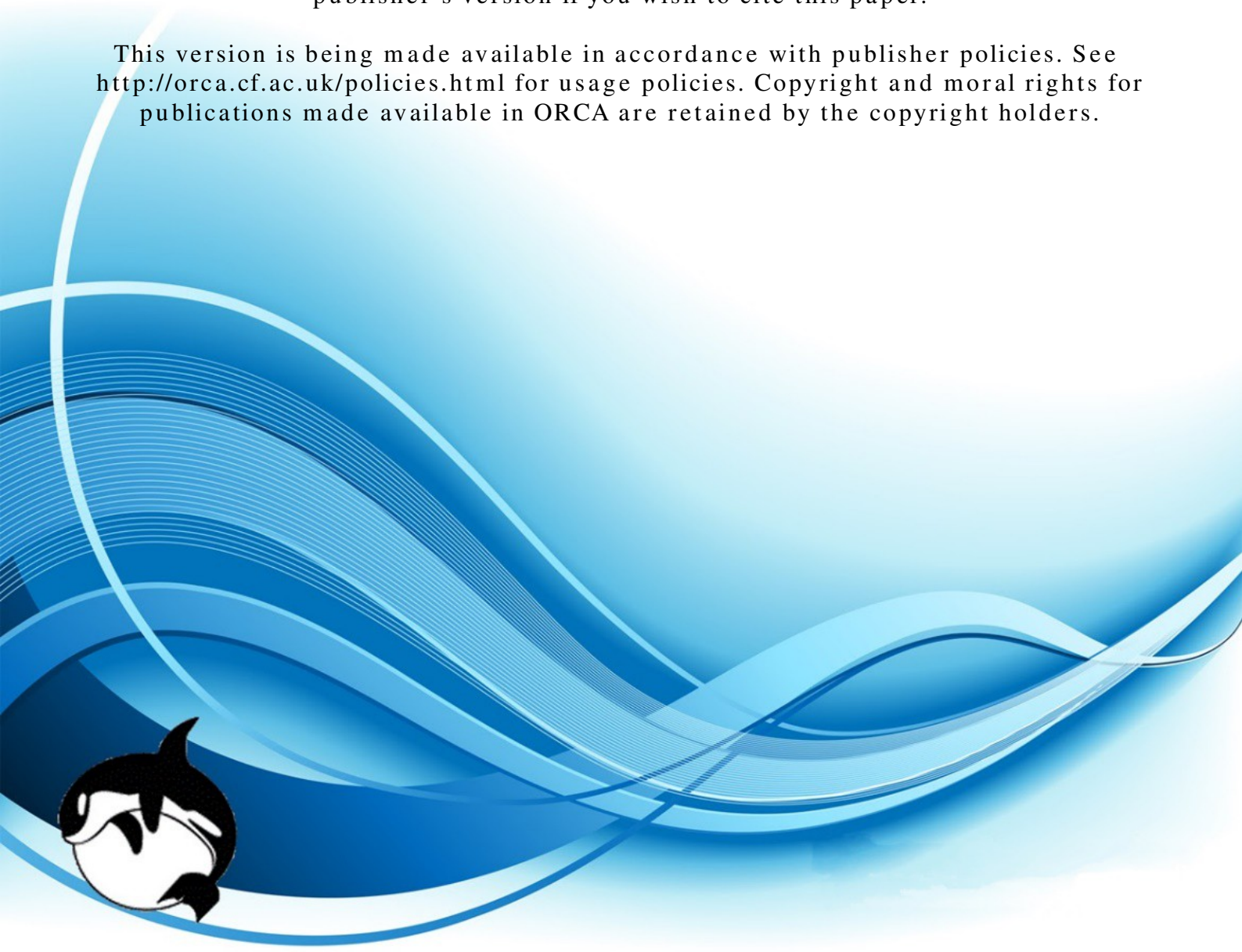

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Evidence for seasonal reproduction in UK domestic cats

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Abstract

Objectives To analyse a large body of data obtained by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) Greater Manchester Animal Hospital on the breeding pattern of owned domestic cats in the UK, and to provide clear statistical evidence of whether seasonal variation remains present in temperate climates.

Methods The total number of cats spayed and the number of cats found to be pregnant were recorded on a monthly basis from December 2005 to July 2014 by the RSPCA Greater Manchester Animal Hospital. The percentage of cats found to be pregnant was calculated for each month and the 8.5 years of data were binned into calendar months. The mean and SD of the monthly pregnancy rate was calculated for each calendar month bin, as was the difference between the mean percentage of detected pregnancies and the global mean. The Z score for each month's difference was then calculated.

Results Data were available for 5414 cats neutered during the 8.5 consecutive years of this study. A global average of 8.9% of cats spayed were found to be pregnant. The mean calendar month pregnancy rate exhibited a very significant variation, with the highest positive deviation being in April (Z score +2.9) and the highest negative deviation being in November/December (Z score -4.5). When aggregated into 3 month averages, an extremely significant difference between 'spring' and 'winter' months of >7 SE (P <<0.01) was found.

Conclusions and relevance This study provides clear statistical evidence, from a large data set, that seasonal breeding patterns are still present under UK temperate conditions. We discuss the impact that this has on charity rescue shelters and propose that a campaign targeted at clients of animal welfare charities encouraging autumn neutering will be the most cost-effective method of cat population control, and aid the relief of demand on welfare charity resources.

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Introduction

Cat welfare organisations are hugely overstretched. It is estimated that 131,070 cats entered UK welfare charities in 2009, and that 66% of cat shelters are working at full capacity constantly throughout the year.[1] The vast majority of cat litters (80%) are unplanned,[2] with unplanned litters generating a direct demand on welfare charity resources. This is most problematic during the summer, indicating that spring/summer is when the greatest numbers of litters are born.

Cats are known to be seasonal polyoestrus breeders, with induced ovulation.[3] Previous studies have described the seasonality of the cat oestrous cycle to be manipulated by the length of the photoperiod.[4] They have shown that a change from short day length to a longer day length induces oestrus in the cat and that this is mediated by the release of melatonin from the pineal gland, which is controlled by the circadian rhythm. Melatonin is released during darkness, and inhibits the generation of gonadotropin-releasing hormone and the hypothalamic–pituitary–gonadal feedback loop. The free- roaming cat population in the USA has also exhibited seasonal differences in pregnancy rates in trap–neuter–return programmes.[5,6] Both studies found the percentage of female cats found to be pregnant to peak in March, April and May.

In the UK, oestrus can occur all year round, with the greatest number of oestrus days occurring during the summer months.[7] Under temperate conditions, cats do not have a period of seasonal anoestrus.[7] This, coupled with the onset of puberty as early as 3.5 months,[8] is contributing to the current overpopulation problems that welfare charities face.

Various strategies are used by welfare centres to cope with overpopulation; increasing fostering and refusing to take in cats not deemed to be in immediate danger.[2]

However, the seasonality of UK litters is currently not generally considered. We propose that a better knowl- edge of the seasonal nature of UK feline reproduction could be used to target better the charity resources allocated to reducing the number of unwanted litters. A drive to neuter during the autumn would clearly aid prevention of spring litters; this would have a higher impact on reducing the number of unwanted kittens if the majority of litters are born in spring.

Material and methods

The purpose of this study was to take a representative sample of domestic cats and assess them for reproductive state. To achieve this, we retrieved data from the records of the Royal Society for the Prevention of Cruelty to Animals (RSPCA; Greater Manchester Animal Hospital) of female cats brought in by owners to be neutered. The data were restricted to include only owned female cats; strays were excluded.

The following data were recorded on a monthly basis: total number of cats spayed and number of cats found to be pregnant. The detection limit of pregnancy was 2 weeks' gestation. The span of the data was from December 2005 until July 2014 inclusive, giving 103 separate data points. The pregnancy data were represented in relative terms by taking the fraction, expressed as a percentage, of the number of detected pregnancies in each month. The data were then separated into yearly blocks and combined to give 12 value pairs, one pair for each month in the year, consisting of the average number of cats treated in that month and the percentage of pregnancies detected. The zeroth hypothesis taken was that of no seasonality, and this was represented by taking the global percentage of the cats found pregnant over the period of the study.

The SD of the percentage of detected pregnancies in each month was calculated, as was the difference between the actual percentage of detected pregnancies and the global mean. The Z score for each month's actual percentage detected pregnancies was then calculated as the difference multiplied by the square root of the number of years of data available for that month and divided by the SD for that month. It should be noted that, owing to the fact that data sets for the years 2005 and 2014 are incomplete, the number of samples in months August to November was only eight whereas for other months it was nine. The assumption is that any variation of pregnancy rate is randomly distributed about the mean and that the Z score is therefore two- tailed; the P value was calculated accordingly.

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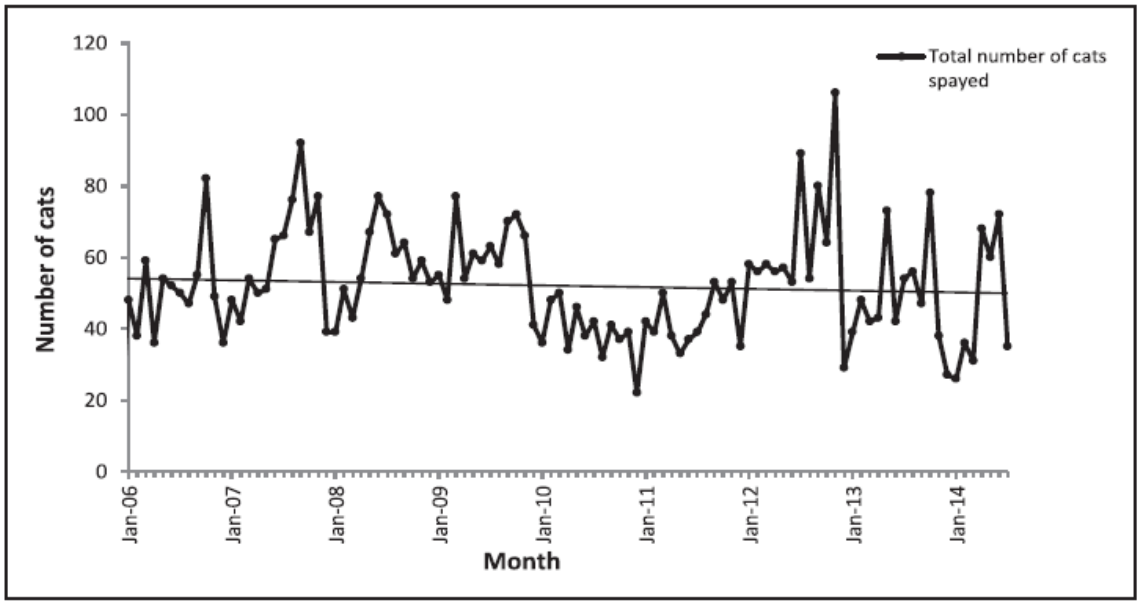

Figure 1: Plot of the total number of cats spayed per month by the Royal Society for the Prevention of Cruelty to Animals' Greater Manchester Animal Hospital (y = -0.04x + 54.19)

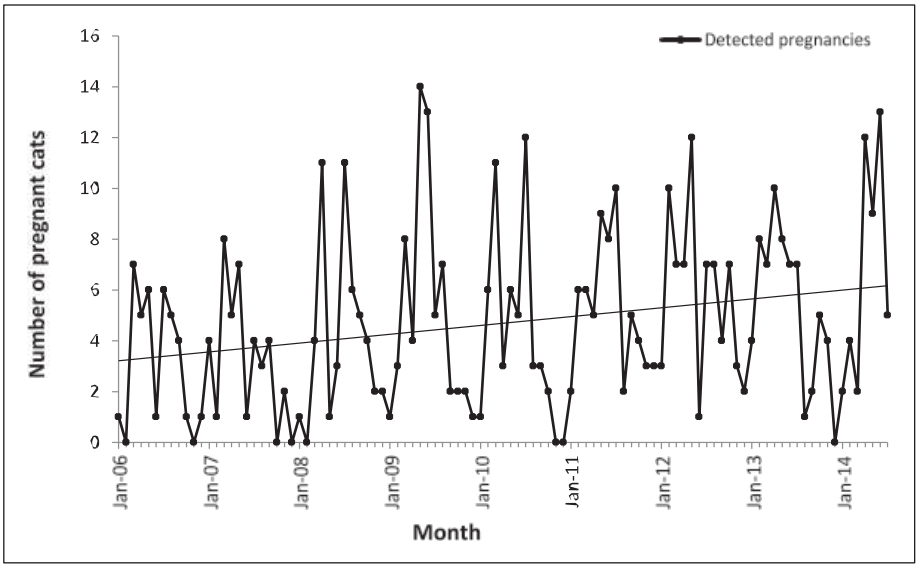

Figure 2: Plot showing the number of pregnant cats detected per month over time (y = 0.03x + 3.07)

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Results

The total number of cats treated during the study period was 5414 and the total number of pregnancies detected was 484. The global percentage of cats found to be pregnant was therefore 8.9%. Figure 1 shows a plot of the total number of cats treated in each month from December 2005 to July 2014.

A linear trend line is fitted to the data and shows a gradient of a 0.04 per month decrease with a SE of 0.05, indicating that there was no statistically significant change over time in the number of cats treated.

In Figure 2 the numbers of pregnancies per month are plotted over time. A linear trend line is fitted to the data and shows a gradient of a 0.03 per month increase with a SE of 0.01; thus, there is a statistically significant increase over time in the number of cats treated and found to be pregnant (95% confidence level).

In Figure 3 the average percentage of cats spayed and found to be pregnant is plotted vs calendar month. The error bars for each month represent 1 SE of the data mean value recorded for that month over the years 2005–2014. For comparison, the global mean pregnancy rate of 8.9% is plotted as a horizontal dotted line.

In Figure 4 the average percentage pregnancy rate per calendar month is compared with the global average pregnancy rate by plotting the Z score of each month's mean value using that month's SE. There is a peak in percentage pregnancy rate centred on the month of April and a trough centred on December. If the data for these two 3 month periods are aggregated, the average 'spring' (March, April, May) pregnancy rate is 13.9%, with a SE of 1.1%, and the 'winter ' (November, December, January) rate is 3.8%, with a SE of 0.64%. The SE for the difference is 1.3% (the root sum of squares of the 2 SEs); thus, the Z score of the difference is (13.9–3.8)/1.3 = 8 (1 sf). Crudely, taking the difference in Z scores averaged over the same 3 month period gives a similar result (2.6–(–4.3)) = 7 (1 sf). This is an extremely significant difference, equivalent to a P value of << 0.01.

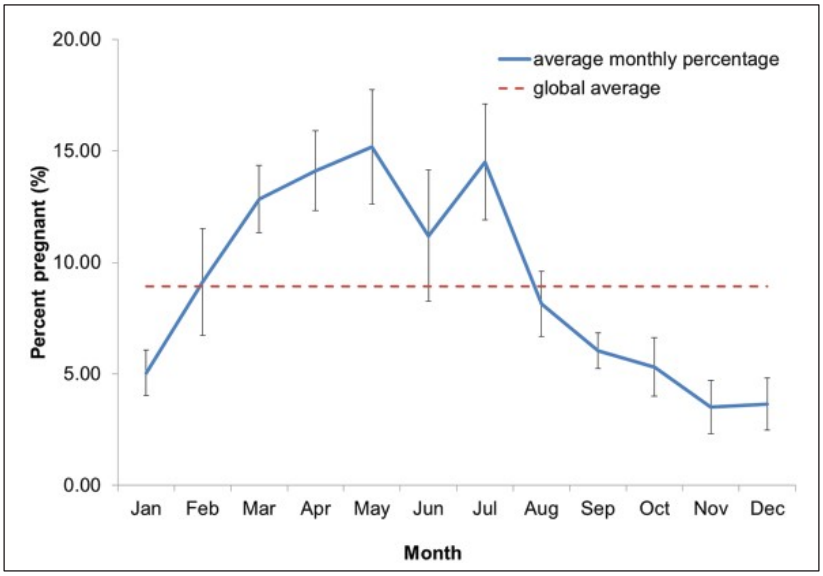

Figure 3 Plot showing the average percentage of cats neutered and found to be pregnant vs calendar month (over 8.5 years of study data). Error bars are +/-1 SE for that month

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Discussion

The key assumption of this study is that the samples of cats presenting for spaying at the RSPCA are representative of the reproductive state of the entire population of owned domestic cats. The data only include cats that are owned and are eligible for treatment by the RSPCA. This requires that the owner is living in the Manchester area and can demonstrate a low income (earning <£200 per week) or that they are in receipt of one or more UK state benefits. The low income or benefits status of all cat owners conveniently ensures that all owners were of roughly the same economic status. It was therefore considered unnecessary to consider effects of bias due to any difference in treatment resources for the cats presenting.

It can be seen from Figure 1 that the number of female cats presenting for neutering did not change significantly in the period December 2005 to July 2014. However, there is an increase in the instance of cats presenting as the year progresses. It is unclear why this may be, but it possibly reflects a long-term effect of Christmas debt upon household finances; affecting the willingness of owners to bring their cats to the RSPCA. There is a clear dip in the number of cases in December. This is most likely a combination of reduced RSPCA opening hours and/or staffing levels during the Christmas period, reducing the capacity for elective operations, combined with the reduced resources available to owners (time and money) for elective treatment of their cats. Neither of these effects should alter the proportion of cats found to be pregnant (only the number presenting) and therefore do not explain the extreme difference in pregnancy rates between the 'spring' months (March– May) and the 'winter ' months (November–January) (see Figures 3 and 4). It is possible that owners may be pre-empting the possibility of pregnancy over the Christmas period by bringing cats to the RSPCA in the immediately preceding months. Again, this would only affect the number of cats presenting and not the proportion found to be pregnant.

It is possible that the owners choose only to present cats that they believe are not pregnant. However, as more cats are presented in the 'winter ', this suggestion (presumed not pregnant) reinforces the results of seasonal pregnancy. If the 'apparently not pregnant' criterion is assumed to be applied by the owners all year round, this would only result in an increased number of cats presenting if fewer cats were thought to be pregnant in 'winter '. Also, if the diagnostic skill of the owners is assumed to be constant all year round, then the proportion of actual pregnancies presenting should not vary.

Conversely, it is an unfortunate possibility that the low income status of the owners may predispose them to actively bring pregnant cats to the RSPCA for neutering (to prevent the negative financial consequences of a litter of kittens). Again, if the pregnancy rate of cats is constant, this would not result in the observed variation in the actual percentage of cats found to be pregnant over the year. Indeed, if a systematic low income and the additional financial pressure of Christmas are combined, it would suggest that there should be an increase in the percentage of pregnant cats presenting in the run up to and the months after December. This is the opposite of the trend observed.

Figure 4 shows a plot of the Z score for the average percentage of cats found to be pregnant for each calendar month in the period December 2005–July 2014 when compared with the global average pregnancy rate for that period. The seasonal variation in pregnancy rate is clear, with the Z score varying from +2.9 in April to -4.5 in November/December. The difference in pregnancy rates over the year is therefore extremely statistically significant. The variation is also smoothly varying over the year with Z scores being consistently positive in spring and consistently negative in winter. Taking the 3 month averages of the 'spring' months (March–May) and 'winter ' months (November–January) either in terms of aver- aged Z scores or in the Z score of the difference in averaged percentage of cats found to be pregnant in each 3 month block, shows a difference of >7 SE and a P value of approximately zero.

Faya et al found that temperate climate cats do not have periods of anoestrus and have a maximum number of days in oestrus during the short but increasing photo-period days of the year [7] Given a ~65 day gestation, this implies that in Manchester domestic cats mate most successfully (or preferentially) in February, which is similarly correlated with the short but increasing photoperiod of

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spring. [HM Nautical Almanac Office data for sunrise and sunset times in Manchester, UK, gives an average of 9 h 49 m (increasing) daylight in mid-February and 10 h 39 m (declining) in mid-October [9]. In Manchester (northern hemisphere) the photoperiod hits its maximum of 17 h in June.] There remains a question as to whether cats living indoors might experience a different photoperiod owing to artificial lighting. It is not known what percentage of time the cats in this study spent indoors. However, as this study consists of data from cats being brought in to be spayed, it is unlikely that any pregnancies detected were arranged by owners. It is therefore probable that the pregnant cats were not contained entirely indoors but gained access to other cats outdoors and, therefore, to natural light. Nevertheless, an indoor cat could have its photoperiod affected. However, there is no obvious reason why owners would use lighting/curtains to arrange a different photoperiod in February. It is more likely that lighting is used to create a constant photoperiod (either longer or shorter than the UK's longest day depending on the average hours slept per night). Similarly, it is likely that owners would try to maintain, in general, a more constant indoor environment, than that outdoors. Thus, a domestic cat will tend to experience a more temperate climate, but a more constant photoperiod, than an outdoor cat the more time it spends indoors. This study provides clear evidence that cats have a seasonal breeding pattern when living in the temperate UK environment; however, a direct comparison of indoor vs outdoor cat colonies would be required to deconvolute the effect of photoperiod.

The approximate clinical detection limit for pregnancy was 2 weeks into gestation (D Yates, 2014, personal communication). This has the effect of biasing the data towards under-reporting of pregnancy rates. As it may safely be assumed that the diagnostic efficiency was constant over the study, it can be assumed that any bias was constant and therefore did not contribute to the observed seasonal variation.

The age of the cats presented was not considered. It is assumed that the ages are randomly distributed and determined only by the selection temperament of the owner population, which is assumed to be unknown but constant.

It is interesting to note that, although the number of cats presenting to the RSPCA for neutering did not vary significantly over the period of the study, there has been a significant increase in the percentage of cats found to be pregnant. This suggests that there has been a shift towards fewer owners neutering their cats at the earliest opportunity, or, conversely, an increase in the delay before owners spend resources on neutering.

Neutering is a cost-effective, long-term strategy for welfare charities and individual owners. In addition to controlling the population of unwanted litters, neutering benefits the individual cat. It prevents ovarian cancer, and dramatically reduces the incidence of cervical and mammary cancer (fatal in 90% of cats).10 It also eliminates unwanted behaviours associated with oestrus. [11]

Similarly, neutering of male cats decreases unwanted behaviour, such as urine marking and fighting (a risk factor for feline immunodeficiency virus and feline leukaemia virus), and testicular cancer. [11]

In a survey of cat owner beliefs,[2] it was found that the most significant factor for unplanned litters was the belief that a cat should have a litter before it is neutered. This belief was twice as likely to be held by respondents living in households with an annual income <£20,000. Therefore, clients of the RSPCA are likely to be a representative sample of individuals holding these beliefs, as RSPCA clients must demonstrate a low income (earning <£200 per week), or be in receipt of one or more UK state benefits. Neutering campaigns that address these commonly held myths, targeting clients in receipt of charity veterinary care, are clearly indicated. The implications of our study is that an autumn neutering campaign directed at clients of animal welfare organisations, such as the RSPCA, would be the most effective route to the reduction in unwanted litters.

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Conclusions

We sampled the reproductive state of the owned domestic female cat population by taking the clinically determined pregnancy state of cats presented to the RSPCA Manchester for neutering in the period December 2005 to July 2014. Arguments have been presented that support the premise that the data are a truly random and unbiased sampling, at monthly intervals, of the owned cat population. When averaged over the years of the study, the percentage of cats found to be pregnant in each calendar month was found to exhibit a seasonal variation. The data shows an extremely statistically significant difference between the 'spring' months of March to May and the 'winter ' months of November to January of >7 SEs (P value <<0.01). A statistically significant trend in the number of cats presenting for neutering over the year was found, with the rate of neutering rising steadily from January to November. This correlates both with possible owner bias towards not presenting cats that are visibly pregnant (higher probability in the first half of the year) and with possible variations in affordability over the year (lowest at Christmas and in the following months).

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Conflicts of interests

The authors do not have any potential conflicts of interest to declare.

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