# Bridging the Gap Between Scientific Knowledge and Owner Perception of Canine Cognitive Dysfunction Syndrome

Sofia Gigante[1]; Filipa Cabecinhas[1]; Manuela Lourenço[1]; Carolina Silva[1,2].

*1 Escola Superior de Biociências de Elvas, Instituto Politécnico de Portalegre, Portugal*

*2 VALORIZA- Research Centre of Endogenous Resource Valorization, Portugal.*

**Email: sofiagigante@gmail.com*

## Summary

Canine Cognitive Dysfunction Syndrome (CCDS) is a progressive neurodegenerative disorder associated with aging, sharing clinical and pathological similarities with Alzheimer's disease in humans. Despite its increasing prevalence, CCDS remains significantly underdiagnosed, largely due to limited awareness among dog owners and challenges in early detection. This study aimed to assess the prevalence of CCDS and evaluate owner awareness in the Alentejo region of Portugal, as well as to identify associated risk factors. A cross-sectional observational study was conducted using structured questionnaires administered to owners of dogs aged eight years or older (n = 86). Results revealed that only 9.3% of dogs had a prior diagnosis, whereas 58% exhibited clinical signs consistent with cognitive impairment, indicating substantial underdiagnosis, in agreement with previous findings (Salvin et al., 2010). Additionally, a significant proportion of owners lacked awareness of CCDS. These findings highlight a critical gap between scientific knowledge and owner perception, emphasizing the need for educational strategies and early screening protocols.

Keywords: canine cognitive dysfunction syndrome; geriatric veterinary medicine; owner perception; cognitive impairment; early screening.

## Resumo

Síndrome de Disfunção Cognitiva Canina (SDCC) é uma doença neurodegenerativa progressiva associada ao envelhecimento, que partilha semelhanças clínicas e patológicas com a doença de Alzheimer em humanos. Apesar da sua prevalência crescente, a SDCC continua a ser significativamente subdiagnosticada, em grande parte devido ao reduzido conhecimento dos tutores de cães sobre a doença e às dificuldades na sua deteção precoce. O presente estudo teve como objetivo avaliar a prevalência da SDCC e o nível de conhecimento dos tutores na região do Alentejo, Portugal, bem como identificar fatores de risco associados. Foi realizado um estudo observacional transversal, recorrendo à aplicação de questionários estruturados a tutores de cães com idade igual ou superior a oito anos (n = 86). Os resultados revelaram que apenas 9,3% dos cães tinham um diagnóstico prévio, enquanto 58% apresentavam sinais clínicos compatíveis com défice cognitivo, indicando um subdiagnóstico substancial, em concordância com estudos anteriores (Salvin et al., 2010). Verificou-se ainda que uma proporção significativa dos tutores desconhecia a existência da SDCC. Estes resultados evidenciam uma importante discrepância entre o conhecimento científico disponível e a perceção dos tutores, reforçando a necessidade de implementar estratégias de sensibilização e protocolos de rastreio precoce.

Palavras-chave: síndrome de disfunção cognitiva canina; cães geriátricos; medicina veterinária geriátrica; rastreio precoce; bem-estar animal.

## Introduction

Advances in veterinary medicine, nutrition, and preventive care have significantly increased the lifespan of companion animals, leading to a growing population of geriatric dogs and, consequently, a higher prevalence of age-related diseases (Landsberg et al., 2012; Mazzola & Fatjó, 2018). Among these, Canine Cognitive Dysfunction Syndrome (CCDS) has emerged as a major concern in veterinary geriatrics due to its progressive nature and impact on animal welfare.

CCDS is a neurodegenerative disorder characterized by cognitive decline and behavioral alterations, with strong similarities to Alzheimer's disease in humans, both clinically and pathophysiologically (Dewey et al., 2019; Prpar Mihevc & Majdič, 2019). Neuropathological features include β-amyloid plaque deposition, oxidative stress, mitochondrial dysfunction, and neuronal loss (Head, 2008; Borràs et al., 2021). These alterations are associated with deficits in learning, memory,

and executive function, which progressively impair the animal's daily functioning.

Behaviorally, CCDS manifests through a cluster of signs commonly summarized by the acronym DISHA (Disorientation, Interaction changes, Sleep-wake disturbances, House-soiling, and Activity alterations) (Landsberg et al., 2012). These signs often develop gradually, making early detection challenging. Furthermore, studies have shown that subtle cognitive decline may begin years before clinical recognition, suggesting that CCDS is frequently identified at advanced stages (Madari et al., 2015; Szabó et al., 2016).

Epidemiological data indicate that the prevalence of CCDS increases markedly with age, affecting a significant proportion of dogs over eight years old (Salvin et al., 2010; Chapagain et al., 2018). However, prevalence estimates vary widely due to differences in diagnostic criteria and assessment tools. Importantly, several studies highlight that a large percentage of affected dogs remain undiagnosed, primarily due to under-recognition by owners and insufficient screening in clinical practice (Salvin et al., 2010).

The role of owners in the detection of CCDS is critical. Since behavioral changes are often first noticed in the home environment, owner perception directly influences the likelihood of seeking veterinary care. However, research indicates that many owners interpret cognitive changes as normal aging, leading to delays in diagnosis and intervention (Fast et al., 2013; Mazzola & Fatjó, 2018). This misinterpretation represents a major barrier to early detection and management.

In addition to age, several risk and protective factors have been identified. Environmental enrichment, regular physical activity, and social interaction have been associated with better cognitive outcomes (Mongillo et al., 2013; Chapagain et al., 2018). Nutritional interventions, particularly diets enriched with antioxidants and medium-chain triglycerides, have demonstrated neuroprotective effects and may slow cognitive decline (Pan et al., 2011; Studzinski et al., 2005).

At the neurobiological level, experimental studies in aging dogs have provided valuable insights into cognitive decline mechanisms. Longitudinal research has shown progressive impairments in learning and memory tasks, reinforcing the validity of dogs as a model for human neurodegenerative diseases (Milgram et al., 2005; Siwak et al., 2001; Tapp et al., 2004).

More recently, advances in diagnostic approaches, including neuroimaging and electrophysiological biomarkers, have opened new possibilities for early detection. Techniques such as electroencephalography (EEG) have shown potential in identifying functional brain changes associated with CCDS (Barnes Heller et al., 2022). However, these methods are not yet widely accessible in routine veterinary practice.

Despite growing scientific knowledge, a significant gap remains between research findings and their application in clinical settings. In particular, the discrepancy between owner perception and clinical reality continues to contribute to underdiagnosis and suboptimal management of CCDS.

Therefore, this study aims to evaluate both the prevalence of CCDS and the level of awareness among dog owners, contributing to a better understanding of this gap and supporting the development of more effective diagnostic and educational strategies.

# Material and Methods

A cross-sectional observational study was conducted. The study included 86 dogs aged ≥8 years, recruited from a veterinary clinical setting in Évora, Portugal. Data were collected through structured questionnaires administered to dog owners. Data were collected using a structured questionnaire divided into five sections and designed to obtain detailed information on factors potentially associated with Canine Cognitive Dysfunction Syndrome (CCDS). Section I recorded general animal information, including demographic and signalment data. Subjects were divided into five age groups: 8–10 years, 11–12 years, 13–14 years, 15–16 years, and >16 years. Section II collected information on concurrent medical conditions and the animal's clinical history, including previous diagnosis or suspicion of CCDS. Section III assessed diet type and feeding habits. Section IV evaluated the dog's level of physical activity and social interaction. Section V investigated behavioural changes associated with CCDS, using six ordinal frequency scales to quantify the occurrence of clinical signs commonly associated with cognitive dysfunction. Behavioral changes were evaluated using criteria aligned with validated tools such as the Canine Cognitive Dysfunction Rating Scale (Madari et al., 2015). Behavioural frequency was assessed by owners using a 4-point scale (0 = never, 1 = once per month, 2 = once per week, 3 = daily). Total scores were obtained by summing individual items and multiplying the result by two to generate the final CCDS score. Dogs were then classified as normal ageing (0–7), mild cognitive impairment (8–40), or severe cognitive impairment (41–69).

The scoring system was based on previously established associations between behavioural alterations and neuropathological changes observed in geriatric dogs, supporting its clinical relevance.

Statistical analyses were performed using Jamovi software (version 2.7). Descriptive statistics were used to analyze the data and normality was assessed using the Shapiro–Wilk test. As the assumption of normality was violated, a one-way Welch ANOVA was applied to compare differences between groups, followed by post-hoc Tukey tests for pairwise comparisons.

# Results

A total of 86 questionnaires were collected from owners of dogs aged eight years or older. The sample was predominantly composed of dogs between eight and ten years of age (43%), followed by those aged 11 to 12 years (27%), with progressively fewer individuals represented in older age groups. Males accounted for 55% of the sample, and 57% of the dogs were sterilized.

A clear discrepancy emerged between clinical diagnosis and questionnaire-based assessment of CCDS. Only 9.3% of dogs (8 individuals) had received a formal clinical diagnosis, whereas behavioral scoring indicated that 46.5% of the animals presented mild CCDS and 11.6% severe CCDS (Figure 1.). Overall, approximately 58.1% of the dogs exhibited some degree of cognitive impairment. In addition,

| Evaluated CCDS | Count | % Total | % Accumulated |
|---|---|---|---|
| Light | 40.0 | 46.5% | 46.5% |
| Severe | 10.0 | 11.6% | 58.1% |
| Natural ageing | 36.0 | 41.9% | 100.0% |

**Figure 1.** Distribution of individuals with CCDS diagnose

Analysis of potential risk factors revealed a higher presence of CCDS in small and medium-sized dogs, while no severe cases were identified among large or giant breeds (Figure 2). All clinically diagnosed cases occurred in sterilized animals, although cognitive impairment surged similarly in both reproductive status.

| Evaluated CCDS | Weight | Count | % Total |
|---|---|---|---|
| Light | small | 17.00 | 19.8% |
| | medium | 12.00 | 14.0% |
| | large | 9.00 | 10.5% |
| | giant | 2.00 | 2.3% |
| Severe | small | 4.00 | 4.7% |
| | medium | 6.00 | 7.0% |
| | large | 0.00 | 0.0% |
| | giant | 0.00 | 0.0% |
| Natural ageing | small | 10.00 | 11.6% |
| | medium | 12.00 | 14.0% |
| | large | 12.00 | 14.0% |
| | giant | 2.00 | 2.3% |

**Figure 2.** CCDS diagnose across different body size categories

The distribution of CCDS categories was similar between sexes. Mild cognitive impairment was the most frequent category in females (25.9% of the total sample), whereas physiological ageing was more commonly observed in males (28.2%). Severe CCDS was uncommon and occurred at the same frequency in both sexes (5.9% each) (figure 3).

Dietary patterns showed that dogs receiving senior-specific diets had higher proportions of mild and severe CCDS, a finding that likely reflects dietary adjustments following the onset of clinical signs rather than a causal relationship. Although physical activity and environmental enrichment were considered potentially relevant, no conclusive associations were established. Furthermore, no consistent relationship between breed and CCDS was identified.

| Evaluated CCDS | Sex | Count | % Total |
|---|---|---|---|
| Mild | F | 22.00 | 25.9% |
| | M | 17.00 | 20.0% |
| Severe | F | 5.00 | 5.9% |
| | M | 5.00 | 5.9% |
| Natural ageing | F | 12.00 | 14.1% |
| | M | 24.00 | 28.2% |

**Figure 3.** Distribution of dogs across CCDS categories by sex, including frequencies and percentages.

Behavioral alterations were commonly reported by owners, with reduced activity being the most prevalent sign, followed by disorientation, anxiety, learning and memory deficits, changes in social interaction, and sleep disturbances. These findings suggest that decreased activity and spatial disorientation are the most noticeable manifestations of cognitive decline in this population.

The assumption of normality was assessed using the Shapiro–Wilk test, which indicated that the data were not normally distributed. Therefore, a one-way Welch ANOVA was conducted to compare differences between groups (different ages and body size categories).

The analysis of differences between age groups revealed a statistically significant effect of group on the CCDS score ($F(4, 23.7) = 9.75$, $p < 0.001$). Post-hoc comparisons using Tukey's test showed a significant difference between group 1 (aged from 8 to 10 years old) and group 3 (aged from 13 to 15 years old) ($p < 0.05$), following the same tendency when comparing group 1 with group 4 (aged from 15 to 16 years old), while no other pairwise comparisons reached statistical significance. The analysis of differences in SDCC scores among body size categories (small, medium, large, and giant breeds) showed no statistically significant effect of body size on CCDS scores, as determined by a one-way Welch ANOVA ($F(3, 13.5) = 0.809$, $p = 0.511$). Post-hoc Tukey tests revealed no significant

pairwise differences between any of the body size groups (all $p > 0.05$).

# Discussion

The present study underscores the increasing importance of CCDS in veterinary medicine, particularly in the context of extended canine lifespan resulting from advances in veterinary care and improved owner awareness (Neilson et al., 2001; Rofina et al., 2006; Salvin et al., 2010). The most notable finding is the marked discrepancy between the low rate of clinical diagnosis and the substantially higher prevalence suggested by behavioral assessment. The fact that only 9.3% of dogs had a former clinical diagnosis, despite 58.1% showed signs of cognitive impairment, strongly supports previous reports that CCDS is widely underdiagnosed (Salvin et al., 2010). This underdiagnosis is likely multifactorial. One key factor is the tendency for owners to interpret behavioral changes as a normal consequence of aging rather than as indicators of pathology (Chapagain et al., 2018). The considerable proportion of respondents unfamiliar with CCDS further reinforces the role of limited awareness in delaying or preventing diagnosis. Additionally, the reliance on subjective behavioral assessments contributes to diagnostic inconsistency. These findings highlight the need to incorporate routine cognitive screening into geriatric veterinary evaluations, as previously recommended (Landsberg et al., 2012).

The study also illustrates the inherent challenges associated with CCDS diagnosis. Currently, diagnosis is largely presumptive, based on clinical signs and the exclusion of other medical conditions (Chapagain et al., 2018; Landsberg et al., 2012). Although advanced diagnostic tools such as neuroimaging and biomarker analysis show promise, their use in clinical practice remains limited due to cost, accessibility, and procedural constraints, including the need for anesthesia (González-Martínez et al., 2011; MacQuiddy et al., 2022).

Regarding risk factors, the higher prevalence observed in smaller dogs may be related to their longer lifespan, which increases the likelihood of developing age-related neurodegenerative conditions (Azkona et al., 2009; Neilson et al., 2001). However, conflicting evidence in the literature suggests that this relationship is not yet fully understood (Katina et al., 2016). Indeed, in the present study, no significant differences in SDCC scores were found among the different body size categories, indicating that body size was not significantly associated with cognitive dysfunction in the studied population. The relatively small sample size within some body size categories may have limited the ability to detect subtle differences, highlighting the need for studies involving larger populations.

The observed lack of significant differences in SDCC scores between sterilized and non-sterilized animals in the present study does not support a strong association between reproductive status and cognitive dysfunction, although a hormonal influence has been previously suggested (Hart, 2001). This finding should be interpreted with caution and further investigated in larger studies.

Dietary patterns indicated higher proportions of mild and severe CCDS in dogs receiving senior-specific diets; however, no statistically significant association was found between diet type and CCDS severity, suggesting that this distribution may reflect dietary adaptation associated with ageing and the potential onset of clinical signs rather than a causal relationship. Existing evidence supports the neuroprotective effects of diets enriched with antioxidants and other functional components (Katina et al., 2016), which may help delay or mitigate the progression of CCDS, suggesting that owners may be acting accordingly when selecting these diets. .

The behavioral patterns identified in this study differ somewhat from previous reports. While reduced activity and disorientation were the most prominent signs in this population, other studies have emphasized changes in social interaction and memory deficits (Azkona et al., 2009). This discrepancy may reflect differences in caregiver perception, as well as the inherent difficulty in recognizing subtle cognitive impairments such as memory decline (Landsberg et al., 2012).

Overall, the findings emphasize the importance of early detection and intervention in CCDS. Improving caregiver education, implementing standardized screening protocols, and strengthening the role of veterinary professionals in geriatric care are essential steps to enhance diagnosis and management. Early identification of cognitive decline may allow for interventions that slow disease progression and improve the quality of life of affected animals (Landsberg et al., 2012).

# Conclusion

CCDS is a significant and increasingly recognized condition in aging dog populations, with important implications for animal welfare and veterinary practice. The present study identified a discrepancy between behavioral signs consistent with cognitive impairment and formal clinical recognition, suggesting potential underdiagnosis, likely influenced by limited owner awareness and delayed identification of early signs.

Although nutritional, lifestyle, and biological factors are commonly proposed as modulators of cognitive health, no significant associations were found between CCDS severity and diet type, body size, or reproductive status. Nevertheless, dogs receiving senior-specific diets showed higher proportions of mild and severe CCDS, likely reflecting dietary adaptation following ageing and clinical progression rather than a causal relationship.

From a clinical perspective, early detection remains essential, and routine cognitive screening in geriatric consultations, together with improved owner education, may support earlier intervention. The limited sample size in some subgroups may

have reduced statistical power, highlighting the need for larger and more balanced studies to improve the robustness and generalizability of future findings.

Overall, improving CCDS recognition in clinical practice requires continued efforts to bridge the gap between scientific evidence and owner perception, alongside the development of standardized diagnostic approaches and preventive geriatric care strategies.

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