

# Profile of studies on the welfare of dogs: a systematic review of the literature from 1999 to 2020

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**Abstract:** This systematic review of the literature investigates the characteristics of studies related to the welfare of dogs. A survey of the literature data was carried out using PRISMA criteria. It searched for scientific articles published in the electronic database PubMed between 1990 and 2021, in English and/or Portuguese, that offered free electronic access. We searched for the following descriptor terms: apartment dogs, confined dogs, dog welfare, dog well-being, free-ranging dogs, household confined dogs, indoor dogs, movement restrictions of dogs, roaming owned dogs, sheltered dogs, and spatial restriction. Using the PICO strategy included 4 components: studies on dogs (population); welfare assessment (intervention); studies that used positive behavior measures, such as interaction and behavioral responses, to assess dog welfare (comparator); peculiarities of studies referring to the welfare condition of dogs (result). In total, 44 articles published on PubMed were reviewed. Studies related to dog behavioral assessment comprised 50% of those reviewed. The studied population involved 85,492 animals, of which 75% belonged to the following categories: domiciled (household confined – 2 studies – 4,55% plus indoor – 7 studies – 15,9%); free-ranging (7 studies – 15,9%); and shelter (4 studies – 9,1%). The descriptor term most cited in the articles was roaming-owned dogs (10 studies – 22,7%). We conclude that the behavioral assessment of dog welfare is fundamental to improve the relationship between humans and dogs to prevent abandonment.

**Keywords:** Ethology; Dog; Comfort; Temperament.

## 1. Introduction

Welfare assessment is a complex variable that depends on hematological, immunological, biochemical, and behavioral parameters, among others. In relation to shelter dogs, there is a protocol often used denominated Shelter Quality, based on four welfare principles: good feeding, good housing, good health, and appropriate behavior (Barnard et al., 2016).

Dogs are affected by experiences lived throughout their lives, in their relationships with humans and other animals. From the evolution of the concept of the five freedoms, the Farm Animal Welfare Council (Fawc, 2009) formulated the concept of animal welfare as a life worth living. This concept aims to minimize negative experiences and maximize those that are positive from the point of view of the animal. For this, we luckily have several tools to assess animal welfare.

Space deprivation can certainly be included among the limiting situations for the comfort that one hopes to offer animals. However, free access to the outdoors can also be life-threatening. Therefore, domiciled and loose dogs are expected to be the group with the best quality of life. In the British Animal Welfare Act (Animal Welfare Act, 2006), we find the concept of Duty of Care, which mentions that a person responsible by an animal must steps as are reasonable in all the circumstances to ensure that its needs are met according good practice. In the case that this not occur, the person commits an offense. Thus, examples of these needs are a suitable environment, a suitable diet, to be able to exhibit normal behavior patterns, to be housed with, or apart from, other animals, and to be protected from pain, suffering, injury and disease (Animal Welfare Act, 2006).

There is a trend toward assessing dog welfare via measures that reflect positive response behaviors, indicators of positive emotional status. These measures include animal autonomy, play, positive affect, positive human-animal relationships, social interaction, and appropriate genetic selection. Since this, positive welfare measures are more aligned with preventing behavioral disorders and, consequently, dog abandonment to the detriment of behavioral responses indicating responses to negative experiences, such as fear, stress, and pain (Vigors and Lawrence, 2019).

Finally, it is important to mention that the prioritized welfare issues include the lack of knowledge of welfare needs, social behavior issues, problem behaviors, inappropriate diet and environment, lack of veterinary care, consequences from breeding decisions, poor pain management, delayed euthanasia and chronic ill health (Rioja-Lang et al, 2020). However, a study listed the top 10 reasons for relinquishment due behavior of dogs: bites, aggressive toward people, escapes, destructive inside, destructive outside, disobedient, problems between new pet and other pets, aggressive toward animals, soil house, and loud vocalization (Salman et al., 2000).

In view of the above, we conducted a descriptive study via a systematic review of the literature using the criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMA) (Moher et al., 2015), which seeks to identify the main characteristics of studies analyzing dog welfare.

## 2. Materials e Methods

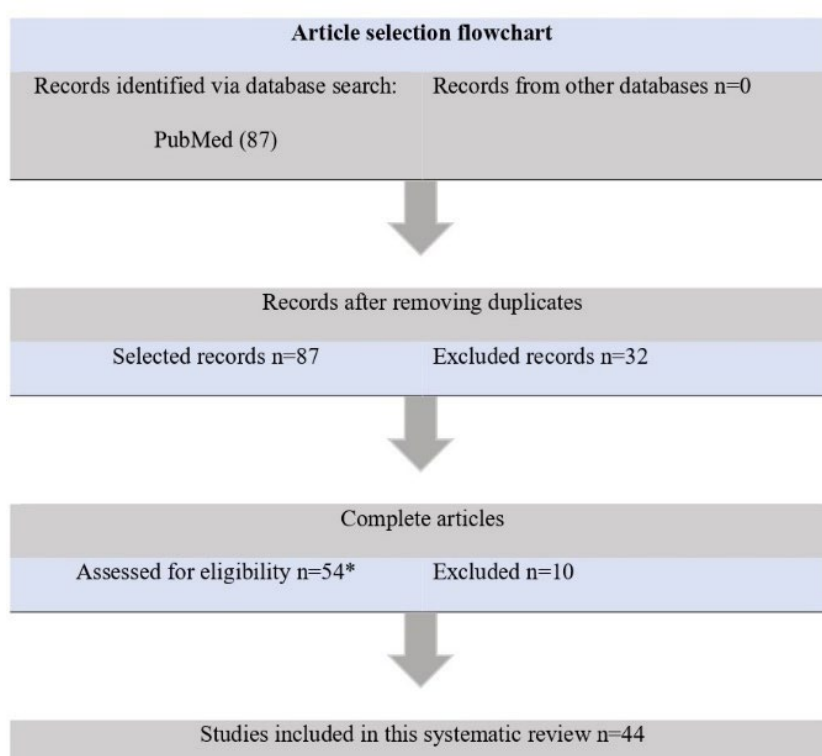
A survey of literature data was carried out by selecting scientific articles published on the PubMed database between January 1990 to January 2021 which were written in English or Portuguese and offered free electronic access. We searched for the

following descriptor terms: apartment dogs, confined dogs, dog welfare, dog well-being, free-ranging dogs, household confined dogs, indoor dogs, movement restrictions of dogs, roaming owned dogs, sheltered dogs, and spatial restriction of dogs. Initially, the studies were separated by title, and then by abstract. Finally, the selected studies were fully read. Studies were chosen as eligible only after these steps. Studies involving purebred dogs; mixed-breed; female; male; of any age; in variable body condition; spayed or not; neutered or not; owned confined, owned free-roaming, free-ranging, and shelter dogs were included. Studies assessing the welfare of dogs in any type of confinement via clinical, physiological, hormonal, and immunological parameters were selected, as well as studies measuring behavior by ethograms.

This systematic review sought to compare studies which used measures of positive behavior for evaluating dog welfare, such as interaction and behavioral responses. Our results show the connection between the preference of dogs for human proximity as gauged by their positive behavioral outcomes. For the construction of the Wordcloud data from the articles were imported into a spreadsheet using Bibliometrix. The analysis was conducted with a focus on titles, enabling the identification of the most frequent words. Consequently, the Wordcloud was generated to illustrate the terms that exhibited higher occurrences.

### 3. Results

Our results evinced the peculiarities of the studies assessing dog welfare. Initially, we found 87 articles containing the search terms descriptors (Figure 1) on the PubMed database.



**Figure 1** – Article selection flowchart. \* One of the articles identified was neither a duplicate nor a complete article.

However, we included 44 articles in this systematic review, as follows: confined dogs (6), dog welfare (1), dog well-being (1), free-ranging dogs (7), household confined dogs (2), indoor dogs (7), movement restrictions of dogs (3), roaming owned dogs (10), sheltered dogs (4) and spatial restriction of dogs (3) (Table 1). The most common descriptor term in the studies was roaming owned dogs with a 22.72% frequency.

Title		Year	Country
<i>Confined dogs</i>			
1	Care of Dogs and Attitudes of Dog Owners in Port-au-Prince, the Republic of Haiti	2012	Haiti
2	Prevalence of antibody against rabies among confined, free-roaming and stray dogs in a transit city of Nigeria.	2011	Nigeria
3	Companion and free-ranging Bali dogs: Environmental links with personality traits in an endemic dog population of South East Asia	2018	Bali

4	Escape rates and biting histories of dogs confined to their owner's property through the use of various containment methods	2017	United States
5	Elimination behavior of shelter dogs housed in double compartment kennels	2014	United States
6	Fecundity and longevity of roaming dogs in Jaipur, India	2008	India
<i>Dog welfare</i>			
7	Health-related welfare prioritisation of canine disorders using electronic health records in primary care practice in the UK	2019	United Kingdom
<i>Dog well-being</i>			
8	One Health Solutions to Obesity in People and Their Pets	2017	United Kingdom
<i>Free-ranging dogs</i>			
9	Assessing reproductive patterns and disorders in free-ranging dogs in Jodhpur, India to optimize a population control program	2010	India
10	Free-ranging dogs prefer petting over food in repeated interactions with unfamiliar humans	2017	India
11	What influences the home range size of free-roaming domestic dogs?	2017	Australia
12	Denning habits of free-ranging dogs reveal preference for human proximity	2016	India
13	The great Indian joint families of free-ranging dogs	2018	India
14	The role of life experience in affecting persistence: A comparative study between free-ranging dogs, pet dogs and captive pack dogs	2019	Austria
15	Free-ranging dogs show age related plasticity in their ability to follow human pointing	2019	India
<i>Household confined dogs</i>			
16	Clinical features and outcome in dogs and cats with obsessive-compulsive disorder: 126 Cases (1989-2000)	2002	United States
17	The influence of poverty and rabies knowledge on healthcare seeking behaviors and dog ownership, Cameroon	2018	Cameroon
<i>Indoor dogs</i>			
18	Increases in heart rate and serum cortisol concentrations in healthy dogs are positively correlated with an indoor waiting-room environment	2014	Italy
19	Interspecific behavioural synchronization: Dogs exhibit locomotor synchrony with humans	2017	France
20	Impact of feeding method on overall activity of indoor, client-owned dogs	2019	United States
21	Pet dogs synchronize their walking pace with that of their owners in open outdoor areas	2018	France
22	Locomotor activity rhythms in dogs vary with age and cognitive status	2003	United States
23	Association between indoor air pollution and respiratory disease in companion dogs and cats	2018	Taiwan
24	Behavioural risks in male dogs with minimal lifetime exposure to gonadal hormones may complicate population-control benefits of desexing	2018	United States
<i>Movement restriction of dogs</i>			
25	Short term consequences of preventing visitor access to kennels on noise and the behaviour and physiology of dogs housed in a rescue shelter	2014	United Kingdom
26	Parasitologic examination and associated risk factors of domestic dogs at the domestic-wildlife interface in the Iberá wetlands Ecoregion, Argentina	2020	Argentina
27	Investigation of the temporal roaming behaviour of free-roaming domestic dogs in Indigenous communities in northern Australia to inform rabies incursion preparedness	2019	Australia
<i>Roaming owned dogs</i>			
28	Census and vaccination coverage of owned dog populations in four resource-limited rural communities, Mpumalanga province, South Africa	2017	South Africa
29	Survey of <i>Campylobacter</i> spp. in owned and unowned dogs and cats in Northern Italy	2015	Italy
30	Evaluation of community-based dog welfare and rabies project in Sanur, a sub-district of the Indonesian island province of Bali	2019	Indonesia
31	The demography of free-roaming dog populations and applications to disease and population control	2014	United Kingdom
32	Dog demographics and husbandry practices related with rabies in Cameroon	2020	Cameroon
33	Fatal dog attacks in Canada, 1990-2007	2008	Canada

34	Epidemiology and surveillance of human animal-bite injuries and rabies post-exposure prophylaxis, in selected counties in Kenya, 2011-2016	2018	Kenya
35	Rabies vaccination of 6-week-old puppies born to immunized mothers: A randomized controlled trial in a high-mortality population of owned, free-roaming dogs	2020	South Africa
36	Demographic studies of owned dogs in the Northern Peninsula Area, Australia, to inform population and disease management strategies	2018	Australia
37	Understanding Dog Bites: The Important Role of Human Behavior	2020	United States
<i>Sheltered dogs</i>			
38	The effects of human attentional state on canine gazing behaviour: a comparison of free-ranging, shelter, and pet dogs	2019	Germany
39	Do behaviour assessments in a shelter predict the behaviour of dogs post-adoption?	2020	Australia
40	Relationship between sociability toward humans and physiological stress in dogs	2017	South Korea
41	When Walking in an Outside Area, Shelter Dogs (Canis familiaris) Synchronize Activity With Their Caregivers but Do Not Remain as Close to Them as Do Pet Dogs	2019	France
<i>Spatial restriction of dogs</i>			
42	Exploring anhedonia in kennelled dogs: Could coping styles affect hedonic preferences for sweet and umami flavours?	2020	Chile
43	Chronic Stress in Dogs Subjected to Social and Spatial Restriction. I. Behavioral Responses	1999	Netherlands
44	Chronic Stress in Dogs Subjected to Social and Spatial Restriction. II. Hormonal and Immunological Responses	1999	Netherlands

**Table 1** – Articles selected grouped by descriptor term and included in the systematic review.

Regarding the year of publication of the studies included in this review, we found that 65.91% (29) were published in the years 2017, 2018, 2019, and 2020. This finding shows the growing interest in animal welfare in recent years. The countries of origin of the selected studies with the highest frequency were: United States (7); India (6); Australia (4); United Kingdom (4); and France (4), representing 54.54% (24) of the studies included in this research. The n sampling of dogs in the studies included in this systematic review totaled 85,492 animals (Table 2). Only 10 articles provided information about the sex of the studied dogs. Of these, 30,581 were females and only 6,505 were males.

N sampling		Group of dogs
<i>confined dogs</i>		
1	1290 residents and 1804 dogs	Owned dog
2	190 dogs	Confined, free-roaming, and stray
3	105 dogs	Companion; free-ranging; puppies (excluded)
4	974 owners and 1053 dogs	Owned dogs
5	579 dogs	Shelter dogs
6	25.000 females caught for spaying	Roaming dogs
<i>dog welfare</i>		
7	557 dogs	Dogs
<i>dog well-being</i>		
8	36 dogs e 92 human participants	PP (human participants and companion dogs) PO (people alone)
<i>free-ranging dogs</i>		
9	5400 dogs; females	Free-ranging dogs
10	103 dogs	Adult free-ranging dogs
11	135 dogs	Free-roaming domestic dogs
12	148 dogs	Free-ranging dogs
13	23 litters	Free-ranging dogs; puppies, and adults
14	72 tested; 43 females and 29 males	Free-ranging dogs, pet dogs and captive pack dogs

15	209 dogs	Free-ranging dogs - adults, juveniles, and puppies
<i>household confined dogs</i>		
16	126 cases; obsessive-compulsive disorder	Dogs and cats
17	208 households; 141 dogs	Owned dogs
<i>indoor dogs</i>		
18	24 dogs	Owned dogs
19	48 dogs; 24 females, and 24 males	Owned dogs
20	24 dogs; 8 females, and 16 males	Owned dogs
21	36 dogs; 18 females, and 18 males	Pet dogs
22	79 dogs; <i>Beagle</i> breed; 42 females, and 37 males	Shelter dogs
23	230 dogs and 118 cats	Companion dogs and cats
24	6235 castrated male dogs	Owned dogs
<i>movement restriction of dogs</i>		
25	15 dogs	Shelter dogs
26	51 dogs	Domestic dogs
27	132 dogs; 8 communities	Free-roaming domestic dogs in Indigenous communities
<i>roaming owned dogs</i>		
28	942 dogs; 2969 households	Owned dogs
29	171 dogs and 102 cats	Household pets; shelter housed dogs; dogs from breeding kennels
30	2098 dogs	Owned dogs
31	3240 dogs	Owned dogs
32	707 dogs; 2500 households	Owned dogs
33	28 fatalities from dog-bite injuries	Owned dogs
34	6720 dogs; 7307 bite records	Owned free-roaming dogs
35	346 dogs	Owned free-roaming dogs
36	813 dogs	Free-roaming dogs
37	478 bite records	Roaming dogs (both feral and owned)
<i>sheltered dogs</i>		
38	72 dogs; 36 females, and 36 males	Free-ranging, shelter, and pet dogs
39	123 dogs	Shelter dogs
40	37 dogs	Companion dogs and shelter dogs
41	30 dogs	Shelter dogs
<i>spatial restriction of dogs</i>		
42	14 dogs; <i>Beagle</i> breed	Shelter dogs
43	15 dogs; <i>Beagle</i> breed; 5 females and 10 males	Shelter dogs
44	15 dogs; <i>Beagle</i> breed; 5 females and 10 males	Shelter dogs

**Table 2** – Characterization of the studied dog population grouped by descriptor term.

Regarding the group of dogs studied in the articles included in this review: 75% belonged to the following categories: domiciled (16); strays (9); and shelter dogs (8) (Table 2).

Concerning the assessed parameters (Table 3), the highest rate (50%/22) were related to dog behavioral assessment; and the rest, to the following main indicators: vaccination, neutering and access to the outdoors (2); vaccine response (5); survival and fecundity (4); canine diseases (6); attacks (3); and stress (2).

Parameters evaluated grouped by descriptor term
<i>confined dogs</i>
Confinement, neutering, and vaccinations for rabies
Antibodies against rabies virus in sera
Behavioral observations: <i>Dog Personality Questionnaire</i>
Survey of dog owners about escape rates for confined dogs and history of biting
Elimination behavior of shelter dogs
Estimates of fecundity and longevity in roaming dogs
<i>dog welfare</i>
Retrospective study about eight common canine disease
<i>dog well-being</i>
Assessment of the effectiveness of a combined people and pet weight loss programme
<i>free-ranging dogs</i>
Assessment of reproductive patterns and disorders during neutering
Immediate social reward and long-term food and social rewards
Roaming monitoring in free-roaming domestic dogs using global positioning system (GPS); identification of roaming predictors (the sex and reproductive status of the dogs)
Denning habits and preference for human proximity
Behavioral interactions
Persistence when presented with a novel object containing food that could not be accessed
Responsiveness
<i>household confined dogs</i>
Obsessive-compulsive disorder (OCD)
Dog confinement, history of rabies vaccination, and history of biting
<i>indoor dogs</i>
Effect of waiting rooms environment on serum cortisol, glucose, and heart rate
Behavioral synchronization between owners and indoor dogs
Activity time using food dispensing toys versus bowls
Behavioral synchronization between owners and outdoor dogs
Locomotor activity that varied as a function of age, cognitive status, and housing environment
Questionnaires to pet owners regarding air pollution and respiratory diseases
Reported behavior to the online Canine Behavioral Assessment and Research Questionnaire
<i>movement restriction of dogs</i>
Visitor access to kennels
Intestinal parasites, richness, and dog movement restriction
Roaming activities and risk factors (age, sex, location, season, and time of day)
<i>roaming owned dogs</i>
Information on number, sex, age, and rabies vaccination status
Prevalence, species distribution, and risk factors for <i>Campylobacter</i> sp.
Evaluation of dog welfare and rabies control Project: rabies vaccination coverage, body condition, sterilization, and confinement practices
Demography study to disease and population control



Vaccine status against rabies
Predominant factors to dog-bite injuries owned, known dogs; residential location; children's unsupervised access to area with dogs; and rural/remote areas
Human animal-bites and post-exposure rabies prophylaxis
Effect of rabies vaccination of six-week-old puppies born to immunized mothers
Survey to estimate dog demographic information and investigate owners' dog management behaviors
Abandonment contributes to dog bite risk human
<i>sheltered dogs</i>
Response of dogs to human attentional state; gazing behavior
Behavior assessment of friendliness/sociality, fear, and anxiety before and post-adoption
Relation between sociability and physiological stress
Behavioral synchronization between caregivers and outdoor dogs
<i>spatial restriction of dogs</i>
Acceptability and preference for sucrose and monosodium glutamate; anhedonia assessment in domestic dogs
Behavioral and physiological measurements of dogs in chronic stress subjected to social and spatial restriction
Hormonal and immunological responses of dogs in chronic stress subjected to social and spatial restriction; catecholamines, cortisol, and leucocytes

**Table 3** – Parameters evaluated in selected studies.

Regarding the diagnostic tools used in the reviewed studies, we found the following: assessment of human-animal interaction (14); rabies vaccination and serology (7); assessment of behavioral problems (6); questionnaires (5); retrospective studies (3); cortisol measurement (2); neutering (2); bacteriological examination (1); demographic study (1); estimation model (1); GPS monitoring (1); and parasitological exam (1).

Regarding behavioral parameters, 54.55% (12) of studies were related to positive behavior measures, such as interaction and behavioral responses, whereas 45.45% (10) of the behavioral studies emphasized negative measures of behavior such as disorders and stress. Among the studies that used positive behavior measures, seven (58.33%) evinced the preference of dogs due to human proximity and five (41.67%) were conducted only with canine behavior. Finally, when we build a Wordcloud (Figure 2) including the most cited words in the articles.



**Figure 2** – Wordcloud with the main words presented into the 44 articles included in this systematic review.

#### 4. Discussion

In view of the importance to perform studies of welfare of dogs, the present review of literature compiled 44 studies around this issue, demonstrating the main characteristics of dog welfare studies. The studies address domiciled (named household confined dogs and plus indoor) dogs; totaling 85.492 animals. However, the studies described more about free-ranging dogs.

In relation to dogs behavior, the studies included in this review demonstrated different standards when analyzed by category as domiciled, free-ranging or shelter dogs. In this sense, domiciled dogs prefer to stay near humans and this preference of dogs for

denning close to humans is a behavior adaptation (Majumder et al., 2016). Furthermore, the dogs tend to build trust based on affection, not food (Bhattacharjee et al., 2017). However, free-ranging dogs show a different behavior than that of the shelter and pet dogs (Bhattacharjee et al., 2019). According a study performed by Brubaker et al. (2019) studying canine gazing behavior, they found that free-ranging dogs responded to the human's change in attentional state by looking significantly less at the human in the inattentive condition compared to the attentive condition. On the other hand, pet and shelter dogs gazed significantly more at the human in both the inattentive and attentive conditions and also spent more time in the proximity of the experimenter.

According to a Serpell (2017) study, pet and shelter dogs pay special attention to humans and especially to their owners or caregivers with whom they usually have a more interactive relationship, different from free-ranging dogs. As an example for this, Duranton and her group of researchers conducted three studies with indoor pet dogs (Duranton et al., 2017), outdoor pet dogs (Duranton et al., 2018) and shelter dogs (Duranton et al., 2019). Regarding indoor pet dogs, they visibly synchronized their location with their owner (staying in close proximity and moving to the same area), as well as their activity and temporal changes in activity (moving when their owner moved, standing still when their owner stood still, and gazing in the same direction as their owner) (Duranton et al., 2017). About outdoor pet dogs, they synchronized both their location (staying in close proximity) and their activity (moving when their owner moved, and at the same pace, and standing still when their owner stood still) with those of their owners (Duranton et al., 2018). Finally, in relation to shelter dogs, they synchronized their locomotor activity with their caregiver less strongly than pet dogs of the both previous studies. Shelter dogs also maintained greater distances to their caregivers than pet dogs with their owners (Duranton et al., 2019).

## 5. Conclusion

There is a growing interest in monitoring dog welfare, especially in developed countries. This study found that most studies on dog welfare use tools to assess the behavior of owned dogs, following the trend of using positive welfare indicators. With the advances in our understanding of canine behavior, we will be able to use tools and strategies to improve our relationship with dogs, preventing undesirable behaviors that often lead to their abandonment. Dogs prefer proximity to humans and are even able to synchronize their behavior with their owners or caregivers. The history of the relationship between humans and dogs started centuries ago, motivated by mutual benefit. This relationship, nowadays, requires commitment from humans, as well as respect for our friendship with dogs.

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## 6. References

- Animal Welfare Act. UK Public General Acts. Promotion of welfare, c. 45: Section 9, 2006. <https://legislation.gov.uk/ukpga/2006/45/section/9>
- Barnard S, Pedernera C, Candeloro L. et al. Development of a new welfare assessment protocol for practical application in long-term dog shelters. *Veterinary Record*, 178 (1): 18, 2016. doi: 10.1136/vr.103336
- Fawc. Farm animal welfare in Great Britain: Past, present and future. Farm Animal Welfare Council. Fawc, October: 70, 2009. <https://gov.uk/government/publications/fawc-report-on-farm-animal-welfare-in-great-britain-past-present-and-future>
- Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, 4 (1): 1–9, 2015. doi: 10.1186/2046-4053-4-1
- Rioja-Lang F, Bacon H, Connor M, et al. Prioritisation of animal welfare issues in the UK using expert consensus. *Veterinary Record*, 187 (12): 490, 2020. doi: 10.1136/vr.105964
- Salman MD, Hutchison J, Ruch-Gallie R, et al. Behavioral Reasons for Relinquishment of Dogs and Cats to 12 Shelters. *Journal of Applied Animal Welfare Science*, 3 (2): 93-106, 2000. doi: 10.1207/S15327604JAWS0302\_2
- Serpell, J. *The Domestic Dog*. 2. ed. United Kingdom: Cambridge University Press, 2017. 432p.
- Vigors B, Lawrence A. What Are the Positives? Exploring Positive Welfare Indicators in a Qualitative Interview Study with Livestock Farmers. *Animals*, 9 (694), 2019. doi: 10.3390/ani9090694
- Arega S, Conan A, Sabeta CT, et al. Rabies vaccination of 6-week-old puppies born to immunized mothers: A randomized controlled trial in a high-mortality population of owned, free-roaming dogs. *Tropical Medicine and Infectious Disease*, 5 (1): 1–14, 2020. doi: 10.3390/tropicalmed5010045
- Bartges J, Kushner RF, Michel KE, et al. One Health Solutions to Obesity in People and Their Pets. *Journal of Comparative Pathology*, 156 (4): 326–333, 2017. doi: 10.1016/j.jcpa.2017.03.008
- Beerda B, Schilder MBH, Bernadina W, et al. Chronic Stress in Dogs Subjected to Social and Spatial Restriction. II. Hormonal and Immunological Responses. *Physiology and Behavior*, 66 (2): 243–254, 1999. doi: 10.1016/s0031-9384(98)00290-x
- Beerda B, Schilder MB, Hooff JA, et al. Chronic stress in dogs subjected to social and spatial restriction. I. Behavioral responses. *Physiology and Behavior*, 66 (2): 233–242, 1999. doi: 10.1016/s0031-9384(98)00289-3



- Bhattacharjee D, Dev N., Gupta S, et al. Free-ranging dogs show age related plasticity in their ability to follow human pointing. *PLoS ONE*, 12 (7): 1–17, 2017. doi: 10.1371/journal.pone.0180643
- Bouli FPNO, Awah-Ndukum J, Mingoas KJ, et al. Dog demographics and husbandry practices related with rabies in Cameroon. *Tropical Animal Health and Production*, 52(3):979–987, 2020. doi: 10.1007/s11250-019-02085-9
- Brubaker L, Bhattacharjee D, Ghaste P, et al. The effects of human attentional state on canine gazing behaviour: a comparison of free-ranging, shelter, and pet dogs. *Animal Cognition*, 22(6):1129–1139, 2019. doi: 10.1007/s10071-019-01305-x
- Clay L, Paterson MBA, Bennett P, et al. Do behaviour assessments in a shelter predict the behaviour of dogs post-adoption? *Animals*. 10(7): 1225, 2020. doi: 10.3390/ani10071225
- Conan A, Geerdes JAC, Akerele OA, et al. Census and vaccination coverage of owned dog populations in four resource-limited rural communities, Mpumalanga province, South Africa. *Journal of the South African Veterinary Association*, 88: 1–7, 2017. doi: 10.4102/jsava.v88i0.1529
- Corrieri L, Adda M, Miklósi A, et al. Companion and free-ranging Bali dogs: Environmental links with personality traits in an endemic dog population of South East Asia. *PLoS ONE*, 13 (6): 1–12, 2018. doi: 10.1371/journal.pone.0197354
- Costa GB, Gilbert A, Monroe B, et al. The influence of poverty and rabies knowledge on healthcare seeking behaviors and dog ownership, Cameroon. *PLoS ONE*, 13 (6): 1–19, 2018. doi: 10.1371/journal.pone.0197330
- Durantón C, Bedossa T, Gaunet F, et al. Interspecific behavioural synchronization: Dogs exhibit locomotor synchrony with humans. *Scientific Reports*, 7 (1): 1–9, 2017. doi: 10.1038/s41598-017-12577-z
- Durantón C, Bedossa T, Gaunet F, et al. Pet dogs synchronize their walking pace with that of their owners in open outdoor areas. *Animal Cognition*, 21 (2): 219–226, 2018. doi: 10.1007/s10071-017-1155-x
- Durantón C, Bedossa T, Gaunet F, et al. When Walking in an Outside Area, Shelter Dogs (*Canis familiaris*) Synchronize Activity With Their Caregivers but Do Not Remain as Close to Them as Do Pet Dogs. *Journal of Comparative Psychology*, 133(3):397–405, 2019. doi: 10.1037/com0000171
- Dürr S, Dhand NK, Bombara C, et al. What influences the home range size of free-roaming domestic dogs? *Epidemiology and Infection*, 145 (7): 1339–1350, 2017. doi: 10.1017/S095026881700022X
- Fielding WJ, Gall M, Green D, et al. Care of Dogs and Attitudes of Dog Owners in Port-au-Prince, the Republic of Haiti. *Journal of Applied Animal Welfare Science*, 15 (3): 236–253, 2012. doi: 10.1080/10888705.2012.683760
- Giacomelli M, Follador N, Coppola LM, et al. Survey of *Campylobacter* spp. in owned and unowned dogs and cats in Northern Italy. *Veterinary Journal*, 204 (3): 333–337, 2015. doi: 10.1016/j.tvjl.2015.03.017
- Hewison LF, Wright HF, Zulch HE, et al. Short term consequences of preventing visitor access to kennels on noise and the behaviour and physiology of dogs housed in a rescue shelter. *Physiology and Behavior*, 133: 1–7, 2014. doi: 10.1016/j.physbeh.2014.04.045
- Hudson EG, Brookes VJ, Ward MP. Demographic studies of owned dogs in the Northern Peninsula Area, Australia, to inform population and disease management strategies. *Australian Veterinary Journal*, 96 (12): 487–494, 2018. doi: 10.1111/avj.12766
- Lazzaroni M, Range F, Bernasconi L, et al. The role of life experience in affecting persistence: A comparative study between free-ranging dogs, pet dogs and captive pack dogs. *PLoS ONE*, 14 (4): 12–14, 2019. doi: 10.1371/journal.pone.0214806
- Lin CH, Lo PY, Wu HD, et al. Association between indoor air pollution and respiratory disease in companion dogs and cats. *Journal of Veterinary Internal Medicine*, 32 (3): 1259–1267, 2018. doi: 10.1111/jvim.15143
- Luna D, Carrasco C, Álvarez D, et al. Exploring anhedonia in kennelled dogs: Could coping styles affect hedonic preferences for sweet and umami flavours? *Animals*, 10 (11): 1–15, 2020. doi: 10.3390/ani10112087
- Maher EK, Ward MP, Brookes VJ, et al. Investigation of the temporal roaming behaviour of free-roaming domestic dogs in Indigenous communities in northern Australia to inform rabies incursion preparedness. *Scientific Reports*, 9 (14893), 2019. doi: 10.1038/s41598-019-51447-8
- Majumder SS, Paul M, Sau S, et al. Denning habits of free-ranging dogs reveal preference for human proximity. *Scientific Reports*, 6 (August): 1–8, 2016. doi: 10.1038/srep32014
- McGreevy PD, Wilson B, Starling MJ, et al. Behavioural risks in male dogs with minimal lifetime exposure to gonadal hormones may complicate population-control benefits of desexing. *PLoS ONE*, 13 (5): 1–14, 2018. doi: 10.1371/journal.pone.0196284
- Morters MK, McKinley TJ, Restif O, et al. The demography of free-roaming dog populations and applications to disease and population control. *Journal of Applied Ecology*, v. 51, n. 4, p. 1096–1106, 2014. doi: 10.1111/1365-2664.12279
- Natalini B, Gennuso S, Beldomenico PM, et al. Parasitologic examination and associated risk factors of domestic dogs at the domestic-wildlife interface in the Iberá wetlands Ecoregion, Argentina. *Veterinary Parasitology: Regional Studies and Reports*, 20(January): 100378, 2020. doi: 10.1016/j.vprsr.2020.100378
- Ngugi JN, Maza AK, Omolo OJ, et al. Epidemiology and surveillance of human animal-bite injuries and rabies post-exposure prophylaxis, in selected counties in Kenya, 2011–2016. *BMC Public Health*, 18 (1): 1–9, 2018. doi: 10.1186/s12889-018-5888-5
- Olugasa BO, Aiyedun JO, Emikpe BO, et al. Prevalence of antibody against rabies among confined, free-roaming and stray dogs in a transit city of Nigeria. *Veterinaria italiana*, 47 (4): 453–60, 2011. <https://pubmed.ncbi.nlm.nih.gov/22194227>

PLoS ONE, 9 (5): 5–9, 2014. doi: 10.1371/journal.pone.0096254

- Overall KL, Dunham AE. Clinical features and outcome in dogs and cats with obsessive-compulsive disorder: 126 Cases (1989-2000). *Journal of the American Veterinary Medical Association*, 221 (10): 1445–1452, 2002. doi: 10.2460/javma.2002.221.1445
- Paul M, Bhadra A. The great Indian joint families of free-ranging dogs. *PLoS ONE*, 13 (5): 1–18, 2018. doi: 10.1371/journal.pone.0197328
- Perego R, Proverbio D, Spada E, et al. Increases in heart rate and serum cortisol concentrations in healthy dogs are positively correlated with an indoor waiting-room environment. *Veterinary Clinical Pathology*, 43 (1): 67–71, 2014. doi: 10.1111/vcp.12118
- Raghavan M. Fatal dog attacks in Canada, 1990-2007. *Canadian Veterinary Journal*, 49 (6): 577–581, 2008. doi: <https://pubmed.ncbi.nlm.nih.gov/18624067>
- Reece JF, Chawla SK, Hiby EF, et al. Fecundity and longevity of roaming dogs in Jaipur, India. *BMC Veterinary Research*, 4 (6): 1–7, 2008. doi: 10.1186/1746-6148-4-6
- Reese LA, Vertalka JJ. Understanding Dog Bites: The Important Role of Human Behavior. *Journal of Applied Animal Welfare Science*, 24 (2): p. 1–16, 2020. doi: 10.1080/10888705.2020.1790371
- Shin YJ, Shin NS. Relationship between sociability toward humans and physiological stress in dogs. *Journal of Veterinary Medical Science*, 79 (7): 1278–1283, 2017. doi: 10.1292/jvms.16-0403
- Siwak CT, Tapp PD, Zicker SC, et al. Locomotor activity rhythms in dogs vary with age and cognitive status. *Behavioral Neuroscience*, 117 (4): 813–824, 2003. doi: 10.1037/0735-7044.117.4.813
- Starinsky NS, Lord LK, Herron ME, et al. Escape rates and biting histories of dogs confined to their owner's property through the use of various containment methods. *Journal of the American Veterinary Medical Association*, 250 (3): 297–302, 2017. doi: 10.2460/javma.250.3.297
- Su DK, Murphy M, Hand A, et al. Impact of feeding method on overall activity of indoor, client-owned dogs. *Journal of Small Animal Practice*, 60 (7): 438–443, 2019. doi: 10.1111/jsap.13003
- Summers JF, O'Neill DG, Church D, et al. Health-related welfare prioritisation of canine disorders using electronic health records in primary care practice in the UK. *BMC Veterinary Research*, 15 (1): 1–20, 2019. doi: 10.1186/s12917-019-1902-0
- Totton SC, Wandeler AI, Gartley CJ, et al. Assessing reproductive patterns and disorders in free-ranging dogs in Jodhpur, India to optimize a population control program. *Theriogenology*, 74: 1115–1120, 2010. doi: 10.1016/j.theriogenology.2010.05.008
- Utami NWA, Agustina KK, Atema KN, et al. Evaluation of community-based dog welfare and rabies project in Sanur, a sub-district of the Indonesian island province of Bali. *Frontiers in Veterinary Science*, 6 (MAY): 1–12, 2019. doi: 10.3389/fvets.2019.00193
- Wagner D, Newbury S, Kass P, et al. Elimination behavior of shelter dogs housed in double compartment kennels.