Universidade de Évora - Escola de Ciências e Tecnologia

Mestrado Integrado em Medicina Veterinária

Dissertação

Clinical presentation of feather damaging behaviour in lovebirds (Agapornis spp.)

Filipa Sofia Badagola Vermelho

Orientador(es) | Luís Miguel Lourenço Martins
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A dissertação foi objeto de apreciação e discussão pública pelo seguinte júri nomeado pelo Diretor da Escola de Ciências e Tecnologia:

Presidente	Ricardo Jorge Romão (Universidade de Évora)
Vogais	Luís Miguel Lourenço Martins (Universidade de Évora) (Orientador) Pedro Miguel Canavilhas de Melo (Centro de Recuperação de Animais Selvagens do Núcleo da Quercus de Santo André) (Arguente)

Évora 2024

To my grandma Generosa,

for making my dreams come true.

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Writing the acknowledgments for my own thesis comes with a bittersweet feeling. It is a mixture of pride for how far I've come, apprehension for the future, and excitement for both.

First and foremost, I would like to express my gratitude to my supervisors, Dr. Joana Ferreira and Prof. Dr. Luís Martins, for making this dissertation possible and for being my biggest inspiration in life. Prof. Dr. Luís Martins, I now venture into the world, striving to emulate the joyful, compassionate, and conscientious personality that you introduced me to, because I believe everyone deserves the presence of an uplifting person like you in their lives, especially the animals. Dr. Joana, I cannot even put in words the way you contributed to my personal and professional development. Following you restored my passion for veterinary medicine, taught me discipline, and gave me confidence in failing, as it is an excellent opportunity for learning. For you, I am thankful.

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Last but not least, Ziva and Igor, thank you for coming this far with me.

"Ever tried, ever failed, no matter. Try again, fail again, fail better."

-Samuel Beckett

ABSTRACT

Feather damaging behaviour (FDB) is a prevalent condition among pet parrots, particularly lovebirds (*Agapornis* spp). This retrospective study involved 119 lovebirds that first presented with FDB to an exotic animal veterinary centre and aimed to better understand the factors associated to its onset. Sexual maturity, a seed-based diet, and inappropriate settings in the parrot's household seemed to be related to the manifestation of the condition. Seasonality was evident (p=0.004), particularly in the summer. Respiratory and nonspecific signs were present in 41.2% and 26.1% of the patients, respectively. FDB in the neck, chest, inner wings, and axillary regions was prevalent, as well as self-mutilation. A statistically relevant association was found between FDB in the cloaca area and dystocia (p=0.047). This study effectively identified potential underlying causes associated with the development of FDB in lovebirds. Nonetheless, comprehensive clinical investigations and further studies are essential to improve the management of this behavioural disorder.

Keywords: Feather damaging behaviour; lovebirds; agapornis spp.; clinical presentation; causes

RESUMO

APRESENTAÇÃO CLÍNICA DO PICACISMO EM *AGAPORNIS* SPP.

O picacismo afeta frequentemente psitacídeos em cativeiro, particularmente *Agapornis* spp. Este estudo retrospetivo incluiu 119 agapornis que apresentaram picacismo pela primeira vez, visando compreender os fatores associados à sua ocorrência. Foi possível relacionar a maturidade sexual, uma dieta à base de sementes e a presença condições de maneio inadequadas à manifestação deste comportamento. Verificou-se a existência de sazonalidade (p=0,004) à condição, particularmente no verão. Sinais respiratórios e inespecíficos foram observados em 41,2% e 26,1% dos casos, respetivamente. As principais regiões afetadas incluíram o pescoço, o peito, a face interna das asas e as axilas, sendo a automutilação igualmente prevalente. A associação encontrada entre picacismo na zona da cloaca e presença de distócia foi considerada estatisticamente relevante (p=0,047). Este estudo permitiu identificar as causas subjacentes à apresentação clínica do picacismo em *Agapornis* spp., no entanto são necessários estudos adicionais e uma análise clínica detalhada, para uma gestão eficaz deste problema comportamental.

Palavras-chave: Picacismo; comportamento; agapornis spp.; apresentação clínica; causas

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LIST OF ABBREVIATIONS

ALB – Albumin

APV – Avian polyomavirus

AST – Aspartate aminotransferase

BA – Bile acids

Ca – Calcium

CBC – Complete blood count

CK – Creatine kinase

CUD – Chronic ulcerative dermatitis

CVEP – Centro Veterinário de Exóticos do Porto

FDB – Feather damaging behaviour

GI – Gastrointestinal

Glu – Glucose

GnRH – Gonadotropin-releasing hormone

K – Potassium

Na – Sodium

P – Phosphorus

PaBV – Parrot bornavirus

PBFD – Psittacine beak and feather disease

PBFDV – Psittacine beak and feather disease virus

PCR – Polymerase chain reaction

PCV – Packed cell volume

TP – Total protein

UA – Uric acid

WBC – White blood cell

PREFACE

The present dissertation represents the author's final project for the veterinary medicine integrated master's degree at the University of Evora, marking its completion. This study was conducted based on data collected during the five-month curricular internship at the Centro Veterinário de Exóticos do Porto (CVEP) in Portugal, which took place from October 3rd, 2022, to February 28th, 2023. During the internship and seeing the author's interest in avian species, CVEP's clinical director, Dr. Joel Ferraz, proposed an investigation into why lovebirds with feather picking frequently presented respiratory signs. In a preliminary search, no conclusive answers were found, as the underlying causes of feather damaging behaviour remained largely unknown. At the time, the author was attempting to study the therapeutic efficacy of respiratory infections in pet birds. However, as results began to emerge, it was revealed that most of the lovebirds admitted for respiratory infection to the centre over a five-year period, additionally displayed feather picking. This further instigated the author's curiosity, previously cultivated by Dr. Joel, redirecting the focus of this dissertation.

In consultation with the dedicated Dr. Joana Ferreira, and in consideration of the profound interest in dermatology of Prof. Dr. Luís Martins, a new topic was proposed - to study the clinical presentation of feather damaging behaviour in lovebirds (*Agapornis* spp.).

1. INTRODUCTION

Feather damaging behaviour (FDB), also known as feather destructive behaviour, feather picking, feather plucking, or pterotillomania, is estimated to affect 13% to 17.5% of captive psittacines and can be a challenging condition to manage (Gaskins & Bergman, 2011; Kinkaid et al., 2013a; Costa et al., 2016a). Costa et al. (2016a), found the prevalence of FDB in lovebirds (*Agapornis* spp.) to be as high as 26.3%, and more recently, Ebisawa et al. (2021) placed it approximately at 23.7%.

Affected birds use their beak to pluck, chew, fray, or bite the reachable plumage, resulting in damage or loss of coverage mainly in the areas of the neck, chest, inner thighs, flanks, and wings (Van Zeeland, 2016; Langlois, 2021). Feathers submitted to this erroneous conduct will often appear irregular, with missing barbs from the shaft, and V-shaped wedges (Figure 1 and 2). When lesions occur to the skin or muscle, the condition is then called “self-mutilation” (Van Zeeland et al., 2016). While injury is usually self-inflicted, when areas like the head and face are involved, assault by cage mates or other illnesses should be suspected (Lightfoot & Nacewicz, 2006).

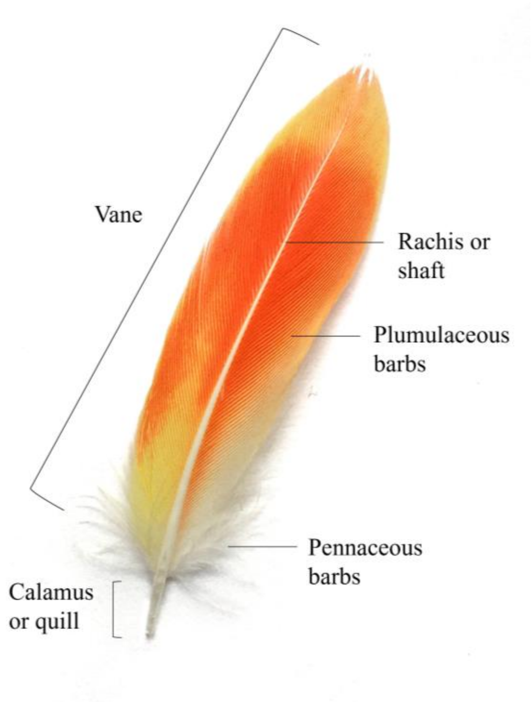


FIGURE 1 Anatomy of the feather (author’s original).

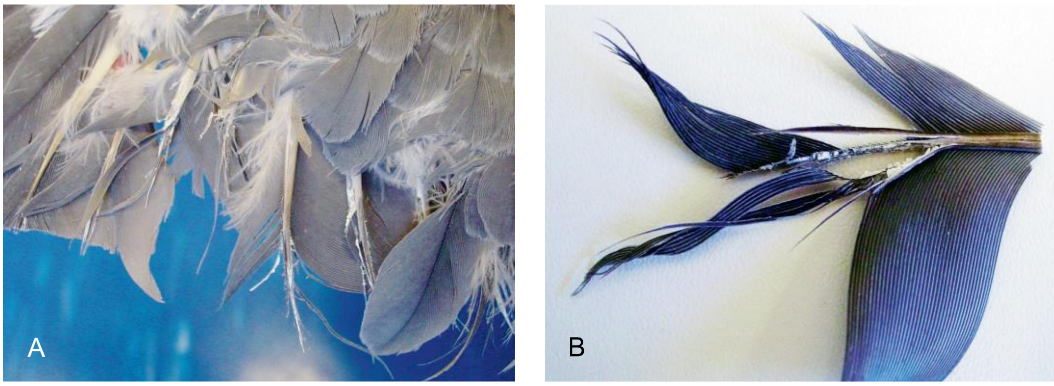


FIGURE 2 (A) and **(B)** Feathers displaying the characteristic irregular appearance, with some barbs missing and others oriented longitudinally along the shaft, as a result of FDB (adapted from Van Zeeland et al., 2016).

Feather destructive behaviour has been associated with a variety of genetic, psychological, neurobiological, socioenvironmental, and medical factors. However, a reliable causal relationship is yet to be identified (Van Zeeland et al., 2009, 2016). It is advisable to rule out any medical conditions before attributing the problem to environmental and/or psychogenic issues (Chitty, 2003a; Rubinstein & Lightfoot, 2012). Each case requires a thorough investigation, including a comprehensive review of history, a detailed physical examination and further diagnostic testing. The aim of the treatment should consist in providing assistance to the patient both physically and mentally (Seibert, 2006; Langlois, 2021).

Three main behavioural pathways were proposed associated with feather-picking: i) a *maladaptive behaviour,* where the animal tries to adapt to its dysfunctional surroundings (Mills, 2003); ii) a *malfunctioning behaviour* due to altered brain development and neurochemistry (Garner, 2005, 2006); and iii) an abnormal behaviour arising from primary physical problems (Seibert, 2006). Distinguishing between these might be a key-component for the successful treatment of FDB (Van Zeeland, 2016).

1.1. SOCIOENVIRONMENTAL FACTORS

Stress indicators have long been associated with FDB, in which potential stress sources include disturbances of routine, inadequate husbandry conditions, and ultimately, the inhibition to develop species-specific behaviour (Owen & Lane, 2006; Ferreira et al., 2015; Costa et al., 2016b; Ebisawa et al., 2022). The inability to forage displayed a direct relation to FDB (Meehan et al., 2003). Parrots revealed the need for stimulation and environmental enrichment, has they would rather scavenge and engage in time consuming activities to attain food, instead of going for readily available food sources (*contrafreeloading* behaviour) (Joseph, 2010; Van Zeeland et al., 2010, cited in Van Zeeland, 2016). Acharya and Rault (2020) remarks that "The fact that feather-damaging behaviour is unique to companion parrots, and not seen in wild parrots, highlights the shortfall of common captive environments to fulfil the parrots' needs."

Feather picking is thus thought to occur as a coping mechanism for negative states (e.g., 'stress', 'boredom', 'frustration'), where the bird uses preening as an attempt to comfort himself and, decrease arousal and tediousness. In this light, FDB can be considered a *maladaptive behaviour* (Mills, 2003; Garner et al., 2006; Van Zeeland et al., 2009, 2016).

1.1.1. POOR HUSBANDRY

Deleterious conditions in the household comprehend the exposure to unnatural light-cycles (due to artificial lighting and dependence on human schedules), malnutrition (commonly used seed-based diets), sleep deprivation (birds living in busy areas of the house might maintain their alert state throughout the night and be unable to sleep), small cages (besides stress, can also lead to trauma, pain and feather damage; see Figure 3), overcrowding, lack of recreational items, infrequent bathing, lack of exercise, and lack of routine (Chitty, 2003b; Seibert, 2006; Gaskins & Hungerford, 2014; Kubiak, 2015). The air quality and humidity, and the presence of airborne (e.g., cigarette smoke, scented candles, perfume, air fresheners, hair spray) or topical (e.g., hand lotion and creams) toxins/chemicals are also believed to influence the health of the feather coat (Koski, 2002; Chitty, 2005; Van Zeeland et al., 2009).

Furthermore, inappropriate husbandry interferes with and dysregulates the bird's otherwise normal reproductive cycle. These particularly include a diet too high in fat, increased daylength, easy access nesting sites and materials or the lack of them, inadvertent sexual stimulation by the owner through mouth feeding or caressing of the parrot's body, and toys or mirrors that can be sensed as potential mates and increase reproductive displays (e.g. regurgitation and masturbation) (Gill, 2001; Chitty, 2003b; Seibert, 2006; Langlois, 2021). Altered photoperiods can additionally dysregulate sleeping and moulting cycles, which can lead to exhaustion of the parrot (Koski, 2002; Seibert, 2006). Further consequences of malnutrition will be discussed in more detail in the next chapter (medical factors).

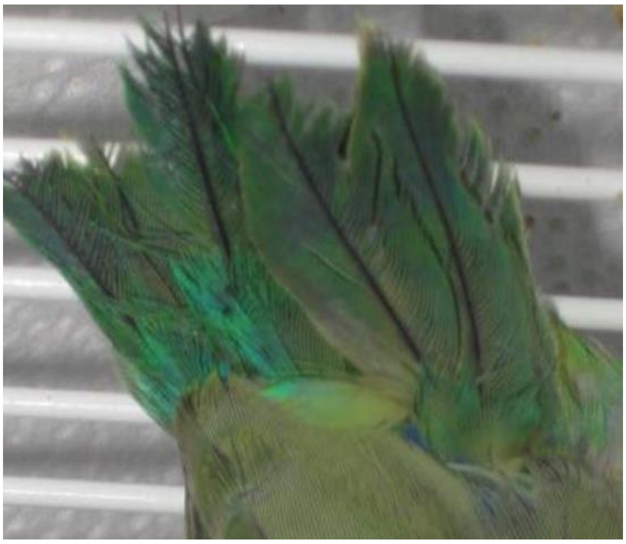


FIGURE 3 Deterioration of tail feathers as a result of friction against bars of a small-sized cage (Rubinstein & Lightfoot, 2012).

1.1.2. AVERSIVE STIMULI

Where the absence of entertainment can be detrimental, the addition of aversive interactions (with other animals or humans), and abrupt modifications to the surroundings (like climate, housing, ambience, and companion changes) can also compromise the welfare of the animal (Seibert, 2006; Davenport et al., 2008; Costa et al., 2016a). In fact, in one study, up to two-thirds of owners reported an altering or troubling setting at the beginning of feather picking (Jayson et al., 2014). In another, a simple male/female ratio change in the group structure of golden conures (*Guaruba guarouba*) reflected on lower levels of stress and FDB (Dislich et al., 2017). Gaskins and Hungerford (2014) hypothesised that the process of being rescued or rehomed, could also put the parrot at risk of developing separation anxiety, and therefore FDB.

1.2. MEDICAL FACTORS

Any disease that causes pain, discomfort, irritation and/or pruritus can trigger the onset of FDB. The feather damage might be exhibited either directly above the area of distress or distributed in a generalised, diffuse manner (Seibert, 2006; Van Zeeland et al., 2009; Rubinstein & Lightfoot, 2012). An up-to-date summary of the different regions associated to the various conditions is presented in Table 1.

TABLE 1 Conditions associated to the different regions of FDB display.

Region	Condition
Neck	▪ Chronic ulcerative dermatitis (CUD) usually affects the patagium, neck, back and axillary regions of lovebirds (Lightfoot & Schmidt, 2006). ▪ Polyfolliculitis lesions are usually showcased on the rump, flank, and neck (Koski, 2002; Reavill, 2003).
Back	▪ CUD usually affects the patagium, neck, back and axillary regions of lovebirds (Lightfoot & Schmidt, 2006). ▪ One cockatoo (*Cacatua galerita galerita*) with pancreatitis displayed FDB over the back and dorsal wings (Doneley, 2001). ▪ Polyomavirus can affect the down feathers of the back and the abdomen (Gill, 2001).
Rump	▪ FDB over the synsacrum can be a sign of renal disease (Burgos-Rodríguez, 2010; Pollock, 2006). ▪ Polyfolliculitis lesions are usually showcased on the rump, flank, and neck (Koski, 2002; Reavill, 2003).
Wings and axillaries	▪ CUD usually affects the patagium, neck, back and axillary regions of lovebirds (Lightfoot & Schmidt, 2006). ▪ One cockatoo with pancreatitis displayed FDB over the back and dorsal wings (Doneley, 2001). ▪ Some birds with giardiasis display intense pruritus in the axillary region (Reavill, 2003).
Chest	▪ FDB involving the breast, abdomen, and legs has been related to the breeding season. Sometimes this presentation can also be associated with ventral abdominal hernia (Bowles, 2003; Langlois, 2021). ▪ Septic alopecia is often exhibited over the chest (Chitty, 2005). ▪ Langlois (2021), noted one case of iatrogenic feather picking over the pectoral area following microchip administration.
Abdomen and flank	▪ Hepatic disease can result in FDB over the ventrum or in a diffuse, generalised manner (Grunkemeyer, 2010; Van Zeeland & Schoemaker, 2014a). ▪ FDB involving the breast, abdomen, and legs has been related to the breeding season. Sometimes this presentation can also be associated with ventral abdominal hernia (Bowles, 2003; Langlois, 2021). ▪ Polyfolliculitis lesions are usually showcased on the rump, flank, and neck (Koski, 2002; Reavill, 2003). ▪ Polyomavirus can affect the down feathers of the back and the abdomen (Gill, 2001).

TABLE 1 (Continued).

Region	Condition
Legs and Feet	▪ FDB involving the breast, abdomen, and legs has been related to the breeding season. Sometimes this presentation can also be associated with ventral abdominal hernia (Bowles, 2003; Langlois, 2021). ▪ Contact dermatitis may be considered when lesions are confined to the legs and feet (Lightfoot & Schmidt, 2006).
Generalised	▪ Hepatic disease can result in FDB over the ventrum or in a diffuse, generalised manner (Grunkemeyer, 2010; Van Zeeland & Schoemaker, 2014a). ▪ Weller and Phalen (2012), reported the presence of FDB over the site of *Aspegillus* spp. granulomas.

1.2.1. NON-INFECTIOUS DISEASES

1.2.1.1. Hepatic, Renal, and Pancreatic

Liver disease, recognised for inducing pigmentary changes and darkening of feathers, has additionally been linked to FDB (Davies, 2000; Grunkemeyer, 2010). Pruritis may be the key element of this process, assumption made based on evidence found on humans with chronic cholestatic disorders (Orosz, 2006; Elferink et al., 2011; Kremer et al., 2015). However, whether analogous processes occur in birds remains elusive (Langlois, 2021).

Connections between feather plucking and renal and pancreatic disease have also been made. FDB is described as a signalment of pain in renal disease (Pollock, 2006; Burgos-Rodríguez, 2010). In Doneley (2001), a case of FDB remitted after the diagnosis and treatment of pancreatitis.

1.2.1.2. Reproductive

Reproductive tracts disorders (e.g., dystocia) and hormonal imbalances can contribute to the manifestation of FDB (Chitty, 2003b). The emergence of feather picking at the onset of sexual maturity suggests a hormonal control of the condition, as it is found on other animals that suffer from similar disorders (Van Zeeland et al., 2009). Prevalence of FDB was shown to increase continuously until the bird reaches adolescence, plateauing in adulthood (Kinkaid et al., 2013b; Ebisawa et al., 2021). Likewise, the seasonal recurrence of FDB further suggests a hormonal implication, and Chitty (2003b) proposes an increase in reproductive hormones related to the mating season as a contributing factor. Some birds instinctively remove feathers from the abdominal area to be in direct contact with the eggs during the breeding season. Nonetheless, if this ‘brood patch’ behaviour continues past the appropriate period, it can be considered abnormal feather plucking (Seibert, 2006; Van Zeeland and Schoemaker, 2016b).

1.2.1.3. Traumatic

FDB may appear on account of painful conditions, hence its association with trauma related events like chronic fractures, joint dislocation, and soft tissue damage (Langlois, 2021). Frequently observed lesions involve iatrogenic and husbandry causes. Obesity and poor wing feather trims can cause the bird to experience difficulties landing, leaving it susceptible to accidental lacerations (Reavill, 2003). Feather picking developed in a parrot following a microchip administration and the behaviour ceased once the device was removed (Langlois, 2021). Constant rubbing and irritation of the feather follicle (e.g., the effect of small cages) can lead to abnormal feather regrowth and cyst formation, causing uneasiness and potentially FDB (Van Zeeland & Schoemaker, 2016a). Birds usually display FDB at the site of injury, accompanied by secondary infection (Reavill, 2003).

1.2.1.4. Toxic

Heavy metal toxicosis (particularly zinc and lead) have been proposed, but no concrete evidence has been found (Jenkins, 2001; Koski, 2002). One author has seen results to chelation therapy in parrots with FDB and warns that, in addition to acute toxicosis, chronic ingestion of small quantities of heavy metals over time can also pose a threat; however more studies need to be conducted (Gill, 2001).

1.2.1.5. Nutritional

Dietary imbalances can affect the moulting process, resulting in feather abnormalities, and overall impact the health of the skin (Rubinstein & Lightfoot, 2012). Generalised changes in pigmentation, brightness, and structure of feathers can be caused by malnutrition (Figure 4) (Gill, 2001; Koski, 2002). Depigmented, dull, brittle, and ragged feathers, as well as thick and scaly skin, may portray the signs of nutritional disease (Lightfoot & Schmidt, 2006; McDonald, 2006; Van Zeeland & Schoemaker, 2014a). New feather formation augments protein demand by 4-8%, particularly on the methionine, cysteine, and lysine amino acids. A lack of these is therefore expected to affect the plumage condition (Stanford, 2005). Deficiencies in methionine and other sulphur-containing amino acids have been seen causing stress bars and abnormalities in the vane, rachis, and sheath (keratinized layer that involves the feather as it grows) of feathers, although experiments where shortages of these nutrients were induced failed to provoke FDB (Koutsos et al., 2001; McDonald, 2006). Hypovitaminosis A, notoriously involved in skin squamous metaplasia, has additionally been associated with FDB (Péron & Grosset, 2014).

The particularities of the existent correlation between poor diet and FDB are however still uncertain (Rubinstein & Lightfoot, 2012). It was hypothesised that FDB could be manifested as a way for the bird to dispose of dystrophic feathers and discomfort or as a consequence of concurrent diseases associated with malnutrition, such as hepatic lipidosis and skin infections (Gill, 2001; Lightfoot & Schmidt, 2006; Rubinstein & Lightfoot, 2012).

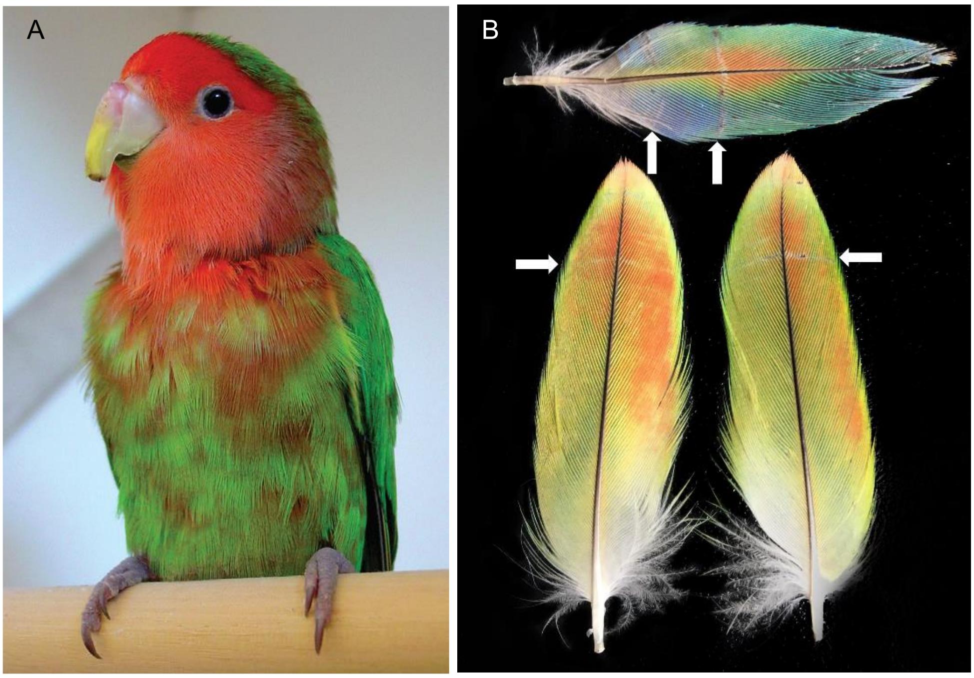


FIGURE 4 Integument abnormalities of lovebirds (*Agapornis* spp.). **(A)** Altered pigmentation of feathers and deformation of the beak (adapted from Van Zeeland & Schoemaker, 2014a) **(B)** Feathers displaying stress bars (white arrows) (author's original).

1.2.1.6. Vascular

Atherosclerosis has been identified multiple times in the vessels irrigating areas suffering from chronic dermatologic issues, such as self-mutilation and FDB. Hypoperfusion stemming from this vascular disease might cause sensations like pain, numbness, and tingling, which is assumed to be the triggering factor (Fitzgerald & Beaufrère, 2016). A phenomenon similar to angina pectoris in humans, where the hypoperfusion of the myocardial muscle irradiates unsettling sensations to other body parts, has also been postulated (Fricke et al., 2009). Although evidence remains anecdotal, atherosclerosis merits some investigation, especially if the patient is of old age (Beaufrère, 2013).

1.2.1.7. Immune-mediated

Hypersensitivity reactions are recognised to cause discomfort and pruritus, both of which known FDB promoters (Langlois, 2021). A retrospective study focused on the skin histopathology of parrots displaying feather-picking and self-mutilation, found lesions compatible with type IV hypersensitivity in more than 50% of samples (Garner et al., 2008). In another study, hypersensitivity dermatitis was histologically diagnosed in around 25% of birds with FDB, that was initially believed to be psychological in origin (Bennett, 2002). FDB-birds demonstrated statistically higher positive reactions to intradermal skin tests to allergens (aspergillus, sunflower, house dust mites and/or maize) when compared to non FDB-birds (Macwhirter et al., 1999, cited in Lightfoot and Schmidt, 2006). Although difficult to diagnose, existing research and seasonal recurrence may indicate an allergenic role in self-harming syndromes (Lightfoot & Schmidt, 2006; Langlois, 2021).

1.2.1.8. Neoplastic and Degenerative

Skin, muscle, and visceral neoplasia can be connected to FDB. This becomes clear if the behaviour ceases once the mass is removed (Langlois, 2021). Feather cysts often become the grounds to basal cell tumours development (Lightfoot & Schmidt, 2006). Squamous cell carcinomas may originate from areas of constant injury to the skin, just like those of feather plucking (Klaphake et al., 2006; Langlois, 2021).

FDB was also linked to osteoarthritis (Hoppes, 2017, cited in Langlois, 2021). Orosz (2006), reported a case where an Amazon parrot (*Amazona* spp.) displayed feather picking over the same side of the body it presented degenerative joint disease in.

1.2.1.9. Idiopathic

Chronic ulcerative dermatitis (CUD), a condition primarily occurring in lovebirds, results from repeated self-mutilation of the skin (Lightfoot & Schmidt, 2006). The injured areas appear haemorrhagic or with abundant scar tissue (Figure 5), that can restrict movement and cause discomfort, leading to the perpetuation of the condition. Secondary bacterial infections might also be involved (Langlois, 2021). A study concerning peach-faced lovebirds (*Agapornis roseicollis)* detected avian polyomavirus (APV) in over half of the birds with CUD and psittacine beak and feather disease virus (PBFDV) in approximately 20% of them. In the same study, APV and PBFDV were found in 16% and 65%, respectively, of the birds exhibiting featherless syndrome (Cornelissen et al., 2001). The premise of a viral aetiology is consistent with outbreak reports of this condition in groups of parrots (Lightfoot & Schmidt, 2006).

Polyfolliculitis is described in budgerigars, cockatiels, and lovebirds as more than one shaft emerging from a single follicle. The feathers can also look bulky, short, and may be curled and stuck in their sheath (FIGURE 6). The condition seems to be pruritic, hence the possible emergence of FDB. Disorders that interfere with moulting must be considered as possible contributors to polyfolliculitis. In lovebirds a viral origin stands out as the primary suspect (Koski, 2002; Reavill, 2003).

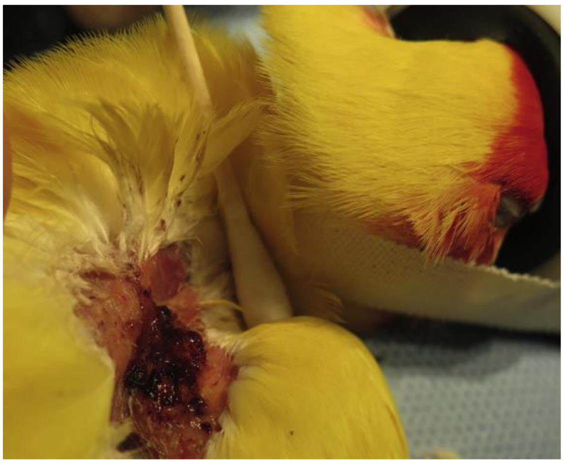


FIGURE 5 Rosy-faced lovebird (*Agapornis roseicollis*) with CUD in the patagium (Langlois, 2021).

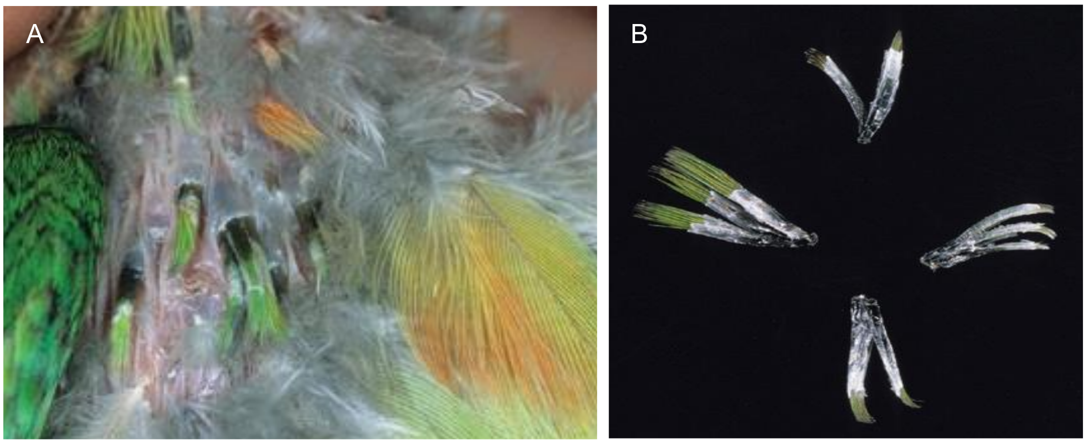


FIGURE 6 Polyfolliculitis in a loverbird (*Agapornis* spp.). Note the multiple feather quills emerging from a single follicle **(A),** and the short quills retained in their sheaths with a bulky appearance **(B**) (adapted from Van Zeeland & Schoemaker, 2014a).

1.2.2. INFECTIOUS DISEASES

1.2.2.1. Parasitic

External parasites are rarely affiliated with FDB, but, due to their potential pruritic and feather-loss effects, should be discarded (Koski, 2002; Reavill, 2003; Langlois, 2021). Severe infestations of *Knemidocoptes pilae* can cause feather loss and FDB. Circovirus and *Mycobacterium* spp. infections may act as precursors for severe infestations of this mite (Gill, 2001; Reavill, 2003; Schmidt et al., 2015). Quill mites are uncommon but may sporadically cause feather damage (Doneley, 2001; Reavill, 2003; Sandmeier, 2006). Depending on the degree of infestation, lice might provoke mild to moderate pruritus, hyperkeratosis, and feather degradation, all triggering factors of FDB (Koski, 2002; Reavill, 2003; Orosz, 2006).

Additionally, the internal parasite *Giardia psittaci* has been shown to generate intense pruritus in cockatiels, possibly due to an inadequate absorption of fat-soluble vitamins in the gastrointestinal (GI) tract, and to be connected to feather picking (Reavill, 2003; Doneley, 2009).

1.2.2.2. Bacterial

Primary or secondary bacterial infections of the skin usually present as folliculitis or generalised dermatitis. Lesions include erythema, oedema, exudation, crust formation, and, in extreme cases, necrosis of the skin. In folliculitis these can be observed surrounding the feather follicle (Lightfoot & Schmidt, 2006; Schmidt et al., 2015). Feather dystrophy, pulp inflammation, and follicular abscessation might also occur, often being intensely pruritic and resulting in feather destruction and self-trauma (Orosz, 2006; Schmidt et al., 2015). Isolated bacteria are commonly gram-positive cocci, primarily *Staphylococcus* spp. (Schmidt et al., 2015). In a recent study dedicated to birds with CUD, the predominant bacteria cultured was *Enterobacter cloacae*, followed by *E.coli* and *S. aureus* (Abou-Zahr et al., 2018).

Skin infections can progress into septicaemia and endocarditis, underscoring the need for vigilance and timely intervention (Hermans et al., 2000; Huynh et al., 2014; Langlois, 2021). Septicaemic alopecia, described by the incessant gnawing of a specific area on the account of generalised fungal or bacterial infection, can also be observed (Chitty, 2005).

Furthermore, systemic bacterial agents like *Chlamydophila psittaci*, known for causing air sacculitis and hepatitis and, consequently, discomfort, may contribute to the development of feather destructive behaviour (Koski, 2002; Van Zeeland & Schoemaker, 2014a; Kubiak, 2015).

1.2.2.3. Fungal

Fungal allergy and dermatitis prompted by agents like *Aspergillus* spp., *Malassezia* spp., and *Candida* spp., have been proposed as triggers for FDB, but evidence remains anecdotal (Lightfoot & Schmidt, 2006; Rubinstein & Lightfoot, 2012) Establishing a correlation is difficult as fungi can be found naturally on the skin and feather of healthy birds, and fungal dermatitis can also occur as a consequence of self-mutilation (Rubinstein & Lightfoot, 2012; Langlois, 2021). Weller and Phalen (2012) identified four cases of self-mutilation regarding feathers, skin, and underlying tissue presumably caused by aspergillosis of the air sacs and coelomic cavity. Higher *Aspergillus* antibody titres were also found in birds with FDB when compared to those without it (Clubb et al., 2007). *Malassezia* infection was seen acting as an itching factor in galahs (*Eolophus roseicapilla*) (Gill, 2001). *Candida albicans* can seldom affect feather follicles and is usually a secondary infection, thus requiring a comprehensive search for a primary cause. Both *Candida* spp. and *Malassezia* spp. infections may result in flaky skin and feather loss (Reavill, 2003).

1.2.2.4. Viral

Parrot bornavirus (PaBV) and feather plucking might be associated, but a definitive causal relation is still lacking (Zantop, 2010; Rubinstein & Lightfoot, 2012; Horie, 2019). Several studies identified PaBV in birds manifesting FDB (Melillo, 2006; Gancz et al., 2009; Horie et al., 2012; Philadelpho et al., 2014). A correlation between the level of PaBV-specific antibodies and the severity of clinical signs in parrots with unexplained feather picking was also documented (Fluck et al., 2019). Peripheral neuritis has been suggested as the linking mechanism (Berhane et al., 2001; Sassa et al., 2013; Rossi et al., 2018). PaBV testing is advised in the absence of another obvious disease process (Fluck et al., 2019; Horie, 2019) as the infection can be subclinical (Payne et al., 2011).

Poxvirus infections have become rare since parrots started being captive bred instead of wild-caught (Langlois, 2021). Lovebird pox is characterized by dark, discoloured areas of skin, and, when secondary infections exist, severe pruritus, which may conceivably give rise to FDB (Reavill, 2003; Langlois, 2021).

Members of the Psittaculidae family are frequently found infected with APV and/or PBFDV while displaying FDB (Jenkins, 2001). Polyomavirus infection in its chronic form can affect the growth of the down and contour feathers, causing dystrophy or absence of these, similar to what occurs in the chronic presentation of psittacine beak and feather disease (PBFD) (Gill, 2001; Koski, 2002; Reavill, 2003). Lovebirds are among the species that are more susceptible to APV and the disease occurs from nestling birds up to one year of age. Concurrent infection with PBFDV can explain the late susceptibility in this species (Phalen, 2006a).

Circovirus, also known as PBFDV, is highly prevalent among lovebirds. A prevalence of 40% and 60% was found in a group of lovebird samples sent to one laboratory and in lovebird collections in Texas, respectively (Phalen, 2006a). Most infected lovebirds do not show clinical signs. When disease does manifest in these species, its usually chronic and affects adolescents to young adults. In these cases, dystrophic feathers gradually replace normal ones, and the lovebird may present with simple dull and worn-out plumage, or in more advanced stages, feather malformation and loss. The feather dystrophies seen may involve hypertrophic retention of feather sheaths, stress lines in the vane, clubbed and curled feathers, haemorrhagic shafts, and annular constrictions of the calamus (Figure 7). A portion of these birds might survive for years and even recover and eliminate de virus (Reavill, 2003; Phalen, 2006a; Rubinstein & Lightfoot, 2012).

Besides contributing to the development of FDB, APV and PBFDV may also mimic it, so essays should always be performed to rule them out (Langlois, 2021).

FIGURE 7 Feather dystrophy in the form of annular constrictions and haemorrhage within the calamus (Wellehan et al., 2016)

1.3. INTERNAL FACTORS

Changes in neuroanatomy and neurochemistry can be congenital, developmental, or acquired due to chronic exposure to detrimental stimulants. Under these circumstances, FDB can be perceived as a *malfunctioning behaviour* (Mills, 2003; Garner et al., 2006; Van Zeeland et al., 2009, 2016).

1.3.1. GENETIC

Garner et al (2006), documented high heritability in a group of Amazon parrots suggesting a genetic basis to FDB. In chickens, feather pecking genetic links are well known and selective breeding was proven to reduce the incidence of this behaviour (Rodenburg et al., 2004; Jensen et al., 2005; Rodenburg et al., 2008). Comparative studies with compulsive/impulsive disorders in other animals (e.g., trichotillomania in humans, feather pecking in laying hens) have also demonstrated that a *proactive coping style* (i.e., an hands-on personality, where the individual displays a tenacious attitude, is more territorial, and is less flexible to routine changes) can predispose parrots to pterotillomania (Van Zeeland et al., 2013c).

1.3.2. EARLY LIFE CONDITIONS

Deprivation of interaction with conspecifics and natural environment denies the bird the opportunity to learn appropriate behaviour, generating an individual that is socially impaired, insecure, and unreceptive to new experiences. Furthermore, the isolated bird can imprint on its caretaker, expecting him to satisfy its sexual and social necessities (Schmid et al., 2006; Van Zeeland et al., 2009). Imprinted parrots exhibit a clear preference for human companionship, even if members of the same species are present (Fox, 2006; Costa et al., 2016a; Ebisawa et al., 2021). This can lead to problems such as separation anxiety, sexual frustration, and/or attention seeking, which are important predisposing factors to FDB (Seibert, 2006; Welle & Wilson, 2006; Costa et al., 2016a; Ebisawa et al., 2022). In Costa et al (2016a), parrots that lived closely to humans developed feather picking more frequently than those who lived always caged.

The aforementioned scenery holds particularly true for hand-reared parrots (Schmid et al., 2006; Van Zeeland et al., 2009). Chicks raised without maternal interactions demonstrated higher hypothalamic-pituitary-adrenal responsiveness, which is also found in birds with FDB (Clubb et al., 2007; Rensel et al., 2010; Banerjee et al., 2012; Ebisawa et al., 2022). In peach-faced lovebirds, Ebisawa et al. (2022) revealed that the prevalence of FDB for hand-reared subjects is five times higher than those who were parent raised.

1.3.3. NEUROBIOLOGY

Neurotransmitter imbalances, like deficiencies and/or excesses of dopamine, serotonin, and endorphins, are thought to have a part in the development and persistence of FDB. In laying hens suffering from feather pecking, high dopamine and low serotonin levels were found (Van Hierden et al., 2002a; Van Hierden et al., 2002b; Van Hierden et al., 2004; Bolhuis et al., 2009). The results of psychopharmacological intervention in humans and parrots also suggest a neurochemical aetiology to the problem (Van Zeeland et al., 2009).

Abnormal repetitive behaviours (e.g., obsessive-compulsive disorders) develop when the behaviour becomes rewarding by itself through changes in the brain's chemistry, occurring even if the underlying stressors that might have led to it are fixed. This might also be applicable to FDB (Garner, 2005, 2006).

1.4. CLINICAL APPROACH

Primarily, the clinician should determine if the damage to the feathers is in fact self-inflicted (Van Zeeland & Schoemaker, 2014a). Care should be taken into differentiating what the owner might consider to be FDB from natural states (Seibert, 2006; Van Zeeland & Schoemaker, 2016b; Langlois, 2021). Inexperienced owners might misinterpret normal apteria or moulting areas as abnormal (Van Zeeland & Schoemaker, 2014a). The creation of a brood patch might also not be recognised by the owners as a normal behaviour (Van Zeeland & Schoemaker, 2016b). Lack of feathers on the head is a powerful indicator that the bird's condition might be caused by something else entirely, such as bullying by cage mates or infectious diseases, as this area is unreachable by the animal. In addition, a lack of regrowth can also be a sign that a condition other than behavioural is involved, such as hypothyroidism, malnutrition, and PBFD (Chitty, 2003a; Van Zeeland & Schoemaker, 2016b). Evaluation of the feather structure to look for evidences of chewing or biting, can also provide valuable information (Langlois, 2021).

Once established the bird is the solo perpetrator of the feather and/or skin damage, it is important to determine whether we might be dealing with socioenvironmental, medical, or internal causes, or even, most commonly, a combination of these. It is equally important to point out that the diagnosis of a psychogenic FDB must only be made once health and husbandry issues have been ruled out (Figure 8) (Van Zeeland et al., 2016; Van Zeeland & Schoemaker, 2016b).

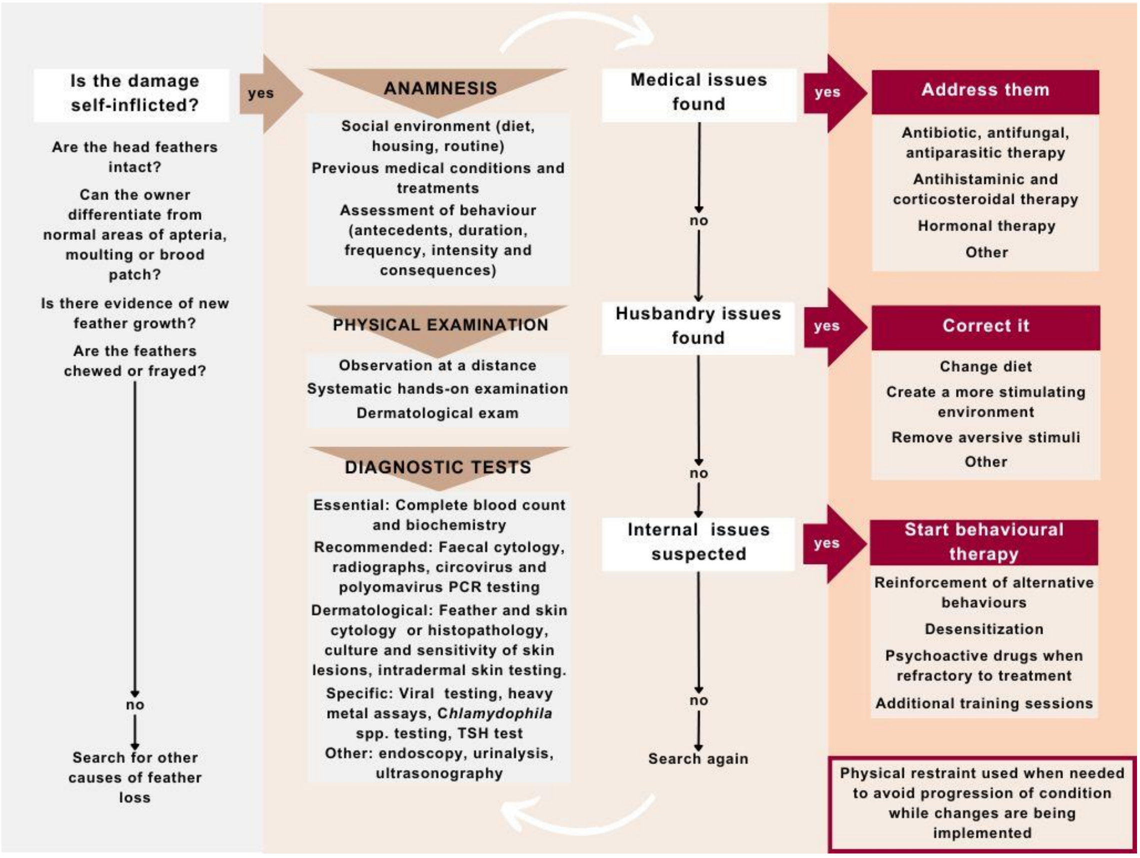


FIGURE 8 Clinical and therapeutic approach for FDB (author's original).

1.4.1. PATIENT HISTORY

A thorough and comprehensive anamnesis is critical to identify possible FDB aetiologies. To simplify the process, premade questionnaires can be provided for owners to fill out before the appointment (Chitty, 2003a; Orosz, 2006; Van Zeeland et al., 2016). Video recordings of the behaviour and husbandry settings could additionally help to evaluate the condition more objectively (Van Zeeland et al., 2016; Langlois, 2021).

Data regarding the bird's diet, housing, daily routine, exposure to toxins, early living conditions, prior or current illnesses and treatments, as well as its relationship with the owner and other cohabitants, should be collected (Chitty, 2003a; Van Zeeland et al., 2016).

1.4.1.1. Behavioural Assessment

The *ABCs of behaviour* can be used to identify more easily what is triggering the unsuitable conduct (antecedents), how it affects the animal (behaviour), and what is perpetuating it (consequences), giving the clinician higher chances to successfully manage FDB. Its application can be as follows: (A) Determine the events that precede the behaviour and make it more likely to happen. Ask about the onset, progression, and timing of the behaviour, what environmental changes were associated with it, the time of day or year the behaviour is most intense in, the response to previous treatments, and in which instances it ceases (where, when, and with whom?). (B) Analyse the behaviour itself. Seek information about the frequency, duration, and magnitude of the problem (how often, how long, and how much?). (C) Identify what happens immediately after the behaviour. Inquire the owner on his response, as it might be inadvertently reinforcing the behaviour, for example, by giving the bird attention or 'rewards' instantly after the display (what does the animal gain, escape or avoid?) (Lightfoot & Nacewicz, 2006; Seibert, 2006; Van Zeeland et al., 2016).

1.4.2. PHYSICAL EXAMINATION

The physical exam begins with observation of the animal at a distance, followed by a hands-on examination, with especial concern for the dermatologic system (Van Zeeland et al., 2016). Changes in the bird's mentation, stance and posture are important indicators of disease (Orosz, 2006). The hands-on approach should be conducted methodically, addressing all systems, just as for any other patient.

1.4.2.1. Dermatological exam

For dermatologic assessment, inspect the skin, feather and feather shafts across the entire body of the bird (Rubinstein & Lightfoot, 2012). Where skin lesions (e.g., nodules, papules, plaques, ulcers and/or exudate) and/or feather abnormalities are found, study the type, location (i.e., area of the body), and distribution (i.e., symmetry, sidedness, and extent). Investigating the type of feather abnormalities include noting the affected feathers (primary, secondary, tail, down or covert; see Figure 9), the changes in appearance (colour and structure), and the damage dealt by the parrot (removal, fraying or breakage) (Van Zeeland & Schoemaker, 2014b; Kubiak, 2015; Van Zeeland et al., 2016). Presence or absence of pruritus should also be noted (Lightfoot & Schmidt, 2006).

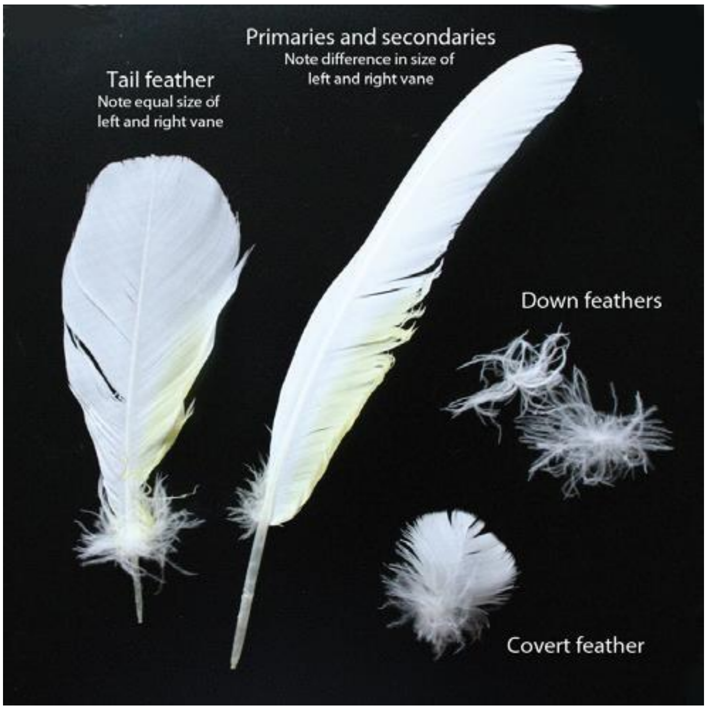


FIGURE 9 Type of feathers include the tail, primary, secondary, covert, and down feathers (Van Zeeland & Schoemaker, 2014a).

1.4.3. DIAGNOSTIC TESTS

Generally, a complete blood count (CBC) and plasma biochemistry are deemed essential (Lightfoot & Schmidt, 2006; Orosz, 2006; Van Zeeland & Schoemaker, 2016b). Faecal cytology, including wet-mount preparations, and radiographs are also recommended (Rubinstein & Lightfoot, 2012). To further evaluate the body's organic function and systemic condition, other procedures like urinalysis, ultrasonography, and endoscopy may also be considered (Van Zeeland & Schoemaker, 2014a; Van Zeeland et al., 2016).

Focusing on the dermatologic system, cytology of the skin lesions (scrapings, tape strip, impression smear, swab, fine needle aspirate) and feather pulp (feather digest), or more precise methods, such as histopathology of the skin and feather follicles (biopsy), can be performed. The previous tests prove to be valuable to detect a variety of infectious, inflammatory and/or neoplastic diseases, including bacterial or fungal folliculitis or dermatitis, abscesses, circovirus or polyomavirus infections, ectoparasites (particularly mites), squamous cell carcinomas, and feather follicle cysts. To diagnose and treat bacterial and fungal dermatitis or folliculitis, culture and sensitivity tests are also useful (Rosenthal et al., 2004; Lightfoot & Schmidt, 2006; Van Zeeland & Schoemaker, 2014a; Van Zeeland & Schoemaker, 2016b). While intradermal skin testing is an option for identifying allergic skin diseases, its reliability is compromised by the reduced response of birds to histamine (Colombini et al., 2000; Nett et al., 2003; Van Zeeland et al., 2016). Hypersensitivity reactions are therefore difficult to diagnose, although paired skin biopsies (from healthy and unhealthy tissue from the same patient) studies revealed some results (Rosenthal et al., 2004; Garner et al., 2008; Van Zeeland, 2016).

Specific screening tests such as PCR testing for PBFDV (on whole blood, feather pulp or tissue) and APV (on faecal swab or tissue) might be warranted (Lightfoot & Schmidt, 2006; Van Zeeland & Schoemaker, 2014b; Langlois, 2021). Further complementary exams according to findings include the collection of swabs and blood samples for *Chlamydophila* spp. and/or PaBV PCR testing, haematologic heavy metal tests for zinc and lead toxicosis, and TSH stimulation test for hypothyroidism (Chitty, 2003a; Van Zeeland & Schoemaker, 2014b; Van Zeeland & Schoemaker, 2016b).

1.5. THERAPEUTIC CONSIDERATIONS

A treatment plan for FDB must be established according to the clinical findings (Van Zeeland, 2016). It may encompass correction of environmental problems (for maladaptive behaviours), addressing health issues (for medically induced abnormal behaviours), habit breaking techniques (for malfunctioning behaviours), or, frequently, a multimodal approach. Whenever medical and husbandry issues are found, tackling them may not always translate into a curative treatment of FDB, as the behaviour might have become intrinsic through ritualization and reinforcing conditions, requiring additional behavioural intervention (Van Zeeland et al., 2016).

1.5.1. REMOVING STRESSORS

Remodelling the bird’s diet along with its physical and social environment might be the first step. The latter can include acquiring a bigger cage, relocating the animal to a different room, separating cage mates, encouraging bathing and frequent exercise, improving hygiene, establishing a routine, and avoiding contact with smoke and cosmetic products. Existing adverse stimuli, causing consternation to the parrot (e.g., disruptive sounds/actions), should also be fixed (Van Zeeland & Schoemaker, 2014a, 2016).

Creating a more stimulating environment, particularly by promoting foraging, must be regarded as a crucial component of the treatment plan for minimizing FDB (Meehan et al., 2003; Lumeij & Hommers, 2008; Van Zeeland et al., 2009). Ways of enhancing foraging opportunities comprehend the supply of complex food items (e.g., pomegranate, pineapple, corn on the cob), puzzle feeders, homemade toys with food hidden inside, scattered food mixed in with inedible materials, and dispersed feeding spots (Van Zeeland, 2016). Extra means of improving the entertainment level in the parrot's enclosure involve introduction of natural wooden branches with different textures and widths, chewable (e.g., wooden, cardboard, paper) objects, and additional social interaction (Rubinstein & Lightfoot, 2012; Van Zeeland & Schoemaker, 2014a).

Reproductive catalysts can be controlled through a change in diet, reduction of the photoperiod, redirection of sexual attention from inadequate entities to a potential same-species partner, and limitation of the owner's enticing engagements (Seibert, 2006).

1.5.2. MEDICAL INTERVENTION

Every disease process requires a unique resolution elected according to the diagnosis made for each individual patient. Therapeutic intervention may include the use of antibiotic, antifungal, and/or antiparasitic drugs (Van Zeeland & Schoemaker, 2014a). For hypersensitivity cases, the treatment should incorporate the trial and removal of possible allergenic sources (e.g., diet, fumes) and the administration of antihistaminic and/or corticosteroid therapy (Van Zeeland & Schoemaker, 2014b; Van Zeeland, 2016). The usage of depot gonadotropin-releasing hormone (GnRH), such as deslorelin, leuprolide acetate, or medroxyprogesterone acetate, can be helpful in the control of endocrine related FDB (Seibert, 2007).

1.5.3. PHYSICAL RESTRAINT

Mechanical restriction of feather picking should only serve as a temporary measure while changes are being implemented, aimed at preventing the condition from worsening and breaking the ritualization pattern. This procedure is not a standalone treatment, and its application should be carefully weighed in as it can cause additional stress to the animal. Options include topical employment of foul-tasting substances on the targeted area, fabric 'vests', neck braces, and Elizabethan collars (Figure 10) (Chitty, 2003b; van Zeeland, 2016).

FIGURE 10 Examples of an Elizabethan collar **(A)** and a neck brace (made from a tape core) **(B)** to prevent the birds from reaching their feathers (adapted from Van Zeeland, 2016; Van Zeeland et al., 2016).

Every bird should undergo hospitalization in order to ensure the correct placement of the collar and that the bird adjusts to it (i.e., is able to perform basic functions such as eating, drinking, and perching) (Langlois, 2021). Sedation, using midazolam at a dosage range of 0.3-0.5 mg/kg administered intramuscularly, can be employed to mitigate the stress experienced by the parrot during the process (Van Zeeland, 2016).

1.5.4. BEHAVIOUR MODIFICATION

Once established the FDB is likely inherent to the bird, behavioural therapy yields the most favourable outcomes, whereupon owner's compliance becomes pivotal (Friedman et al., 2006; Seibert, 2006; Van Zeeland et al., 2016). The main objective is to redefine the antecedents and consequences to which the bird has been exposed to, in an effort to turn the unwanted behaviour less appealing for the animal (Farhoody, 2012). Fundamental training techniques that can be implemented to modify the parrot's conduct include: (1) rewarding a new behaviour, whilst ignoring the undesirable one, in means of replacing it (e.g. giving attention or treats to the parrot whenever it is playing with appropriate toys instead of disturbing its feathers); and (2) desensitization through gradual exposure of the parrot to small increments of the aversive stimuli, ultimately enabling the bird to become accustomed to it, rather than disrupted by it (Friedman et al., 2006; Van Zeeland et al., 2016). These two methods can also be combined wherein each time the bird responds pacifically to what used to be a triggering event, gets a reward, fostering this new alternative behaviour (Seibert, 2006).

Complemental teaching of simple added commands (e.g., step-up, step-down) may also extremely benefit the bird, as to further occupy its time, both physically and mentally (Jenkins, 2001; Van Zeeland & Schoemaker, 2014b; Van Zeeland, 2016). Short and regular training sessions proved to be the most effective treatment for FDB in sulphur-crested cockatoos (*Cacatua galerita*) (Peng et al., 2014).

1.5.4.1. Psychoactive agents

The use of psychopharmaceuticals can be justified for chronic cases, this is, when medical and environmental factors have been discarded or addressed, behavioural therapy has been applied, and the bird remains refractory to treatment (Seibert, 2007; Van Zeeland, 2016). Similar to physical restraint, psychotherapy should only be implemented as a temporary and adjuvant measure to other regimens (Chitty, 2003b). Psychotropic drug selections may entail: anxiolytic drugs like diazepam (Seibert, 2007); antipsychotic drugs like dopamine antagonist haloperidol (Iglauer & Rasim, 1993); tricyclic antidepressants such as amitriptyline, cloripramine, and doxepin (Seibert et al., 2004; Seibert, 2007); serotoninergic reuptake inhibitors such as paroxetine and fluoxetine (Seibert, 2007; Van Zeeland et al., 2013b); and opioid antagonists such as naltrexone (Seibert, 2007). The tricyclic antidepressant clomipramine has been the most studied, however it showed inconsistent results (Seibert et al., 2004).

1.6. PROGNOSIS AND MONITORING

Feather plucking can be hard to tackle, as identifying the underlying causes and treating chronic states has proven to be difficult (Van Zeeland, 2016). The prognosis is often guarded, with decreasing chances of a successful treatment as time passes following initial presentation (Van Zeeland & Schoemaker, 2016b). A substantial portion of parrots suffering from FDB end up being rehomed or euthanised due to the inability of the proprietor to provide a good quality of life for the animal, so full disclosure should be had with the owners about the challenges this condition poses to avoid feelings of frustration and discouragement (Chitty, 2003b; Van Zeeland & Schoemaker, 2014b).

A close monitoring of FDB is crucial, particularly in birds following behavioural changing strategies, as the condition tends to worsen in the beginning (Van Zeeland et al., 2016). Feather scoring systems can be useful to objectively evaluate the progression of the syndrome (Van

Zeeland et al., 2013a; Van Zeeland & Schoemaker, 2014b). A period of at least four weeks between check-ups is ideal to allow new feather growth (Van Zeeland, 2016).

1.6.1. CONSEQUENCES

Besides the obvious aesthetic impact, feather-plucking may generate more serious repercussions. Feathers play a significant role in insulation, impermeabilization, thermoregulation, and physical protection, leaving the parrot vulnerable to disease and trauma in their absence. Constant feather damage and regrowth comes at a high energetic cost, conceivably compromising the bird's immune system and eventually leading to the cessation of feather regeneration altogether (Nett & Tully, 2003). Moreover, continuous bruising of the skin can increase the risk of secondary infections (Seibert, 2006).

When FDB is targeted at blood feathers (newly formed feathers with an extensive blood supply), it poses a real life-threatening concern given the significant risk of severe blood loss (Seibert, 2006).

1.6.2. PREVENTION

Feather picking highlights the importance of educating clients about the proper conditions and interactions required for responsible pet parrot ownership. A good quality diet and reproductive settings that closely resemble those found in nature are of utmost importance for preserving the bird’s health. Considering the remarkable intelligence of these creatures, it is also imperative to house them in engaging and stress-free surroundings to mitigate the chances of developing abnormal behaviours (Van Zeeland & Schoemaker, 2016b).

Regular medical check-ups are critical in proactively identifying potential FDB causes in a timely manner. Wing trims ought to be discouraged in an attempt to prevent traumatic events. Nonetheless, when performed, special care should be taken to avoid over trimming (as it can lead to further lesions and flight accidents), or under trimming (as the protruding shafts from the wing covert feathers may tempt the bird to even out the area), which can ultimately lead to FDB. Furthermore, clipping the wings of non-fledged birds may interfere with socialization and ability to fly later in life (Chitty, 2003b).

Efforts should also be directed towards dissuading the practice of hand-rearing psittacines. Parent-reared birds with occasional human handling, can present an alternative for hand-rearing methods, as the former proved to be equally capable of taming the bird, without socially impairing it (Seibert, 2006).

2. OBJECTIVES

The aim of this study was to characterise the feather damaging behaviour in lovebirds (*Agapornis* spp.) in order to identify possible patterns and contribute to a better diagnosis of the underlying causes, namely:

I. Characterise the affected population of lovebirds in terms of age, sex, and weight;
II. corroborate the existence of seasonality to the condition;
III. determine the aspects of patient history potentially relevant to the development of the behaviour;
IV. encapsulate the overall clinical presentation of the feather picking patient;
V. identify the main physical areas affected by the feather destructive behaviour, and
VI. understand the complementary exams findings associated with the problem.

Additionally, to test the hypothesis of the parrot targeting certain regions according to specific disease processes, a relationship analysis between the area of display and the clinical signs was also carried out.

3. MATERIALS AND METHODS

3.1. DATA COLLECTION

A retrospective study was conducted from cases registered in CVEP's database. A total of 119 animals that fitted the criteria of the study were included between the period of 2017 to 2022.

The system, personally developed by Dr. Joel Ferraz in conjunction with the Sincelo (Sistemas de Informação, Lda, Porto, Portugal) company, allowed to refine the search for 'Class: Avian', 'Order: Psittaciformes', and 'Species: *Agapornis* spp.' within the 'List of animals', and to select specifically the FDB cases, which in Portuguese has a unique term, 'picacismo'. Information regarding patient characteristics, time of the year, patient history, and clinical findings was then collected for each eligible case at the time of FDB onset.

3.2. INCLUSION AND EXCLUSION CRITERIA

In the present study were included all lovebirds (*Agapornis* spp.) that first presented with FDB to the clinic, encompassing both existing and new patients. Only cases with a confirmed diagnosis of FDB (i.e., self-inflicted damage) by a clinician were investigated, including those where the owner was unaware of the condition prior to the consultation.

At the same time, all cases in which the clinician held uncertainty about whether the observed feather damage was self-inflicted by the bird, cases where the condition had manifested over two months prior to the consultation, or situations where the bird had already started receiving treatment from another clinic, were excluded from the study.

3.3. STUDY VARIABLES

3.3.1. DEMOGRAPHIC

The age, sex, and weight of each patient at the time of FDB presentation was recorded. Since the majority of lovebirds (*Agapornis* spp.) have no sexual dimorphism (Turcu et al., 2020), sex was only noted when confirmed by laboratory testing. The month of birth was unknown in most of the cases, so age was calculated through the difference between the year of FDB onset and the birth year of the bird. The age of the patients that displayed FDB in the same year of birth was considered zero.

3.3.2. SEASONALITY

Portugal has four seasons and, according to the Koppen's climate classification, a temperate climate with hot and dry summers and rainy winters (Kottek et al., 2006; Peel et al., 2007; IPMA 2023). The date of consultation where FDB was diagnosed was registered and, as for the northern hemisphere, winter was designated after December 21st or 22nd, spring after March 20th or 21st, summer after June 20th or 21st, and autumn after September 22nd or 23rd.

3.3.3. ANAMNESIS

All information potentially related to the development of FDB, such as parrot's living conditions, nutrition, and events that the owner could associate with the appearance of the behaviour, was deemed essential for the present study. Parrots that only ate seeds, even with the occasional produce intake, were put under 'Seed-based diet'. Birds that were exhibiting sudden territorial and aggressive behaviours, chronic egg laying, increased regurgitation and masturbation towards the owner or toys, nest selection, and nest-building behaviour were put under 'Reproductive behaviour'. The acknowledgement by the owner of a tumultuous environment (ex: fighting with cage mates) or of sudden changes (ex: owner went on vacation, change of room divisions, introduction of a new pet, rehoming, or recent adoption of the parrot) in close relation to the onset of FDB was considered 'Presence of aversive stimuli'. 'Poor husbandry' was designated in cases where the bird had a small cage, inappropriate photoperiods, poor hygiene of the surroundings, no form of entertainment (no toys), and was never allowed to fly or leave the cage. Trauma events closely related to the appearance of FDB were also registered.

The occurrence of any recent haemorrhagic episodes in consequence of the behaviour (wound, blood feather) was also considered important for the clinical presentation of the animal and, therefore, included in the variables as ‘Recent haemorrhage’.

3.3.4. CLINICAL SIGNS

The clinical signs documented on the physical exam, to which all lovebirds were submitted, were interpreted. The direct consequences of FDB or self-mutilation (i.e., damage to the feathers and skin) were not considered to be a part of this variable. In order to facilitate the understanding of the exhibited symptomatology, the signs were grouped according to their nature. In this regard: respiratory effort, tail bobbing, audible respiratory noises, abnormal air sac auscultation, changes in voice, and sneezing were all considered ‘Respiratory signs’; lethargy, emaciation, coelomic distension, anorexia, fluffed feathers, and shivering were considered ‘Nonspecific signs’; pruritus, beak overgrowth, pododermatitis, dystrophic feathers, abnormal feather pigmentation, and hyperkeratosis were considered ‘Dermatologic signs’; ataxia, head tilt, seizures, hind limb weakness, and muscle tremors were considered ‘Neurologic signs’; vomiting, biliverdinuria, green faeces, tenesmus, diarrhoea, and haematochezia were considered ‘GI and accessory glands signs’; otorrhea and otitis were considered ‘Otologic signs’; polyuria was put under ‘Urinary signs’; and dystocia accounted for the ‘Reproductive signs’.

The number of signs of each category was also recorded in a means to understand the severity of the patient’s condition.

3.3.5. AREA OF DISPLAY

The region affected by the bird’s behaviour was noted for every case and, to simplify the results and optimize visualization, six colour-coded regions were considered: blue region - neck and chest; green region - flank, abdomen, and hind limbs; orange region - back and outer surface of the wings; yellow region - inner surface of the wings and axillaries; red region - cloaca; and purple region - rump and tail (Figure 11).

Additionally, the presence of self-mutilation to the area was also registered as a variable.

FIGURE 11 Areas of FDB divided by colour: blue region - neck and chest; green region - flank, abdomen and hind limbs; orange region - back and outer surface of the wings; yellow region - inner surface of the wings and axillaries; red region - cloaca; purple region - rump and tail (adapted from Forshaw, 2010).

3.3.6. DIAGNOSTIC TESTS

The number of diagnostic tests performed to the FDB patient, and their findings, were collected. Faecal cytology involved wet-mount preparations and, occasionally, Gram-staining. High numbers of budding yeast was considered ‘Candidiasis’ (Dahlhausen, 2006). Overgrowth of gram-positive bacillus and cocci was considered ‘Dysbiosis’. *Macrorhabdus ornithogaster* detection was denominated ‘Megabacteria’, a term that is still used due to its rod-like appearance, despite his recent classification as an anamorphic ascomycetous yeast (Tomaszewski et al., 2003; Phalen, 2014).

The CBC and biochemistry findings were classified according to the values present in the following Table 2 and 3. The evaluation of differential white blood cell (WBC) counts was based only on their relative percentages.

TABLE 2 Lovebirds (*Agapornis* spp.) reference values for haematology (adapted from Guzman et al., 2023).

Measurement	PCV (%)	WBC ($10^3/\mu L$)	Heterophils $10^3/\mu L$ (%)	Lymphocytes $10^3/\mu L$ (%)	Monocytes $10^3/\mu L$ (%)	Eosinophils $10^3/\mu L$ (%)	Basophils $10^3/\mu L$ (%)
Normal Range	44-55	7-16	3.33-9.21 (40-75)	3.34-6.20 (20-53)	0-0.12 (0-1)	0-0.23 (0-2)	0-0.23 (0-6)

TABLE 3 Lovebirds (*Agapornis* spp.) reference values for chemistries (adapted from Guzman et al., 2023).

Measurement	AST (U/L)	BA (μmol/L)	CK (U/L)	UA (mg/dL)	Glu (mg/dL)	Ca (mg/dL)	P (mg/dL)	TP (g/dL)	ALB (g/dL)	K (mmol/L)	Na (mmol/L)
Normal Range	125-377	12-90	58-337	2.5-12	246-381	7.2-10.6	2.8-4.9	2.4-3.6	0.98-1.68	2.1-4.8	125-155

PCR for circovirus was either positive or negative, depending on whether the virus was detected or not, respectively.

3.4. STATISTICAL ANALYSIS

The data from each variable was collected and organized using Microsoft® Excel® for Microsoft 365 (version 2307) and later analysed with the IBM® SPSS® Statistics (version 28.0.0.0) program. A descriptive analysis was performed, consisting of absolute and relative frequencies for the qualitative data and of central tendency and dispersion measures (mean and standard deviation) for the quantitative data. An inferential analysis using the chi-square goodness-of-fit test was also undertaken to assess if there was a frequency tendency within the different qualitative variables that met the conditions of this method (no frequencies below 1% and less than 20% of variables <5%). When the tendency of occurrence proved to be statistically relevant between the tested variables, adjusted residuals were used to evaluate the degree of tendency, with values >1.96 indicating a higher tendency of occurrence, and values <-1.96 indicating a lower tendency. The remaining values were ignored.

Furthermore, to evaluate the relationship between the areas of display and the clinical signs, a prevalence ratio between the presence and absence of each clinical sign in face of each area of display was calculated and assessed via the Poisson regression test, since the dependent variables (areas of display) were of dichotomous and qualitative type (present/not present). A prevalence ratio equal to one signified equality between the presence and absence of a clinical sign in a given area, while a coefficient >1 indicated a higher prevalence of that sign in the determined region affected by FDB. To interpret the statistical significance of the ratios >1, a p-value was obtained by the Poisson regression, using the Wald chi-square test.

A p-value <0.05% was considered statistically relevant.

4. RESULTS

4.1. DEMOGRAPHIC

Characterisation of the bird population in study is presented in Table 4. It can be observed that 28.6% consisted of male lovebirds and 23.5% of females. Nearly half (47.9%) of the birds had not been sexed.

No patients displayed FDB before completing their first year of age (0). Age ranged from 1-14 years, with an average of 3.71 years (SD=2.89). Half of the lovebirds had up to 3.00 years. Their weight varied between 36 and 68 g, with an average of 49.21 g (SD=5.56), and half weighing up to 49.00 g.

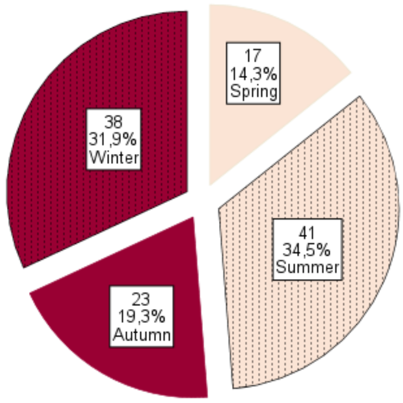
TABLE 4 Demographic analysis of the population in study (N=119).

Characteristic	**n**	**%**
Sex		
Male	34	*28.6*
Female	28	*23.5*
No data	57	*47.9*
Age (years)		
Minimum-Maximum (*Median*)	1-14	*3.00*
Mean (*Standard Deviation*)	3.71	*2.89*
Weight (grams)		
Minimum-Maximum (*Median*)	36-68	*49.00*
Mean (*Standard Deviation*)	49.21	*5.56*

4.2. SEASONALITY

The season of the year in which feather plucking was manifested is presented in Graphic 1. It can be noted that summer and winter were the seasons in which the behaviour most frequently emerged, accounting for 34.5% and 31.9% of the birds in the population, respectively. Feather picking emerged in the autumn for 19.3% of the birds and in the spring for 14.3%. The observed tendency is statistically significant ($X^2_{(3)}$ = 13.538; p = 0.004), indicating that in the cases studied, FDB tends to occur more frequently in the summer (Adjusted Residual = 2.33) and less frequently in the spring (Adjusted Residual = -2.07).

GRAPHIC 1 Season of FDB manifestation.



X^2 Test

$X^2_{(3)}$ =13.538

p=0.004

Adjusted Residuals:

Summer = 2.33

Spring = -2.07

4.3. ANAMNESIS

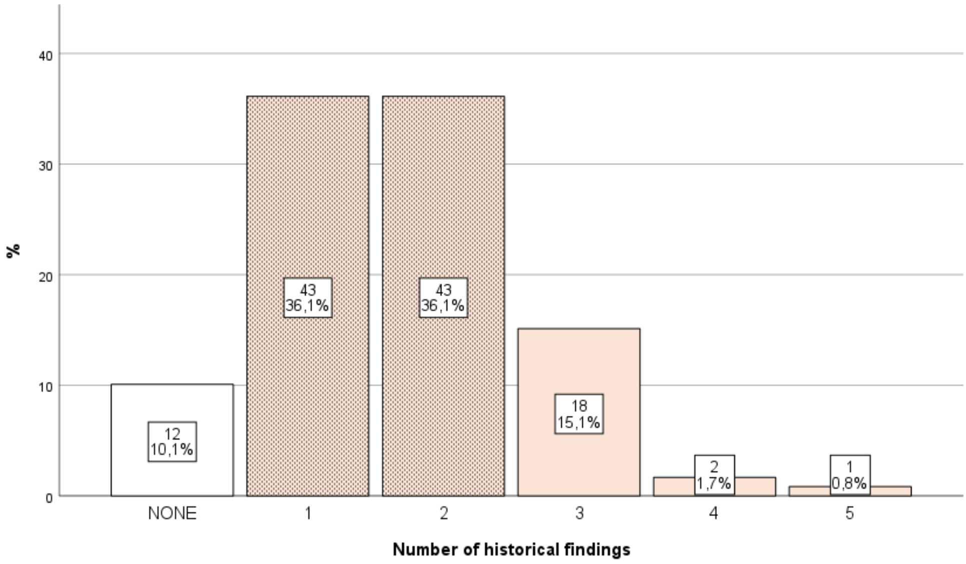
The historical findings related to the appearance of FDB are displayed in Table 5. From its reading, it is observed that seeds as the primary food source were the most common encounter, specifically in 66.4% of the birds. Following that, reproductive behaviour was detected in 30.3% of the cases, presence of aversive stimuli in 26.9%, poor husbandry in 19.3%, and recent haemorrhagic episodes due to feather picking in 10.1%. Hand-rearing and trauma situations were each referenced in 5.9% of the cases. In only 10.1% of the patients no clinically relevant history was found.

TABLE 5 Historical findings associated with FDB in the population studied.

Patient history	**n**	**%**
Seed-based diet	79	*66.4*
Reproductive behaviour	36	*30.3*
Presence of aversive stimuli	32	*26.9*
Poor husbandry	23	*19.3*
Recent haemorrhage	12	*10.1*
Hand-reared	7	*5.9*
Trauma	7	*5.9*
No relevant history	12	*10.1*

In most patients, only one or two anamnestic remarks were discovered, accounting for 36.1% of cases each. Less frequently, there was 15.1% of birds with three historical findings, 1.7% with four, and 0.8% with five (Graphic 2).

GRAPHIC 2 Distribution of the studied lovebird population based on the total number of historical findings registered in association to FDB.



4.4. CLINICAL SIGNS

The nature of the clinical signs and the amount of signalling is described in Table 6. In this study, 57.1% (n=68) of birds showed clinical signs other than those directly created by FDB and self-mutilation, while 42.9% did not. Respiratory signs were the most observed, identified in 41.2% of lovebirds. Of these, 30.3% of birds presented only one respiratory sign, 8.4% presented two signs, 1.7% presented three signs, and 0.8% presented four signs. The nonspecific signs were the second most seen, recognised in 26.1% of birds, followed by dermatologic signs, recognised in 13.4%. The least referenced signs included the GI and accessory glands, detected in only 6.7% of the patients, the neurological in 5.0%, the otologic in 3.4%, and the reproductive in 1.7%.

Considering the 57.1% of patients with identified changes to the physical exam, it is evident that the frequencies showcase the existence of statistically significant tendencies for the manifestation of certain types of clinical signs ($X^2_{(6)}$ = 109.569; p <0.001). Therefore, it was seen that, among the 68 considered lovebirds, there was a statistically significant tendency for a higher frequency of respiratory signs (Adjusted Res = 7.95), as well as nonspecific signs (Adjusted Res = 3.53), albeit with lower prevalence. In contrast, the evidence also indicates a tendency for reproductive signs (Adjusted Res = -3.58), otologic signs (Adjusted Res = -3.09), neurologic signs (Adjusted Res = -2.60), and GI and accessory glands signs (Adjusted Res = -2.11) to be displayed less frequently.

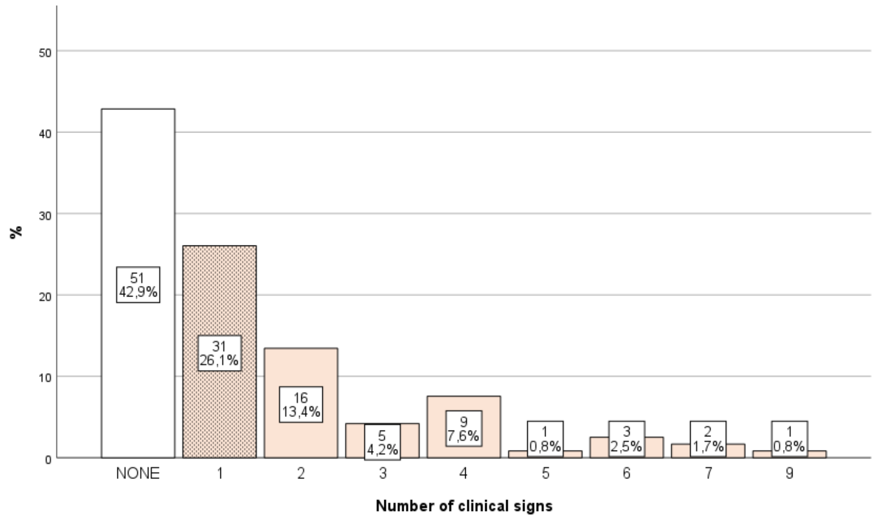
TABLE 6 Prevalence of clinical signs presented by the population in study, other than FDB and self-mutilation, based on their number and type.

Clinical Signs			Number of signs							
			1		2		3		4	
	N	%	n	%	n	%	n	%	n	%
Respiratory	49	*41.2*	36	*30.3*	10	*8.4*	2	1.7	1	0.8
Nonspecific	31	*26.1*	22	*18.5*	6	*5.0*	3	2.5	---	---
Dermatologic	16	*13.4*	11	*9.2*	4	*3.4*	1	0.8	---	---
GI and accessory glands	8	*6.7*	5	*4.2*	2	*1.7*	---	---	1	0.8
Neurologic	6	*5.0*	4	*3.4*	1	*0.8*	1	0.8	---	---
Otologic	4	*3.4*	3	*2.5*	1	*0.8*	---	---	---	---
Reproductive	2	*1.7*	2	*1.7*	---	---	---	---	---	---
NO OTHER SIGNS	51	*42.9*								

$X^2_{(6)}$ =109.569; p <0.001;
Adjusted Residuals: Respiratory=7.95 Systemic=3.53
Reproductive=-3.58 Otologic=-3.09 Neurologic=-2.60 GI and accessory glands=-2.11

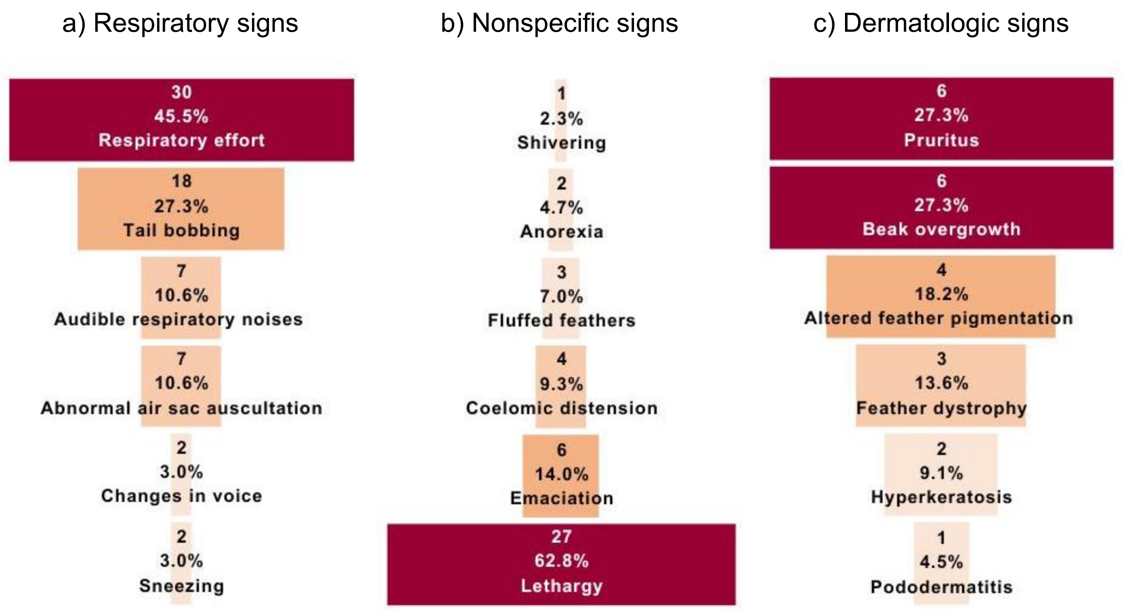
As previously mentioned, 42.9% of the birds studied did not exhibit any additional clinical signs besides the FDB. On the other hand, 26.1% exhibited only one clinical sign, 13.3% exhibited two clinical signs, and a total of 17.6% exhibited three or more clinical signs (Graphic 3).

GRAPHIC 3 Distribution of the studied lovebird population based on the total number of clinical signs presented, other than FDB and self-mutilation.



Attending to the 49 birds with respiratory signs, 45.5% were presented with respiratory effort, 27.3% with tail bobbing, 21.2% with abnormal respiratory sounds, and only 6.0% with changes in voice or sneezing. Of the nonspecific signs noticed, the main one was lethargy (62.8%), followed by emaciation (14.0%) and coelomic distension (9.3%). Fluffed feathers (7.0%), anorexia (4.7%), and shivering (2.3%) were also noted to a lesser extent. In the dermatologic field, the patients exhibited pruritus and beak overgrowth as the main signals, representing both 27.3%, succeeded by altered feather pigmentation (18.2%), feather dystrophy (13.6%), hyperkeratosis (9.1%), and ultimately, pododermatitis (4.5%). The distribution of the main clinical signs recorded, based on their nature, is presented in Graphic 4.

GRAPHIC 4 Frequency of the main clinical signs recorded based on their nature.

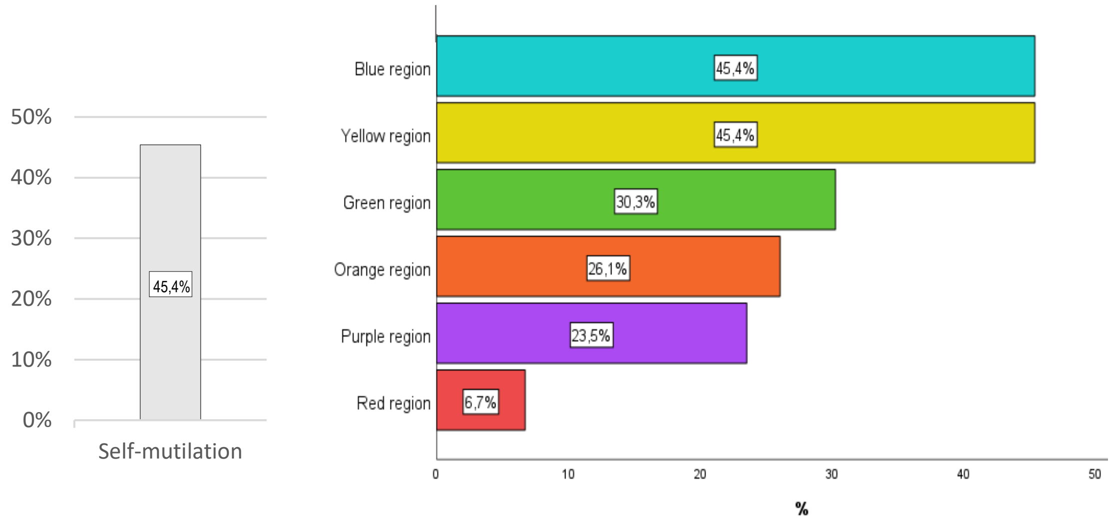


4.5. AREA OF DISPLAY

The frequency distribution of the areas in which the parrot displayed FDB is presented in Graphic 5. It can be observed that the blue region (neck and chest) and the yellow region (inner wing and axillaries) were the most frequently affected, both observed in 45.4% of the birds, along with self-mutilation. In succession, feather picking was seen on the green region (abdomen, flank and hind limbs) of 30.3% of patients, on the orange region (back and outer wing) of 26.1%, and on the purple region (rump and tail) of 23.5%. Only 6.7% of birds exhibited FDB on the cloaca (red region).

These results indicate a significantly higher prevalence of feather picking in certain areas ($X^2_{(6)}$ = 48.098, p <0.001), particularly in the blue and yellow region (Adjusted Res = 2.61), and with lower frequency in the cloaca (Adjusted Res = -4.86). The prevalence of self-mutilation (Adjusted Res = 2.61) was also shown to be high.

GRAPHIC 5 Prevalence of each area of FDB considered and of self-mutilation in the lovebird population studied.

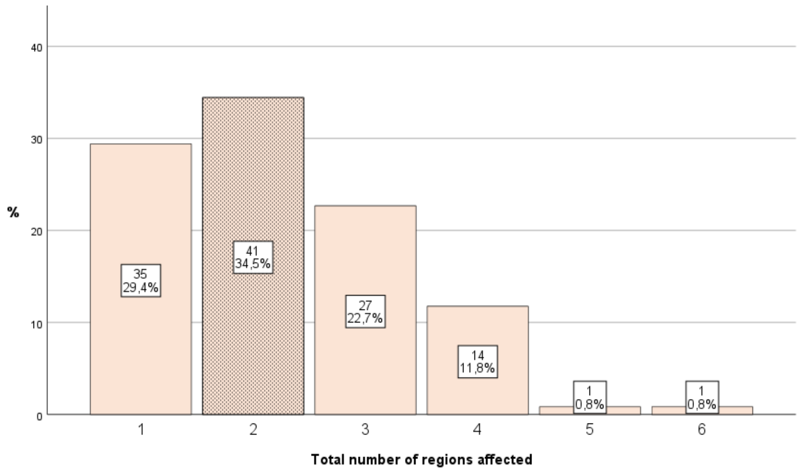


$X^2_{(6)}$ = 48.098 p<0.001;

Adjusted Residuals: Blue region, Yellow region, Self-mutilation = 2.61; Red region = -4.86

In Graphic 6, it is possible to observe that the most frequently reported situations were related to birds exhibiting two areas (34.5%) or only one area (29.4%) of feather plucking. After that, 22.7% of birds displayed FDB on three areas and 11.8% on four.

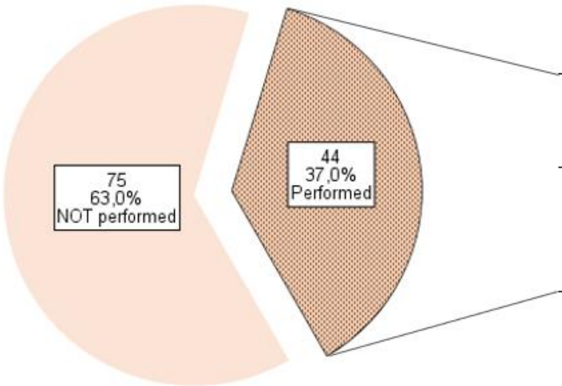
GRAPHIC 6 Distribution of the studied lovebird population based on the total number of regions affected.



4.6. DIAGNOSTIC TESTS

Out of the 119 birds in the sample, the majority, 63.0%, did not undergo any additional examinations, while 37.0% underwent at least one type of complementary exam. Specifically, 24.4% of patients were submitted to one diagnostic test, 6.7% to two diagnostic tests, 5.0% to three, and 0.8% to four (Graphic 7).

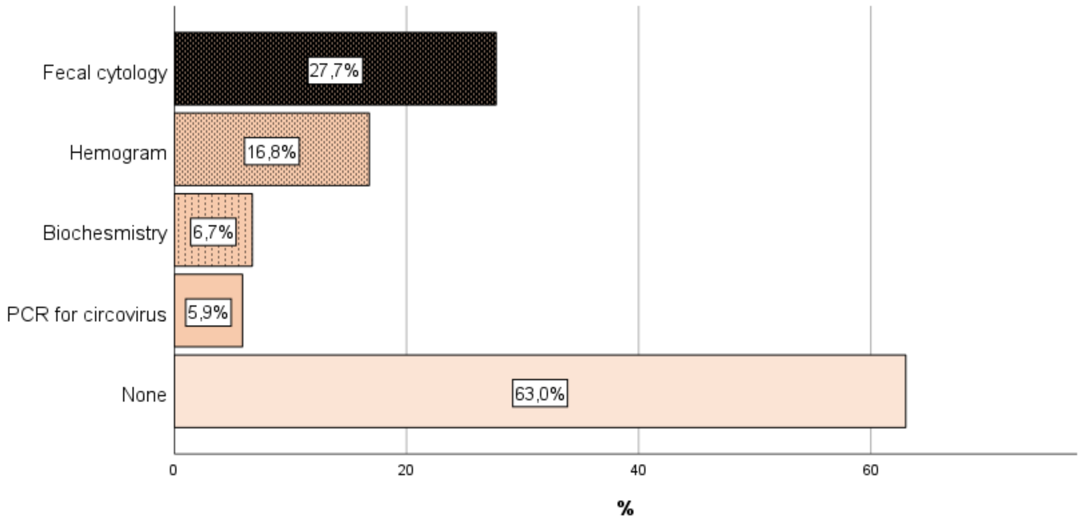
GRAPHIC 7 Diagnostic test performance and number of diagnostic tests performed.



Number of diagnostic tests performed	n	%
1	29	*24.4*
2	8	*6.7*
3	6	*5.0*
4	1	*0.8*

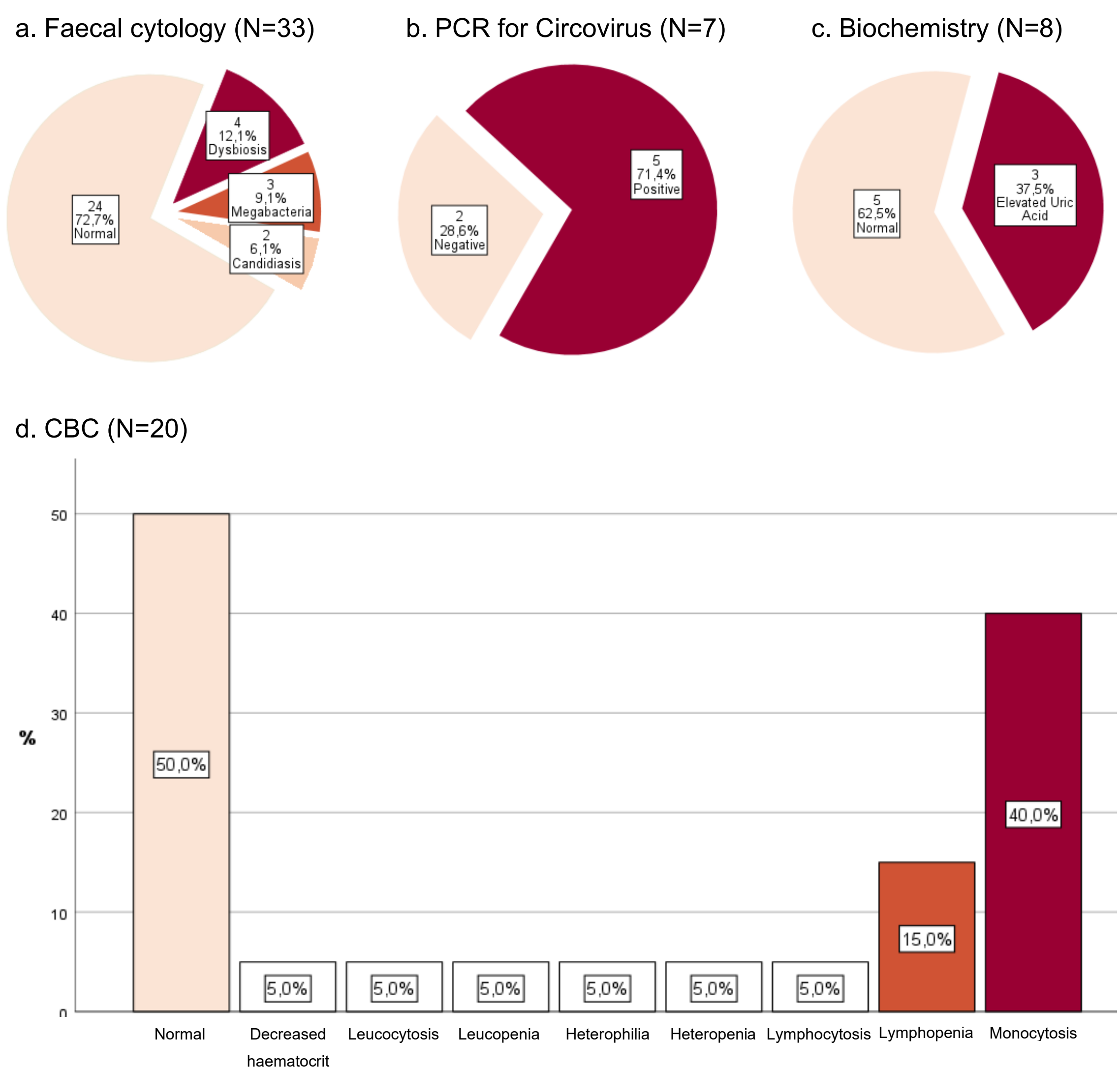
Faecal cytology was the most performed exam, with 27.7% (n=33) of the patients being submitted to it, followed by the CBC (16.8%). The least frequently performed tests were the biochemistry analysis, carried out in 6.7% (n=8) of the birds, and the PCR testing for circovirus, performed only in 5.9% (n=7) birds (Graphic 8).

GRAPHIC 8 Distribution of the studied lovebird population based on the type of diagnostic test performed.



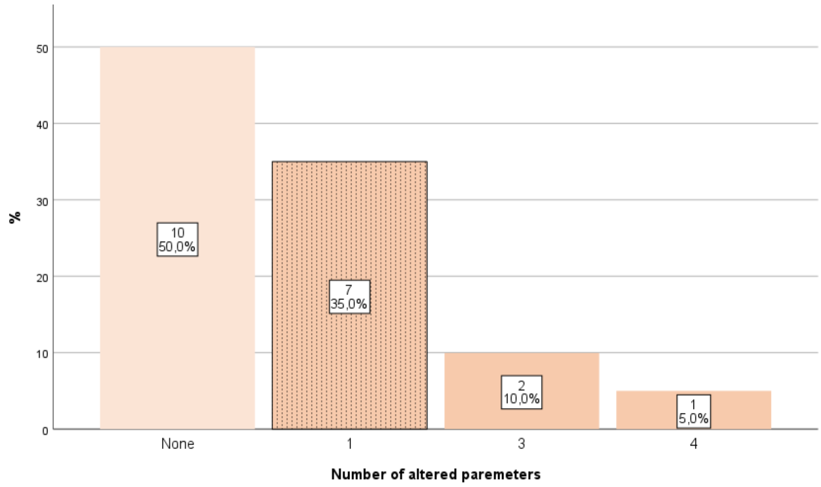
The results of complementary exams for the birds that underwent each type of diagnostic tests are shown in Graphic 9 (a, b, c, and d). From its analysis, it is observed that out of the 33 birds that underwent faecal cytology, 72.7% had no abnormalities, while dysbiosis was detected on 12.1%, megabacteria on 9.1%, and candidiasis on 6.1%. Regarding the PCR test for circovirus performed on seven birds, the majority, 71.4%, tested positive. As for the eight biochemical analyses, the only abnormality detected was elevated uric acid (UA), which was present in 37.5% of samples. Finally, out of the 20 CBC executed, a total of 50.0% (n=10) had no alterations in any of the parameters. Among the altered parameters, monocytosis was the most frequently detected, specifically in 40.0% (n=8) of the birds, followed by lymphopenia, which was present in 15.0% (n=3). Other changes to the CBC included lymphocytosis, heteropenia, heterophilia, leucopenia, leucocytosis, and decreased haematocrit, which were only present in 5% (n=1) of the birds each.

GRAPHIC 9 Diagnostic test results.



In general terms, it is also known that 37.0% of birds showed only one altered parameter to the CBC, 10.0% showed three, and 5.0% showed four (Graphic 10).

GRAPHIC 10 Distribution of the studied lovebird population based on the number of altered parameters to the CBC.



4.7. ASSOCIATION BETWEEN THE AREA OF DISPLAY AND THE CLINICAL SIGNS

In the Appendix A is presented the distribution of clinical signs according to the presence or absence of FDB in each considered area, along with the association analysis between each clinical sign and the manifestation of feather picking in the different regions.

Based on its interpretation it can be seen that FDB in the neck and chest (blue region) is 1.232 times higher for birds with respiratory signs (51.0%) than for birds without respiratory signs (41.4%), 1.287 times higher for birds with dermatologic signs (56.3%) than those without (43.7%), 1.507 higher for birds with neurologic signs (66.7%) than those without (44.2%) and 1.106 times higher for birds with otologic signs (50.0%) than those without (45.2%). These ratios are not statistically relevant, showing no evidence that respiratory signs (Wald $X^2_{(1)}$=0.582; p=0.445), dermatologic signs (Wald $X^2_{(1)}$=0.479; p=0.489), neurologic signs (Wald $X^2_{(1)}$=0.622; p=0.430), and/or otologic signs (Wald $X^2_{(1)}$=0.019; p=0.889) are associated to the development of FDB on the neck and chest region.

Furthermore, the absence of feather picking in the blue region was more prevalent in birds with GI and accessory gland signs (75.0%) compared to those without them (53.2%). Similarly, birds displaying nonspecific signs had a slightly higher absence of feather picking in the blue region (54.8%) compared to those without such signs (54.5%). However these differences proved to be statistically irrelevant, hence no evidence is found that the presence of GI and accessory gland signs (Wald $X^2_{(1)}$ = 0.760; p= 0.383) and of nonspecific signs (Wald $X^2_{(1)}$=0.000; p=0.983) is associated to the absence of FDB in the neck and chest area.

The prevalence of birds with reproductive signs that displayed FDB in the blue region was 0.0%, thus no calculation tests were conducted to test this association.

The same goes for the green region (abdomen, flank, and hind limbs) where the presence of GI and accessory gland sings (37.5%), dermatologic signs (43.8%), nonspecific signs (32.3%), and neurologic signs (33.3%) was shown to be higher than the absence of them, but no statistical relevance was found, and therefore no association could be seen. The absence of FDB in the green region was also higher in face of respiratory and otologic signs, but no association was detected between the presence of these signs and the inexistence of feather plucking in the abdomen, flank, and hind limbs. One the other hand, all patients that exhibited reproductive signs showed FDB in the green region, invalidating the performance of an association analysis due to this reductant value. Nonetheless, the ratio between these two variables was one of the highest in the study, indicating that the prevalence of FDB in the abdomen, flank, and hind limbs was 3.436 higher for birds with reproductive signs (100%) than for those without reproductive signs (29.1%).

In terms of FDB display in the orange region, no statistically relevant association was found between its presence or absence and the clinical signs studied. The same is true for the yellow and purple regions, as well as for self-mutilation.

Ultimately, the presence of feather picking in the cloaca area (red region) revealed to be 8.357 times more prevalent for birds with reproductive signs (50.0%) compared to those that did not exhibit them (6.0%). This ratio was proven to be statistically significant, which allows to state that the manifestation of FDB in the cloaca region is associated to the presence of reproductive signs (Wald $X^2_{(1)}$=3.944; p=0.047). No other association was seen for the remaining clinical signs in the red region, although the presence of GI and accessory glands signs for birds with feather picking in the cloaca (25%) was demonstrated to be considerably higher than the absence of them (5.4%).

5. DISCUSSION

Out of the 762 lovebirds (*Agapornis* spp.) seen in CVEP between the period of 2017 to 2022, 15.6% (n=119) were new cases of FDB that were included in this study. This prevalence can be considered high and falls upon the average registered in captive psittacine birds (Gaskins & Bergman, 2011; Kinkaid et al., 2013a; Costa et al., 2016a), although for lovebirds higher prevalences have been documented (Costa et al., 2016a; Ebisawa et al., 2021).

Sex predilection has been ambiguous between studies, with some stating that feather plucking is more prevalent among males (Jayson et al., 2014; Costa, et al., 2016a), while others refer female birds as the main affected (Garner et al., 2006; Van Zeeland et al., 2009). Kinkaid et al. (2013) and Gaskins and Hungerford (2014) both found the prevalence of FBD in parrots to be similar between sexes and this study aligns with their results, with the male exceeding the female only by 5%. However, in 47.9% of the birds studied the sex was unknown. Chitty (2005) defends that sex determination should be considered as a primary test for all FDB cases, as sex could be a significant factor in the occurrence of the condition, since skin hormonal regulation, sexual behaviours, and the impact of hand-rearing is different between males and females (Chitty, 2003a; Fox, 2006; Jayson et al., 2014).

Kinkaid et al. (2013) classified the bird's life stages as juvenile from fledging to the beginning of sexual maturation, adolescent in the period of sexual maturation, and adult after full sexual maturity is reached. In Guzman et al. (2023), the sexual maturity of lovebirds is put between six and 12 months. The results of this study are in accordance to previous ones where FDB seems to appear once sexual maturity is reached, increasing with age and being more common in young adults, with all the birds being over 12 months and up to half having between one and three years of age (Gaskins & Bergman, 2011; Kinkaid et al., 2013a; Ebisawa et al., 2021). These results could confirm the theory of a hormonal implication to the development of feather picking, or, as Ebisawa et al. (2022) suggested, the increased probability of encountering stressful events (e.g., change of home, loss of a companion) that could trigger FDB with age.

The weight of lovebirds recorded is in agreement with the average for this species (49 g) (Guzman et al., 2023), excluding issues such as obesity or emaciation from the list of suspects for FDB development in this study.

Seasonality seemed to be an important factor, with summer and winter revealing to be the seasons in which FDB most occurred and proven to be statistically relevant ($X^2_{(3)}$ = 13.538; p = 0.004). In the African wilderness, lovebirds experience two seasons with steady temperatures, one rainy and one dry. In the rainy season, they are known to engage in breeding behaviours and in the dry season they initiate their shed after raising of the young, so precipitation seems to be an importance regulator for their reproductive and moulting cycles (Warburton & Perrin, 2005;

Ndithia et al., 2007; Mzumara et al., 2018). In Portugal, summer and winter exhibit the most extreme weather conditions, with the former being considered as dry and the latter as rainy, although with varying temperatures. In our homes, pet birds may not experience the full range of climate changes. This, associated with artificial lighting and temperature, may lead to breeding and moulting cycles occurring throughout the year. Nevertheless, considering these findings, one could postulate that changes in humidity (that may impact the health of the feather coat), initiation of breeding and moulting cycles (with the beginning and ceasing of the rain, and changes in daylength), and, possibly, heightened allergen levels during the summer season, could plausibly be associated with the development of FDB.

In terms of historical findings, essentially two-thirds of lovebirds in this study were found to consume a diet based entirely of seeds. This seed-based diet is considered multideficient. Commercially available seeds do not possess nutrient profiles remotely comparable to those found in wild seeds, lacking essential amino acids, such as lysine and methionine, and containing excessive omega-6-fatty-acids (McDonald, 2006; Péron & Grosset, 2014). Additionally, seeds are also found to be deficient in vitamins A, D3, E, K, B7, and B12 and are known to have a poor Ca/P ratio (Hess et al., 2002; McDonald & Harrison, 2006). Adding fresh produce to the seed-based diet does not completely solve the nutritional problem, as finding the right proportion of fruits and vegetables, that mimic those found in the wild and compensate the seeds' multiple nutrient deficiencies, can be difficult. In the wild, birds' diets are dependent on the available seeds and plants that grow throughout the year, providing them a balanced nutrition. In captivity, birds have demonstrated a limited ability to make healthy dietary choices independently, often opting for high energy (sugary and fatty) food sources, such as seeds and fruit, instead of available options that better suppress their nutritional needs. For this reason, it is vital to inform the owners about the nutritional inadequacy of seed-based diets, even when complemented with fruits and vegetables. Deficiencies in methionine, biotin, and choline have been associated with hepatic lipidosis and obesity, which are commonly seen in parrots fed an high-fat diet primarily consisting of seeds and nuts (McDonald & Harrison, 2006). Besides this, the high lipidic content with low polyunsaturated fatty acids of seeds can also predispose birds to atherosclerosis (Bain, 2012). Conversely, the presence of a-linoleic acid in common seed-mixtures can also put the bird at risk of this vascular disease (Péron & Grosset, 2014). Ultimately, the unbalanced nutrition provided by seeds may also immunocompromise the avian patient. Hypovitaminosis A is frequently seen in parrots with an all-seed diet and can affect the protective function of the mucosal barriers, predisposing the animal to GI, urogenital, and respiratory infections (aspergillosis and chlamydiosis) (Pendl & Tizard, 2016). Squamous metaplasia can further cause dermatological and renal diseases (Péron & Grosset, 2014; Zsivanovits & Monks, 2016). Hypocalcaemia, metabolic bone disease and egg binding are also possible complications from a seed-based diet (McDonald, 2006; Weston & Memon, 2009). Many of the clinical findings in this study, as well as the appearance of FDB, could therefore be explained by malnutrition.

Formulated diets can pose a healthy alternative for the nutrition of captive birds. High quality uniform pellets are completely based on the parrot's nutritional needs and eliminate the problems caused by parrots selective feeding behaviours. Specific formulations based on different energy and nutrient requiring stages of the birds' life are also emerging, but the aim should still be to provide a good quality diet all year round (McDonald & Harrison, 2006; Péron & Grosset, 2014). The recommended proportions for a daily diet of psittacines consists of 75% pelleted food along with 25% of fresh produce (fruits and vegetables) (Brightsmith, 2012). A good quality diet associated with foraging techniques can improve the birds' overall health and prevent physiological and behavioural disorders, such as feather picking (Péron & Grosset, 2014).

Enhanced reproductive behaviour at the time of FDB onset was referenced in 30.3% of cases. These included cases where the reproductive displays were directed towards the owner or toys. Feather plucking may surface to reduce arousal and stress in socially and sexually frustrated birds, particularly among parrots that have imprinted on humans, or that simply lack a suitable same-species partner. Furthermore, potentially increased hormone levels attributed to suboptimal conditions within our households, such as inadequate photoperiods and diets, may also lead to sexual displays and FDB through similar pathways (Chitty, 2003b).

Following that, 26.9% of owners remarked presence of aversive stimuli, such as changes in the environment and a tumultuous setting, coinciding with the start of FDB, similar to the findings of Jayson et al. (2014). In addition, up to 20% of lovebirds in this study had poor cage conditions, inappropriate photoperiods, no form of entertainment or were not allowed to fly. These results highlight the importance of educating parrot owners about proper husbandry practices, not only to avoid these situations that can be related to the appearance of FDB, but also to improve the overall health and quality of life of the avian patient.

Hand rearing and trauma episodes, although in minority, were detected and may also be risk factors for the development of feather picking. In 10.1% (n=12) of the studied cases, haemorrhagic episodes were mentioned in the consultation as a consequence of FDB. Some of these episodes lead to the consultation itself and left the bird severely debilitated, potentially posing a life-threatening situation if not treated promptly. Remarkably, only 10% of the patients had no clinically relevant history that could either contribute to the development of FDB or be caused by it. Considering this, its fundamental to focus on the prevention of feather destructive behaviour, since environmental factors known to trigger this condition have been extensively described, and significant health risks can result from this disorder.

More than half (57.1%) of lovebirds in this study showed clinical signs other than FDB. Of the statistically significant tendencies observed ($X^2_{(6)} = 109.569$; $p < 0.001$), respiratory signs (Adjusted Res = 7.95) and nonspecific signs (Adjusted Res = 3.53) were proven to be displayed more frequently. Respiratory effort, tail bobbing, audible respiratory noises, abnormal air sac auscultation, changes in voice, and sneezing were among the respiratory signs observed, while the nonspecific signs consisted of lethargy, emaciation, coelomic distension, fluffed feathers, anorexia, and shivering. Respiratory disease can be a cause or a consequence of feather picking, or may simply appear as a concomitant condition, given its prevalence among pet birds. Respiratory signs are usually attributed to air sacculitis and/or pneumonia (Girling, 2005). Nonspecific signs, such as lethargy, anorexia, emaciation, and fluffed feather, as well as voice changes and increased respiratory effort and sounds are commonly noted in pneumonia (Strunk, 2016). Abnormal air sac noises, such as friction rubs, are frequently associated with air sacculitis (Harrison et al., 2006a). Air sacculitis is preponderantly associated with *Aspergillus* spp., *Mycoplasma* spp., and *Chlamydophila psittaci* infections (Girling, 2005). Aspergillosis is the most common avian respiratory disease and all pet birds are susceptible to it (Arca-Ruibal, 2016; Redig, 2016). It is mainly a condition of the respiratory system, generally involving air sacculitis and extension to the lungs (Phalen, 2000; Beernaert et al., 2010). The clinical signs are usually nonspecific (lethargy, weight loss) and respiratory (harsh breathing sounds on auscultation, change in vocalization, dyspnoea), though the latter may only become evident in late stages of the disease (Tell, 2005; Phalen, 2006b; Costanzo, 2016). Infection by *Aspergillus* spp. should therefore be considered as a differential diagnosis for most respiratory and systemic diseases (Jones & Orosz, 2000) and as a cause or consequence of FDB. The discomfort caused by the *Aspergillus* spp. granulomatous lesions is hypothesised to induce FDB over the site of injury (Weller & Phalen, 2012). Aspergillosis usually comes as an opportunistic disease in birds, meaning some form of immunosuppression (e.g., circovirus infection, malnutrition, poor husbandry, stress, toxins) is usually at play at the time of infection (Jones & Orosz, 2000; Girling, 2005). Owing to the high energetic demand of constant feather regrowth and the loss of coverage against climatic conditions, FDB can act as an immunosuppressant, consequently predisposing the affected bird to secondary infections.

Chlamydiosis is also a common opportunistic disease in pet parrots (Arca-Ruibal, 2016). Clinical signs can too be nonspecific and vary according to the bird's species and age, as well as the virulence of the *Chlamydophila* strain, but the respiratory system is frequently involved (Phalen, 2006b; Schnee et al., 2018). In captive birds the most frequent signs encountered are lethargy, weight loss, ocular and nasal discharge, sneezing, diarrhoea, biliverdinuria, and respiratory distress (Andersen & Franson, 2007; Schnee et al., 2018). In chronic conditions the bird will have an unthrifty appearance and a poor feather coat (Ravichandran et al., 2021). A survey of “avian chlamydiosis as it is seen by avian veterinarians in the world” reported the diagnosis of chlamydiosis to be made most often by the detection of respiratory signs, feather damaging behaviours, poor feather condition, and oculonasal signs (Wellehan et al., 2016).

Mycoplasma spp. are also known to cause upper respiratory signs, such as sneezing and sinusitis (Girling, 2005). Intense pruritus was detected on a parrot with sinusitis leading to self-damage of the feathers and skin of the head (Chitty, 2003a).

Opportunistic bacteria, such as *Pseudomonas aeruginosa, Pasteurella multocida,* and *E.coli,* may also cause respiratory disease in psittacine birds secondary to airborne irritants (Girling, 2005). Other predisposing factors to respiratory disease include hand rearing, systemic disease, immunosuppression, poor husbandry (malnutrition, unhygienic environment), and stress (Strunk, 2016). This shows that many conditions that lead to feather plucking are intertwined with those causing respiratory disease. As mentioned before, hypovitaminosis A, a common problem of birds on an all-seed diet, promotes squamous metaplasia of the mucous membranes and directly affects the respiratory tract immunity. The altered barrier function of the respiratory epithelium, as well as the build-up of keratinised debris along the airways, can create a favourable environment for the development of secondary infections, particularly aspergillosis (Girling, 2005; Harrison et al., 2016a). Poor hygiene, as seen in some cases of this study, and poor ventilation, can result in high concentrations of ammonia, destroying the trachea cilia and putting the bird at risk of respiratory infections (Meehan & Mench, 2006; Phalen, 2006b; Magno, 2016)**.** Besides the risk of feather destructive behaviour, exposure to smokes and other airborne toxins (e.g., scented candles, air fresheners, air products, cooking and cleaning fumes) can also irritate and damage the respiratory tract and compromise the local immune system (Harrison et al., 2006a; Lightfoot & Yeager, 2008; Kubiak, 2015). Ammonia and other inhalable respiratory irritants can cause upper respiratory signs, including coughing, sneezing, rhinitis and conjunctivitis (Richardson, 2006).

Chronic heavy metal toxicosis is a possible aetiology for systemic and respiratory disease. Gastrointestinal, urologic, and neurologic signs may also be seen (Clippinger & Platt, 2000; Frazier, 2000; Desmarchelier, 2016; Wismer, 2016). Lead ingestion can lead to immunosuppression and further secondary infections (Wismer, 2016). While zinc toxicosis is believed to be underdiagnosed in many cases, the diagnosis of this condition in FDB birds is considered to be excessively frequent (Lawrie, 2005). However, the accessibility to zinc materials (e.g., zinc coated cage bars) and the parrots' inquisitive nature makes intoxication always a possibility (Lawrie, 2005).

Space-occupying coelomic conditions, such as egg-binding, can restrict respiratory movements and cause respiratory distress (Girling, 2005; Harrison et al., 2006a). Lethargy, anorexia, coelomic distension, and hind limb weakness may also be seen with prolonged dystocia (Chen, 2016). This reproductive disease is common in lovebirds fed seed-based diets, and can also be related to the onset of FDB (Chitty, 2003b; Harrison et al., 2006b). In this study, however, egg-binding was shown to be displayed less frequently (1.7%) and probably did not account for the respiratory and nonspecific signs observed.

Haemorrhagic episodes, malnutrition, and lead poisoning could be sources of anaemia, also giving rise to nonspecific signs and respiratory changes (tachypnoea) (Girling, 2005; Cervasio, 2016). Chronic mycobacteriosis, and avian poxvirus may also be considered for the respiratory, dermatologic and nonspecific signs presented (Koski, 2002; Forrester & van Riper, 2007; Lennox, 2016). Renal and pancreatic disease and PaBV infections may produce only nonspecific signs and can also be associated with FDB (Doneley, 2001; Lierz, 2016).

Despite the fact that neurological signs seemed to appear less frequently in this study (5%), their presence can potentially be attributed to occasional occurrences in cases of bacterial, viral, and fungal respiratory infections, as well as respiratory toxicities (Guzman, 2016). Neurologic signs such as tremors, torticollis and ataxia, may be exhibited in *Aspergillus* and *Chlamydophila* infections (Wellehan et al., 2016). Atherosclerosis, a condition also linked to FDB, may present as combination of respiratory, neurologic, and nonspecific signs, although antemortem diagnosis proves to be difficult (St Leger, 2008). In addition, atherosclerosis typically affects older birds, which does not align with the median age of the population in this study.

The main dermatologic signs encountered in this study were pruritus and beak overgrowth, followed by altered feather pigmentation, feather dystrophy, and, to a lesser extent, hyperkeratosis and pododermatitis. These signs could potentially be attributed to a range of factors, including nutritional deficiencies, hepatic disease, parasitic infestations, and viral infections, as well as suboptimal husbandry practices, traumatic injuries, and toxic exposures (Olsen, 2000; Gill, 2001; Koski, 2002; Harrison et al., 2006a). Poor feather condition (pigment changes, depigmentation, stress bars, FDB) and beak overgrowth are a common encounter in chronic hepatic disease (Davies, 2000; Grunkemeyer, 2010; Wellehan et al., 2016). Other signs of hepatopathy, also noted in this study, include biliverdinuria and nonspecific signs (lethargy, inappetence, and weight loss) (Harrison et al., 2006b; Wellehan et al., 2016). Furthermore, consequences of liver disease, such as hepatic enlargement and ascites, can also restrict respiratory movements and cause dyspnoea (Welle, 2016). A pruritic condition with dermatitis and feather loss on the abdomen related to hepatic disease has also been postulated (Koski, 2002; Orosz, 2006; Rubinstein & Lightfoot, 2012). The high fat and low nutrient content of an all-seed diet contributes immensely for the development of hepatic disorders, which makes this a very common conditions in birds (Harrison et al., 2006b; Park, 2006; Welle, 2016). Whether beak and nails deformities are a direct consequence of hepatic disease or simply another sequela of nutritional disease remains unclear (Olsen, 2000). Chronic malnutrition interferes with the moulting process and the normal feather growth, causing a variety of feather dystrophies (Rubinstein & Lightfoot, 2012; Schoemaker & van Zeeland, 2016). An inappropriate diet is considered the main reason for generalised depigmentation or altered pigmentation of the bird's feathers (Koski, 2002; Van Zeeland & Schoemaker, 2014a). Hyperkeratinisation caused by vitamin A deficiency can also impact the health of the feet skin and lead to pododermatitis (Péron

& Grosset, 2014). Clinical signs of nutritional imbalances involving the integumentary system also include beak and nails overgrowth (Koski, 2002; Péron & Grosset, 2014).

Abnormally pigmented and dystrophic feathers are also documented in the chronic form of circovirus infection (Orosz, 2006; Raidal, 2012; Wellehan et al., 2016; Langlois, 2021). Beak dystrophy can occur with this infection, although it usually only affects cockatoos (Gill, 2001). In fact, some argue that the name psittacine beak and feather disease (PBFD), given to the disease caused by circovirus (PBFDV), may be misleading since the beak is rarely affected in non-*Cacatua* spp. (Rubinstein & Lightfoot, 2012). Secondary infections due to immunodeficiency and nonspecific signs (failure to thrive, lethargy) are also associated with PBFD (Schmidt et al., 2016a). Since the disease can mimic and possibly cause feather damaging behaviour due to the progressive feather dystrophy and loss, PCR testing should be considered for old world species, as the virus seems to affect them the most (Orosz, 2006). Avian polyomavirus infection can likewise result in feather dystrophy and should additionally be ruled out (Rubinstein & Lightfoot, 2012; Langlois, 2021).

Knemidokoptes spp. mite infestation in parrots can be a cause of beak growth abnormalities and honeycomb-like hyperkeratosis in apteria regions (e.g., feet, eyelids) (Olsen, 2000; Gill, 2001; Wernick, 2016; Worell, 2016), although no mites were detected in the patients included in this study.

Constant trauma to the feather can result in damage to the follicle and impaired regrowth, either by the feather destructive behaviour itself or by other aggression sources (Schoemaker & van Zeeland, 2016). Additionally, in young birds, hand rearing can induce trauma to the growth areas of the beak, resulting in deformities such as scissor occlusion and overgrowth (Olsen, 2000). Incorrect beak trimmings may interfere with the normal beak development (Olsen, 2000). Additionally, but less frequently, lack of abrasive materials, bacterial or fungal infections, neoplasia (squamous cell carcinoma), and possible genetic causes can be related to beak overgrowth (Olsen, 2000; Gill, 2001; Koski, 2002; Worell, 2016).

Despite the challenges of assessing pruritus, which can be subjective and often unproven, it is still commonly regarded as a clear trigger for FDB. In fact, most feather plucking psittacine owners describe the bird to be pruritic, and in this study, pruritis constituted 27.3% of the dermatological clinical findings (Rosenthal et al., 2004). Hypersensitivity reactions have been proposed has the primary suspect in the pruritic condition seen in feather picking or self-mutilating birds (Garner et al., 2008; Nett-Mettler, 2013). While progress is being achieved in diagnostic testing for allergies in parrots, the role of pruritus, allergies, and hypersensitivity on the development of FDB is yet to be defined (Colombini et al., 2000). Secondary skin infections can come as a consequence or a cause of FDB and can also be extremely pruritic (Lightfoot & Schmidt, 2006; Orosz, 2006). In lovebirds, CUD and polyfolliculitis are common and can cause intense pruritus, with the latter also being accountable for feather dystrophy (Koski, 2002; Lightfoot & Schmidt, 2006).

Evaluating the area of display for each lovebird included in the present study revealed a higher prevalence of FDB in certain regions ($X^2_{(6)}$ = 48.098; $p < 0.001$), particularly in neck and chest (blue region) and in the internal face of wings and axillary area (yellow region) (Adjusted Res = 2.61). These areas coincide with those commonly affected in lovebirds with CUD (patagium, neck, back and axillary regions) (Lightfoot & Schmidt, 2006). Furthermore, no association was seen between the predominantly affected areas of this study (blue and yellow regions) and the clinical signs exhibited by the birds, possibly suggesting an idiopathic origin to the feather destructive behaviour, like CUD. The prevalence of self-mutilation (45.4%) was also shown to be high in this study and to have no association with any specific disease process. This can further suggest idiopathy, particularly since mutilation of the skin is a key component of CUD.

The only statistically relevant association found was between the area of the cloaca (red region) and the presence of reproductive signs (Wald $X^2_{(1)}$=3.944; p=0.047), which in this study corresponded solely to dystocia cases. This is understandable, given that prolonged straining, in an attempt to relieve dystocia, may traumatize the cloaca, and even cause it to prolapse in some cases (Chen, 2016; Taylor, 2016). The presence of feather picking in the cloaca was also shown to be higher in patients with GI and accessory gland signs than those without them. It is reasonable to consider that the bird might instinctively attempt to alleviate GI tract discomfort through the cloaca, given the close proximity and interconnectedness of these anatomical structures. Additionally, disorders of the digestive system, like enteritis, can extend to the cloaca, making it the direct source of pain or pruritus (Sandmeier, 2016).

The prevalence of FDB in the abdomen, flank, and hind limbs (green region) in the presence of reproductive signs (100%), agrees with the findings of Bowles (2003), where feather picking in the breast, abdomen, and legs was related to the breeding season. During the culmination phase of the breeding cycle, birds were also commonly seen pecking at the synsacrum, as well as the lateral thighs and flanks (Orosz, 2006).

Even though data was collected from the moment lovebirds first presented with FDB to the clinic, the majority of birds was already picking feathers in two different regions, with some even displaying damaged feathers throughout the whole body. Cases where the owner brought in the birds for other reasons and FDB was firstly noticed at the time of consultation were included in this study, so it is possible that the condition was going on for longer and caught at a more advanced stage. On the other hand, these results could indicate a rapid development of feather picking.

Regarding the diagnostic test findings, from the 33 faecal cytologies performed to evaluate the GI flora of the lovebirds in the study, only 27.3% had alterations. High levels of gram-positive rods or cocci (dysbiosis), *Macrorhabdus ornithogaster* (Megabacteria), and budding yeast (Candidiasis), were seen in 12.1%, 9.1% and 6.1% of the birds, respectively. None of these should be present in the Gram's stain of the healthy birds (Sandmeier, 2006). The normal GI flora of parrots includes low levels of gram-positive rods or cocci (Harrison, 2003; McDonald & Harrison, 2006). High numbers of these bacteria reflect an imbalance in the intestinal microflora and, depending on the bird's immune status, are capable of causing disease (McDonald & Harrison, 2006). Gram-negative rods should also not be detected in the normal birds' faecal cytology, as the natural resident microbiota helps maintain an inhospitable acidic environment for these bacteria (Harrison, 2003; McDonald & Harrison, 2006). A balanced diet is also crucial in preserving the GI homeostasis (Glunder, 2002; Stanford, 2003). Nutritional deficiencies and hepatic disease are associated with dysregulations of the microbial population seen in faecal Gram's stains (McDonald & Harrison, 2006). Transition from a seed-based diet to a nutritionally adequate one was shown to nearly eradicate gram-negative bacteria found on faecal cytologies of African grey parrots (Stanford, 2003). Malnutrition can further influence the integrity of the GI wall, facilitating the penetration of bacteria and predisposing the bird to infections, sepsis, and even death (McDonald & Harrison, 2006).

Yeast are part of the normal flora of the bird's digestive system, but can also act as opportunistic agents (Velasco, 2000; McDonald & Harrison, 2006; Campbell & Grant, 2022a). Large quantities of budding yeast serve as diagnosis for a *Candida* spp. infection (McDonald & Harrison, 2006). Candidiasis affects particularly birds suffering from GI dysbiosis and immunosuppression (Campbell & Grant, 2022a). The greater the number of budding yeast found, the more compromised the patient's immune system might be (McDonald & Harrison, 2006). FDB may therefore act as a predisposing factor to this condition.

There is some uncertainty as to whether *Macrorhabdus ornithogaster* represents a pathogenic or a commensal organism in birds (Phalen, 2014). Lovebirds are among the species most commonly infected with this organism. Concurrent circovirus infections have been associated with megabacteriosis, and may play a role in the development of disease (Phalen, 2016b).

Out of the seven circovirus PCR tests conducted on the lovebirds studied, 71.4% yielded positive results. The detection of this virus in this study may be coincidental, since circovirus is widespread in lovebirds (Lightfoot & Schmidt, 2006; Phalen, 2016a). Nonetheless, it is also possible that circovirus infection played a role in the development of FDB or contributed to the onset of immunosuppression, which could potentially explain other clinical signs observed in this study. The misdiagnosis of FDB in birds suffering from PBFD is also a possibility. In Caldas (2021), a lovebird initially diagnosed with feather picking in CVEP, displaying beak overgrowth and feather loss, was later confirmed to have a chronic PBFDV infection. In peach-faced lovebirds (*Agapornis roseicollis)* with CUD, a condition that might be relevant to the FDB areas of display encountered in this study, APV was detected in over half of the birds and PBFDV in approximately 20%. In the same study, APV and PBFDV were found in 16% and 65%, respectively, of the birds exhibiting featherless syndrome (Cornelissen et al., 2001). Although the number of tests included in this study were low, circovirus, as well as polyomavirus, should be considered for lovebirds presented with FDB, as suggested by previous authors (Jenkins, 2001; Orosz, 2006; Langlois, 2021).

Of all the biochemical analyses performed, the only altered parameter corresponded to the increased UA levels seen in three of the cases. Renal disease, sometimes due to heavy metal toxicity or nutritional imbalances, can lead to hyperuricaemia, although severe dehydration may also be considered (Pollock, 2016; Schmidt et al., 2016b). A follow-up analyses would be necessary to take conclusions about this data, namely a remeasurement of the UA value after rehydration of the animal, information that the author does not have access to, with this being a point in time (i.e., at the appearance of the FDB) study.

Half of the CBCs revised in this study were completely normal. In cases of feather picking the CBC frequently remains unaltered, however, when deviations do occur, they usually manifest as increased leucocyte counts with heterophilia or as anaemia due to blood loss (Orosz, 2006). Monocytosis consisted of the main finding (40%) within the altered parameters. An elevated WBC count with monocytosis it typically seen in chronically ill feather picking patients (Chitty, 2003a; Orosz, 2006). Despite the effort to gather information regarding the early stages of FDB, the presence of underlying disease processes and the tendency to seek clinical care only in severe cases of feather plucking or when other clinical signs were manifesting, could have played a significant role in the chronic changes observed. Monocytosis in avian patients is commonly linked to granulomatous inflammation, often resulting from *Mycobacterium* spp., *Chlamydophila* spp., and *Aspergillus* spp. infections (Campbell & Grant, 2022b). In Weller and Phalen (2012), monocytosis was noticed in all cases reported of FDB birds diagnosed with aspergillosis, so a similar situation could be affecting this study. Lymphopenia was noted in 15% of the cases in this study. While a viral aetiology has been proposed for the decrease in this WBC line, it is not well-documented in birds (Schoemaker et al., 2000). A decrease relative to other elevated blood cell types (e.g., monocytes) is a more plausible explanation for the observed lymphopenia in cases of infectious and inflammatory diseases (Bale et al., 2020).

Overall, few complementary exams and, consequently, few definitive diagnoses, apart from FDB itself, were made for the lovebirds included in this study. As data collection was limited to the time of FDB initial presentation, no information regarding subsequent diagnostic testing and the eventual treatment of other conditions, with possible concurrent resolution of FDB, was analysed. Consequently, any causal relationship between feather picking and any underlying disease process remains purely speculative.

The retrospective nature of this study facilitates the loss of valuable details, especially when regarding the patient's medical history. Moreover, the inclusion of cases where FDB went unnoticed by the owner until consultation, allowed for ambiguity concerning the timing of FDB onset among patients and potentially interfered with the results, thereby probably rendering this study's depiction of the initial clinical presentation of FDB in lovebirds inaccurate in part.

6. CONCLUSION

Feather damaging behaviour is a common condition appearing in the exotic animal practice, as it frequently affects pet parrots, particularly lovebirds. This behaviour can significantly impact the bird's quality of life and potentially put the bird at risk of immunosuppression, secondary infections, trauma, and even severe haemorrhage. To this date, feather picking continues to be considered a multifactorial disorder, with socioenvironmental, medical, and internal factors thought to be involved, although no definitive causal relationship has been established. An extensive diagnostic work-up is therefore required for each case and the treatment should prioritize addressing the underlying issues, as psychoactive agents and physical restraint alone are insufficient for an effective management of the condition.

In this study, seasonality seemed to be related to the onset of FDB, which could be attributed to the beginning of breeding and moulting cycles, changes in humidity, and possibly the presence of allergens in the summertime. Historical findings potentially related to feather picking were also substantially prevalent. A seed-based diet remains one of the major health debilitants of birds in captivity and was found in 66.4% of the lovebirds studied. The nutritional imbalances deriving from this diet can affect practically all bodily systems, potentially resulting in metabolic, hepatic, renal, respiratory, urogenital, dermatologic, GI, cardiovascular, and reproductive diseases. Hence, it is not surprising to observe its association with FDB in both this and prior research studies. A balanced formulated diet complemented by daily consumption of fresh produce could offer a healthy dietary alternative for captive psittacines. Reproductive displays towards the owner or toys were also prevalent in this study in association to the beginning of FDB. This, coupled with the presence of aversive stimuli (a tumultuous environment and sudden changes to it), as well as suboptimal husbandry practices identified in relation to feather picking, underscores the pressing concern of parrots being kept in inadequate conditions within our households. Parrots are extremely intelligent and sensitive creatures that require constant care, entertainment, space to fly, a good diet, and a safe environment with light periods, resources, and social conditions similar to those found in their natural habitats. Educating the owners about the correct settings in which to have a pet psittacine is of utmost importance to prevent health and behavioural issues, such as FDB. Additionally, implementing foraging and training techniques can be tremendously beneficial to the bird.

More than half of the lovebirds in this study showed clinical signs other than FDB, with respiratory signs being the main encountered. Respiratory disease could be a consequence or cause of feather picking, as opportunistic agents, such as *Aspergillus* spp. and *Chlamydophila* spp. could take advantage of the debilitated FDB-birds' immune system or be a source of discomfort, possibly playing a primary role in its development. The dermatologic signs observed in this study further suggested nutritional, hepatic, and viral causes. However, no diagnosis could be made by the clinical examination alone, as further complementary exams would be needed (Raftery, 2005). Thoroughly investigating the potential causes of feather plucking, especially when accompanied by other clinical signs, is, once again, crucial to better understand and effectively treat the condition.

In lovebirds, engaging in feather picking could also be linked to idiopathic causes, such as CUD. The occurrence of this affliction is suggested in this study by the main areas of FDB displayed (chest, neck, inner surface of the wings, and axillary regions) and the high prevalence of self-mutilation, which were unrelated to any of the clinical signs encountered. In the present analysis, a statistically relevant association was only found between feather picking in the cloaca and a dystocia case. This finding further implies the existence of medical factors tied to the emergence of FDB, particularly in certain areas. However, further studies are warranted to substantiate it.

Ultimately, the results found in this study insinuate the implication of circovirus in FDB cases of lovebirds. Circovirus and polyomavirus infections are widespread among lovebirds and the clinical signs associated with these can closely resemble those of feather plucking birds. In lovebirds, APV and PBFDV were additionally related with CUD and feather-less syndrome. PCR testing for circovirus and polyomavirus is therefore advised for lovebirds presenting to the consultation with feather loss and damage to the feathers and skin.

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APPENDIX A – DISTRIBUTION AND ASSOCIATION ANALYSIS BETWEEN THE AREA OF DISPLAY OF FDB AND THE CLINICAL SIGNS

Clinical signs \ Area of display			Blue region		Green region		Orange region		Yellow Region		Red region		Purple region		Self-mutilation	
			Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Respiratory	Yes	n	25	24	12	37	12	37	27	22	5	44	13	36	19	30
		%	51,0	49,0	24,5	75,5	24,5	75,5	55,1	44,9	10,2	89,8	26,5	73,5	38,8	61,2
	No	n	29	41	24	46	19	51	27	43	3	67	15	55	35	35
		%	41,4	58,6	34,3	65,7	27,1	72,9	38,6	61,4	4,3	95,7	21,4	78,6	50,0	50,0
		B	0,208			0,336		0,103	0,357		0,868		0,214			0,254
		Wald $X^2_{(1)}$	0,582			0,906		0,078	1,717		1,411		0,318			0,796
		p	0,445			0,341		0,780	0,190		0,235		0,573			0,372
		Exp(B)	1,232			1,400		1,108	1,429		2,381		1,238			1,289
GI and accessory glands	Yes	n	2	6	3	5	1	7	3	5	2	6	1	7	3	5
		%	25,0	75,0	37,5	62,5	12,5	87,5	37,5	62,5	25,0	75,0	12,5	87,5	37,5	62,5
	No	n	52	59	33	78	30	81	51	60	6	105	27	84	51	60
		%	46,8	53,2	29,7	70,3	27,0	73,0	45,9	54,1	5,4	94,6	24,3	75,5	45,9	54,1
		B		0,628	0,232			0,771		0,203	1,531			0,666		0,203
		Wald $X^2_{(1)}$		0,760	0,148			0,575		0,117	3,518			0,427		0,117
		p		0,383	0,700			0,448		0,732	0,061			0,513		0,732
		Exp(B)		1,874	1,261			2,162		1,225	4,625			1,946		1,225
Dermatologic	Yes	n	9	7	7	9	3	13	6	10	0	16	7	9	3	10
		%	56,3	43,8	43,8	56,3	18,8	81,3	37,5	62,5	0,0	100,0	43,8	56,3	37,5	62,5
	No	n	45	58	29	74	28	75	48	55	8	95	21	82	48	55
		%	43,7	56,3	28,2	71,8	27,2	72,8	46,6	53,4	7,8	92,2	20,4	79,6	46,6	53,4
		B	0,253		0,441			0,371		0,217			0,764			0,217
		Wald $X^2_{(1)}$	0,479		1,095			0,374		0,252	(a)		3,061			0,252
		p	0,489		0,295			0,541		0,616			0,080			0,616
		Exp(B)	1,287		1,554			1,450		1,243			2,146			1,243
Nonspecific	Yes	n	14	17	14	21	6	25	18	13	4	27	3	28	14	17
		%	45,2	54,8	32,3	67,7	19,4	80,6	58,1	41,9	12,9	87,1	9,7	90,3	45,2	54,8
	No	n	40	48	26	62	25	63	36	52	4	84	25	63	40	48
		%	45,5	54,5	29,5	70,5	28,4	71,6	40,9	59,1	4,5	95,5	28,4	71,6	45,5	54,5
		B		0,006	0,088			0,384	0,350		1,043			1,077		0,006
		Wald $X^2_{(1)}$		0,000	0,056			0,713	1,472		2,177			3,106		0,000
		p		0,983	0,819			0,399	0,225		0,140			0,078		0,983
		Exp(B)		1,006	1,092			1,468	1,419		2,839			2,936		1,006
Neurologic	Yes	n	4	2	2	4	1	5	3	3	0	6	1	5	1	5
		%	66,7	33,3	33,3	66,7	16,7	83,3	50,0	50,0	0,0	100,0	16,7	83,3	16,7	83,3
	No	n	50	63	34	79	30	83	51	62	8	105	27	86	53	60
		%	44,2	55,8	30,1	69,9	26,5	73,5	45,1	54,9	7,1	92,9	23,9	76,1	46,9	53,1
		B	0,410		0,102			0,466	0,102					0,360		1,035
		Wald $X^2_{(1)}$	0,622		0,020			0,210	0,030		(a)			0,125		1,051
		p	0,430		0,888			0,647	0,863					0,724		0,305
		Exp(B)	1,507		1,108			1,593	1,108					1,434		2,814
Reproductive	Yes	n	0	2	2	0	0	2	1	1	1	1	0	2	0	2
		%	0,0	100,0	100,0	0,0	0,0	100,0	50,0	50,0	50,0	50,0	0,0	100,0	0,0	100,0
	No	n	54	63	34	83	31	86	53	64	7	110	28	89	54	63
		%	46,2	53,8	29,1	70,9	26,5	73,5	45,3	54,7	6,0	94,0	23,9	76,1	46,2	53,8
		B							0,099		2,123					
		Wald $X^2_{(1)}$	(a)		(a)		(a)		0,010		3,944		(a)		(a)	
		p							0,992		0,047					
		Exp(B)							1,104		8,357					
Auditory	Yes	n	2	2	1	3	1	3	3	1	0	4	0	4	1	3
		%	50,0	50,0	25,0	75,0	25,0	75,0	75,0	25,0	0,0	100,0	0,0	100,0	25,0	75,0
	No	n	52	63	35	80	30	85	51	64	8	107	28	87	53	62
		%	45,2	54,8	30,4	69,6	26,1	73,9	44,3	55,7	7,0	93,0	24,3	75,7	46,1	53,9
		B	0,101			0,197		0,043	0,525							0,612
		Wald $X^2_{(1)}$	0,019			0,038		0,002	0,019		(a)		(a)			0,367
		p	0,889			0,846		0,967	0,376							0,545
		Exp(B)	1,106			1,217		1,043	1,691							1,843

(a) Wald chi-quare test and p-value not calculated due to a redundant value (0,0% of cases with/without region affected in the presence of the clinical sign)