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The burden of domestication: a representative study of welfare in privately owned cats in Denmark

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Abstract

The way in which domestic cats are kept and bred has changed dramatically over the last two centuries. Notably, a significant number of cats are kept indoors, most of them are neutered and many are selectively bred. This likely has consequences for their welfare. A few studies link housing, neuter status and breeding in cats to risks of welfare problems. However, the study presented here is the first to quantify the risks and document the prevalence of risk factors. It builds on results from a questionnaire sent to a representative sample of the Danish population. Using the responses from cat owners who keep cats in the home (n = 378), the paper aims to investigate how indoor confinement, neutering and selective breeding affect health, behaviour and other factors relating to cat welfare. The paper reports that confined cats had significantly more behavioural problems than free-roaming cats; that a smaller proportion of the free-roaming cats suffered from the behavioural problems investigated; and that entire cats had significantly more behavioural problems than neutered cats. Finally, significantly more purebred cats than domestic shorthair cats were found to have diseases. Being confined, being intact and being purebred are therefore significant risk factors for behavioural or health problems associated with reduced welfare in privately owned cats.

Keywords: *animal welfare, behavioural problems, confinement, health issues, neuter status, purebred cats*

Introduction

In the last fifty years there has been a dramatic increase in the number of people keeping cats as companion animals. For example, in the UK between 1965 and 2004, the number of cats kept per hundred inhabitants increased from fewer than eight to more than 16 (Sandøe *et al* 2016a). Today, in most Western societies, cats enjoy popularity as companions that is comparable to dogs, and in Europe there are more households with a cat than households with a dog (FEDIAF 2014). In Denmark, although there are fewer households with cats than with dogs, the total number of domestic cats kept is higher than that of dogs (Danmarks Statistik 2000), as is the case in the United States (AVMA 2012), whereas in Australia domestic cats are reported to be the second most common companion animal, with numbers just below those of dogs (Richmond 2013). Over this rapidly rising period of cat popularity as a companion animal, dramatic changes in the way cats are bred, kept and cared for have taken place. However, little is known about how these changes affect the welfare of the cats.

One important shift concerns the housing of cats. Today, many cats are confined indoors; seemingly this happens more commonly in the US than in Europe (Rochlitz 2005; Bayer 2013). Confinement protects the cat from road accidents, injuries from fights and other dangers, but it may at the same time prevent the cat from performing important natural behaviours (Palmer & Sandøe 2014). It appears that it also puts the cat at higher risk of developing certain diseases (Robertson 1999; Rand *et al* 2004; Slingerland *et al* 2009). The main cause of this is believed to be an inactive lifestyle, which can put individuals at greater risk of developing certain lifestyle-related diseases. Similarly, behavioural problems have been linked to confinement, and specifically cats' inactivity and their uniform, unchanging life and environment (Heidenberger 1997; Amat *et al* 2009; Bain & Stelow 2014). A bored or stressed cat might also perform unwanted behaviour, such as excessive vocalisation, aggressiveness or house soiling.

A second shift is that the majority of domestic cats are now neutered (Chu *et al* 2009; Sandøe *et al* 2016b). The surgical removal of reproductive organs to prevent cats from breeding has an impact on welfare for various reasons. The neutered cat needs to undergo surgery and recovery, and complications may develop from anaesthesia or surgical trauma. In the longer term, neutering increases the risk of obesity, which can lead to diabetes and other health-related

diseases (Robertson 1999; Rand *et al* 2004; Colliard *et al* 2009). On the other hand, neutering also protects cats from disease; and in both males and females it appears to reduce aggressiveness (Finkler & Terkel 2010). In males, neutering significantly reduces roaming and fighting activity, thereby indirectly reducing the risk of traffic injuries and bite wounds with associated complications, such as abscesses, transmission of feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) (Hart & Barrett 1973). Neutering in female cats reduces the risk of developing oestrogen responsive mammary tumours (Overley *et al* 2005) and it indirectly decreases malnutrition and disease in kittens, by reducing the population density in a given area.

The third major shift of note concerns organised cat breeding for specific traits. Although feline domestication has existed for a long period of time, selective breeding of purebred cats is relatively recent (O'Brien & Johnson 2007). Despite the good intentions of breeders pure-breeding can have a negative effect on animal welfare. Sandøe and others (2016a) have divided these negative effects into three groups: breeding of extreme phenotypes which in themselves create health and welfare problems; increased prevalence of diseases caused by a lack of genetic diversity; and increased prevalence of behavioural problems.

In sum, then, domestic cats may suffer from a number of serious welfare problems as a result of the way they are housed, taken care of, and bred. However, to the authors' knowledge no representative studies which link different factors in the breeding and lifestyle of companion cats to the prevalence of welfare problems in the domestic cat population have been published. The purpose of the current study is to make a start on filling this research gap.

The paper is based on results from a questionnaire sent to a representative sample of the Danish population. Based on the responses of cat-owning respondents (n = 415), we examine how indoor confinement, neuter status and selective breeding affect cat health and behaviour.

The paper does not look into effects of selective breeding on specific breeds but only looks at how purebred cats as a group are affected. To look at specific breeds would not have been feasible given the limited number of owners of purebred cats participating in the questionnaire and the wide diversity of breeds owned. However, the study does seek to clarify whether purebred cats, as a group, have a higher frequency of behavioural and health problems than domestic shorthair cats and/or mixed breed cats.

The study uses results relating to Danish domestic cats, but the correlations it identifies can most likely be generalised beyond Denmark, and its findings should therefore be of relevance to authorities, private organisations, veterinarians and other professionals with an interest in the welfare of privately owned cats worldwide.

Materials and methods

Survey design

The data are based on a survey containing 45 questions (Questionnaires 1 [in English] and 2 [in Danish] can be seen in the supplementary material to papers published in *Animal Welfare* on the UFAW website: http://www.ufaw.org.uk/t-ufaw-journal/supplementary-material). All participants were asked a number of demographic questions as well as questions relating to their attitudes to cats in general, to roaming and to stray cats. Additional questions were given to cat owners regarding their cat, such as age, breed, gender, neuter status, regarding the number of cats in the household, the cat's behaviour, health status, the type of activities provided by the owner, environmental enrichment, feeding, veterinary care, housing of the cat and potential problems related to housing. Data collection was carried out by a Danish survey company (Norstat) in October 2015. The respondents belonged to Norstat's pre-recruited panel. A gross sample from this panel (n = 6,120) was invited to participate in the survey. Sampling had quotas on age, gender and geography (NUTS2 regional level) according to Danish census data.

A combined online and telephonic design was performed. Respondents aged between 18–64 years responded online and respondents over the age of 65 years were interviewed by telephone. This mixed mode design was chosen with a view to obtaining a high degree of representativeness while holding data collection costs down. Specifically, while internet data collection is less expensive, it is known that Danes in the +65 age segment use the internet less frequently and are best reached by telephone. The final, net sample was n = 2,003, resulting in a response rate of 33%. To account for non-response bias the cases were weighted according to official statistics on gender × age × region. Of the 2,003 people who responded, 415 (weighted frequency) were cat owners. Cat owners were instructed to complete the survey for their oldest cat, and those responses form the basis of the results presented here.

Statistical analysis

Descriptive analyses were conducted to display the prevalence of cats in Denmark, breed type, neutering status, how the cats were kept, behavioural problems, and health issues (ie the cat being overweight or suffering from one of the following diseases: arthritis, oral disease, kidney disease, urinary disease, diabetes, metabolic disease). After this the data were analysed to discover whether the main explanatory variables under investigation, ie breed type, neutering status, and how cats are kept, were associated with behavioural problems. This was done by reporting the unadjusted prevalence of behavioural problems across the different categories of the explanatory variables. Following this, odds ratio results were reported (with 95% CI) from multivariate logistic regression models for each main explanatory variable after adjustment for the age of the cats (cat age was inserted

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as a categorical variable with five brackets ('0-1 year' to 'more than seven years') and the two other main explanatory variables. The data were also analysed to find whether breed type, neutering status and how cats are kept were associated with health issues. Results from this were again reported with prevalence and odds ratio results (with 95% CI) from logistic regression models after adjustment for the age of the cats and the two other main explanatory variables.

Confined cats were defined as cats that are either indoor cats with no outdoor access or indoor cats with limited outdoor access part of the year (eg in a summer-house). Garden cats were defined as cats with access to a closed garden, and free-roaming cats were defined as indoor cats with the opportunity to roam freely outside. A final category was outdoor cats that rarely or never came inside the house. Apart from featuring in the demographic characteristics of the cat population (Table 1), these outdoor cats were excluded from the study, as welfare problems are difficult to study in them.

All statistical analyses were performed using IBM SPSS Statistics Version 21. In all analyses, statistical significant difference was set at the 95% level.

Results

Size of the cat owner population

In all, 2,003 people were asked if they had cats (ie at least one cat) in their household or had previously had so. The majority of people, 1,327 (66.2%), answered negatively, 261 (13.0%) people had previously had a cat in the household, and 415 (20.7%) persons currently had at least one cat. Thus, 33.7% of the sampled Danish households keep or have previously kept at least one cat.

Demographic characteristics of the cat population

Table 1 displays the distribution of the three variables that are linked in this paper to behavioural and health problems in privately owned cats: breed of the cat, neuter status, and housing type.

As can be seen, 15% of domestic cats in Denmark are purebred. The prevalence of the reported breeds were as follows: Abyssianian 0.7%, British Shorthair 0.5%, Burmese 1.2%, European shorthair 0.5%, Birman 0.7%, Maine Coon 3.9%, Norwegian Forest cat 2.9%, Persian 1.2%, Ragdoll 0.7%, Russian Blue 0.5%, Siamese/Oriental shorthair 0.5%, other breeds 1.5%; 0.2% of respondents did not know which breed their purebred cat was. Since most of the breeds involve small numbers of individuals we decided to treat purebred cats as a single, undifferentiated group.

Regarding neuter status, it can be seen from the survey that 86% of the cats are neutered while 4% of the male cats and 9% of the female cats are intact. Owners house their cats in a wide variety of ways. Around 9% of cats live more or less permanently outdoors, and since it is likely that the owners have limited knowledge of their cats' welfare and behaviour they are excluded from the remainder of the study. Among the remaining cats, a significant minority, 22%, are classified as 'confined' in that they never have access to outdoors or are only allowed out on specific occasions (eg when the family is in a summer-house), and a small fraction, 9%, have access to an enclosed garden ('garden access'), but the large majority, 69%, are allowed to roam freely outdoors either by using a cat-flap or by being let out by the owner ('free-roaming').

Table 1 Prevalence of cat breeds, sex/neutering status, and housing in Danish households with cats.

Factor	Prevalence
Breed (n = 415)	
Domestic shorthair	61.5%
Mixed breed	20.5%
Purebred	15.0%
Don't know	3.0%
Sex/neutering status (n = 415)	
Intact male	3.9%
Intact female	9.2%
Neutered male	47.0%
Neutered female	39.1%
Don't know	0.9%
How cats are kept (n = 415)	
No outdoor access†	16.8%
Only outdoor access part of the time†	3.6%
Access to a closed garden‡	7.8%
Outdoor access through cat-flap§	25.0%
Outdoor access when owner lets the cat out§	38.0%
Outdoor cats that rarely or seldom come inside	8.8%
How cats are kept (reduced sample: n = 378)	
Confined	22.4%
Garden access	8.5%
Free-roaming	69.1%

Prevalence of behavioural problems and health issues

When asked about behavioural problems, 21.7% of owners report that their cat damages furniture or other items, eg by scratching, 15.1% report fear of other cats, dogs or people, 12.4% report problems with house-soiling, 11.0% report that their cat displays signs of boredom, eg excessive vocalisation, 4.4% report aggressive behaviour towards owner, 4.0% towards guests, and 3.8% towards other pets in the household. Furthermore, 5.4% report that they have 'other behaviour problems'. Approximately half of the owners report that they have none of the problems listed. In sum, it can, based on our study, be said that half of all cats in Denmark show one or more behaviour that the owner views as a problem.

When asked about their cats' health, owners reported the following: 9.5% of the cats are overweight, 4.9% have arthritis, 4.0% have oral disease, 2.1% have kidney disease,

Table 2 Prevalence of behavioural problems in confined, garden and free-roaming cats (and total) as reported by the owners in a representative study of Danish cats (n = 378).

	Prevalence (%)				Adjusted OR (95% CI)*			
	Confined	Garden	Free-roaming	Total	Confined		Garden	
					OR	(95% CI)	OR	(95% CI)
House-soiling	18.2%	18.4%	9.8%	12.4%	2.38	(1.12, 5.02)	4.17	(1.41, 12.32)
Damage furniture or things	35.5%	25.1%	16.8%	21.7%	2.44	(1.35, 4.42)	2.10	(0.85, 5.21)
Aggressive behaviour towards owner	5.4%	11.4%	3.2%	4.4%	1.08	(0.28, 4.13)	2.56	(0.61, 10.69)
Aggressive behaviour towards guests	6.6%	4.0%	3.1%	4.0%	1.99	(0.58, 6.87)	1.57	(0.21, 11.54)
Aggressive behaviour towards other pets in the household	5.1%	3.6%	3.4%	3.8%	0.70	(0.15, 3.29)	0.78	(0.10, 6.14)
Displays signs of boredom	19.1%	6.1%	9.0%	11.0%	2.63	(1.28, 5.40)	0.65	(0.14, 3.10)
Fears other cats, dogs or people	13.1%	8.6%	16.5%	15.1%	0.93	(0.44, 1.94)	0.71	(0.19, 2.65)
Other problems	9.5%	3.3%	4.4%	5.4%	3.03	(1.14, 8.09)	1.21	(0.15, 9.62)
None of the problems listed	37.1%	44.7%	54.7%	49.9%	0.51	(0.30, 0.86)	0.59	(0.27, 1.29)

* Results from binary logistic regression (n = 359), where 'free-roaming' cat was set as reference value. Adjusted for age of the cat, breed type, and neutering status.

2.1% have urinary disease, 1.3% have diabetes, and 0.6% have metabolic disease. A large proportion, 75.9%, of the cats were reported by their owners as having none of the mentioned diseases, and just 2.9% of the owners did not know if their cat had any of the mentioned diseases. Apart from being overweight, the health problems at issue were reported quite infrequently. In the remainder of the analysis, diabetes, arthritis, oral disease, kidney disease, urinary disease and metabolic disease were therefore collapsed into one variable: disease. After this, 13.8% of the cats were found to have one or more of these diseases, 10.3% of the cats were overweight, whilst 75.2% had none of these conditions.

What explains behavioural problems?

Table 2 reports prevalence of the behavioural problem for confined, garden and free-roaming cats.

Significantly more owners of free-roaming cats than those of confined cats report that their cats have none of the studied behavioural problems. Specifically, confinement increases the probability of house-soiling and that the cat damages furniture or other items and displays signs of boredom.

On the other hand, few differences in behavioural problems were seen between purebreds, domestic shorthair and mixed breed cats (Table 3).

However, significantly fewer purebred cats than domestic shorthair cats have house-soiling problems; and significantly more mixed breed cats than domestic shorthair cats fear other cats, dogs or people.

In the analysis of associations between neutering status and behavioural problems (Table 4), non-neutered female and male cats were collapsed (non-neutered cat; n = 41). Likewise, neutered female and male cats were collapsed (n = 335).

Significantly fewer owners of non-neutered cats report that none of the behavioural problems listed are present. Among specific problems, non-neutered cats have significantly more aggressive behaviour towards guests and 'other problems'.

What explains health issues?

Table 5 displays the prevalence of health issues for domestic shorthair, purebred and mixed breed cats.

Significantly more purebreds than domestic shorthair cats had one or more of the previously mentioned diseases (arthritis, oral disease, kidney disease, urinary disease, diabetes, or metabolic disease); and significantly more domestic shorthair cats had none of the studied health issues.

Also, when owners were asked their opinion on their cat's general health, there was a significant difference between purebreds and the two other breed types, Pearson's $Chi^2 = 29.456$, df = 2; $P < 0.000$, n = 368. Thus, 62.3% of owners of purebred cats responded that their cat was 'generally healthy' compared to 85.9 and 90.6% of owners of mixed breed and domestic shorthaired cats, respectively.

An additional analysis shows that there is a clear difference in the prevalence with which owners of purebred (75%), mixed breed (35%), or domestic shorthaired cats (48%) have their cat vaccinated (Pearson's $Chi^2 = 20.88$, df = 2; $P < 0.000$). To check whether the differences found in observed disease occurrences between purebred and other cats were confounded by the difference in vaccination levels — as a proxy for concern about the

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Table 3 Prevalence of behavioural problems in purebred, domestic shorthair and mixed breed cats (and total) as reported by the owners in a representative study of Danish cats (n = 367).

	Prevalence (%)				Adjusted OR (95% CI)*			
	Purebred	Mixed breed	Domestic shorthair	Total	Purebred		Mixed breed	
					OR	(95% CI)	OR	(95% CI)
House-soiling	1.4%	12.2%	14.5%	12.4%	0.06	(0.01, 0.55)	0.93	(0.41, 2.13)
Damage furniture or things	18.3%	26.7%	19.8%	21.7%	0.74	(0.34, 1.58)	1.59	(0.84, 3.01)
Aggressive behaviour towards owner	9.1%	3.0%	3.3%	4.4%	2.23	(0.65, 7.67)	0.81	(0.17, 3.90)
Aggressive behaviour towards guests	4.1%	5.7%	3.1%	4.0%	1.11	(0.24, 5.25)	2.07	(0.57, 7.52)
Aggressive behaviour towards other pets in the household	6.8%	1.5%	3.0%	3.8%	2.36	(0.64, 8.71)	0.53	(0.07, 4.14)
Displays signs of boredom	13.1%	17.0%	9.2%	11.0%	1.39	(0.56, 3.48)	2.15	(0.98, 4.71)
Fear other cats, dogs or people	8.1%	25.6%	14.4%	15.1%	0.58	(0.21, 1.60)	2.21	(1.13, 4.32)
Other problems	1.8%	7.3%	6.0%	5.4%	0.24	(0.03, 1.81)	1.30	(0.43, 3.87)
None of the problems listed	47.9%	46.5%	52.2%	49.9%	0.98	(0.54, 1.79)	0.76	(0.44, 1.32)

* Results from binary logistic regression (n = 359), where 'domestic shorthair' cat was set as reference value. Adjusted for age of the cat, how the cat is kept, and neutering status.

Table 4 Prevalence of behavioural problems in neutered and non-neutered cats (and total) as reported by the owners in a representative study of Danish cats (n = 376).

	Prevalence (%)			Adjusted OR (95% CI)*	
	Not neutered	Neutered	Total	Not neutered	
				OR	(95% CI)
House-soiling	14.6%	11.9%	12.4%	1.55	(0.56, 4.28)
Damage furniture or things	11.9%	22.7%	21.7%	0.52	(0.19, 1.45)
Aggressive behaviour towards owner	2.6%	4.6%	4.4%	0.41	(0.05, 3.19)
Aggressive behaviour towards guests	10.7%	3.2%	4.0%	3.73	(1.06, 13.16)
Aggressive behaviour towards other pets in the household	2.6%	4.0%	3.8%	0.80	(0.10, 6.29)
Displays signs of boredom	17.8%	10.2%	11.0%	1.68	(0.65, 4.35)
Fear other cats, dogs or people	17.5%	14.9%	15.1%	1.64	(0.64, 4.19)
Other problems	12.9%	4.5%	5.4%	4.13	(1.32, 12.97)
None of the problems listed	28.6%	52.5%	49.9%	0.32	(0.15, 0.68)

* Results from binary logistic regression (n = 359), where 'neutered' cat was set as reference value. Adjusted for age of the cat, how the cat is kept, and breed type.

health of the cats — we ran the analysis of the relationship between cat breed and disease (cf Table 5) with additional explanatory variables inserted indicating whether the cat is vaccinated. However, the significant differences laid out in Table 5 were retained also after controlling for vaccination.

Table 6 displays the prevalence of health issues for non-neutered and neutered cats and Table 7 that of health issues for confined, garden and free-roaming cats.

As can be seen, no significant differences were found here; neither neuter status nor whether cats are confined or are allowed outdoor access did affect the probability of health issues.

Table 5 Prevalence of overweight, disease or none of the diseases listed in purebred, domestic shorthair and mixed breed cats (and total) as reported by the owners in a representative study of Danish cats (n = 367).

	Prevalence (%)				Adjusted OR (95% CI)*			
	Purebred	Mixed	Domestic short-hair	Total	Purebred		Mixed breed	
					OR	(95% CI)	OR	(95% CI)
Overweight	3.3%	15.5%	9.4%	10.3%	0.34	(0.08, 1.49)	1.78	(0.80, 3.96)
Disease**	36.1%	14.1%	7.2%	13.8%	7.11	(3.30, 15.29)	1.95	(0.84, 4.52)
None of the diseases listed	57.4%	69.0%	82.6%	75.2%	0.29	(0.15, 0.55)	0.47	(0.26, 0.88)

* Results from binary logistic regression (n = 359), where 'domestic shorthair' cat was set as reference value. Adjusted for age of the cat, how the cat is kept, and neutering status.
** Diseases prompted for: arthritis, oral disease, kidney disease, urinary disease, diabetes, metabolic disease.
Totals across type of cat breed do not sum to 100%, because a subset of respondents responded 'don't know'.

Table 6 Prevalence of overweight, disease or none of the diseases listed in neutered and non-neutered cats as reported by the owners in a representative study of Danish cats (n = 376).

	Prevalence (%)			Adjusted OR (95% CI)*	
	Not neutered	Neutered	Total	Not neutered	
				OR	(95% CI)
Overweight	7.3%	10.4%	10.3%	0.82	(0.23, 2.86)
Disease**	17.1%	13.7%	13.8%	1.51	(0.57, 4.01)
None of the diseases listed	75.6%	75.2%	75.2%	0.93	(0.41, 2.10)

* Results from binary logistic regression (n = 359), where 'neutered' cat was set as reference value. Adjusted for age of the cat, how the cat is kept, and breed type.
** Diseases prompted for: arthritis, oral disease, kidney disease, urinary disease, diabetes, metabolic disease.
Totals across type of cat breed do not sum to 100%, because a subset of respondents responded 'don't know'.

Table 7 Prevalence of overweight, disease or none of the diseases listed in confined, garden and free-roaming cats (and total) as reported by the owners in a representative study of Danish cats (n = 376).

	Prevalence (%)				Adjusted OR (95% CI)*			
	Confined	Garden	Free-roaming	Total	Confined		Garden	
					OR	(95% CI)	OR	(95% CI)
Overweight	11.8%	9.4%	10.0%	10.3%	1.03	(0.42, 2.51)	1.30	(0.34, 5.00)
Disease**	16.5%	25.0%	11.5%	13.8%	0.98	(0.44, 2.16)	1.46	(0.53, 4.01)
None of the diseases listed	69.0%	65.6%	78.2%	75.2%	0.75	(0.41, 1.39)	0.68	(0.29, 1.61)

* Results from binary logistic regression (n = 359), where 'free-roaming' cat was set as reference value. Adjusted for age of the cat, breed type and neutering status.
** Diseases prompted for: arthritis, oral disease, kidney disease, urinary disease, diabetes, metabolic disease.
Totals across type of cat breed do not sum to 100%, because a subset of respondents responded 'don't know'.

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Discussion

Behavioural problems

The current study found a correlation between confinement and behavioural problems. This is important since there are strong voices arguing in favour of more confined cats, particularly in the US and in Australia. Still, as we saw, 69.1% of cats in Denmark are allowed to roam freely outside, and only 22.4% are confined indoors. Across the world the proportion of cats confined indoors varies. In the UK, as with Denmark, the majority of cats are allowed to roam outdoors (Rochlitz 2005). In the US, by contrast, it is estimated that 50–60% of cats are confined indoors (Patronek *et al* 1997; Bernstein 2007). In recent years a number of studies have investigated the benefits and other consequences of keeping cats confined as opposed to allowing roaming; both ways of living appear associated with risks and benefits.

The current study found that confined cats had a higher prevalence of virtually all behavioural problems studied, compared to those that were free-roaming. Confined cats also had a higher frequency of behavioural problems than garden cats in every aspect assessed except aggressiveness towards the owner and house-soiling. Our results are supported by other work, such as the study of Amat and others (2009), which identified five risk factors for the development of behavioural problems, with no outdoor access being one of them.

The reasons for higher levels of behavioural problems in confined cats are numerous and vary from one problem to another. In general, behavioural problems are likely to be due to increased stress, insufficient mental stimulation and lack of physical activity (Bain & Stelow 2014). Confinement reduces space and the variety and forms of potential activity available to most cats, and it locates cats in places designed around human convenience and comfort (Palmer & Sandøe 2014). The current study confirms the association between the way the cat is kept and behavioural problems, and that confinement increases the likelihood of behavioural problems. Although confinement does confer some advantages, not all cats adapt to an indoor environment equally well (Jongman 2007).

We did not procure information relating to the owners' previous experience and knowledge about cat behaviour. One study showed a reduction in behavioural problems in kittens where owners were given advice on feline behaviour and on the appropriate education of their kitten by veterinary behaviourists during initial vaccination visits (Gazzano *et al* 2015). It is likely that behavioural problems can be reduced if owner awareness of feline behaviour and education is increased and veterinarians show a responsibility to support this awareness.

We also found a correlation between neuter status and behavioural problems. Neutered cats had significantly fewer behavioural problems than intact cats. Among specific behavioural problems, the amount of aggressive behaviour towards guests was significantly higher in intact cats than in neutered. This supports the widespread belief that neutering not only prevents reproduction but also curbs problems humans encounter with the behaviour of cats (Knol & Egberink-Alink 1989; Scarlett *et al* 2002; Fatjó *et al* 2006).

The link between behavioural problems and welfare is not simple. Some behavioural problems may simply be a sign of the cat enjoying natural behaviour, such as scratching and chewing, which is only a problem for the cat when it is deprived of appropriate environmental outlets for these behaviours (Herron & Buffington 2010). Other motivations or emotions causing behavioural problems, eg increased anxiety, may be a sign that the cat actually has a welfare problem (Levine 2008). Some may be more difficult to interpret. Inappropriate elimination, for example, may both be a perfectly natural behaviour (eg marking behaviour or preference for an alternative substrate for the elimination) or a consequence of increased anxiety (Neilson 2004a). Furthermore, there may be an indirect link here with welfare in that cats with increased levels of welfare problems may have a more difficult time with their owner, making it more likely that the cat is relinquished or euthanased (Salman *et al* 2000; Kass *et al* 2001). Although it is true that behavioural problems are only to some extent direct signs of compromised cat welfare, they may indirectly affect welfare and longevity through owner reactions. Thus, problem behaviour may need to be redirected to avoid owner frustrations (Jongman 2007).

The most frequently reported behavioural problem with cats in this study was the display of destructive behaviour. This behaviour is not a direct problem for the cat, but it will typically be a problem for the owner. Cats can damage furniture and other things in the home in several ways, but scratching probably accounts for most of the reported problems in our study. Scratching is a natural marking behaviour for the cat. It causes scent marks to be deposited from the inter-digital glands, leaving olfactory and visual signs, and it helps to maintain the cats' claws (Rochlitz 2007; Herron & Buffington 2010). Surfaces for scratching, such as scratching posts, should therefore be provided in attractive places in order to avoid unwanted scratching on furniture (Rochlitz 2005). Indoor cats may be short of suitable places to perform their scratching behaviour, and the display of destructive behaviour can therefore be a sign of boredom and lack of stimulation. Damage to household objects will often draw the owners' attention, and even if the consequence is scolding the cat will still learn to link the destructive behaviour and owner attention. In time, some cats will develop the habit of scratching as a means of attracting the owner's attention.

Significantly more confined and garden cats than free-roaming cats had house-soiling problems and eliminated in places other than their litter box or outside. A cat's house-soiling can be a cause of considerable frustration to the owner, and cats that show inappropriate elimination behaviour have a higher risk of relinquishment (Sung & Crowell-Davis 2006). The problems here can be categorised under three main categories: medical problems, marking, and toileting problems (Neilson 2004b). They may have

underlying motivations that owners find hard to understand. It is important to find the underlying motivation for the house-soiling problem and to rule out or remedy any medical problem before wider adjustments are made. Urine marking is a natural behaviour that has a variety of communicative functions, including identification, and laying down emotional, temporal, and spatial information (Crowell-Davis *et al* 2004), but it is problematic when performed indoors. The motivation for indoor urine marking can be anxiety/stress, whereas toileting problems are often caused by medical issues, anxiety, aversions or preferences over litter boxes (Neilson 2004b). Marking behaviour is primarily performed by fertile cats, but it can also occur in neutered cats.

Amat and others (2009) report an increased prevalence of behavioural problems in purebred cats. This finding is not supported by this study, since purebred cats did not have a significantly higher frequency of any of the studied behavioural problems as compared with domestic shorthair and mixed breed cats.

It should be noted that factors other than those we studied may have an effect on the prevalence of behavioural problems, eg the age of the cat when adopted, its provenance, how long the person has been the owner of the cat and how long the cat has lived in the same environment. It is a limitation of our study that we have not looked at these factors.

Health issues

Recent studies of confinement and free-roaming in cats have found that both ways of living are associated with risks and benefits. It has been found, for example, that indoor cats are at greater risk of developing such diseases as Feline Lower Urinary Tract Disease (FLUTD), hyperthyroidism, dental disease (Buffington 2002; Buffington *et al* 2006; Rochlitz 2007), of suffering from diabetes mellitus (Rand *et al* 2004; Slingerland *et al* 2009), and of being 'skinny fat' (Bjornvad *et al* 2011). None of these diseases can be confirmed by this study, which found that confined cats did not have more health issues than garden cats or free-roaming cats. Part of the explanation for this may be that owners of confined animals spend more time stimulating their cats and give them extra resources indoors to compensate for missing behavioural opportunities.

Several studies have described a relationship between confinement and obesity in cats (eg Sloth 1992; Robertson 1999). It is worth mentioning that not all studies confirm this association (Colliard *et al* 2009; Courcier *et al* 2010), and neither did this study. The proportion of overweight cats found in our study is lower than that found in other studies (Allan *et al* 2000; Lund *et al* 2005; Colliard *et al* 2009). This may be because the owners reported in this study were not given any tool to estimate their cats' body condition and make subjective assessments. Also, studies show that owners underestimate their cats' body condition and are unable to recognise that their pet is overweight (Colliard *et al* 2009; Courcier *et al* 2010). Furthermore, a recent Danish study of confined, adult, neutered cats found that body condition score (BCS) underestimates the level of body fat percent (BF%) in these cats (Bjornvad *et al* 2011). The study suggests that confined cats have higher BF% as a result of low activity level, resulting in less muscle mass, and thus a higher BF%, as compared with control cats. The cats are skinny fat or suffer from sarcopaenic obesity, ie a situation whereby an individual shows an increase in fat mass and a reduction in lean mass. The current study did not isolate sarcopaenic obesity as a health issue, but it may be reasonable to expect that some of the confined cats in it were skinny fat.

Owing to a lack of genetic diversity, purebred cats are predisposed to various diseases (Sandøe *et al* 2016). Since only 62 of 415 (15.0%) of the cats in this survey were purebred cats, no breed-specific analyses were performed. However, when purebred cats as a group were compared with domestic shorthair and mixed breed cats, the result was evident: a significantly higher prevalence of disease was reported by owners in the purebred group.

Selective breeding has led to purebred cat breeds that are fancied by many cat owners, but it has also compromised the health of purebred cats as a result of limited genetic diversity (Sandøe *et al* 2014). More than 20 diseases linked to inbreeding are seen within purebred cats, although not all breeds are affected (Lipinski *et al* 2008). According to our study, the two most popular breeds in Denmark are the Maine Coon and Norwegian Forest cat. Both breeds suffer from chronic gingivo-stomatitis (Kortegaard *et al* 2006; Fødevareministeriet 2013) and approximately 6.3% of Maine Coons suffer from hypertrophic cardiomyopathy (Godiksen *et al* 2011).

It may be suspected that the finding that purebred cats suffer from higher levels of disease compared to the other groups of cats is a reflection of the fact that the owners of these cats, in addition to the higher monetary investment at the time of procurement, also, in general, invest more and that they are more engaged in their cats' well-being than owners of non-purebred cats. Thus, these owners could be more likely to notice and/or report health problems than owners of non-purebred cats; and the reported higher levels of disease could be a reflection of this rather than of a level of disease that is actually higher.

It is, indeed, the case that owners of purebred cats show a higher level of engagement, in that, for example, they have their cats vaccinated more often. However, even when we control for level of vaccination we still find a higher level of disease among purebred cats. Thus, the findings of this study leave little doubt that, viewed as a group, purebred cats suffer more from health issues than mixed breeds and domestic shorthairs. However, it should be stressed that it is compatible with the findings in our study that some breeds of purebred cat may not be particularly prone to diseases.

Animal welfare implications and conclusion

The aim of this study was to investigate how the ways in which cats are bred, live and are taken care of influences their welfare. The study focused on three factors, which were linked to risks of welfare problems. These are confinement, being intact and being purebred. The link with reduced welfare in purebred cats proceeds through

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increased disease load. By contrast, in the case of confinement and being intact there is a more indirect link to welfare via behavioural problems. Only some of the latter problems will directly affect welfare, but they all have an indirect effect via negative owner reactions.

For purebred cats there is a clear need for more research into the disease problems linked to different breeds, and for greater focus on health in the breeding of cats. On both counts, research into purebred cats lags behind the canine sector by some distance. As regards the way cats are housed, there is a requirement for better information to be provided for prospective cat owners on the need to accommodate the behavioural needs of their cats if they are confined indoors; and clearly our findings are also of relevance to the often polarised indoor-outdoor debate. Finally, our findings support the already widespread view that there are good reasons for neutering cats that are not kept for breeding purposes.

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