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Cat admissions to RSPCA shelters in Queensland, Australia: description of cats and risk factors for euthanasia after entry

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Objective A lack of information limits understanding of the excess cat problem and development of effective management strategies. This study describes cats entering Royal Society for the Prevention of Cruelty to Animals (RSPCA) Queensland shelters and identifies risk factors for euthanasia.

Methods Data for cats entering relevant shelters (July 2006–June 2008) were obtained from the RSPCA's electronic database. Univariable and multivariable logistic regression analyses were conducted to identify risk factors for euthanasia.

Results Of 33,736 cats admitted, 46% were adult cats (≥3 months) and 54% were kittens (<3 months). The most common reason for admission was stray (54%), followed by owner surrender (44%). Euthanasia was the most common outcome (65%), followed by adoption (30%). The odds of euthanasia were lower for kittens and for cats that were desexed prior to admission. Of the strays, 8% had been desexed. For cats of similar age, sex, desexed and feral status, stray cats were more likely to be adopted than owner-surrenders.

Conclusions Strategies are needed to reduce numbers of cats admitted and euthanased. Given the high proportion of admissions that were kittens, reducing the incidence of delayed sterilisation of owned cats may be an important strategy for reducing the number of unwanted kittens. Many cats admitted as strays were rehomable, but given the high proportion of admissions that are strays, further research on stray populations is needed. Future studies of cats entering shelters would be enhanced if data collection definitions, categories and methods were standardised.

Keywords animal welfare; cats; epidemiology; euthanasia

Abbreviations CI, confidence interval; EAD, early-age desexing; OR, odds ratio; QLD, Queensland; ROC, receiver-operating characteristic; RSPCA, Royal Society for the Prevention of Cruelty to Animals

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Stray and unwanted cats (*Felius silverus domesticus*) are commonly admitted to animal shelters, where more than half are euthanased.[1] As well as serious ethical issues associated with euthanasing healthy cats, research indicates that symptoms of perpetrator-induced traumatic stress syndrome are evident in 50% of people in occupations with duties directly associated with euthanasia of dogs and cats.[2] The high numbers of animals euthanased have also been linked to high staff turnover in animal shelters.[3]

Management of excess domestic cats in Australian society is a financial burden to the community, with local government spending an estimated A$82 million annually on management strategies.[4] It is estimated that more than A$180 million is spent annually by animal welfare agencies to manage the problem of excess pets.[1,4]

There is an urgent need to better understand the cat population that is entering shelters.[5–9] Limited statistical information, published annually by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) in Australia, shows that, in the past 7 years, there has been little decrease in the number of cats entering shelters, and no reduction in the numbers being euthanased.[1] However, this information does not include detailed descriptions of the characteristics of cats entering shelters and information from other countries is also limited.[9] The number and variety of organisations, the large size of the respective cat populations, the geographic size of each country, logistics of obtaining data from paper-based records and some unwillingness by shelters to provide data, all contribute to the lack of statistics on unwanted pet populations in the USA and Australia.[10–15]

The lack of detailed information about the characteristics of cats entering and exiting shelters means that the reasons for the current numbers of cats being euthanased are difficult to understand, which in turn creates difficulties in developing, implementing and evaluating strategies to manage the situation.[9,16,17]

There are an estimated 386,000 owned cats in Queensland, with an average of 90 cats per 1000 people.[18] This is approximately 17% of Australia's owned cat population.[19] Cat admissions to RSPCA shelters in Queensland (RSPCA-QLD) account for approximately 25% of the national RSPCA intake annually.[1] The aims of this collaborative study were to describe the characteristics of the cat population entering RSPCA-QLD shelters and to identify risk factors for euthanasia after entry.

Materials and methods

Study design overview and data collection

A retrospective single cohort study was conducted using all cats arriving from 1 July 2006 to 31 June 2008 at all 11 RSPCA-QLD shelters (nine shelters and two collaborating groups that accepted cats during the study period, including four shelters operating local government (i.e. municipal council) pounds). Based on RSPCA cat identification numbers, some cats were admitted more than once during this period, so only data for their first admissions were included in the analyses.

During the study period, every cat presented to a RSPCA-QLD shelter was accepted. Each cat was held for a minimum of 1 day prior to

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assessment, depending on age, cat identification and shelter workload. Generally, kittens were held for 1 day and adult cats for 3 days, but the adult cat holding time sometimes decreased to 2 days in summer.[20]

Data obtained for the present study included cat identification number, name of shelter, year of admission, age category (adult, >3 months; kitten, ≤3 months), admission source, sex, breed, desexed (yes/no), date desexed, feral status (yes/no), microchip number, microchip implant date, and outcome. For the purposes of this study, the terms 'cat' and 'cats' refer to cats collectively, regardless of age. The RSPCA defines feral cats as 'unable to be handled and/or wild in apparent behaviour'. Cats with 'yes' for desexed that did not also have a desex date were assumed to have been desexed prior to admission; all other cats were assumed to have not been desexed prior to admission. The corresponding approach was used to identify whether or not cats were microchipped prior to admission. RSPCA protocol dictates that all cats are scanned for a microchip on admission.[20]

Data were imported from ShelterMate©, the RSPCA's data management system, into Microsoft Excel for manipulation. Unstructured interviews were conducted with key shelter staff to clarify information and details about shelter operations.

Each cat was categorised as being admitted from one of nine sources, which were later collapsed to three groups, as follows, for descriptive purposes.

1. General public admissions: owner surrender (a cat presented by someone who claimed to be the owner or agent of the owner), stray (presented by someone who did not claim to be the owner or agent of the owner), returns (adopted animals returned within 1 month of adoption) and euthanasia request (presented to the shelter by owner requesting euthanasia).
2. Authorised personnel admissions: ambulance admissions (presented by RSPCA animal ambulance officers after being reported as injured. These can include free-roaming owned, stray, feral and lost cats), council admissions (surrendered, trapped and stray cats collected by municipal councils and admitted after a minimum holding period or directly under a pound management agreement) and humane officer admissions (presented by an inspector, generally after having been seized from identified owners in response to cruelty reports, but including some cats of unidentified ownership).
3. Other admissions: transferred in (from other shelters or organisations) or born in the shelter.

Outcome was classified as adopted (purchased by a member of the public), euthanased, reclaimed (reclaimed or returned to original owner) or other. The 'other' category comprised cats that escaped or were taken from the shelter without approval, were transferred to another shelter or organisation, were surrendered by an owner who later returned to reclaim the animal, that died unassisted within the shelter and those whose outcome was unresolved when the data were extracted. These categories contained very small numbers of cats. Cats with unresolved outcomes (0.8%) were excluded from both univariable and multivariable analyses of risk factors for euthanasia.

Statistical analysis

Statistical analyses were performed using Stata IC/11 (StataCorp, College Station, TX, USA, 2009) and WinPepi (version 10.5).[21]

Two-tailed exact binomial goodness-of-fit tests[21] were used to assess whether the ratio of male and female cats admitted differed from a 50 : 50 ratio. Admission source and outcome were compared between male and female cats, and between kittens and adults, using likelihood ratio Chi-square tests.[21] Comparisons by sex were performed for all cats and for adult cats and kittens separately. Only cats whose sex was recorded were included in these analyses.

Each cat was classified as being either euthanased or not (i.e. adopted, reclaimed or other outcome). Potential animal-level risk factors for euthanasia (age, sex, breed, admission source, desexed prior to admission, feral status and year of admission) were assessed using univariable logistic regression analysis, with clustering of euthanasia by shelter accounted for by fitting shelter as a random effect in all models using Stata's -xtlogit- command. Potential risk factors that were associated with euthanasia in the univariable analysis were simultaneously fitted in a multivariable logistic regression model with shelter fitted as a random effect. Overall significances of each factor in the multivariable model were assessed using likelihood ratio test P values and standard errors were assessed for evidence of collinearity. 'Microchipped prior to admission' was not included in these analyses because the apparent prevalence of cats microchipped prior to admission was unexpectedly high relative to previous research.[22]

Clustering of euthanasia by shelter was assessed using the intraclass correlation coefficient calculated as: random intercept variance/(random intercept variance + $\pi^2/3$). Under this approach, the logistic model is viewed as a threshold model of a latent variable. If the risk of euthanasia varied between shelters, but within each shelter was either 0% or 100%, the intraclass correlation coefficient would be 1 (i.e. complete clustering by shelter). If the risk of euthanasia was the same in every shelter, the intraclass correlation coefficient would be 0 (i.e. no clustering by shelter). Clustering was assessed after accounting for all fixed effects in the multivariable model.

Goodness-of-fit of the fixed part of the multivariable model fitted using Stata's -xtlogit- command was assessed using the Hosmer-Lemeshow goodness-of-fit statistic and table, and the predictive (or discriminatory) ability of the fixed part of this model was assessed as area under the receiver-operating characteristic (ROC) curve and by inspection of the sensitivity-specificity (2-graph ROC) plot.[23] The predictive ability of the combined fixed and random parts of this model was also assessed, using predictions after fitting the same model using Stata's -xtmelogit- command.

Results

All age categories

A total of 33,736 cat admissions (15,492 (46%) adult cats and 18,244 (54%) kittens) were included in the study. Sex was recorded for 86% of cats (of which 54% were female; $P < 0.001$).

Most of the cats were presented by members of the general public (84%); only 15% were admitted by authorised personnel. Of the general public admissions, more than half (54%) were recorded as strays and 46% were surrendered (including 2% for euthanasia) (Table 1). The most common outcome was euthanasia, with 65% of all cats euthanased (Table 2). Of the 894 cats that were reclaimed, 13% (116) were categorised as being microchipped prior to admission.

Only 13% of cats were categorised as being desexed prior to admission (16% of males, 14% of females) and of these, 47% were surrendered by

Table 1. Summary of admission group and source for 33,736 cats processed through RSPCA Queensland shelters (July 2006–June 2008)

Admission group	Female[a] (%)		Male[a] (%)		All cats[b] (%)		
	Adult	Kitten	Adult	Kitten	Adult	Kitten	Total
General public	6565 (83)	6744 (87)	4528 (75)	6290 (88)	12,162 (78)	15,989 (88)	28,151 (84)
Stray	3051 (47)	3506 (52)	2349 (52)	3307 (53)	6216 (51)	8980 (56)	15,196 (54)
Owner surrender	3164 (48)	3218 (48)	1936 (43)	2961 (47)	5341 (44)	6950 (44)	12,291 (44)
Euthanasia request	336 (5)	20 (<1)	231 (5)	12 (<1)	579 (5)	49 (<1)	628 (2)
Returns	14 (<1)	0 (0)	12 (<1)	10 (<1)	26 (<1)	10 (<1)	36 (<1)
Authorised personnel	1315 (16)	864 (11)	1488 (25)	805 (11)	3214 (20)	2017 (11)	5231 (15)
Council	790 (60)	592 (68)	842 (57)	527(65)	1920 (60)	1319 (65)	3239 (62)
Ambulance	285 (22)	163 (19)	464 (31)	183 (23)	807 (25)	439 (22)	1246 (24)
Humane officer	240 (18)	109 (13)	182 (12)	95 (12)	487 (15)	259 (13)	746 (14)
Other	61 (1)	101 (2)	46 (<1)	88 (1)	116 (1)	238 (1)	354 (1)
Transfer in	60 (100)	41 (41)	46 (100)	38 (43)	115 (99)	88 (37)	203 (57)
Born in shelter	1 (<1)	60 (59)	0 (0)	50 (57)	1 (1)	150 (63)	151 (43)
Total	7941	7709	6062	7183	15,492	18,244	33,736

[a]Sex known. [b]All admissions, including cats of unrecorded sex.

Table 2. Summary of outcomes for 33,736 cats after entry to RSPCA Queensland shelters (July 2006–June 2008)

Outcome	Female[a] (%)		Male[a] (%)		All cats[b] (%)		
	Adult	Kitten	Adult	Kitten	Adult	Kitten	Total
Euthanased	5543 (70)	4074 (53)	4061 (67)	3761 (52)	10,987 (71)	11,061 (61)	22,048 (65)
Adopted	1829 (23)	3436 (45)	1406 (23)	3235 (45)	3236 (21)	6698 (37)	9934 (30)
Reclaimed	407 (5)	99 (1)	430 (7)	101 (2)	894 (6)	254 (1)	1148 (3)
Other	162 (2)	100 (1)	165 (3)	86 (1)	375 (2)	231 (1)	606 (2)
Unresolved file	60	65	50	56	126	147	273
Unassisted death	58	17	93	21	163	49	212
Escaped	31	8	12	4	60	14	74
Returned	7	2	5	1	14	6	20
Transfer out	3	5	3	3	7	8	15
Stolen	3	3	2	1	5	7	12
Total	7941	7709	6062	7183	15,492	18,244	33,736

[a]Sex known. [b]All admissions, including cats of unrecorded sex.

owners and 28% were strays. Of the owner-surrendered cats, 17% were categorised as having been desexed prior to admission, compared with 8% of stray cats and 14% of council admissions. Feral status was recorded for 80% of cats and of these, 12% were identified as feral. Only 6% of cats presented as owner-surrenders were identified as feral, compared with 18% of strays and 17% of council admissions.

Comparison of adult cats and kittens

A higher proportion of kittens than adult cats entered shelters as strays (56% vs 51%; $P < 0.001$) (Table 1). A lower percentage of kittens (3%) than adults (25%) were categorised as having been desexed prior to admission. Approximately the same percentage of admissions were recorded as feral for adult cats (8%) and kittens (9%). Outcomes differed between adult cats and kittens ($P < 0.001$). A higher percentage of adult cats (71%) than kittens (61%) were euthanased. Kittens (37%) were more likely to be rehomed than adults (21%) and adult cats (6%) were more likely to be reclaimed than kittens (1%) (Table 2). Of cats without recorded sex, 96% were euthanased and 69% were kittens.

Adult cat admissions

Most of the adult cats (78%) were presented by members of the general public; 22% were admitted by authorised personnel or other means. Of the adult cats presented by the general public, similar proportions were recorded as stray (51%) and surrendered (including euthanasia requests and returns; 49%) (Table 1). Of adult cats with sex

recorded (90% of all adult cats), 57% were female; this sex ratio differed significantly from 50 : 50 ($P < 0.001$). Overall, 25% of adult admissions were categorised as having been desexed. When examined by admission source, 34% of surrendered and 16% of adult strays were desexed prior to admission.

Over two-thirds (71%) of adult cats admitted were euthanased (Table 2), one-fifth (21%) were adopted and a small percentage (6%) were reclaimed.

The pattern of outcomes differed significantly between female and male adult cats, with a slightly lower percentage of male adult cats being euthanased (67% vs 70%) and a higher percentage being reclaimed (7% vs 5%; $P < 0.001$) (Table 2).

Kitten admissions

Most kittens (88%) were presented by members of the public. Of these, 56% were classified as strays and 44% as owner surrendered. A further 11% were admitted by authorised personnel, mostly by municipal council officers (65% of authorised admissions), leaving just 1% in the 'other' category (Table 1).

Of the kittens with sex recorded (82%), slightly more were female (52% vs 48% males). This ratio differed significantly ($P < 0.001$) from 50 : 50. Admission sources varied by sex ($P = 0.008$), with a greater percentage of female than male kittens admitted by council and less by ambulance (Table 1). Only 3% of kitten admissions were categorised as having been desexed prior to admission.

Euthanasia (61%) was the most frequent outcome for kittens, followed by adoption to new homes (37%). Only 1% were reclaimed (Table 2).

Risk factors for euthanasia

Of the 33,736 cat admissions, the outcome was unresolved for 273 (0.8%). The data for the remaining cats were used in the risk factor analyses. All potential risk factors assessed (age, sex, breed, admission source, desexed prior to admission, feral status and year of admission) were associated with euthanasia in the univariable analysis ($P < 0.001$). As none was postulated as being an intervening variable for others, and as direct effects of each were of interest, all were simultaneously fitted in a multivariable logistic regression model. Overall significances of each factor in the multivariable model were low ($P < 0.001$) and there was no evidence of collinearity, so all were retained in the model. The multivariable model included 23,722 cats, with exclusions because of missing data for sex, feral status and/or shelter.

Results of the univariable and multivariable analyses are shown in Table 3. The most extreme adjusted odds ratio (OR) was for feral status, with the odds of euthanasia for cats identified as feral much higher than for non-feral cats (OR 8.0) (Table 3).

Kittens were slightly less likely to be euthanased than adults (OR 0.4) and males were slightly less likely than females to be euthanased (OR 0.9). Domestic Short-hair and Long-hair cats were at greater risk of euthanasia than Domestic Medium-hairs, pure breeds and other breeds (Table 3). Domestic Short-hair cats had particularly high odds of euthanasia; this group comprised 80% of all admissions and were 3.1-fold more likely to be euthanased than pure breeds and other breeds (Table 3). Cats that were sexually entire on admission were more likely to be euthanased than cats desexed prior to admission (OR 1.5).

Owner-surrenders, adoption returns and cats born in shelters had lower crude odds of being euthanased compared with strays (Table 3). Although crude risk of euthanasia was a little higher for strays than for owner-surrenders, after adjusting for age, sex, breed, desexed prior to admission, feral status and year of admission, cats surrendered had slightly higher odds (1.1) of euthanasia than cats admitted as strays (Table 3). The odds of euthanasia did not differ markedly by year of admission (Table 3).

Crude proportions of cats euthanased by shelter varied between 43% and 84% (Table 3). After accounting for all variables in the multivariable model, substantial clustering of euthanasia by shelter remained; the intraclass correlation coefficient was 0.36, which indicates that important differences in the risk of euthanasia between shelters remained after accounting for the variables in the multivariable model.

Model fit and predictive ability

The Hosmer-Lemeshow goodness-of-fit statistic P value was <0.001, supporting rejection of the hypothesis that the fixed part of the multivariable model fitted the data perfectly. However, this was likely to have been related to the large number of subjects, as the observed numbers of cats euthanased were within 90–104% of expected numbers in each decile of predicted probability of euthanasia, indicating that the model fit was quite good.[24] Observed numbers euthanased were generally lower than expected, based on the multivariable model in all predicted probability categories. This could be due to additional (protective) risk factors for euthanasia that were not included in that model.

The predictive (or discriminatory) ability of the fixed part of the multivariable model (the ability of the fixed part of the model to discriminate between euthanased and non-euthanased cats) was just acceptable. The area under the ROC curve was 0.71 (95% confidence interval (CI) 0.70–0.72). At a probability cutpoint of 0.54, sensitivity and specificity of the model were both approximately 0.64. For the combined fixed and random parts of the multivariable model, the area under the ROC curve was 0.74 (95% CI 0.73–0.74). These results indicate that there are other important risk factors for euthanasia (including protective factors), in addition to the variables included in the multivariable model, and that these additional factors are not accounted for by fitting shelter as a random effect.

Discussion

The overall euthanasia rate of 65% in the present study was similar to that reported from a study of 134,405 cat admissions to 176 shelters in Michigan (71%).[25] However, in both studies there was considerable variation between shelters, which in our study was only partially accounted for by differences in cat factors. Human socioeconomic factors influence cat populations[26] and may explain some differences between shelters. A recent study in Boston found that 77% of the variation in cat euthanasia between neighbourhoods was explained by numbers of human premature deaths at the neighbourhood level,

Table 3. Descriptive statistics and odds ratios for euthanasia for 33,736 cats after entry to RSPCA Queensland shelters (July 2006–June 2008)

	No. of cats (%)	No. euthanased (%)	Crude OR[a] (95% CI)	P value	Adjusted OR[b] (95% CI)	P value[b]
Age				<0.001		<0.001
Adult	15,366 (46)	10,987 (72)	Reference		Reference	
Kitten	18,097 (54)	11,061 (61)	0.6 (0.6–0.7)	<0.001	0.4 (0.4–0.4)	<0.001
Sex				<0.001		<0.001
Female	15,525 (46)	9,617 (62)	Reference		Reference	
Male	13,139 (39)	7,822 (60)	0.9 (0.9–0.9)	<0.001	0.9 (0.8–1.0)	<0.001
Not recorded	4799 (14)	4609 (96)				
Breed				<0.001		<0.001
Pure breed/other breed	2120 (6)	950 (45)	Reference		Reference	
Domestic Short-hair	26,857 (80)	18,654 (69)	2.8 (2.6–3.1)	<0.001	3.1 (2.8–3.5)	<0.001
Domestic Medium-hair	4099 (12)	2210 (54)	1.4 (1.3–1.6)	<0.001	1.7 (1.5–2.0)	<0.001
Domestic Long-hair	387 (1)	234 (60)	1.9 (1.5–2.3)	<0.001	2.4 (1.8–3.1)	<0.001
Admission source				<0.001		<0.001
Stray	15,065 (45)	10,107 (67)	Reference		Reference	
Owner surrender	12,192 (36)	7416 (61)	0.8 (0.7–0.8)	<0.001	1.1 (1.0–1.2)	0.001
Council	3216 (10)	2241 (70)	1.1 (1.0–1.2)	0.004	1.0 (0.9–1.1)	0.528
Ambulance	1241 (4)	922 (74)	1.4 (1.2–1.6)	<0.001	2.1 (1.8–2.5)	<0.001
Humane officer	741 (2)	513 (69)	1.1 (0.9–1.3)	0.226	0.5 (0.3–0.7)	0.001
Euthanasia request	618 (2)	610 (99)	37.4 (18.6–75.2)	<0.001	78.0 (34.7–175.3)	<0.001
Transfer in	203 (1)	163(80)	2.0 (1.4–2.8)	<0.001	3.0 (2.1–4.5)	<0.001
Born in shelter	151 (<1)	63 (42)	0.4 (0.3–0.5)	<0.001	0.4 (0.2–0.6)	<0.001
Returns	36 (<1)	13 (36)	0.3 (0.1–0.5)	<0.001	0.4 (0.2–0.8)	0.009
Desexed prior to admission				<0.001		<0.001
Yes	4337 (13)	2504 (58)	Reference		Reference	
No	29,126 (87)	19,544 (67)	1.5 (1.4–1.6)	<0.001	1.5 (1.4–1.6)	<0.001
Feral status				<0.001		<0.001
No	23,567 (70)	13,693 (58)	Reference		Reference	
Yes	3337 (10)	3162 (95)	13.1 (11.2–15.2)	<0.001	8.0 (6.7–9.5)	<0.001
Not recorded	6559 (19)	5193 (79)				
Year				<0.001		<0.001
1 (2006–07)	15,899 (48)	10,165 (64)	Reference		Reference	
2 (2007–08)	17,564 (52)	11,883 (68)	1.2 (1.1–1.2)	<0.001	1.1 (1.0–1.1)	0.009

[a]Estimates from univariable analyses; shelter was fitted as a random effect in all analyses.
[b]Adjusted using a multivariable model with fixed effects fitted for age, sex, breed, admission source, desexed prior to admission and feral status; shelter was fitted as a random effect.
CI, confidence interval; OR, odds ratio.

suggesting that the same constellation of socioeconomic factors that negatively affect human health may also strongly influence cat mortality in shelters.[26] Shelter capacity and shelter policies and procedures may also explain differences. A detailed study of these factors is needed to help identify strategies that would effectively reduce cat admissions and risk of euthanasia.

The euthanasia rate for kittens in our study (61%) was lower than reported from an earlier study of one shelter in Victoria (72%).[22] An important consideration when comparing studies, however, is that RSPCA-QLD defines kittens as ≤3 months of age, whereas other reports have defined kittens as ≤6 months of age.[7,22,25] If the euthanasia risk for kittens between 3 and 6 months of age differs relative to adult cats and kittens less than 3 months, comparisons of results with other studies are potentially invalid, highlighting the need for standardised age category definitions.

Although the percentage of kittens euthanased (61%) in our study was lower than for adults (71%), a greater number of kittens were euthanased because more were admitted. Thus, strategies to reduce the total number of cats euthanased should include a major focus on reducing kitten numbers entering shelters. This may also benefit adult cats, as fewer kitten admissions may increase adoption opportunities for adult cats.[17,27]

The percentage of cats desexed prior to admission in this study (13%) was higher than previously reported in Australia (4%),[22] possibly because of our method of identifying desexed status prior to admission; however, RSPCA staff advised that our method of categorisation was likely to be accurate. Additionally, our results are similar to those of previous studies from the USA, reporting prevalences from 9%[28] to 13%.[25] Although the majority of owned cats in Australia are desexed (approx. 90%),[18,29–31] only 34% of owner-surrendered adult cats were categorised as desexed, which suggests there are important differences between cat owners who surrender their pets to shelters and other cat owners.

Given that 54% of all admissions were cats aged less than 3 months of age, and that almost half of these were surrendered, it is clear that, despite the high prevalence of desexing in domestic cats in Australia, excess breeding is still a key contributor to shelter admissions. There is evidence that many owned cats produce kittens prior to being desexed,[32] with reports that at least 13–20% of owned female cats had produced a litter prior to desexing.[33,34] Although female cats can have their first oestrus as early as 3.5 months,[32] approximately 45% of cats in one USA study[34] were at least 1 year old when they were desexed and it was calculated that the average sterilised cat had 2.46 kittens before being sterilised. In fact, the number of kittens born from cats that were ultimately desexed was calculated to be only slightly less, and not statistically different, than the number of kittens born from cats that were never desexed.[34]

Reducing the number of kittens born to owned cats as a result of delaying sterilisation is therefore an important strategy for those seeking to reduce shelter admission numbers. A potential factor contributing to unwanted kittens being born to owned cats is the reluctance of veterinarians to incorporate early-age desexing (EAD) into initial preventative health programs for owned kittens. Given that mortality associated with EAD is not higher than traditional age desexing (>6 months) and that subsequent health and behaviour are better in cats desexed at less than 5 months of age,[35] veterinarians should embrace EAD as a means of reducing euthanasia rates and the subsequent adverse mental health effects on the personnel involved.[35]

A previous report concluded that the domestic cat population in Australia is becoming smaller and suggested that high levels of desexing among owned cats may limit the availability of kittens for purchase or adoption.[29] However, a recent Australian study determined that only 2% of cat owners experienced difficulty sourcing a kitten for purchase or adoption.[37] Those who did experience difficulty usually required a specific breed or were attempting to obtain a kitten out of breeding season.[36] The results of our study confirm that kittens are not in short supply within Queensland.

Strays were the single largest (45%) admission group, although this percentage may not reflect the true proportion of strays. Some people present owned cats as strays because they do not want to admit to surrendering their own animal and/or are unwilling to pay the fee (Reid, pers. comm.). RSPCA-QLD charges a small fee per private cat admission, but not for stray cats.[20] Also, admissions not presented by the general public (22% of adults, 12% of kittens) were unable to be classified as stray or owned and may comprise a higher proportion of strays than general public admissions. Because stray cat admissions will not be directly influenced by strategies that focus on owned cats (e.g. mandatory registration and microchipping, desexing, etc.), additional strategies focussed on stray cats are required to reduce overall admission numbers.

'Semi-owned' cats may constitute an important subset of 'strays'. In Australia and the USA, there are reports of 'semi-owned' populations of cats that are fed by people who do not perceive the cat as their own. In a Victorian study, 22% of survey respondents said that they provided care, including food, to a cat that was not their own.[37] This indicates that there is a substantial population of cats in the community that are tolerant of human interaction, but not under the direct influence of legislative requirements for pet ownership.

There may also be a large population of 'pre-owned strays' in Queensland. Although the crude risk of euthanasia was higher in strays than in cats surrendered by owners, after adjusting for other variables in the multivariable model the stray cats in our study were actually at lower risk of euthanasia. This reflects the finding that many of the cats admitted as 'strays' were suitable for rehoming and 16% were categorised as having been desexed prior to admission, which suggests that at least 16% of the 'stray' cats older than 3 months had been 'pre-owned' at some point prior to admission. The actual percentage of pre-ownership may be much higher.

It is commonly speculated that a considerable portion of cats euthanased in Australian shelters are feral. One study of cats entering three urban shelters in Melbourne reported 47% of euthanased cats as feral or wild.[22] By contrast, in our study only 19% of euthanased cats were recorded as feral. As described in the Methods section, cats are categorised as feral by the RSPCA based on a subjective visual assessment of behaviour, often at the time of arrival at the shelter when the cat may be extremely distressed. This is likely to be inaccurate, as indicated by the fact that 6% of owner-surrendered cats in this study were recorded as feral. An alternative definition based on the cat's apparent level of socialisation towards humans may be more accurate. However, if data in the current study are accurate, the majority of cats euthanased in RSPCA-QLD shelters are tolerant of human proximity and interaction, and therefore potentially rehomable.

The percentage of cats reclaimed was very low (3%) in the current study. Of cats that were reclaimed, only 13% were categorised as microchipped prior to admission. The true prevalence may be even lower because of inaccurate data recording. Of all 36,736 cats admitted during our study, 29% were categorised as being microchipped prior to admission: 33% of kittens and 25% of adult cats. In contrast, Marston and Bennett reported that 1.5% of 15,206 cats admitted to a Melbourne shelter were recorded as having a microchip detected on admission.[22] The high prevalence in our study, especially in kittens, suggests that our method of interpreting the microchip data resulted in frequent misclassification errors. Further inquiry indicated that microchip number was recorded in the same field within the database, regardless of whether the cat was microchipped prior to or after admission, and that for cats microchipped after admission, staff often entered the microchip number but neglected to record the date of implantation. Under our categorisation method, such cats would have been erroneously classified as being microchipped prior to admission. The estimated prevalence of microchipped prior to admission in

reclaimed cats is therefore reported, but likely to be an overestimate. This finding indicates that microchipping was not an important factor in owner reclamation of cats from RSPCA-QLD. Accurate recording of microchip status at admission is important because it allows the effect of mandatory microchipping (promoted as a means of reducing euthanasia of lost owned cats) to be assessed. We did not ascertain if reclaimed cats had other forms of identification (e.g. collars and identification tags) on admission. However, microchips do not provide a visual indication of a cat's ownership status and identifications tags may play a vital role in reuniting lost cats with owners prior to, or following, shelter admission.[38]

Study limitations

Some of the limitations of this study were related to the methods used by shelters to record and manage data collection. Computer-based record keeping systems are becoming more common, enabling higher quality research. However, high levels of data integrity and consistency in terminology are necessary for valid research. Consistency is challenging when data are entered by numerous people in multiple shelters, and when there are no overarching requirements for the data that shelters are required to collect. Some variables that may not seem important from an operational standpoint, such as microchip status prior to admission, are essential data for developing effective strategies to decrease euthanasia numbers.

Conclusions

Our findings indicate that euthanasia rates in RSPCA-QLD shelters are consistent with other Australian and overseas reports, with a greater proportion of kittens admitted and euthanased compared with adults. Excessive breeding remains a serious problem, contributing to the large numbers of cats admitted to, and euthanased in, shelters. Although half of all admissions were categorised as stray; many cats admitted as 'strays' were rehomable and have probably been owned or semi-owned previously. The number of reclaimed cats was very low and, of those that were reclaimed, only a very small percentage were microchipped prior to admission. These results suggest that effective strategies for reducing numbers of cats admitted and euthanased will include reducing the incidence of delayed sterilisation of owned cats and, possibly, increasing the prevalence of microchipping and other forms of identification. However, management strategies that exclusively target the owned cat population will have limited impact. Further research is required to better understand the stray cat population in the community and how cats transition between owned, semi-owned and stray populations. Meaningful comparisons initially require implementation of standardised data collection definitions, categories and methods.

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BOOK REVIEW

Equine MRI. Edited by Rachel C. Murray. Wiley-Blackwell Publishing, 2011. 592 pages. Price A$195. ISBN 978 1 4051 8304 8.

Equine MRI (magnetic resonance imaging) is the first comprehensive text published on this subject. This imaging modality has been available for less than 20 years for equine clinical applications and although once the domain of research and academic centres, it is now available in large equine practices, due mainly to the availability of low-field scanners used on standing, sedated patients. MRI provides highly detailed three-dimensional information on bone and soft tissue structures for the diagnosis of pathological conditions. The application in horses is principally in lameness diagnosis, but options for investigation of opthalmological, neurological and cranial pathology are becoming a reality. This hardback book is edited by Rachel Murray, who has over 10 years research and clinical MRI experience at the Animal Health Trust, UK. Written by many of the world's leading experts, the text is divided into four sections: Principles of MRI in horses, Normal MRI anatomy, Pathology, and Clinical management and outcome. The information is based on previous validation work and experience with clinical cases. There are almost 950 normal and abnormal MR images, each clearly labelled as to the sequence depicted, relevant anatomical positioning and areas or pathology of note.

For beginners, and to get full use of the text, it should be read in order. This means negotiating the complex physics described in the first 37 pages, which is mandatory to understanding how the MR image is produced, manipulated and consequently interpreted. It is a 'difficult read' and will more than likely require re-reading when one gets further along. However, a very useful glossary at the end of this chapter gives definitions of the key physics terms used. The remainder of this section focuses on high-field and low-field MRI, including practicalities and image acquisition. This is an excellent section that gives good advice on what would be required to set up an MR facility. However, for someone wanting to set up MRI in their hospital or practice, specialist advice in this area is a must. Lastly, the basics of image interpretation and common artefacts are described. It is clear that there is a steep learning curve when it comes to image interpretation and the problems of image artefacts.

This first edition will need to be re-written in due course as knowledge in this area expands. Suggested improvements include updating some suboptimal images, shortening the overly long descriptions for some images and, where possible, making sure the text relating to the images is on the same or opposing pages. Flicking back to the text or forward to the images can be irritating. There is some duplication between chapters, and the section on clinical management and outcome might be improved with more images of related clinical pathology, particularly in the section on the tarsus.

There are some causes of lameness (particularly of the foot) which are not able to be diagnosed without MRI and the material on subchondral bone disease is a must read for veterinarians working with the high-performance horse. It is clear that MRI will become more and more common in the years to come and it is likely that horses referred for specialist lameness evaluation will have MRI performed. Therefore, an understanding of the technology and how it is used will be needed so that effective communication with clients is possible. The production of this book was a mammoth task and the volume and quality of information presented is immense. The authors are to be congratulated on an excellent job and this text, like those dedicated to other imaging modalities, will be required reading for equine veterinarians working with lame horses. *Equine MRI* is recommended for specialist radiologists and equine clinicians already using MRI, but because of the way it has been written, students, residents and general practitioners working with lame horses would also be interested in this book.

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