International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM May 2023, 14(5):789-795 Print ISSN 0976-3988 Online ISSN 0976-4038 **Article** AR3483

Review Article *Stress Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2023.3483

A Review on the Influence of Noise on the Welfare of Dogs

R. Raghy[1], Ninan Jacob[2] and J. Tamizhkumaran[3]

[1]Dept. of Livestock Production and Management, Rajiv Gandhi Institute of Veterinary Education and Research, Kurumbapet, Pondicherry (605 009), India

[2]Dept. of Veterinary Physiology, Rajiv Gandhi Institute of Veterinary Education and Research, Kurumbapet, Pondicherry (605 009), India

[3]Veterinary Services, Dvara E Dairy, Chennai, Tamil Nadu (600 113), India

Open Access

Corresponding raghy91@gmail.com

0009-0002-2372-280X

ABSTRACT

The purpose of ears is to receive and transmit sound information to the brain. All ears have a dynamic functioning range but if sounds are excessively loud, it may harm the auditory system whereas those that are too low in intensity are simply not processed. One-third of canine population suffers from noise aversion. Dogs are frequently startled by loud noises like gunshots, thunder, or fireworks. Research indicates that some dog breeds are significantly less likely to experience loud noise phobia. Older dogs are more prone to react emotionally negatively to loud noises. Extreme phobic reactions can result from a single traumatic encounter as well as recurrent exposure to frightful stimuli. While phobic responses might include panic, acute agitation, and/or destructive activity, mild fear responses can include panting, pacing and hiding attempts. Sudden, loud noises are one of the most common triggers for fearful behaviours in dogs and many companion dogs suffer from noise sensitivity. This review deals with physiology of canine ear, breed differences in hearing capacities, frequencies of sound that affect dogs and the physiological and behavioural responses of dogs to noise stress. The effect of music on canine welfare and strategies for noise abetment is also elucidated. To protect the wellbeing of dogs and to limit the emergence of anxiety-related behavioural stress issues, a better understanding of interpreting canine responses to noise is imperative.

KEYWORDS: Breed, dogs, health, sound, noise, noise sensitivity, welfare

***Citation* (VANCOUVER):** Raghy et al., A Review on the Influence of Noise on the Welfare of Dogs. *International Journal of Bio-resource and Stress Management*, 2023; 14(5), 789-795. HTTPS://DOI.ORG/10.23910/1.2023.3483.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 18th March 2023 RECEIVED in revised form on 28th April 2023 ACCEPTED in final form on 10th May 2023 PUBLISHED on 27th May 2023

1. INTRODUCTION

Sound is defined as "a vibration that normally propagates as an audible wave of pressure, across a transmission medium such as a gas, liquid, or solid" (Shipman et al., 2012). Dogs have greater emphasis on their sense of smell than on their hearing (Stitzel et al., 2011). However, dogs who lose their hearing later in life, due to various reasons might in fact be aware that they are different from their fellow canines and might feel the loss of hearing more keenly than canines who are born deaf (Scheifele et al., 2012). Dogs may be able to hear sounds up to four times farther away than people can hear (Audicus, 2015, Cole, 2010). Furthermore, dogs' hearing abilities vary widely given their tremendous morphological and functional diversity (Barber et al., 2020).

An intense fear of loud noises, such as those from fireworks or thunderstorms, is often termed as noise anxiety in dogs (Storengen and Lingaas, 2015). Extreme phobic reactions can result from a single traumatic encounter as well as recurrent exposure to frightful stimuli (Gracia, 2017). While phobic responses might include panic, acute agitation, attempts to flee, and/or destructive activity, mild fear responses can include panting, pacing, and hiding attempts (Sherman and Mills, 2008). Thunderstorms, fireworks, and gunshots are just a few examples of random, unpredictable sounds which professionals have interpreted to be stimuli that causes stress, anxiety, and fear in dogs (Franzini et al., 2018, Franzini et al., 2016, Araujo et al.,2013). Although the vast majority of affected dogs also exhibit fear of gunshots and thunderstorms, fireworks appear to be the most common cause of noise phobias in dogs (Overall et al., 2016). With a prevalence of up to 49%, fear responses to noises are fairly prevalent in dogs (Blackshaw et al., 1990). Almost always, exposure to a phobic stimulus result in an instantaneous behavioural response and accompanying indicators of autonomic arousal (Sherman and Mills, 2008). Each sound is distinguished by its wavelength hertz (Hz), intensity (decibel), speed and direction (Shipman et al., 2012).

Familiarity and habituation play an important role in auditory preferences. (Heffner & Heffner, 1998). Domestication of dogs has considerably affected their auditory and visual system (Mcgreevy et al., 2004). The capacity of each dog to handle stress varies, and not all dogs exhibit overt sensitivity or phobias toward noise (Stephen and Ledger, 2005) whereas in humans, frequencies between 2000-4000 Hz have highest potential for annoyance (McDermott, 2012). In dogs the frequency around 8000 Hz is found to be problematic (Barber et al., 2020). Heffner (1983) reported that poodle breed of dog hears at a frequency of 40Hz and at 59dB frequency, they detect sound. Dogs in kennels exposed to sounds around 100–108 dB over six months showed a decline in hearing ability (Scheifele, 2012). Several publications list the behavioural responses of dogs to loud noises such as shaking, freezing, panting, salivation, lowered body posture, tucked tail, hiding, escape attempts, social withdrawal, pacing, and destructive behaviour with or without self-injury (Overall et al., 2016, Cracknell and Mills, 2008, Levine et al., 2007). When exposed to audio recordings of thunderstorms or fireworks, some experimental studies found contradictory behavioural responses, showing either a decrease in activity (Wormald et al., 2016) or an increase in activity (Landsberg et al., 2015). These disparate results may be explained by the active and passive responses that dogs use as coping mechanisms in reaction to fear-inducing noises.

2. ANATOMY AND PHYSIOLOGY OF THE CANINE EAR

The canine ear consists of the pinna, external ear canal, middle ear and inner ear (Figure 1) The pinna is used to focus and collect sound waves and then send them to the tympanic membrane (Evans, 1993).

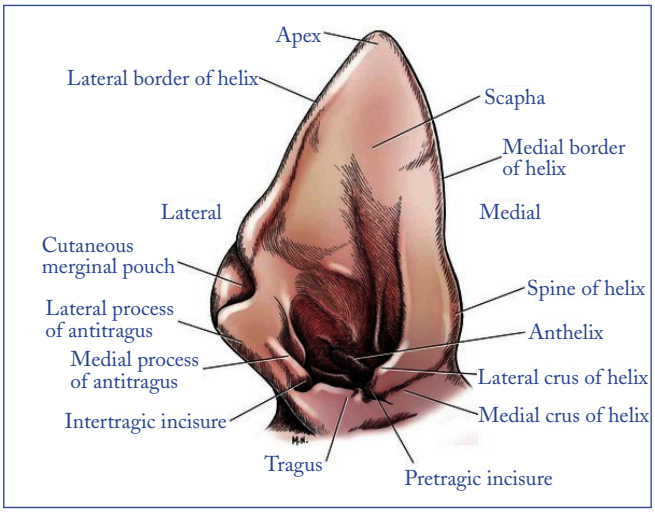

Figure 1: Right external ear of the dog. L, lateral, M, medial (Evans, 1993)

The pinna varies with different breed conformation in dogs. Pinnae can be either upright or pendulous (Kumar, 2005). The ear canal of dogs is substantially deeper than those of humans, which makes for a better funnel for sound to travel through on its way to the eardrum. Usually, dogs can hear sounds at greater frequencies than the average person can, and does so around four times better. The eardrum and a small, air-filled chamber with the stirrup, anvil, and hammer bones are located in the middle ear. Two muscles, the oval window, and the eustachian tube (a small tube that connects the middle ear with the back of the nose, allowing

air to enter the middle ear) are also included. The cochlea (the hearing organ) and the vestibular system are parts of the intricate inner ear structure (the organ of balance) (Cole, 2009).

3. BREED DIFFERENCES IN HEARING CAPACITY OF DOGS

Breed differences exist as to the perception of sound in dogs. Dogs have highly mobile ears with around eighteen muscles that can tilt, rotate, raise and lower a dog's ear. This allows them to quickly pinpoint the exact location of the sound. The following Table 1 and Figure 2, highlights the hearing characteristics of few dog breeds (Sreekumar and Ninan, 2016).

Table 1: Hearing characteristics of few dog breeds

Sl. No.	Breed	Characteristics	Type of ear
1.	St. Bernard, Newfoundland	Best at hearing subsonic sound	Big square head and large ears
2.	German Shepherd dog, Collie	Prick ears are better than hanging ears as they can move their ear slightly or together towards the source of sound	Prick ears
3.	Basset Hound, Cocker Spaniel		Hanging ears
4.	Lunde Hund breed	Can close their ears	-
5.	Dalmatian	30% are reported to be deaf in one or both ears	-

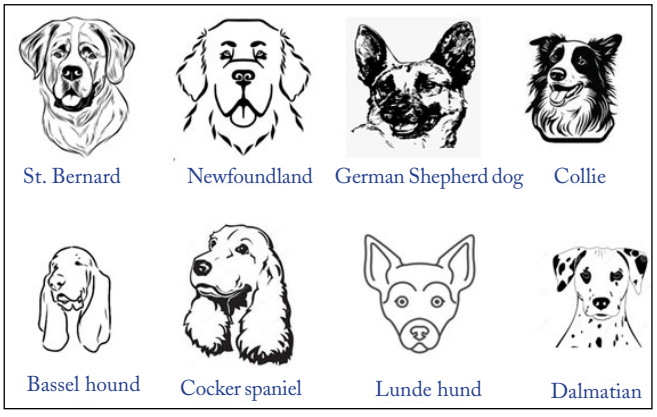

Figure 2: Dog breeds with different ear types

However, Heffner (1983) found no systemic relation among the Poodle, Dachshund, Saint Bernard and Chihuahua breeds between high frequency hearing sensitivity and head size, body weight or tympanic membrane area.

Dogs depending upon their breed and head size have different sizes of pinna. Dogs with ear size of 34.9 cm has been recorded in Guinness world record. Three main forms of pinna noted in dogs (Strain, 2011), are listed below Table 2.

Table 2: Types of pinna in few dog breeds

Sl. No.	Type of pinna	Breed of dog
1.	Erect	German Shepherd dog, Siberian Husky
2.	Semi-erect	Grey Hound, Pug
3.	Drooping	Poodles, Beagle

Strain (2011) also noted that localisation of sound is best in dogs with large erect ears. Further the ability to control the orientation of their pinnae improve hearing sensitivity by as much as 28dB particularly at higher frequency. Also, dog with erect upright pinnae amplify both high and low frequency sounds.

4. FREQUENCY OF SOUND

Dogs, regardless of their body size, have particularly high sensitivity for hearing in the range 1,000–8,000Hz (Heffner, 1983). The consistency and frequency of the sound play a significant role in the dog's response, with many species responding more strongly (increased alertness and attention) to high frequency sounds than low frequency sounds. Though dogs are, more sensitive to high-frequency sounds than humans are at lower frequencies, there is very little difference in response between the two. Dogs may also be more negatively impacted by high frequency sounds in the home than their human partners because dog's amplification mechanisms may be stronger than that of human being (Barber et al., 2020). Heffner and Heffner (2008) found the hearing frequency range in dogs to be 1800–22000 Hz at 10 dB amplitude. Whereas in 1998, Heffner reported frequency range of 67–44000 Hz can be heard at 60 dB. The loudness or intensity of sound is measured in decibels (dB). At high frequencies, dogs can detect much softer sounds than humans can. Corner (1994) found that at sounds in between frequency of 3000–12000 Hz, dogs can hear better than humans. When frequency range crosses 12,000 Hz, dog ears have more sensitivity. Dogs are used as watchdogs, guard dog due to better hearing ability. Also, whistles, which emit ultrasonic sound are used in dog training (Condon, 2003).

Franzini et al. (2018) observed no differences between sound-sensitive and non-sensitive dogs with regard to sex, age, weight and castration. The development of fear reactions to noises involves interactions between the personality traits of the dog, its early surroundings and exposure to certain loud noises (Emily et al., 2013).

Dog's hearing capability can be detected by using Brainstorm Auditory Evoked Response hearing test. In this test electrodes are placed on dog's head and earphones on the ears. Sound played through the earphones are reflected as electrical activity in the brain, if the dog hears the sound. This test is also used to check deafness in dogs. As a dog ages, its hearing capacity reduces (Heffner and Heffner, 2007).

5. NOISE

The word "noise" comes from the Latin word "nausea," which refers to an "unwanted sound" or a loud, unpleasant or unexpected sound. It can be described as the wrong sound, in the wrong place, at the wrong moment (Firdaus and Ahmad, 2010). One of the most frequent catalysts for scared behaviour in dogs is sudden, loud noise. (Landsberg et al., 2003). Domestic dogs reared in kennel, exposed to sounds around 100–108 dB over 6 months showed a decline in hearing ability (Sacheifele et al., 2012).

While the fear response is a normal and self-protective behaviour, it is exaggerated and inappropriate in sound sensitive fearful dogs, which has a detrimental effect on the welfare of dog (Shull-Selcer and Stagg, 1991). The physical, mental or social health of a dog may suffer as a result of repeated exposure to anxiety-inducing stimuli over time (Mills et al., 2014), which will lower the quality of life in dogs. According to many studies, domestic dogs have notable or even extreme noise sensitivities that can be as high as 50% of the population (Blackshaw et al., 1990; Blackwell et al., 2013, Storengen and Lingaas, 2015, Overall et al., 2016). Undesirable behaviour may result in response to noises in the house which results in making companion dogs fearful and anxious. Fireworks are the most prevalent source of noise phobia in dogs, but the issue is more pervasive than just a seasonal or irregular issue because affected dogs frequently also react to a variety of other noises like thunder or gunshots (McPeake et al., 2017). Based on the video footage, Landsberg (2003) revealed that the dogs were probably going to cease exploring and had behaviour similar to freezing at the beginning and during the thunder, which is comparable with the scared reactions seen in domestic dogs

According to Cracknell and Mills (2008) unpredictable, intermittent and high-intensity noise are to blame for fear reactions at construction sites. The authors also claimed that little is known about how secondary stimuli like light flashes, odours or even changes in barometric pressure affect an animal's behaviour, perception and physiology.

6. PHYSIOLOGICAL AND BEHAVIOURAL RESPONSES TO NOISE STRESS

When the sound is unpredictable and exposure to the sound cannot be avoided, loud noises induce severe fear reactions in dogs, which can be seen in both physiological and behavioural reactions, including a weakened immune system, insulin resistance, cardiovascular illness and digestive issues, in addition to hearing loss (Coppola et al., 2006). Stellato et al. (2017) noted that only respiratory rate increased when dogs were exposed to background noises (people talking, dog's barking, metal doors clanging) and had no impact on behaviour or other physiological parameters (such as temperature or heart rate). However, lip licking, avoidance and postural reductions were more prevalent (Anastasia et al., 2019). Given that olfactory probing is a crucial part of dog exploration (Horowitz et al., 2013), the loud stimulus could cause the dogs to engage in exploratory behaviour, which may increase sniffing and an increase in the rate of respiration (Anastasia et al., 2019).

Animals are at danger of hearing impairment from being exposed to extremely loud noise levels throughout the day, and dogs may experience poorer sleep quality and quantity as a result. Reduced reproductive and cardiovascular function, disrupted sleep-wake cycles, or a restricted capacity to communicate with other canines can all be caused by an unpleasant noise environment (Well, 2009).

Unexpected noises caused quick reactions such as tachycardia, hypertension and increased epinephrine and norepinephrine secretion (Engeland et al., 1990). Dreschel and Granger (2005) reported a significant rise (207%) in salivary cortisol which lasts for 40 m due to exposure to acute, irregular noises. This may be due to stimulation of the HPA axis and a rapid (within 15 m) increase in circulating cortisol concentrations (Gin et al., 2018). Sound stimuli have been shown to significantly alter the autonomic nervous system, favouring sympathetic dominance and pronounced cortisol release (Franzini et al., 2016). Thus, the cortisol release and excessive autonomic activation can ultimately lower immunity and raise risk for diseases like hypertension, heart disease, fatigue and insomnia (McEwen, 2007, Teixeira et al., 2015). Numerous investigators (Engeland et al., 1990, Beerda et al., 1998, Dreschel and Granger, 2005, Siniscalchi et al., 2008) have demonstrated that noise stimulation in awake dogs causes an immediate rise in cortisol production that is consistent with a stress response.

The sensitivity of dogs to sound is frequently linked to other behavioural issues which may lead to property damage and cause danger to the dog itself, to humans and other dogs around it (Storengen and Lingaas, 2015). Loud noises cause a variety of behavioural reactions, such as panting, hiding, pacing, cowering or lowering one's body position, shaking or shivering, barking, trying to flee or retreat and looking for familiar faces (Overall et al., 2016). Exposure to noisy environment especially during transport may cause temporary or permanent hearing loss (Barber et al., 2020).

7. CANINE BEHAVIOUR RESPONSE TO NOISE

In a study on stress related response in companion dogs, the following behavioural responses were noted and are listed below (Grigg et al., 2021). Vocalizations like barking, howling and whining were observed. Body movements like pacing, retreating, hiding, trembling/shaking, spinning, digging, jumping on owner, jumping in place, jumping with forward movement, lunging without making physical contact and an overall frozen rigidity of posture were noticed. Facial orientation changes manifested were lip licking, panting, salivating, tucked ears, yawning, fear grimace (mouth corner pulled back) and agonistic pucker (mouth corner tipped forward). Changes were observed in the orientation of the tail of the dog. Tail wag movements and tucked tail were noted depending on the intensity of the noise.

8. EFFECT OF MUSIC ON CANINE WELFARE

It has been demonstrated that auditory enrichment helps dogs exhibit less arousal-related behaviour (Amaya et al., 2021). Veterinary medicine uses music therapy as a method for behavioural management and enrichment (Alworth, and Buerkle, 2013). Music therapy in animal shelters may also have positive impacts on metabolism and the immune system (Yamasaki et al., 2012). A study found that canine welfare was badly impacted by playing heavy metal music. It was observed that kennelled dogs exposed to classical music spend more time resting and less time vocalising than those exposed to other genres of music or no music. Compared to other music genres, heavy metal music seems to enhance body trembling, a sign of anxiety. It has been proposed that playing classical music in a shelter setting may help reduce some of the stress that many kennelled dogs experience (Lori et al., 2012). Compared to control conditions, animals exposed to classical music seem less agitated or anxious (Abigail et al., 2020). Low-pitched tracks seemed more ominous to dogs, causing them to become more alert and active when they heard them (Amaya et al., 2021).

9. STRATEGIES FOR NOISE ABATEMENT

Effective treatment programmes must be adopted because the welfare of animals may decline if they are continually exposed to noise (Dreschel and Granger, 2005). There are numerous ways to control noise in kennel, including altering kennel management practises or incorporating sound control into the design of new buildings. Barking may be reduced by limiting disruptions in the kennel and establishing a regular schedule for care. Utilizing quieter cleaning tools and replacing noisy overhead fans and creaky kennel doors could all assist to reduce noise levels in the establishment (Garvey et al., 2016). Private spaces allow for the housing of multiple canines, which has been demonstrated to reduce vocal noise and enhance sleeping time (Coppola et al., 2006). However, due to their comparatively high costs and impracticality, self-contained rooms may not be suitable for many facilities, such as high-volume or low-resource shelters or kennels.

Environmental enrichment can be attained by playing classical music in the kennel which encourage relaxed behaviours that are frequently linked to lower levels of stress. This minimises some of the unfavourable characteristics of the kennel environment with comparatively low expense and effort (Kogan et al., 2012).

Veterinary medications such as sedatives and benzodiazepines are frequently opted by owners of noise-phobic dogs (Mills et al., 2003, Overall et al., 2016). Veterinarians may use dexmedetomidine gel, to reduce noise sensitivity (Kevin et al., 2017).

10. CONCLUSION

Research needs to be conducted into sound features such as amplitude, frequency and composition to assess which sound is liked by dogs and which sound disturbs them. Better research is needed to accurately interpret canine body language in order to safeguard dogs' welfare as well as minimize development of anxiety-related behaviour problems occurring due to noise stress.While designing kennels for dogs, noise abatement strategy should be an integral part of the design.

11. REFERENCES

Alworth, L.C., Buerkle, S.C., 2013. The effects of music on animal physiology, behavior and welfare. Laboratory Animal 42(2), 54–61.

Amaya, V., Descovich, K., Paterson, M.B.A., Phillips, C.J.C., 2021. Effects of music pitch and tempo on the behaviour of kennelled dogs. Animals 11(10), 1–14.

Araujo, J.A., de Rivera, C., Landsberg, G.M., Adams, P.E., Milgram, N.M., 2013. Development and validation of a novel laboratory method of sound-induced fear and anxiety in beagle dogs. Journal of Veterinary Behavior 8(4), 204–212.

Barber, A.L.A., Wilkinson, A., Montealegre, Z.F., Ratcliffe, V.F., Guo, K., Mills, D.S., 2020. Comparison of hearing and auditory functioning between dogs and humans. Comparative Cognition and Behavior Reviews 15, 45–94.

Beerda, B., Schilder, M.B.H., Van Hooff, J., de Vries, H.W., Mol, J.A., 1998. Behavioural, saliva, cortisol and heart rate responses to different types of stimuli

in dogs. Applied Animal Behaviour Science 58(3–4), 365–381.

Blackshaw, J.K., Cook, G.E., Harding, P., Day, C., Bates, W., Rose, J., Bramham, D., 1990. Aversive responses of dogs to ultrasonic, sonic and flashing light units. Applied Animal Behaviour Science 25(1–2), 1–8.

Blackwell, E.J., Bradshaw, J.W.S., Casey, R.A., 2013. Fear responses to noises in domestic dogs: Prevalence, risk factors and co-occurrence with other fear related behaviour. Applied Animal Behaviour Science 145(1–2), 15–25.

Cole, L.K., 2009. Anatomy and physiology of the canine ear. Veterinary Dermatology 20(5–6), 412–421.

Condon, T., 2003. Frequency range of dog hearing. The Physics Factbook. Available at https://hypertextbook.com/facts/2003/TimCondon.shtml#:~:text=%22Dogs%20can%20hear%20sounds%20up,%2C%20or%20cycles%20per%20second.%22&text=Humans%20can%20hear%20sounds%20approximately,20%20Hz%20and%2020%2C000%20Hz.

Coppola, C., Enns, R.M., Grandin, T., 2006. Noise in animal shelter environment: Building design and the effects of daily noise exposure. Journal of Applied Animal Welfare Science 9(1), 1–7.

Coren, S., 1994. The intelligence of dogs: A guide to the thoughts, emotions, and inner lives or our Canine companions. Free Press, Simar Schuster, New York, 320. ISBN 13: 978-0-7432-8087-7.

Cracknell, N.R., Mills, D.S., 2008. A double-blind placebo-controlled study into the efficacy of a homeopathic remedy for fear of fi rework noises in the dog (*Canis familiaris*). Veterinary Journal 177(1), 80–88.

Dreschel, N.A, Granger, D.A., 2005. Physiological and behavioral reactivity to stress in thunderstorm-phobic dogs and their caregivers. Applied Animal Behaviour Science 95(3), 153–168.

Engeland, W.C., Miller, P., Gann, D.S., 1990. Pituitary and adrenomedullary responses to noise in awake dogs. American Journal of Physiology 258(3), R672–7.

Evans, H.E., 1993. The ear. In: Evans, H.E. (Ed.), Miller's anatomy of the dog (3rd Edn.). W.B. Saunders Company, Philadelphia, PA, 988–1008.

Firdaus, G., Ahmad, A., 2010. Noise pollution and human health: A case study of municipal corporation of Delhi. Indoor and Built Environment 19(6), 648–656.

Franzini de Souza, C.C., Dias, D.P.M., Souza, R., Medeiros, M., 2018. Use of behavioural and physiological responses for scoring sound sensitivity in dogs. PLoS ONE 13(8), e0200618.

Franzini de Souza, C.C., Maccariello, C.E., Dias, D.P., Almeida, N.A., Medeiros, M.A., 2016. Autonomic, endocrine and behavioural responses to thunder in laboratory and companion dogs. Physiology & Behavior 169, 208–215.

Garcia, R., 2017. Neurobiology of fear and specific phobias. Learning and Memory 24(9), 462–471.

Garvey, M., Stella, J., Croney, C., 2016. Auditory stress: Implications for kenneled dog welfare. Center for Animal Welfare Science, Purdue Extension, Purdue University. Available at https://extension.purdue.edu/extmedia/va/va-18-w.pdf. Accessed on 20th February, 2023.

Gin, T.E., Puchot, M.L., Cook, A.K., 2018. Impact of an auditory stimulus on baseline cortisol concentrations in clinically normal dogs. Domestic Animal Endocrinology 64, 66–69.

Grigg, E.K., Chou, J., Parker, E., Gatesy-David, A., Clarkson, S.T., Hart, L.A., 2021. Stress-related behaviors in companion dogs exposed to common household noises, and owners' interpretations of their dogs' behaviors. Frontiers in Veterinary Science 8, 760845.

Heffner, H.E., 1983. Hearing in large and small dogs: absolute thresholds and size of the tympanic membrane. Behavioral Neuroscience 97, 310–318.

Heffner, H.E., Heffner, R.S., 1998. Hearing. In: Greenberg, G., Haraway, M.M. (Eds.), Comparative psychology: A Handbook. Garland, New York, 290–303.

Heffner, H.E., Heffner, R.S., 2008. High-frequency hearing. In: Dallos, P., Oertel, D., Hoy, R. (Eds.), Handbook of the Senses: Audition. Elsevier, NY, 55–60.

Horowitz, A., Hecht, J., Dedrick, A., 2013. Smelling more or less: investigating the olfactory experience of the domestic dog. Learning and Motivation 44(4), 207–217.

Kevin, M., Nadja, A., Daniel, M., 2017. Noise sensitivities in dogs: A new licensed treatment Option. Veterinary Record 180(14), 353–355.

Kogan, L.R., Schoenfeld-Tacher, R., Simon, A.A., 2012. Behavioral effects of auditory stimulation on kenneled dogs. Journal of Veterinary Behavior 7(5), 268–275.

Kumar, A., 2005. Anatomy of the canine and feline ear. In: Gotthelf, L.N. (Ed.), Small animal ear diseases (2nd Edn.). Elsevier Saunders, St. Louis, MO, 1–21.

Landsberg, G.M., Beck, A., Lopez, A., Deniaud, M., Araujo, J.A., Milgram, N.W., 2015. Dog-appeasing pheromone collars reduce sound-induced fear and anxiety in beagle dogs: a placebo-controlled study. Veterinary Record 177(10), 260.

Landsberg, G.M., Hunthausen, W., Ackerman, L., 2003. Handbook of Behavior Problems of the Dog and Cat. Saunders, Edinburgh, UK, 117–268.

Levine, E.D., Ramos, D., Mills, D.S., 2007. A prospective study of two self-help CD based desensitization and counter-conditioning programmes with the use of dog appeasing pheromone for the treatment of firework fears in dogs (*Canis familiaris*). Applied Animal Behavior Science 105(4), 311–329.

McDermott, J.H., 2012. Auditory preferences and aesthetics: Music, voices, and everyday sounds. In: Dolan, R.J., Sharot, T. (Eds.), Neuroscience of preference and choice: cognitive and neural mechanisms. Academics Press, New York, 227–256.

McEwen, B.S., 2007. Physiology and neurobiology of stress and adaptation: central role of the brain. Physiological Reviews 87(3), 873–904.

McGreevy, P., Grassi, T.D., Harman, A.M., 2004. A strong correlation exists between the distribution of retinal ganglion cells and nose length in the dog. Brain, Behavior and Evolution 63(1), 13–22.

McPeake, K., Affenzeller, N., Mills, D., 2017. Noise sensitivities in dogs: A new licensed treatment option. Veterinary Record 180(14), 353–355.

Mills, D., Karagiannis, C., Zulch, H., 2014. Stress - Its effects on health and behavior: A guide for practitioners. Veterinary Clinics of North America. Small Animal Practice 44(3), 525–541.

Mills, D.S., Estelles, M.G., Coleshaw, P.H., Shorthouse, C., 2003. Retrospective analysis of the treatment of firework fears in dogs. Veterinary Record 153(18), 561–562.

Overall, K.L., Dunham, A.E., Juarbe-Diaz, S.V., 2016. Phenotypic determination of noise reactivity in 3 breeds of working dogs: A cautionary tale of age, breed, behavioral assessment, and genetics. Journal of Veterinary Behavior 16(16), 113–125.

Scheifele, L., Clark, J.C., Scheifele, P.M., 2012. Canine hearing loss management. The Veterinary Clinics of North America. Small Animal Practice 42(6), 1225–1239.

Scheifele, P.M., 2012. Animal audiology: Hearing testing for dogs and others. In: 66th Annual OSLHA Convention. Hilton Columbus, Columbus, OH, March, 8–10.

Sherman, B.L., Mills, D.S., 2008. Canine anxieties and phobias: An update on separation anxiety and noise aversions. Veterinary Clinics of North America. Small Animal Practice 38(5), 1081–1106.

Shipman, J., Wilson, J.D., Higgins, C.A., 2012. Waves and sound. In: Shipman, J., Wilson, J.D., Higgins, C.A. (Eds.), An introduction to physical science. Cengage learning, Boston, MA, 134–142.

Shull-Selcer, E.A., Stagg, W., 1991. Advances in the understanding and treatment of noise phobias. Veterinary Clinics of North America. Small Animal Practice 21(2), 353–367.

Siniscalchi, M., Quaranta, A., Rogers, L.J., 2008. Hemispheric specialization in dogs for 258 processing different acoustic stimuli. PLoS ONE 3(10), e3349.

Sreekumar, D., Ninan, J., 2016. Understanding dogs: a basic guide. Write & Print Publications, 119–120. ISBN 978-9384649289.

Stellato, A.C., Flint, H.E., Widowski, T.M., Serpell, J.A., Niel, L., 2017. Assessment of fear-related behaviours displayed by companion dogs (*Canis familiaris*) in response to social and non-social stimuli. Applied Animal Behaviour Science 188, 84–90.

Stellato, A.C., Hoffman, H., Gowland, S., Widowski, T.M., Dewey, C.E., Niel, L., 2019. Effect of high levels of background noise on dog responses to a routine. Applied Animal Behaviour Science 214, 64–71.

Stephen, J.M., Ledger, R.A., 2005. An audit of behavioral indicators of poor welfare in kenneled dogs in the United Kingdom. Journal of Applied Animal Welfare Science 8(2), 79–95.

Stitzel, S.E., Aernecke, M.J., Walt, D.R., 2011. Artificial noses. Annual Review of Biomedical Engineering 13(1), 1–25.

Storengen, L.M., Lingaas, F., 2015. Noise sensitivity in 17 dog breeds: prevalence, breed risk and correlation with fear in other situations. Applied Animal Behaviour Science 171, 152–160.

Strain, G.M., 2011. Deafness in dogs and cats. CAB International, Cambridge, 160. ISBN 9781845939373.

Teixeira, R.R., Diaz, M.M., Santos, T.V., Bernardes, J.T., Peixoto, L.G., Bocanegra, O.L., 2015. Chronic stress induces a hyporeactivity of the autonomic nervous system in response to acute mental stressor and impairs cognitive performance in business executives. PLoS ONE 10(3), e0119025.

Wells, D.L., 2009. Sensory stimulation as environmental enrichment for captive animals. Applied Animal Behavior Science 118(1–2), 1–11.

Wormald, D., Lawrence, A.J., Carter, G., Fisher, A.D., 2016. Validation of modified open field behaviour as a measure of trait anxiety in the dog. Applied Animal Behavior Science 179, 95–102.

Yamasaki, A., Booker, A., Kapur, V., Tilt, A., Niess, H., Lillemoe, K.D., Warshaw, A.L., Conrad, C., 2012. The impact of music on metabolism. Nutrition 28(11–12), 1075–1080.