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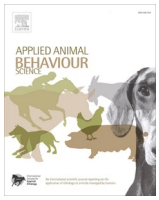

Evaluation of welfare indicators for companion parrots: a Delphi consultation survey

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ABSTRACT

Parrots can experience several welfare challenges when kept as companions. Despite their popularity no science-based guidelines are available to assess parrot welfare. The aim of this Delphi study was to establish consensus on welfare indicators that could be meaningful and practical for owners to monitor parrot welfare. One hundred and twenty-two potential welfare indicators (behaviours, body measurements, husbandry and management conditions) were sourced from a systematic literature review and by consulting an avian medicine specialist. They were presented to participants with expertise on parrots in two rounds of online survey. We identified 73 welfare indicators that could be used by owners to monitor the welfare of all/most parrot species. Abnormal behaviours and management conditions that allow parrots to express their natural behaviours were ranked among the most important indicators. Participants concurred with scientific evidence about the impact of diet, species susceptibility to develop behavioural problems, early life, and pre-acquisition experiences on parrot welfare. When prompted about the suitability of species as companions, participants indicated seven small-sized parrot species as most suitable to be kept as a companion, while cockatoos, critically endangered, and highly trafficked species were evaluated as those that should not be kept as companions. These findings could be useful to monitor and improve parrot welfare.

1. Introduction

Parrots are popular companion animals, appreciated for their intelligence, beauty and vocal ability as well as for the emotional support that they provide to their owner (Kidd and Kidd, 1998; Anderson, 2014; Tygesen and Forkman, 2023). However, parrots can face several welfare challenges when kept in captivity. Poor welfare can arise due to a lack of knowledge or neglect of parrots' biological needs and can manifest through health issues (e.g. obesity, atherosclerosis, fungal and bacterial infections) and behavioural problems, including excessive screaming, aggression, self-injurious behaviours and stereotypies (Seibert, 2005; Engebretson, 2006; Meehan and Mench, 2006; Beaufrere et al., 2013). A lack of cognitive stimulation, opportunities to forage, social interactions, locomotor behaviour and the provision of unbalanced diets are considered the main risks to parrot welfare (Seibert, 2005; Matson and Koutsos, 2006; Wilson, 2022a) as these can lead to (sub)clinical disease and pathology, behaviour problems and compromised physical and emotional health, as in other animals (Mellor et al., 2020). Moreover, inappropriate human-parrot interactions can cause companion parrots to become aggressive, fearful, and excessively vocal (Meehan and Mench, 2006; Wilson, 2022b). The emergence of these behavioural problems can have negative consequences on the parrot-human relationship and is considered one of the main causes of relinquishment for companion parrots (Martin, 2006; Meehan and Mench, 2006; Wilson, 2022b). Data on relinquishment are difficult to find; however, according to the limited information available, a high number of parrots are relinquished every year due to the difficulty of keeping them and fulfilling their needs (Hoppes and Gray, 2010; Erden, 2015). Considering the increasing popularity of parrots as companion animals, their longevity and the serious and multiple welfare challenges faced in relation to the complexity of their needs (Kidd and Kidd, 1998; Meyers, 1998; Anderson, 2003; Engebretson, 2006), evidence-based guidelines for assessing and improving parrot welfare are urgently needed. More specifically, it is necessary to identify scientifically valid welfare indicators that ideally could be used by owners to routinely monitor welfare. This would benefit both parrots and owners in several ways: it would inform about the appropriateness of the husbandry and management conditions provided; it would allow regular assessment of the

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parrot's welfare state; and as a prophylactic measure, it could prevent the emergence of illness or behavioural problems, thus enhancing the possibility to maintain a good parrot-owner relationship and reducing the risk of parrot relinquishment.

Currently a large amount of potentially valuable information regarding parrot welfare is based on expert knowledge or experience and often reported through books or magazine articles, whereas comparatively less information is derived from experimental scientific studies. Nevertheless, we found a number of potential parrot welfare indicators and risk factors in a recent systematic literature review (Piseddu et al., 2024). However, this review revealed a high risk of bias in the peer-reviewed scientific studies gathered, making it difficult to ascertain both the internal and external validity of the findings and therefore requiring an alternative process of validation (Piseddu et al., 2024).

For this purpose, the Delphi method is considered a suitable solution. This method consists of consulting a panel of experts who provide their opinion on a determined topic through multiple rounds of survey (Hsu and Sandford, 2007) and is based on four features: 1) anonymity, to avoid the risk participants could influence each other; 2) iteration, to allow participants to re-assess their judgment through multiple rounds; 3) controlled feedback, to inform about the responses provided by other participants; and 4) statistical aggregation of the group response (Rowe and Wright, 1999). The Delphi technique is a well-established method to assess content-related validity (Sireci, 1998) by reaching consensus among participants, with the assumptions that a group of individuals with different types of expertise and who anonymously and independently provide their opinion is better in decision-making than a single individual (Surowiecki, 2005). The consensus obtained through this standardized process can be considered meaningful when group stability is achieved (Dajani et al., 1979), meaning that the results of successive rounds of survey should not statistically differ (von der Gracht, 2012). Delphi consultation surveys have been used for decision-making in several research fields including animal welfare science (Souza et al., 2018; Campos-Luna et al., 2019; Truelove et al., 2020; Whittaker et al., 2021; Berteselli et al., 2023; Pannewitz and Loftus, 2023; Whay et al., 2023). Notably, this method has been recently applied to identify priority welfare issues for captive parrots (Chalmers et al., 2024). However, to our knowledge, the Delphi method has not yet been used to evaluate welfare indicators that parrot owners could use to monitor their bird's welfare.

The objective of this Delphi study was to screen indicators related to parrot welfare previously identified in the systematic scientific literature review or based on expert knowledge. We aimed to identify which welfare indicators are considered by experts as 1) valid for most parrot species; 2) feasible to use in practice by caregivers; 3) the most important; and 4) which factors are considered to impair parrot welfare. In addition, considering the large variety of parrots species, we aimed to determine which species, according to experts, are best suited to be kept as companions and which should not.

2. Material and methods

2.1. Ethical consideration

The project was assessed by the Ethics Committee of the Medical University of Vienna, which determined that, in accordance with the Good Scientific Practice guidelines and relevant national legislation, an ethical approval was not required for this study. All participants gave their informed consent before participating in both the first and second round of the survey. Only one researcher (AP) was able to trace back the identity of each participant and their responses, ensuring quasi-anonymity (McKenna, 1994). This was required due to the iterative nature of the Delphi method in order to create personalised survey for each participant in the second round based on their previous responses provided in the first round. After completion of the second round, a numeric code was assigned to each participant, allowing analysis of anonymized data. All data were handled and stored in compliance with the European General Data Protection Regulation.

2.2. Identification of potential welfare indicators

Potential welfare indicators were sourced from a systematic literature review that aimed to collect valid and feasible welfare indicators for captive parrots (Piseddu et al., 2024). The outcome measures identified in this systematic review were classified as animal-based indicators (e.g. excessive vocalization, stereotypies, responses to novel object or familiar and unfamiliar humans; n = 64), or environment-based indicators based on risk factors associated with an outcome measure (e.g. provision of foraging enrichment, social housing, cage size, diet composition, manual restraint; n = 35). Following input from one of the authors, an avian medicine specialist (YvZ), twenty-three additional animal- and environment-based welfare indicators were added, resulting in a total of 122 potential welfare indicators presented to the participants, of which 79 were animal-based and 43 environment-based (Table S1, Table S2).

2.3. Recruitment of participants

Participants were recruited by distributing a flyer containing a direct link to an online recruitment form and created with the software "LimeSurvey". The flyer was distributed physically, shared through social media and online forums, and sent by email to potential participants. In the recruitment form, participants were asked to fill out their name and surname, type of expertise, years of experience working with parrots, contact email and professional or personal website. In order to increase our sample size, we also employed the snowball sampling method, meaning that people that registered to our survey could invite new participants by sharing the flyer with their working network (Parker et al., 2019). There are no standards to select participants for the Delphi method, and various ways to qualify someone as "expert" (Shang, 2023). Participants were selected based on their areas of expertise: veterinarians, researchers, behavioural consultants, animal keepers, breeders and other. The 'other' category encompassed additional types of expertise relevant to parrot welfare but less commonly represented such as bird curator and welfare organization president. Additionally, participants were selected on the basis of their years of experience working with parrots (minimum 1 year experience required) as these are commonly accepted requirements in Delphi studies (Grisham, 2009; Trevelyan and Robinson, 2015; Shang, 2023). Being a parrot owner was not considered a sufficient type of expertise. One-hundred and fourteen participants that filled out the recruitment form passed the selection criteria and were invited to participate in the survey.

2.4. Data collection

2.4.1. First round of the survey

This Delphi consultation consisted of two rounds of survey. The first round of survey was created using the online software "LimeSurvey" and it was divided in five sections.

The first section asked participants about their demographic information: area of expertise (veterinarian, researcher, behavioural consultant, animal keeper, breeder, other), number of years of experience working with parrots (generally) and specifically with companion parrots, and current country of residence.

Before starting the second section, participants were invited to imagine the following scenario:

"*You are invited to assess the welfare of a parrot kept as a companion animal. The parrot lives in a house with its owner(s). You are in the house, in front of the parrot and you have to consider the use of several measures in order to assess its welfare. The term 'parrot' refers to all species belonging to the order Psittaciformes*".

In the second section, participants were presented with a list of 79 animal-based indicators grouped in separate categories according to commonalities in their underlying biological construct: abnormal and fear-related behaviours, exploratory behaviours, parrot-human interactions, locomotor behaviours, maintenance behaviours, social behaviours, sexual behaviours, body displays, and body measurements (Table S1). At the end of each category, participants could add animal-based indicators that they considered important but that were missing from the list. For each indicator the participants needed to indicate whether they considered it a valid welfare indicator for all/most parrot species, valid only for certain species, or not valid as a welfare indicator. In the survey, we informed participants that "*we defined 'welfare' as the physical, physiological, and mental state of the parrot in relation to its environment and 'valid welfare indicator' a behavioural or physical measure that provides meaningful information about the welfare state of the parrot*". As our aim was also to identify welfare indicators that could be used by owners, we also asked participants to indicate whether they considered the measure feasible for the parrot's owner, feasible only for experts, or not feasible at all. In the present study we used the term 'owner' to refer to the person caring for the parrot, so we use this term as a synonym for 'caretaker', and not as the concept of owning a living being. In the survey, we defined "*"feasible"* as "*a behavioural or physical measure that could be readily taken within 10 min, without causing acute stress responses of the parrot. This may include the use of minimally invasive routine handling techniques and/or commonly available equipment (e.g. weight scale)*".

In the third section, the participants were presented with a list of 43 environment-based indicators grouped in five categories according to the husbandry or management condition that they represented: housing conditions, provision of enrichment, parrot-human interactions, nutrition, social needs (Table S2). At the end of each category, participants could add environment-based indicators that they considered important but that were missing from the list. Participants were also asked to indicate to what extent the husbandry and management conditions had an impact on companion parrot welfare (high, medium, low) and whether these had an impact on welfare of all/most of the species or only on certain species. Unlike the animal-based indicators, we did not assess the validity of environmental indicators, as these do not reflect the current welfare state at the moment of assessment but rather the likelihood of influencing welfare over time. All environment-based indicators represented husbandry and management conditions that could be easily identified by owners (e.g. living alone vs in group, provision of enrichment, cage characteristics); therefore, we deemed it unnecessary to inquire participants about their feasibility.

In the fourth section, participants were asked to evaluate 20 factors that could potentially affect parrot welfare. With the exception of one factor (hand-rearing with or without siblings), these factors were distilled from the scientific literature through a systematic review (Piseddu et al., 2024), and subdivided into four categories: types of diet, early life/rearing history, species/sex/personality susceptibility to behaviour or medical problems, and species' suitability to be kept as companion animal. These 20 factors were presented as sentences to complete or statements and participants had to choose between three answer options: *always balanced, balanced but only for some species, always unbalanced* to complete sentences related to diets exclusively based on seeds, pellets or mashed food (see survey template in supplementary material); *less likely to develop/show welfare problems*, *more likely to develop/show welfare problems*, *neither more nor less likely to develop/show welfare problems* for the category early life/rearing history; *agree, neither agree nor disagree, disagree* for the categories species/sex/personality susceptibility to behaviour or medical problems, and species' suitability to be kept as companion animal (see survey template in supplemental material).

In the fifth section, participants were presented with a list of all animal- (n = 79) and environment-based (n = 43) indicators and asked to select and rank the 10 animal- and the 10 environment-based welfare indicators that they considered the most important for parrot welfare (1 =most important; 10 =least important). Representing the animal-based and environment-based indicators in two separate, complete lists allowed participants to view all the indicators at once, making it easier for them to select the most important ones. This approach helped reduce the struggle of having to refer back to previous tables where the indicators were first presented, and made the process of selecting and ranking the indicators more efficient.

Prior to sending out the survey, a pilot study was conducted to establish the clarity and appropriateness of the questionnaire, its structure, organization and items, and to determine the time required to complete it. Nine volunteers with an academic background in animal behaviour and welfare reviewed the pilot survey, reporting a completion time of approximately 40 min. Refinements were made according to the feedback of the participants of the pilot study.

The final survey was sent out for the first round and made available for five weeks (from May 18th, 2023 until June 22nd, 2023). Of the 114 participants that were invited to participate, 32 (28 %) completed the entire survey and another 10 (8.8 %) completed at least one category within the survey, which was our minimum requirement to be invited to the second survey round. We decided to adhere to this inclusion criterion to maximize the amount of data collected, as there is no established literature or consensus on the specific criteria for inviting participants to the following round.2.4.2. Second survey round

The second round of survey was created using Microsoft Word (365) and personalized for each participant to only include the items that were answered by this participant in the first survey round (see survey template in supplemental material). This approach allowed participants to refine their opinions and avoided asking them about items regarding which they had not previously provided input, as this would not align with the purpose of the iteration.

The second survey contained the same sections and items presented in the first round of survey, except for the first one (demographic information). Participants were asked to review their answers based on the general agreement between all participants calculated for each parameter from the first round, which was presented to them in the respective sections. Participants could decide based on these results to either alter their previous answers or not. The participants were also presented with new animal- and environment-based indicators that had been suggested by one or more participants during the first survey round (Table S3, Table S4) and, similar to the first round, asked to assess these for their validity and feasibility (animal-based indicators) or for their impact on parrot welfare and applicability to all or most of the species (environment-based indicators).

In the third section, participants were asked to review their answers based on the general agreement between all participants calculated from the first round for the four categories of factors that could potentially affect welfare (i.e. diet, early life and pre-acquisition experiences, species and sex susceptibility to behaviour or medical problems, and species suitability as companion animal). Similar to the previous sections, participants could opt to alter their previous answers or leave these unchanged. When selecting the answer option "agree" on statements related to the species and sex susceptibility to behavioural or medical problems or suitability as companion, the participants were asked to review the lists of species or sex proposed by some participants in round one and to reply whether they agreed, disagreed, or neither agreed nor disagreed (see survey template in supplemental material).

In the last section, participants were presented with the list of the 10 animal-based and environment-based indicators that were deemed most important for parrot welfare according to the majority of the participants. The selection was made based on the rank score of each parameter, which was calculated as followed:

$$Rank\ score = \frac{i_1 w_1 + i_2 w_2 + i_3 w_3 \ldots i_{10} w_{10}}{Total\ responses}$$

where:i_n= number of participants that selected the indicator in rank

position n (1, 2, 3…10)w_n= weight on the rank position (e.g. n-rank position 1 =10, n-rank position 10 =1)

Participants were provided with the option to leave the ranking as it was, or re-rank the indicators if they disagreed with the presented order.

Prior to sending out the email with the second round of survey to all 42 participants that met the criteria for inclusion in the next round, i.e. having completed at least one category of the first round of survey, a pilot survey was again created to evaluate the second survey round, in a similar manner as done for round one. This pilot was subsequently reviewed for its clarity, appropriateness and structure by seven of the nine academics who reviewed the first pilot. Following sending out of the second survey round (July 20th, 2023), participants were given nine weeks to complete the survey (by September 14th, 2023).

2.5. Data analysis

All data collected from both the first and the second rounds of survey were analysed using descriptive statistics with the R statistical software (Core Team, 2022). For all items and for both rounds of survey, we calculated the percentage of participants that chose a specific answer option for a given item. While no standards exist to calculate consensus in Delphi studies (Mitchell, 1991; Holey et al., 2007; von der Gracht, 2012), consensus was estimated by calculating the percentage of agreement between participants (using the "dplyr" function in R (Wickham et al., 2023)), following guidelines provided in previous Delphi studies on animal welfare indicators (Campos-Luna et al., 2019; Truelove et al., 2020; Whittaker et al., 2021; Pannewitz and Loftus, 2023). Consensus was considered to have been achieved if an agreement of at least 70 % was reached. Only those animal-based indicators for which consensus was reached for both the answer options "valid for all/most of the species" and "feasible for owners" were considered to be valid and feasible as indicators to assess the welfare of a companion parrot by caretakers. Similarly, environment-based indicators were considered valid and feasible to be used by caretakers if consensus was reached for both the answer options "high impact on welfare" and "applicable to/all most of the species".

For the items in the third section on which consensus was reached for the answer option "agree", data were further analysed by calculating the percentage of agreement between participants based on the species or the sex suggested to be more likely to develop specific behavioural problems, disease or pathology or the species suggested to be more or less suitable as companion animal.

Group stability between rounds was calculated by using the intra-class correlation coefficient (ICC) (R package "psych" (Revelle, 2024)) as this is considered a reliable method to establish stability in Delphi studies (Trevelyan and Robinson, 2015). All answer options were converted into scores from 1 to 3 and an ICC was computed for each section (animal-based indicators, environment-based indicators, factors that may impair welfare) by combining all answers submitted by the participants. The ICC value ranges between 0 and 1, with values between 0.75 and 0.90, and value greater than 0.90 representing good and excellent stability, respectively (Koo and Li, 2016). For the variable "applicability" (section environment-based indicators) it was not possible to calculate an ICC as this item was binomial (applicable to all/most of the species, applicable to only some species). For this parameter, stability was therefore established by calculating the percentage of times the group altered its answers from the first round to the second round and considered to be stable if changes occurred in less than 15 % of cases, as previously suggested by Scheibe et al. ((2002)

To evaluate the potential effect of experience on the stability of the participants' answers, we ran a generalized linear model that included proportion of times single participants altered their answers from the first to the second round as response variable and years of experience working with parrots as predictor.

Finally, to evaluate whether the rank of the most important animal- and environment-based indicators changed from the first to the second round, we calculated the rank score for each indicator by applying the formula as listed above to analyse the responses submitted in the first round. The rank scores from the first and the second round were then visually compared to verify if the indicators changed their position in the ranks.

3. Results

3.1. Demographics

A total of 42 participants from 14 countries (Austria, Brazil, Denmark, France, Germany, Indonesia, Italy, Pakistan, Spain, Sweden, Switzerland, the Netherlands, United Kingdom, United States of America) completed the first round of the survey. Twenty-one out of 42 participants (50 %) completed the second round of survey. All five types of expertise were indicated by participants and experience working with parrots ranged from 1 to 51 years (Table 1). The percentage of participants with experience working with companion parrots was 85.7 % in both rounds.

3.2. Group stability and influence of years of experience

All sections of the surveys showed excellent group stability between rounds: (animal-based indicators: ICC2k= 0.93; $p < 0.001$; environment-based indicators: ICC2k= 0.94; $p < 0.001$; factors impairing welfare: ICC2k= 0.94; $p < 0.001$). The binomial variable "applicability" also achieved excellent group stability with only 2.8 % responses changing between rounds. We found a small, yet statistically significant effect of years of working experience with parrots on the proportion of times that participants altered their responses between rounds, whereby the likelihood of an altered response decreased by 0.01 times with an increase in the number of years of experience (S.E.= 0.005722, z-value= −2.715, $p = 0.007$).

3.3. Animal-based indicators

Thirty-two animal-based indicators (40.50 %) reached consensus for being both valid welfare indicators for all/most of the parrot species and feasible to be collected by owners (Table 2). Additionally, consensus was reached on five new animal-based indicators that were suggested during the first round (Table 2). These 37 animal-based indicators covered all nine welfare dimensions identified previously by Piseddu et al. (2024); Table 2). Four animal-based indicators reached the consensus for being valid for all/most of the species but were rated as feasible only for experts whereas for the remaining answer options ("valid for only some species", "not valid" and "not feasible") no consensus was reached (Table S5).

3.4. Environment-based indicators

Twenty-six environment-based indicators (60.46 %) reached consensus for having a high impact on parrot welfare and being applicable to all/most of the species (Table 3). Additionally, consensus was reached for ten new environment-based indicators that were proposed during the first round (Table 3). These 36 environment-based indicators covered all five categories of husbandry and management conditions as previously proposed in the systematic literature review (Piseddu et al., 2024) (Table 3). Two indicators reached consensus for having moderate impact on welfare and being applicable to all/most of the species whereas for all remaining environment-based indicators, consensus was reached for the answer option "applicable to all/most of species" but no agreement was achieved about their impact on parrot welfare (Table 3, Table S6).

Table 1
Demographic information from the first and second round of survey. Note that the sum of the areas of expertise in both first and second round does not equal 100 % because many participants identified themselves as expert in more than one area of expertise.

	Area of expertise % (number of participants)					
Round	Veterinarian	Researcher	Breeder	Animal keeper	Behavioural consultant	Other
1	47.6 % (20)	42.8 % (18)	9.5 % (4)	31 % (13)	19.0 % (8)	bird curator (1), welfare organization president (1), sanctuary operator (1), zoologist (1)
2	28.6 % (6)	57.7 % (12)	9.0 % (2)	28.6 % (6)	19.0 % (4)	bird curator (1), welfare organization president (1)
	Years of experience working with parrots % (number of participants)					
Round	< 5 years	Between 5 and 10 years	Between 11 and 20 years	Between 21 and 51 years		
1	19 % (8)	14.4 % (6)	23.8 % (10)	42.8 % (18)		
2	23.8 % (5)	23.8 % (5)	23.8 % (5)	28.6 % (6)		

3.5. Top-10 ranks for animal- and environment-based indicators

Abnormal and fear-related behaviours represented 5 of the top-6 ranking answers with feather destructive behaviour deemed as the most important indicator (Table 4). For all ten animal-based indicators included in the final ranking, consensus was reached for being valid indicators for all/most of the species, but four indicators did not reach consensus for being feasible for owners (Table 4). Among environment-based indicators, those related to provision of enrichment were the most recurrently chosen (n = 4) with opportunities to do physical exercise and time spent out of the cage deemed as the most important ex-aequo. For all ten environment-based indicators included in the final ranking, consensus was reached for the answer option "applicable to all/most of the species", whereas for the answer option "high impact on welfare", consensus was reached for all except for the indicator "access to outdoor spaces" (Table 4). The ranking of both animal- and environment-based indicators did not change much between the two rounds, and mostly just one position, with exception of "level of activity" which moved up two ex aequo positions compared to round one (Table 4).

3.6. Factors with an impact on parrot welfare

3.6.1. Type of diet

Expert consultation revealed consensus for diets always being unbalanced if exclusively based on seeds (89.5 %), based on only one type of seed (100 %), or exclusively based on pellets (70.6 %) (Table S7). Regarding diets exclusively based on mashed food, no consensus was reached (Table S7).

3.6.2. Early-life and pre-acquisition experiences

Participants reached consensus on the statements that hand-reared parrots, wild-caught parrots and parrots acquired before the end of weaning are more likely to develop/show welfare problems. Additionally, consensus was reached for the statement that parrots that are hand-reared with siblings (vs hand-reared alone) are less likely to develop/show welfare problems (Table S8). For all other remaining statements, no consensus was reached (Table S8).

3.6.3. Sex and species susceptibility to develop behavioural problems, diseases or pathological conditions

Participants reached consensus for the statement that "*some parrot species are more likely to develop behavioural problems when kept in captivity*" (83 % agreement; Table S9). Participants agreed that cockatoos (excluding cockatiels) and grey parrots (*Psittacus erithacus*) are more likely to develop behavioural problems when kept in captivity (93.3 % and 86.7 % agreement, respectively; Table S10). Consensus was also reached on cockatoos (excluding cockatiels) being at greater risk for developing feather damaging behaviour, aggressiveness, and hormonal behaviours (100 %, 92.8 % and 100 % agreement, respectively; Table S11), while for grey parrots agreement was reached only for feather damaging behaviour (100 % agreement, Table S11). For the remaining 22 species that were suggested to be prone to develop behaviour problems in captivity, no group consensus was reached for any of the answer options provided (Table S10).

3.6.4. Personality and suitability of species as companion parrots

One hundred percent consensus was reached on the statement that "*assessing parrot personality can improve/ensure parrot welfare*", while 75 % of the participants agreed with the statements "*some parrot species are more suitable to be kept as companion animals*" and "*some parrot species should not be kept as companion animals*" (Table S9). Participants agreed for 7 out of 28 species/genera that these would be more suitable to be kept as companion animals: lovebirds (*Agapornis* spp.; 86.7 % agreement, n = 15), budgerigars (*Melopsittacus undulatus*; 100.0 % agreement, n = 15), *Pyrrhura* spp. (76.9 % agreement, n = 13), green-cheeked conure (*Pyrrhura molinae*) (76.9 % agreement, n = 13), cockatiel (*Nymphicus hollandicus;* 93.3 % agreement, n = 15), parrotlets (*Forpus* spp.; 78.6 % agreement, n = 14), and monk parakeets (*Myiopsitta monachus*; 76.9 % agreement, n = 13; Table S12). Conversely, participants (n = 14) disagreed with the statement that white cockatoos (*Cacatua alba,* 92.9 %) and long-billed corellas (*Cacatua tenuirostris,* 78.6 %) would be suitable to be kept as companion animals. Finally, 76.9 % of participants neither agreed nor disagreed with medium-sized species being suitable as companion animals (Table S12). Among participants, consensus was also reached that cockatoos (excluding cockatiels), large cockatoos, critically endangered species, and heavily trafficked species should not be kept as companion animals (agreement of 86.7 %, n = 15; 85.7 %, n = 14; 75 %, n = 16; and 81.3 %, n = 16, respectively; Table S13).

4. Discussion

4.1. Indicators

We identified 32 animal-based indicators for which consensus was reached on their validity for all/most of the parrot species and feasibility for owners. These included abnormal, fear-related, locomotor, exploratory, social, human-directed, maintenance and sexual behaviours, body displays and body measurements. Abnormal behaviours ranked high among the most important animal-based indicators, but some (e.g., stereotypies, excessive vocalizations) were not deemed feasible for owners to evaluate. Stereotypies can reflect difficulties in the ability of an animal to cope with its environment (Mason, 1991), which may explain why stereotypies were ranked in the top-10. However, stereotypies can easily be misinterpreted and difficult to recognize for inexperienced owners, may remain unnoticed if performed in absence of an owner (Meehan and Mench, 2006), and could persist as 'behavioural scars' despite the triggering event or situation long being resolved as a result of ritualization and emancipation of the behaviour (Mason and Latham, 2023). Additionally, many behaviour problems, including

Table 2
List of the animal-based indicators that reached the 70 % agreement for both the answer options "valid for all/most of the species" and "feasible for owners". Asterisk indicates animal-based indicators that were suggested by some participants in the first round of survey and therefore proposed only in the second round of the survey.

Welfare dimensions	Animal-based indicators	Valid for all/ most of the species (n. respondents)	Feasible for owners (%) (n. respondents)
Abnormal and fear-related behaviours	Expression of avoidance or escape behaviours	90.0 % (20)	85.7 % (21)
	Feather destructive behaviour (chewing, biting, fraying, plucking)	90.0 % (20)	90.5 % (21)
	Hiding*	76.2 % (21)	70.0 % (20)
Exploratory behaviours	Interaction with enrichment	100 % (19)	80.0 % (20)
	Response to novel objects	78.9 % (19)	75.0 % (20)
Locomotor behaviours	Inability to fly (physical restrictions due to cage size or trimming of feathers)	100 % (18)	94.4 % (18)
	Climbing	94.7 % (19)	89.5 % (19)
	Walking	89.5 % (19)	89.5 % (19)
	Flying	83.3 % (18)	88.9 % (18)
	Time spent in high positions (e.g., perches, grid ceiling)	73.7 % (19)	88.9 % (18)
Body displays	Beak opens all the time*	94.7 % (19)	72.2 % (18)
	Wing flapping	78.9 % (19)	84.2 % (19)
	Beak grinding	78.9 % (19)	78.9 % (19)
	Scratching	78.9 % (19)	78.9 % (19)
	Beak whipping across perch	72.2 % (18)	77.8 % (18)
Maintenance behaviours	Amount of time spent sleeping	100 % (19)	94.4 % (18)
	Daily food intake	100 % (19)	88.9 % (18)
	Preening	100 % (19)	83.3 % (18)
	Daily water consumption	89.5 % (19)	83.3 % (18)
	Beak maintenance*	89.5 % (19)	72.2 % (18)
	Time of day (morning, afternoon, evening) spent sleeping/resting	78.9 % (19)	88.2 % (17)
	Interest in bathing	77.8 % (18)	88.2 % (17)
Parrot-human interactions	Response upon contact with caregiver	94.7 % (19)	80.0 % (20)
	Response upon contact with familiar person	94.7 % (19)	80.0 % (20)
	Aggressive behaviours toward humans (e.g. biting, scratching, flying over)*	94.4 % (18)	89.5 % (19)
	Response upon contact with unfamiliar person	84.2 % (19)	73.7 % (19)
	Withdrawal from human interaction	77.8 % (18)	70.6 % (17)
	Food-related interaction (e.g., begging for food, acceptance of food from the hand, regurgitation of food to humans)	77.8 % (18)	76.5 % (17)
Social behaviours	Time spent in vicinity of other parrots	94.7 % (19)	77.8 % (18)
	Aggressive behaviour toward chicks	94.4 % (18)	88.2 % (17)
	Aggressive behaviour toward mates (e.g., chasing, biting, lunging)	84.2 % (19)	83.3 % (18)
Sexual-related behaviours	Physical proximity between mates	94.7 % (19)	83.3 % (18)
	Mate allopreening	89.5 % (19)	94.4 % (18)
	Courtship feeding	78.9 % (19)	72.2 % (18)
	Nest defence*	76.5 % (17)	81.3 % (16)
Body measurements	Body weight	94.7 % (19)	94.4 % (18)
	Number of droppings	73.7 % (19)	84.2 % (19)

stereotypies can reflect learned behaviour that escalates and/or persists due to accidental rewarding or reinforcement by the owner (Friedman et al., 2021). As such, certain level of expertise is therefore required to ensure correct identification and interpretation of stereotypies in relation to the parrot's present welfare state. Similarly, excessive vocalizations and screaming indicating poor welfare in response to frustration, fear or lack of attention, can be challenging for owners to distinguish from the normal, frequent and loud vocalizations produced by parrots in a social context (Wilson, 2022a; c). For other parameters considered valid yet unfeasible by most panellists, including level of activity (which was also ranked in the top-10), feasibility issues may have been related to the time-consuming nature of the measurement.

The remaining animal-based indicators in the top 10 rank (feather destructive behaviours, expression of avoidance or escape behaviours, interaction with enrichment, daily food intake, inability to fly and response upon contact with caregiver) all reached consensus for being considered feasible for owners. These therefore serve as a good starting point for owners to evaluate their bird's welfare, which – together with the support of experts or new technologies (Miller and Whitham, 2016) – could produce a better overview of the parrot's current welfare state.

All 43 environment-based indicators presented to participants reached consensus for being "applicable to all/most of the species", but only 26 indicators reached consensus for having a high impact on welfare. In line with the recent Delphi study of Chalmers and colleagues (2024), environment-based indicators related to environmental enrichment and housing emerged as particularly important aspects, most likely because these provide an opportunity for parrots to meet their biological needs: mental stimulation, opportunities to forage and exercise, and interaction with other parrots - preferably conspecifics (Seibert, 2005; Engebretson, 2006; Meehan and Mench, 2006; Livingstone, 2018; Wilson, 2022a). Considering that lack of owner knowledge is an important risk for parrot welfare (Chalmers et al., 2024), these 26 indicators should be the main focus when educating owners about husbandry, care and nutrition of their parrot, and a useful starting point for professionals when providing advice on how to modify and optimize the parrots' living environment. Aside from the indicators previously identified in a systematic literature review (Piseddu et al., 2024), participants suggested 46 new indicators (27 animal-based; 19 environment-based). While these indicators were not processed following the Delphi methodology (included only in the second round), consensus was reached on 14 of these in the second round, suggesting these parameters to hold potential value as welfare indicators. Chalmers et al. (2024) also identified access to proper veterinary care and behaviour support as an important risk factor for parrot welfare. While this parameter was not directly listed as a risk factor in our study, several of the indicators

Table 3
List of the environment-based indicators that reached the 70 % agreement for both the answer options "high impact on welfare" and "applicable to all/most of the species". Asterisk indicates environment-based indicators that were suggested by some participants in the first round of survey and therefore proposed only in the second round of the survey.

Husbandry and management conditions	Environment-based indicators	High impact on welfare (n. tot respondents)	Applicability to all/most of the species (n. tot respondents)
Housing	Cage characteristics (e.g., dimension, material, bars orientation)	95.0 % (20)	100 % (19)
	Time spent out of the cage	95.0 % (20)	90.0 % (20)
	Presence of a retreating area/room to rest, sleep or withdraw*	90.0 % (20)	100 % (20)
	Provision of bathing opportunities	90.0 % (20)	90.0 (20)
	Air quality (e.g. presence of air purifier, exposure to fresh air)*	85.0 % (20)	100 % (20)
	Exposure to direct sunlight/UV light*	80.0 % (20)	100 % (20)
	Perches' characteristics (e.g., diameter, material)	75.0 % (20)	100 % (20)
	Position and height of the perches (e.g., in relation to feeders or human-eye level)	70.0 % (20)	100 % (20)
	Room where the cage is positioned (kitchen, living room, bedroom, etc.)	70.0 % (20)	100 % (20)
	Frequency of cage cleaning*	70.0 % (20)	100 % (20)
	Exposure to noise*	70.0 % (20)	100 % (20)
	Environmental temperature	70.0 % (20)	90.0 % (20)
Enrichment	Provision of cognitive enrichment	100 % (19)	100 % (19)
	Variety of enrichment provided	100 % (20)	100 % (20)
	Provision of chewable items	100 % (20)	95.0 % (20)
	Provision of foraging enrichment	95.0 % (20)	100 % (20)
	Opportunities to do physical exercise (flying, climbing, etc.)	95.0 % (20)	95.0 % (20)
	Rotation of enrichment	85.0 % (20)	100 % (19)
	Amount of enrichment provided	75.0 % (20)	100 % (19)
	Opportunities to select items based on preference (e.g., for colour, shape or type of material)	75.0 % (20)	100 % (20)
Nutrition	Availability of clean fresh water*	100 % (20	100 % (20)
	Composition of the diet (quantity of fat, cholesterol, fibre, etc.)	100 % (20)	95 % (20)
	Frequency of cleaning the food bowls*	95.0 % (20)	100 % (20)
	Variety of food items provided	85.0 % (20)	100 % (20)
	Manner/way in which food is offered to the bird (presented in a bowl, via enrichment, etc.)	90.0 % (20)	100 % (20)
	Frequency with which food is provided	78.9 % (19 %)	100 % (19)
	Location and number of feeding areas*	70.0 % (20)	100 % (20)
	Frequency of fresh food provision*	70.0 % (20)	100 % (20)
Parrot-Human interaction	Frequency/duration of manual restraint	100 % (20)	100 % (20)
	Rearing history	85.0 % (20)	100 % (20)
	Type of interaction with human (training, mouth to beak feeding, etc.)	84.2 % (19)	100 % (19)
Social needs	Level of social contacts (only vocal, visual and vocal, physical)	100 % (20)	100 % (18)
	Frequency/duration of social separation events	90.0 % (20)	100 % (18)
	Partner/cage mate choice (free vs imposed)*	89.5 % (19)	94.7 % (19)
	Social housing (alone vs pair vs group)	84.2 % (19)	100 % (18)
	Type of social companionship (same vs different in terms of species, size, sex, origin, etc.)	75.0 % (20)	100 % (18)

ranking in the top-10 were deemed impractical to be evaluated by owners, thus emphasizing the importance of expert input to obtain a complete picture of the parrot's welfare, including possible measures to improve its wellbeing. As such, access and use of veterinary and behavioural expertise would likely need to be addressed in a future welfare tool.

According to several participants, the value of many proposed indicators highly depends on three aspects that were omitted in the survey: 1) the context in which a behaviour is observed or a measurement is taken (e.g. aggressive behaviour towards humans, which could either reflect natural behaviour if defending a partner or territory, or poor welfare upon forced interaction or excessive fear) (Welle and Luescher, 2006); 2) the valence of the parameter, which requires further validation because of reliance on anecdotal information (e.g. for body displays) (Mancini, 2006; Wilson, 2022a) and because of their value (positive or negative) depending on intensity, frequency, or duration (e.g. preening, time spent sleeping) or even on species (e.g. response to novel objects for neophilic vs. neophobic parrots (Mettke-Hofmann et al., 2002)); and 3) the personality of the individual, as specific individual traits (e.g. being neophobic, neurotic, explorative, proactive, vigilant) can influence parrots' response to enrichment or food (Fox and Millam, 2007; Ramos et al., 2021), interactions with humans (Franzone et al., 2022), pairing success (Douglas et al., 2023), or the risk of developing abnormal behaviours (Zeeland et al., 2013; Cussen and Mench, 2014), hence influencing their welfare. Further research into the effects of these factors on parrot welfare would thus be important.

4.2. Factors with an impact on parrot welfare

We presented participants with factors identified in a systematic review or that according to common knowledge may impact companion parrot welfare. Participants concurred with 11 out of 17 statements supported by scientific evidence, thereby further validating the impact of diet, hand-rearing, of being wild-caught, and acquisition before weaning on parrot welfare. Several of these factors, particularly those

Table 4
Ranking of the 10 animal-based and environment-based indicators that were proposed by the participants as the most important indicators to assess parrot welfare. Asterisk indicates animal- and environment-based indicators for which consensus was not reached for the answer options "feasible for owners" and "high impact on welfare", respectively.

Welfare dimension	Animal-based indicators	Rank score round 2	Rank position round 2	Rank position round 1
Abnormal and fear-related behaviours	Feather destructive behaviour (chewing, biting, fraying, plucking)	4.8	1	1
	Whole body stereotypies (head bobbing, rocking) *	4.5	2	2
	Expression of avoidance or escape behaviours	3.8	3	4
	Locomotor stereotypies (route-tracing, pacing) *	3.7	4	4
Locomotor behaviour	Level of activity (time spent inactive vs active) *	3.5	5	3
Abnormal and fear-related behaviour	Excessive vocalization/ screaming*	2.7	6	6
Exploratory behaviour	Interaction with enrichment	2.2	7	8
Maintenance behaviour	Daily food intake	2.1	8	8
Locomotor behaviour	Inability to fly (physical restrictions due to cage size or trimming of feathers)	1.7	9	9
Parrot-human interaction	Response upon contact with caregiver	1.0	10	10
Husbandry and management conditions	**Environment-based indicators**	**Rank score round 2**	**Rank position round 2**	**Rank position round 1**
Enrichment	Opportunities to do physical exercise (flying, climbing, etc.)	4.5	1	2
Housing	Time spent out of the cage	4.5	1	1
	Cage characteristics (e.g., dimension, material, bars orientation)	4.0	3	3
Enrichment	Provision of foraging enrichment	3.5	4	5
Social need	Social housing (alone vs pair vs group)	3.4	5	4
Enrichment	Provision of cognitive enrichment	3.0	6	6
Nutrition	Composition of the diet (quantity of fat, cholesterol, fibre, etc.)	2.7	7	7
Parrot-human interaction	Rearing history	1.9	8	8
Enrichment	Variety of enrichment provided	1.7	9	9
Housing	Access to outdoor spaces*	1.0	10	10

related to acquisition or rearing, are difficult or even impossible to alter, but nevertheless warrant consideration by prospective parrot owners to reduce the risks of poor welfare. In line with literature (Kinkaid et al., 2013; Gaskins and Hungerford, 2014; Ebisawa et al., 2021; Mellor et al., 2021), cockatoos and grey parrots were evaluated as species predisposed to develop feather damaging behaviour. Additionally, participants considered cockatoos to be predisposed to aggressive and hormonal behaviours. Hormonal behaviours are innate natural behaviours that parrots display during the breeding season (e.g. allofeeding, courtship behaviours, copulation, defending the nest site and their mate) that in captivity can sometimes be redirected towards humans through physical interactions and other environmental cues that stimulate human-animal pair-bonding, especially in hand-reared, human-imprinted individuals (Fox, 2006; Seibert, 2006; Van Sant, 2006; Welle and Luescher, 2006; Wilson, 2022c). In line with these "hormonal behaviours", Tygesen and Forkman found that emotional closeness as reported by owners and the frequency of interactions with their parrot were positively correlated with their parrot being aggressive towards humans (Tygesen and Forkman, 2023). These observations indicate that hormonal behaviours are of particular interest when keeping parrots in captivity, and likely require further investigation to determine their causes and consequences for parrot welfare and on the parrot-human relationship.

We found inconsistencies between participants' opinion and the scientific literature for other aspects such as the benefit of neonatal handling (Aengus and Millam, 1999; Collette et al., 2000; Fox and Millam, 2004), species or sex susceptibility for specific diseases (Bavelaar and Beynen, 2003; Beaufrere et al., 2013; Beaufrère et al., 2019; Gibson et al., 2019) or behaviour problems (Spoon et al., 2004; Garner et al., 2006; Polverino et al., 2012, 2015; Jayson et al., 2014; Costa et al., 2016), and acquisition of parrots from pet shops or shelters (Gaskins and Hungerford, 2014; Jayson et al., 2014; Acharya and Rault, 2020). These inconsistencies could be explained by the heterogeneous types of expertise in our panel, as assessment of species' or sex predispositions to disease, or effects of neonatal handling, may have required specific, specialist-level knowledge or expertise which some participants may have lacked (Trevelyan and Robinson, 2015).

4.3. Suitability of parrots as companion animals

The statement "parrots should not be kept as companion animals" did not reach a consensus for any answer option available. This could be due to participants' different ethical positions on keeping parrots as companions. Cockatoos (excluding cockatiels) represented the only taxonomic group for which consensus was reached regarding their unfitness as companion parrots. This likely relates to the previously discussed sensitivity of cockatoos to develop behavioural problems. Cockatoos are well known to be "difficult pets"; however, experimental studies on their welfare in captivity are scarce (Piseddu et al., 2024). Heavily trafficked and critically endangered species (IUCN, 2022) were also deemed unsuitable as companion animals according to panel consensus. Parrots are among the most threatened species (Pain et al., 2006) and poaching and illegal pet trade are considered two of the main causes (Pires, 2012). Therefore, participants may have considered banning these species from the pet trade as a means to protect wild parrots' populations from further decline.

For seven small-sized species (i.e., budgerigars, cockatiels, conures, lovebirds, pacific parrotlets (*Forpus coelestis*) and monk parakeets), consensus was reached regarding their higher suitability as a companion animal. Many of these species possess biological characteristics (i.e., relative small brain size, foraging style not requiring extensive food handling) that were linked to a lower likelihood to develop feather damaging behaviour and stereotypies in captivity (Mellor et al., 2021). Nevertheless, while these findings support their suitability as a companion animal relative to other species, it does not imply that these birds are easy to care for. In fact, all seven species display signs of poor welfare when kept in inappropriate conditions (Piseddu et al., 2024). As statements regarding suitability as a pet were not processed in multiple rounds, further validation and evaluation are needed to identify whether and which biological characteristics render a species more or less adaptable to the domestic environment.

4.4. Demographic and stability of responses between rounds

Despite informing participants about the project's iterative nature and attempting to actively engage them to minimize the risk of dropping out (Trevelyan and Robinson, 2015; Shang, 2023), we obtained an attrition rate of almost 50 % between rounds. This might be due to the high number of items included in the survey (Gargon et al., 2019), which may explain why fewer participants filled out the survey compared to other welfare-related Delphi studies. Additionally, we did not inform participants about the time required to complete the second round of the survey, as this was not estimated during the pilot review. While the time required was probably similar to that of the first round, considering that most of the items included were the same, informing participants about this might still have been beneficial in reducing the dropout rate. However, the smaller panel size might also reflect the comparatively smaller number of experts in the field of parrot welfare. Although standards on the number of panellists required to obtain robust results currently do not exist, our final panel size (n = 21) was within the range considered ideal for Delphi studies, i.e., between 8 and 23 participants (Shang, 2023). Additionally, our panel comprised a heterogenous yet balanced group across relevant areas of expertise as is recommended for multi-angled analysis of complex topics such as animal welfare (Bantel, 1993; Powell, 2003), hence contributing to increased quality and reliability of the results.

We found a relationship between years of work experience with parrots and the proportion of times that participants altered their responses between rounds, suggesting that less experienced participants were more likely to adjust their opinions when they were not in line with the general agreement observed in the previous round, possibly influenced by the perceived authority of the other participants. However, this effect was not strong enough to affect group stability, which was stable between rounds. The optimal number of rounds of survey in Delphi studies is considered to be three (Trevelyan and Robinson, 2015); however, given the high attrition rate and stability being achieved after the second round, we decided not to conduct an additional round.

5. Conclusion

Using the Delphi method, we identified 37 animal-based and 36 environment-based welfare indicators that were evaluated by participants with expertise in parrot welfare as valid and feasible for parrot owners to assess the welfare of all/most parrot species. The expert panel also concurred with scientific findings regarding factors potentially affecting companion parrot welfare: types of diet, pre-acquisition experiences, species susceptibility to develop behavioural problems, and suitability of different species as companion animals. This science-based information could be used by parrot owners, (veterinary) professionals, and policy makers to monitor parrot welfare and improve husbandry conditions of captive parrots.

CRediT authorship contribution statement

Jean-Loup Rault: Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Conceptualization. **Andrea Piseddu:** Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Yvonne R. A. van Zeeland:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2025.106526.

Data availability

All data generated or analysed during this study are included in this published article (and its Supplementary Information files)

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