being single-housed), species, being dominant	*Amazona,* "Multiple"	(5, 30-32)
Locomotor behaviours	Flying	26 (4.54%)	Flying (D, F, L, score), escape flight (D)	Small cage, being single-housed, correlation with feather-damaging behaviours, lack of enrichments, bird sex, being hand-reared, insufficient physical activity, wing load (indirect measure of fat mass), personality (being more risk taker)	*Amazona*, *Melopsittacus*, "Multiple", *Pyrrhura*	(5, 9, 29, 33-37)
	Inactivity	9 (1.57%)	Inactivity (PP), stationary position (D)	Lack of enrichment, time of day, correlation with feather-damaging behaviours	*Ara*, *Pyrrhura*	(18, 33)
	Locomotion	34 (5.93%)	Locomotion (F, D), walking (F, D), climbing (D), general activity (D), hopping (D), number of area changes	Being pair-housed, small cage, lack of enrichment, being single-housed), manual restraint	*Amazona*, *Ara*, *Melopsittacus*, *Nymphicus*, *Pyrrhura*,	(4, 5, 8, 10, 13, 18, 19, 21, 33, 36, 38)
	Position occupied in the cage	14 (2.44%)	Standing at the bottom of the cage (F), flights from the perch/wall to the ground (F, D), aggregated flights to the ground (D), fly between walls/perches (F), time spent on the ground, time spent 1m to 2m high, standing at the grid ceiling (F)	Elevated ambient temperature, lack of enrichment, being pair-housed), feeders positioned under the perches in the cage	*Ara*, *Melopsittacus*, *Nymphicus, Pyrrhura*,	(10, 21, 33, 34, 39)
Maintenance behaviours	Drinking	2 (0.35%)	Water intake	Diet based only on seeds, being exposed to artificial light at night	*Amazona, Melopsittacus*	(40, 41)
	Feeding	31 (5.41%)	Food consumption (D), food intake, time spent feeding per day (P), feeding (D, F), visit to feeding dish (F), ratio consumption (grams per bird)	Being single-housed, elevated temperatures, food preference, lack of enrichment (physical/foraging), personality (being more vigilant), time of day, manual restraint, small cage, bird sex, courtship feeding, flight activity (frequency), diet based only on seeds, being exposed to artificial light at night	*Amazona*, *Ara, Melopsittacus*, *Myiopsitta,* Nymphicus, *Psittacus*	(18-20, 23, 29, 34, 36, 39-46)
	Self-care	42 (7.33%)	Preening (D, L, P), bathing (D, L), tail wagging (F), puffing up the feathers (F), scratching (PP), cleaning the beak (PP), wing stretch (F)	Reduced flight ability, being hand reared or sold before the end of weaning, lack of bathing opportunities, correlation with feather damaging behaviours, lack of enrichment, small cage, bird sex, time of day, being pair-housed), being single-housed	*Amazona*, *Ara, Melopsittacus*, "Multiple", *Psittacus*, *Pyrrhura*	(2-5, 8-10, 18, 20, 29, 33, 36, 42)
	Resting	12 (2.09%)	Resting/sleeping (D, F, P)	Lack of enrichment, small cage, being pair-housed, manual restraint, time of day, being single-housed	*Amazona, Ara*, *Melopsittacus*, *Nymphicus*	(4, 5, 13, 19, 20, 42, 44)
Body measurements	Body condition	12 (2.09%)	Body mass, body weight, chest girth	exposure to artificial light at night, lack of exercise, diet based only on seeds, correlation with flight activity, correlation with feeding duration, correlation with wing load (indirect measure of fat mass), bird sex, general activity	*Amazona, Ara, Melopsittacus*	(34, 41, 46-48)
	Indirect measures of feather-damaging behaviour	66 (12.04%)	Presence/absence of feather damages**,** plumage score	Diet needing extensive handling, ≥ 1 vacation per year taken by owners , age, small cage, absence of foraging/chewable devices, receiving command training, personality (being proactive), distance of the cage from the door, variety of the diet, heritability, hours spent outside of the cage, hours of sleep, lack of enrichments, length of ownership, lives with others parrots, position of the cage, bird sex, no toys/only one toy in the cage, inability to fly, other non-bird companion animals (protective), out of the cage for more than 8 h, owner type (Shelter, Woman, Man, Family), being acquired from a pet shop, being hand reared, being sold before the end of weaning, being rescued or rehomed, separation anxiety, species, sprayed with water daily, time of human/bird interaction per day	*Agapornis, Amazona*, *Cacatua*, *Guaruba,* "Multiple", *Psittacus*	(2, 7, 8, 12, 14, 22, 49-60)
Social behaviours	Aggressive	18 (3.14%)	Total aggressive behaviours (F, D), female/male aggressive behaviours (F), aggressive behaviours toward non-mates (F), wins/losses after agonistic interactions (F), number of chicks killed	Dominance rank, agonistic interactions, partner/non-partner affiliation, manual restraint, bird sex, mate/non-mate, being pair-housed	*Amazona*, *Melopsittacus*, *Myiopsitta, Nymphicus*	(19, 61-66)
	Allopreen	12 (2.09%)	Male/female allopreen (F), male/female allopreen solicitation (F), total allopreening (D, PP, P)	Sex of the receiver, small cage, correlation with feather damaging behaviours, lack of enrichments, type of physical enrichment, preference for partner	*Amazona*, *Ara*, *Melopsittacus*, *Nymphicus*, *Pyrrhura*	(18, 20, 33, 36, 61, 62)
	Sexual behaviours	19 (3.31%)	Female/male courting (D, F), intra-pair interaction (D), number of approaches toward mates, synchronicity, female/male copulation (F), female solicits copulation (F), sexually active (U), sexual behaviours (P)	Correlation with feather-damaging behaviours, small cage, being pair-housed, bird sex, comparison between mate and non-mate, lack of physical, foraging, and cognitive enrichments, < 2 weeks in the nest from hatching or hatched from egg incubator	*Ara, Melopsittacus*, *Nymphicus*, *Psittacus*, *Pyrrhura*	(2, 4, 13, 33, 62)
	Social dynamics	21 (3.66%)	Reaction towards other individuals (F), coo-feeding (F), food steeled (F, number of parrots), social interactions (PP), time spent next to each other, approach unfamiliar bird (L), dominance rank, physical distance between subjects (score)	Manual restraint, kinship, age, aggressiveness, time of day, bird sex, lack of enrichment, being single-housed, small cage, lack of mate	*Ara*, *Melopsittacus*, *Nymphicus*	(18, 19, 29, 61, 62, 65, 67)
	Vocalisations	23 (4.01%)	Calm vocalisation (F), singing (D, F), vocalisation (D, F, P), playback response (F)	Affiliation with other birds, correlation with feather damaging behaviours, correlation with accepting food from humans, lack of enrichments, being pair-housed, having reduced flight ability, being separated from the flock, being single housed	*Amazona*, *Ara*, *Melopsittacus*, *"*Multiple*", Myiopsitta, Nymphicus*, *Pyrrhura*	(4, 9, 10, 20, 29, 33, 38, 64)
	Human-animal interaction	34 (6.28%)	Attention bias, , yawning after handling (L, F), response to unfamiliar/familiar handler (score), human aversion score, seeking behaviour toward humans (F), human-direct aggressiveness (yes/no), approach to humans (yes/no), food acceptance (yes/no, score), response to human contacts (score), resistance to being picked up (yes/no), latency to approach humans, begging once adult (yes/no), selective toward humans, tendency to anthropomorphise PCA axis*, vocalise during restrain (D, L, F), learned vocalisation (F), long distance contact call (F)	Unfamiliar human presence, lack of human-animal interaction, inappropriate interaction, neophilia score, lack of neonatal human handling, lack of enrichment, being hand-reared, mouth to beak feeding, human food consumption, owner gender, correlation with feather-damaging behaviours, being single-housed	*Amazona*, *Ara*, *Melopsittacus*, "Multiple", *Psittacus*	(2, 5, 9, 14, 15, 31, 37, 68-73)
	Facial and body displays	13 (2.27%)	Crown, nape, lower/upper mandible, cheek feathers ruffling (scan), nape/crown feather height, erected crest (D), blushing around eyes, beak grinding (F)	Correlation with positive human-parrot interaction, arousal level, being separated from the flock	*Ara, Cacatua*, *Melopsittacus, Nymphicus*	(36, 67, 71, 73, 74)

Table S11. Significant and not feasible outcome measures related to parrot welfare as identified during the systematic literature search, categorised by welfare dimensions and welfare categories. The table reports non-feasible outcome measures grouped by welfare dimensions and categories, showing the types of not feasible outcomes collected, associated feasible risk factors, and the genera of parrots studied, along with their corresponding studies. For detailed associations between outcomes, risk factors, and their effects, refer to the dataset.

Welfare dimension	Welfare categories	Types of not feasible outcomes	Feasible risk factors	Genera	Studies
Diseases and pathologic conditions	Health	Presence of atherosclerosis, severity of atherosclerosis lesions, hepatic haemosiderosis, lipid accumulation lesions, prevalence of lipoid pneumonia, presence of ingluvioliths, health conditions, prevalence of hepatic lipidosis, presence of viral diseases	Increase age, being hand-reared using a tube, diet based only on seeds, species, fibres ingestion (bird sex, age), chicks artificial feeding method	*Amazona, "Multiple", Myiopsitta, Nymphicus, Psittacus*	(2, 46, 75-81)
Body measurements	Feathers Colour	Cheek, front and crown feathers chroma, front feathers hue, crown feathers luminance, cheek feathers structural colours	Manual restraint, correlation with carotenoid levels	*Platycercus*	(82)
Physiological parameters	Lipids-related	Cholesterol concentration, triglyceride concentration, high-density lipoprotein-cholesterol (HDL-C) concentration, low-density lipoprotein-cholesterol (LDL-C) concentration, ratio of total cholesterol and HDL-C,	diet based only on seeds, diet with high cholesterol concentration, diet based on pellet (preventive) , bird sex, lack of exercise	*Amazona, Ara*	(46-48)
	Immune System-related	Humoral response to vaccination, delayed-type hypersensitivity (DTH) response, ratio of heterophils and lymphocytes, leukocytes, lymphocytes, and monocytes count	Lack of human neonatal handling, diet based only seeds, lack of carotenoid supplementation	*Amazona*, *Platycercus*	(46, 69, 82)
	Metabolic	Digestibility of crude fibres, crude proteins and dry matters, daily energy expenditure, malondialdehyde (MDA) concentration	Age, diet based only on seeds, diet based on pellets (preventive) lack of exercise, courtship feeding, correlation with weight and wing load (indirect measure of fat mass)	*Amazona*, Melopsittacus	(34, 35, 83, 84)
	Stress-related	Corticosterone excreta metabolites concentration, plasma corticosterone, cortisol excreta metabolites concentration,	Age, agonistic interactions, exposure to artificial light at night, increase in the dominance rank, bird sex, correlation with feather-damaging behaviour, being hand-reared, correlation with foraging time, manual restraint, lack of human neonatal handling, living conditions (wild > zoo > breeding centre > companions), being single-housed, correlation with locomotor behaviours before implementing enrichment, correlation with object interaction before implementing enrichment, being wild caught	*Agapornis, Amazona*, *Ara*, *Melopsittacus*, "Multiple", *Nymphicus*, *Platycercus, Psittacus*	(10, 19, 41, 60, 66, 69, 82, 85-88)
	Vitamin D-related	Calcifediol concentration, plasma vitamin-D concentration, plasma Ca+ concentration, plasma Mg+ concentration,	Indoor housing, lack of exposure to UV light	*Amazona*	(89, 90)
	Others	DNA damage, telomere length, basal glucose concentration, respiration rate, aortic pressure gradient and speed, haemoglobulin concentration, aspartate amino transferase concentration, glucose concentration,	Increase age, unbalanced diet, type of diet, lack of human neonatal handling, being single-housed, correlation with weight, correlation with activity level	*Amazona*, *Ara*, *Melopsittacus*, *Psittacus*	(46, 47, 68, 69, 84, 91, 92)

Table S12. Significant and feasible welfare-related outcomes measures reported in companion parrots specifically. The table lists welfare categories, types of outcomes observed, the number and percentage of outcomes, risk factors contributing to the increase or decrease of the observed outcome measure (↑/↓), the genera of parrots studied, and the types of interventions used.

Welfare category	Types of outcomes	Number of outcomes (%)	Risk factors	Genera (number of outcomes)	Intervention (number of outcomes)
Indirect measures of feather damaging behaviours	Presence/absence of feather damages, plumage score	51 (75%)	Due to high number, see Table S13	*Agapornis* (3), *Cacatua* (9), *Psittacus* (10), Multiple (29)	Video-Analysis (5), Clomipramine treatment (2), Questionnaire (39), Check-up at veterinary clinic (3)
Fear-related	Phobic behaviour ↑	1 (1.47%)	Being wild caught	*Psittacus*	Questionnaire
		2 (2.94%)	Perches lower than eye level		
			Small cage (max. 80 cm x 100 cm x 120 cm)		
Foraging	Contra-freeloading as foraging enrichment ↑↓	1 (1.47%)	Individuality	*Psittacus*	Contra-freeloading test
Human-Animal Interaction	Anthropomorphising ↑	1 (1.47%)	Female ownership	Multiple	Questionnaire
	Begging once adult ↑	3 (4.6%)	Being hand-reared	*Psittacus*	
			Human mouth to beak feeding		
			Human leftover consumption		
	Selective towards humans ↑	1 (1.47%)	Being hand-reared		
Stereotypies	Multiple Stereotypies ↑	1 (1.47%)	Inappropriate diet	*Psittacus*	Questionnaire
		1 (1.47%)	Only manufactured perches in the cage		
		1 (1.47%)	Being removed from the nest before 5 weeks of age		
	Whole Body Stereotypies↑	1 (1.47%)	Positive correlation with brain volume (species)	Multiple	Questionnaire
	Oral Stereotypies ↑	1 (1.47%)			
Sexual behaviours	Sexual activity ↓	1 (1.54%)	Being removed from the nest before 2 weeks of age or hatched from egg incubator	*Psittacus*	Questionnaire
Self-care	Preening ↑	1 (1.54%)	Being hand-reared	*Psittacus*	Questionnaire
		1 (1.54%)	Being sold before the end of weaning		

Outcomes related to feather-damaging behaviours

From the 690 significant results, 70 outcomes, collected from 19 different studies, were related to feather-damaging behaviours. Most of the outcomes were collected from companion animals (n = 51), followed by parrots kept in laboratories (n = 11), shelter parrots (n = 6) and parrots kept in breeding and rehab centres (both n = 1). Most of the outcomes (n = 22) were associated with risk factors belonging to demographic characteristics such as age, sex, and species

(Table S13). The lack of enrichment opportunities (14 outcomes) and factors related to the human-animal relationship (15 outcomes) turned out to also be common potential risk factors for feather-damaging behaviour (Table S13).

Table S13. Summary of risk factors associated with the emergence of feather-damaging behaviour in parrots as identified during the systematic literature search. The risk factors are organised into categories. For each risk factor, the table shows the number of outcomes related to feather damaging behaviour, the number of studies, the parrot genera studied, and the living conditions of the parrots under investigation.

Category	Risk factor	Outcomes	Number of Studies	Genera	Living condition (number of studies)
Ease of Movement	Inability to fly	1	1	*Psittacus*	Companion
Demographic	Increasing age	6	4	*Agapornis*, Multiple, *Psittacus*	Companion
	Heritability	2	1	*Amazona*	Lab
	Sex	3	3	*Amazona*, *Cacatua*, Multiple	Companion (2), Lab (1)
	Being rescued	1	1	Multiple	Companion
	Species	9	3	Multiple	Companion
	Diet needing extensive handling (species)	1	1	Multiple	Companion
Enrichment	Lack of chewable devices	1	1	Multiple	Companion
	Lack of foraging devices	1	1	Multiple	Companion
	Hour spent outside of the cage	1	1	Multiple	Companion
	Lack of foraging + physical enrichment	2	1	*Amazona*	Lab
	Lack of foraging + human and physical enrichment	4	1	*Amazona*	Lab
	Lack foraging enrichment	3	1	*Psittacus*	Shelter
	No toys/only one toy in the cage	1	1	*Psittacus*	Companion
	Out of the cage > 8 h	1	1	Multiple	Companion
Good Human and Animal relationship	≥ 1 vacation per year taken by owners	2	1	*Cacatua, Psittacus*	Companion
	Receiving command training	1	1	*Cacatua*	Companion
	Negatively correlated with length of ownership	1	1	*Psittacus*	Companion
	Owner type (shelter > woman > man > family)	1	1	Multiple	Companion
	Being bought from a pet shop	1	1	*Cacatua*	Companion
	Rearing method (being hand-reared, being sold before the end of weaning, lack of human neonatal handling)	6	4	*Amazona*, *Agapornis* Multiple, *Psittacus*	Companion (4), Lab (1)
	Separation anxiety	2	2	*Agapornis*, Multiple	Companion
	Negatively correlated with time of human-parrot interaction per day	1	1	Multiple	Companion
Good Housing	Cage volume > 2 m^3	1	1	*Cacatua*	Companion
	Increase distance of the cage from the door	1	1	*Amazona*	Lab
	Location of the cage against >= 1 m wall	1	1	*Cacatua*	Companion
Enrichment+Personality	Lack of enrichments + neuroticism score	1	1	*Psittacus*	Lab
Maintenance	≥ 8 h of sleep	1	1	*Psittacus*	Companion
	Being sprayed with water daily	1	1	*Cacatua*	Companion
Good Feeding	Fed with only seed or pellet	1	1	Multiple	Companion
Personality	Coping style (being proactive)	3	1	*Psittacus*	Shelter
Physiological	Increased adrenocortical activity	1	1	*Guaruba*	Breeding Centre
Social	Living with other parrots	1	1	Multiple	Companion
	Living without other non-bird companion animals	1	1	Multiple	Companion

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