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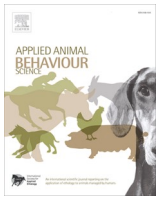

Impact of early socialisation in foster care on kitten behaviour

Gemma R. Campbell [b], Elizabeth R. Arnott [a], Courtney Graham [c], Lee Niel [c], Michael P. Ward [b], Gemma Ma [a,b,*]

[a] RSPCA NSW, Yagoona, NSW 2199, Australia
[b] Sydney School of Veterinary Science, Faculty of Science, the University of Sydney, Camperdown 2006, Australia
[c] University of Guelph, Guelph, ON N1G 2W1, Canada

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ABSTRACT

Objectives: The critical socialisation period for kittens is estimated to be 2–7 weeks of age. Kittens reared in shelters often have poorer outcomes due to high rates of infectious disease. Therefore, many shelters are reliant on foster care programs to improve kitten survival rates and behaviour. However, little is known about the impact of specific early socialisation factors on kitten behaviour and health.

Methods: During a 23-month period, 598 kitten foster carers completed a kitten socialisation questionnaire. The relationships between kitten weight/age at intake, days in care, singleton status, and the presence or absence of the queen during care on kitten behaviour and disease incidence were explored. Associations with exposure to noise, adults, children, location where the kitten was kept in the home, time spent alone, and ringworm treatment were also investigated.

Results: Overall being kept in social areas of the house with less noise/activity and spending some time alone was associated with positive kitten behaviour. There was no difference in fear or anxiety responses for bottle fed kittens, singletons and those without the queen. Ringworm treatment was associated with more fearful behaviour in kittens.

Conclusions: and relevance: Future foster carers should be encouraged to keep kittens in social areas of the house, whilst also ensuring kittens can spend some time alone. If the home is loud, carers should slowly introduce the kitten/s to the louder and busier areas of the house before being housed there all the time. Training of carers to use more positive reinforcement techniques for administering ringworm treatment may benefit kitten behaviour.

1. Introduction

Kittens are considered highly adoptable. However, as cats are seasonal breeders (Nutter et al., 2004), shelters are often overwhelmed by admissions of large numbers of kittens during spring and summer (Marston and Bennett, 2009). The critical socialisation period for kittens is estimated to be 2–7 weeks of age (Karsh and Turner, 1998). In addition, kittens that are reared in shelters have poorer outcomes due to high rates of infectious diseases (Möstl et al., 2013). Therefore, many animal shelters are reliant on kitten foster care programs to reduce shelter overcrowding and improve survival rates, kitten adjustment and future behaviour.

Most shelters require kittens to reach a minimum age of 8–12 weeks prior to desexing and adoption. Considering the critical socialisation window, the impact of foster care might vary with the age the kitten is taken into care and the conditions they experience. One study found that early weaning from the queen (before 8 weeks of age) increased the risk of adulthood aggression (Ahola et al., 2017). Kittens who are separated early from the queen can experience increased stress which might contribute to long term changes in the stress response (Lowell et al., 2020), and potentially increase vulnerability to disease. They have also been noted to exhibit different behavioural responses at the time of weaning (Martínez-Byer et al., 2023). The length of time spent in care might also be related to behaviour and health outcomes. For example, foster kittens are often returned to the shelter for adoption when they reach a specific milestone, such as a certain weight, and this can vary between kittens. Furthermore, anecdotal evidence indicates that kittens hand-reared without litter mates (termed "singletons") have poorer health and behaviour outcomes. However, one retrospective study found no relationship between bottle-fed kittens, singletons and early rehoming age and adulthood aggression (O'Hanley et al., 2021), and another study found no difference in behavioural responses between

* Corresponding author at: RSPCA NSW, Yagoona, NSW 2199, Australia.
E-mail address: gma@rspcansw.org.au (G. Ma).

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single kittens and those hand-reared with littermates at the time of weaning (Martínez-Byer et al., 2023). To date, studies on kitten socialisation and kitten behaviour and health outcomes to weaning have been small and limited in their scope.

Socialisation experiences in the critical window of 2–7 weeks of age, particularly a variety of positive human handling, has been shown to increase friendliness, decrease fear of humans (McCune, 1995), and improve owner reported emotional support from the cat post adoption (Casey and Bradshaw, 2008). Kittens exposed to only one person during this critical period have greater fear of strangers, but more play behaviours, than those exposed to five people (Collard, 1967). However, the effect of different levels of exposure to adults or children during foster care has not been investigated. Although gentle and gradual exposure to a variety of noises during the critical socialisation window is recommended (Quimby et al., 2021), the impact of different noise levels, or the location where the kitten is kept in foster care environments during this critical period has not been assessed.

The aim of our study was to explore foster kitten demographics and management and potential associations with foster carer reported fearful or aggressive behaviour and medical concerns.

2. Material and methods

Kittens with an intake weight under one kilogram arriving at the RSPCA Sydney Shelter who were placed in foster care over a 23-month period (March 2021 – February 2023) were included in the study. Foster carers were informed of the study and consented to participate prior to fostering eligible kittens. When foster carers returned their foster kittens to the shelter for adoption (when kittens were around 1 kg, about 9 weeks old; DiGangi et al., 2020), they completed a questionnaire (see Appendix A). The survey was completed online using Redcap software.

Foster carers were asked for the kitten's tag number, allowing responses to be linked with shelter records. Carers were then asked questions describing the kittens' circumstances in care: number of littermates in care, if they were bottle fed and if the queen was present. They were asked about their household including number and level of exposure to adults and children, other pets in the house and their interaction with the kitten, noise level, and where the kitten spent most time in the house. Carers were asked about exposures during care including car travel, visiting adults and children, other animals, vacuum cleaning, visiting the veterinary clinic, time outdoors, grooming with a brush or comb, and time the kitten spent alone. Carers were asked five questions about their kitten's behavioural responses when the carer enters the room, were being fed, played with, introduced to new objects, or introduced to a new person. Finally, carers were asked about any concerns they had regarding the kitten's health or behaviour whilst in care.

In the shelter environment, the exact age of a kitten is often difficult to accurately determine. Instead, weight can be used as an accurate indication of age up until 10 weeks old (DiGangi et al., 2020). Therefore, weight measured closest to intake date was extracted from shelter records and linked to responses. Other variables extracted from shelter records and linked to responses were treatment for ringworm, current adoption status, sex, breed, coat colour and source (where the kitten came from).

Ethics approval for this project was granted by the Human Research Ethics Committee of the University of Sydney, protocol number 2020/823. Animal ethics was not required as no manipulations of the kittens were involved in this study (an observational design only).

2.1. Statistical analysis

Data was analysed using the statistical program SPSS (version 29, IBM statistics). Significance was set at $\alpha < 0.05$. Descriptive statistics were calculated to characterise the cohort of kittens enrolled in the study, and for all independent and dependent variables. In addition, the number of kitten carers and the types of kittens for which they cared were described. As there were small number of responses in categories for some variables the following composite variables were created so as to facilitate statistical analysis:

- *Situation behaviour score:* For each of the five behavioural response questions (enter room, feed, play, new object and new person), if a kitten responded with fear or aggression, this was coded as a negative response, whereas if they responded neutrally or positively this was coded as a positive response.
- *Total situation behaviour score:* A similar approach was used to create an overall situation response score; a kitten who responded negatively to any of the 5 situations was coded as a negative response, and those who responded positively to all situations coded as positive.
- *Health concern:* All responses to the question "Did you have any concerns about this kitten's health or behaviour during their time in your care? Please describe" were coded as either behaviour, medical or no concern. Medical and no concerns were included in further analysis.
- *Time spent alone:* Responses were collapsed from 5 categories (Not at all, a little, somewhat, quite a bit or a great deal) into 3 categories; not at all, a little/somewhat, or quite a bit/a great deal.
- *Environmental loudness:* 4 categories (Generally quiet, average noisiness, loud or very loud) were collapsed into 3 by combining loud and very loud.
- *Time in social area of house:* This was collapsed from 5 categories (Free access indoors, living area – free roaming, living area – in a crate or other enclosure, spare room or other), to 2 categories. Kittens either spent the majority of their time in social areas (free access and both living rooms), or non-social areas (spare room) of the house in foster care. The description provided of "other" was used to code responses into social or non-social areas.
- *Singleton:* The number of other kittens in care was used to classify singleton kittens (no other littermates) or not singletons (1–5+ littermates). Some kittens who arrived at the shelter without littermates were paired with other kittens for foster; these kittens were treated as not singletons in the analysis.

Chi-squared tests were performed between all categorical independent variables (queen in care, bottle fed, singleton, ringworm treatment, adults handled, child exposure, where the kitten spent time, time spent alone, home noise/activity and ringworm treatment) and the categorical dependent variables (behaviour scores for enter room, feed, play, new object, new person, total behaviour score and medical concerns score). Independent sample t-tests were performed for the continuous independent variables (weight at intake and days in care) assuming unequal variance with the same categorical dependent variables. The Benjamini-Hochberg Procedure was applied to chi-squared and t-tests to adjust for the false discovery rate by ranking the p-values obtained from the tests and comparing each to its corresponding critical value, calculated as $(i/m)*\alpha$, where i is the rank, m is the total number of tests, and α is the false discovery rate (Benjamini & Hochberg, 1995). All tests where the p-value was smaller than the largest p-value that was less than its corresponding critical value were considered significant. The false discovery rate was set at 25 %.

3. Results

Overall, there were 598 survey responses from 223 different carers. Each carer provided an average of 3 responses. Sixty-three carers (28.3 %) cared for bottle fed kittens (an average of 3 kittens each, range of 1–9). Twenty-five different carers (11.2 %) had kittens with queens in care.

Of the responses, there were 287 female kittens (48.0 %) and 311 (52.0 %) male kittens. Most of the kittens were strays (488, 81.6 %) and domestic shorthair or medium hair (595, 99.5 %). Since being returned from foster care, 99.2 % (593) of the kittens were adopted. Four kittens

died (all were bottle fed neonates) and 1 kitten escaped from foster care.

Weight closest to incoming date was recorded for 393 kittens and ranged from 110 g to 2.3 kg. Given kittens over 1 kg at intake were not included in the study, weights over 1 kg were excluded from further analysis, resulting in 302 kitten weights, ranging from 110 g to 1 kg (M= 516 g). Hence, kittens were estimated to be approximately 4.6 weeks old on average (range 1–9 weeks old) when entering foster care (DiGangi et al., 2020). On average, kittens spent 47 days in foster care, ranging from 2 to 185 days. Eighty kittens were in care with their queen, whilst 180 were bottle fed in care. Of the bottle-fed kittens, only 4 were singletons. Most kittens were in foster care with 1 (34.8 %) or 2 (28.8 %) other kittens (Fig. 1).

Household environments varied between foster kittens, with most kept in social areas of the home (73.6 %; Table 1). More than half (307 kittens, 53.2 %) of the kittens spent no time alone (with no people or litter mates), whilst 115 kittens (19.9 %) spent a little time alone, 102 (17.7 %) somewhat, 42 (7.3 %) quite a bit, and only 11 kittens (1.9 %) spent a great deal of time alone in foster care. Overall, the noise and activity level of the household while the kitten was in foster care was generally quiet (221, 37.0 %), of average noisiness (333, 55.7 %), loud (36, 6.0 %) or very loud (8, 1.3 %).

The number of adults who regularly handled the kittens ranged from 0 (8 kittens, 1.3 %), 1 adult (145, 24.3 %), 2 adults (312, 52.4 %), 3 adults (77, 12.9 %), 4 adults (27, 4.5 %) to more than 4 adults (27, 4.5 %). Most kittens had no exposure to children during foster care (308, 51.5 %; Fig. 2). Most interactions with children were described as gentle (59.0 %), playful (78.3 %), or caring (40.0 %), compared to rough (3.5 %), or children showed no interest (3.5 %).

Carers reported health concerns for 185 kittens (31.0 %) whilst in care; 155 of these were medical concerns and 30 were behavioural concerns. Most kittens (411, 69.0 %) had no concerns reported by their carer. Fifteen kittens were treated for ringworm.

For each of the five situations, most kittens were interpreted to display positive behavioural responses (2455 responses, 82.1 %), some neutral (268 responses, 9.0 %), a small number with non-confrontational fear behaviours (e.g. retreats, hides or freezes, 147 responses, 4.9 %), and a smaller number with aggression (e.g. swatting or hissing, 14 responses, 0.5 %; Table 2). Most fearful behaviours were to the presence of a new person, whilst the positive behaviours occurred during feeding or play. The 14 aggressive responses were from 10 kittens, two of which were bottle fed, nine were male, and one was a singleton. Overall, for the situation total, 488 kittens responded positively (82.2 %), 106 negatively (17.9 %).

3.1. Univariate analysis

Kittens with a lower intake weight were more likely to have a negative response (n=8, M=349 g, SD=188 g) than positive (n=291, M=522 g, SD=227 g) to a new object (p=0.036), however this finding was not significant after applying the Benjamini-Hochberg Procedure. Kittens with behavioural concerns were slightly younger, around 4 weeks (M= 425 g), when brought into care than those with medical concerns who were about 5 weeks old entering care (M=523 g). Kittens with no concerns were on average 516 g, around 5 weeks old.

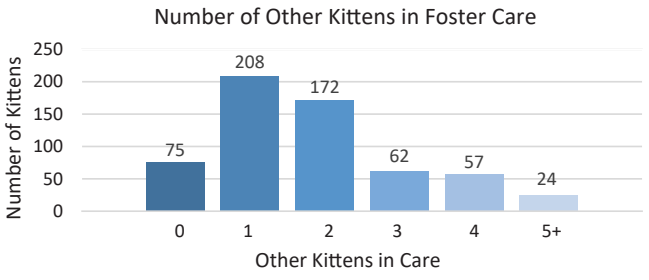

Fig. 1. Number of other kittens in foster care reported by foster carers in a Kitten Socialisation Questionnaire.

Table 1
Frequency (counts) and percentages of kittens kept in each location in the house in foster care reported by carers in a Kitten Socialisation Questionnaire.

Area Type	Area Kept	No. Kittens (%)
Social	Free access to the house indoors	217 (36.97)
	Living area – free roaming	139 (23.68)
	Living area – crate or enclosure	55 (9.37)
	Other – such as a portacot when young, then free roaming	21 (3.58)
	Total	432 (73.59)
Non-social	Spare room	133 (22.66)
	Other - such as in the bathroom, laundry or garage	22 (3.75)
	Total	155 (26.41)

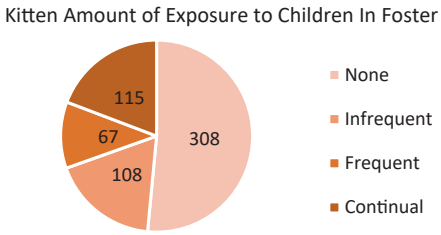

Fig. 2. Amount of exposure kittens had to children in foster care reported by carers in a Kitten Socialisation Questionnaire.

Table 2
Frequencies (counts) of kitten behavioural responses for each situation in a carer reported Kitten Socialisation Questionnaire. Note the number of responses do not sum to the total number of kittens across columns, as they could have the same response in different situations.

Situation Response	Enter room	Feed	New object	New person	Play	Situation Total No. Kittens
Responds positively	484	559	514	343	555	488
Neutral - No response	73	26	47	101	21	
Responds with aggression	1	2	3	5	3	106
Responds with fear	30	5	20	81	11	
Not applicable / Don't know	3	2	6	58	3	4
Missing	7	4	8	10	5	
Total	598	598	598	598	598	598

For kitten related factors significant chi-square test results are reported in Table 3. Applying the Benjamini-Hochberg Procedure did not affect the significance of any chi-square tests. There was no association between kittens with the queen in care or not, being a singleton kitten or not, number of days in foster care or number of adults who regularly handled the kitten and any outcomes included in the study (see Appendix B for all non-significant associations). No significant associations were found between sex and any outcomes (p>0.05).

Bottle fed kittens had 6.6 times greater odds of responding positively to the carer entering the room than those who were not bottle fed (p=0.003). Kittens treated for ringworm had 9.1 times greater odds of responding negatively to a new object than those who were not treated for ringworm (p<0.001; Table 3).

For foster care related factors, significant chi-square test results are reported in Table 4 (see Appendix B for all non-significant associations).

Table 3
Significant Pearson chi-square tests between kitten related factors and behavioural outcomes.

		Outcome			
		New object		Enter room	
		Positive	Negative	Positive	Negative
Ringworm treatment	Yes	9	3	-	-
	No	552	20	-	-
	p-value	<.001		-	
	OR	0.11		-	
Bottle fed	Yes	-	-	175	2
	No	-	-	382	29
	p-value	-		0.003	
	OR	-		6.64	

Kittens who spent most of the time in social areas of the house had 2.2 times greater odds of responding positively to the carer entering the room (p=0.035), 3.3 times greater odds of responding positively to a new object (p=0.003), and 3.0 times greater odds of responding positively to play (p=0.036) than kittens who spent most of their time in non-social areas of the house. Whilst kittens who spent no time alone (from littermates and people) had 1.1 times greater odds of responding *negatively* to play than kittens with some time spent alone (a little and somewhat), they had 4.1 times greater odds of responding *positively* than kittens who spent lots of time alone (quite a bit and a great deal, p=0.041). Kittens in households described to be quiet in noise and activity had 1.9 times greater odds of having an overall positive response to situations compared to those of average noise/activity and had 1.8 times greater odds of responding *positively* than those in loud noise/activity households (p=0.025).

Kittens who had no exposure to children whilst in care had 3.6 times greater odds of responding *negatively* to the carer entering the room compared to those with infrequent exposure to children, they had 2.1 times greater odds of responding *positively* compared to frequent exposure, and 3.7 times greater odds of responding *negatively* compared to continual exposure (p=0.005). Kittens who had no exposure to children whilst in care had 1.2 times greater odds of responding *negatively* to a new person whilst in care compared to those with infrequent exposure to children, they had 2.6 times greater odds of responding *positively* compared to frequent exposure, and 1.6 times greater odds of responding *negatively* compared to continual exposure (p=0.002). Kittens who had no exposure to children whilst in care had 4.0 times greater odds of responding *negatively* to the carer playing with the kitten whilst in care compared to those with infrequent exposure to children, 3.5 times greater odds of responding *positively* compared to frequent exposure, and 4.4 times greater odds of responding *negatively* compared to continual exposure (p=0.013).

4. Discussion

Overall, this study found that foster kittens have positive outcomes during their care, with very low mortality, high adoption rates and infrequently reported concerns from foster carers. The socialisation factors that had the most significant associations with outcomes were if kittens were kept in social areas of the house or not (enter room, new object and to play) and the amount of exposure to children in care (enter room, new person and to play).

Kittens who spent most time in social areas of the home (free access indoors or in the living room) were more likely to respond positively to the carer entering the room, to a new object and to play than kittens kept in non-social areas of the house (including the spare room, garage and laundry/bathroom). This indicates there may be a benefit from keeping foster kittens in more central parts of the home, a previously unstudied foster care factor.

Despite this, it seems to also be important for kittens to spend some time alone, away from littermates and people. Kittens who spent no time alone were more likely to respond negatively to play than kittens who spent some time alone. In the wild, a queen will generally not retrieve a kitten who wanders unless it vocalises (Bradshaw, 1998). It is plausible kittens do not get this same treatment in the foster care environment and so do not spend as much self-directed time alone. Additionally, kittens have a high demand for sleep. When with the queen, kittens spend approximately 55 % of their time in REM sleep at 10 days old, with this gradually decreasing as they age to approximately 20 % of their time spent in REM sleep, and 25 % NREM sleep by 41 days old (Herman et al., 1991). No time alone might impede this need, contributing to negative behavioural responses. However, too much time alone can also be negative, as kittens who spent lots of time alone in this study were more likely to respond negatively to play than those who spent no time alone. Being alone can contribute to adulthood separation anxiety in cats (Schwartz, 2003). Positive interactions with people are also a critical component of socialisation (McCune, 1995). Improving response to play

Table 4
Significant Pearson chi-square tests between foster care factors and behavioural outcomes.

		Outcome									
		Situation total		Enter room		New Person		New object		Play	
		Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
Kept in social area of house	Yes	-	-	410	18	-	-	415	11	423	7
	No	-	-	136	13	-	-	136	12	142	7
	p-value	-		0.035		-		0.003		0.036	
	OR	-		2.18		-		3.33		2.98	
Time spent alone	Not at all	-	-	-	-	-	-	-	-	298	6
	Some	-	-	-	-	-	-	-	-	211	4
	Lots	-	-	-	-	-	-	-	-	49	4
	p-value	-		-		-		-		0.041	
	OR	-		-		-		-		0.94, 4.05	
Noise and activity level	Quiet	193	27	-	-	-	-	-	-	-	-
	Average	260	70	-	-	-	-	-	-	-	-
	Loud	35	9	-	-	-	-	-	-	-	-
	p-value	0.025		-		-		-		-	
	OR	1.92, 1.84						-		-	
Child exposure	None	-	-	283	19	217	41	-	-	293	10
	Infrequent	-	-	106	2	92	15	-	-	108	0
	Frequent	-	-	56	8	39	19	-	-	60	4
	Continual	-	-	112	2	96	11	-	-	115	0
	p-value	-		0.005		0.002		-		0.013	
	OR	-		0.28, 2.13, 0.27		0.86, 2.58, 0.61		-		0.25, 3.51, 0.23	

by allowing kittens to spend some time alone in foster care might improve adoptability when returned to the shelter as they are more likely to engage in play with prospective adopters who are mostly looking for friendly, playful and happy kittens (Gourkow and Fraser, 2006).

Noise and activity levels in foster care were also associated with the kittens' overall responses to the five situations included in this study. Kittens in quiet homes were more likely to respond positively than kittens in households of both average noisiness and those that are loud. Considering that the majority of kittens were strays, this study highlights the disconnect between life as a stray and the foster care environment in a busy and loud home. Additionally, felines have one of the largest hearing ranges of any mammalian species (0.125–60 kHz; Fay and Popper, 1994) and demonstrate increased avoidance and fear behaviours when exposed to larger amounts of sound (Eagan et al., 2021). Gentle and gradual exposure to noise during the critical socialisation window is recommended (Quimby et al., 2021). Therefore, in foster homes that are of average noisiness or those that are loud, it may be beneficial to slowly introduce the kitten/s to louder areas of the house. For example, keeping the kitten in a quieter area of the house (such as a spare room) for its first few days in care, prior to allowing them to free roam, or being kept in the living room, could mitigate the negative effect found in loud households.

Intake weight (used to estimate intake age) had less of an effect than hypothesised and number of days in foster care was not related to any of the outcomes examined. Considering kittens in this foster care program were returned to the shelter when they reached approximately one kilogram, this suggests that although entering foster care at a younger age did have an impact, the overall length of time in care does not. This is a positive outcome, as it suggests that spending longer in foster care does not impact behaviour or health, contrary to our hypothesis. The finding supports the animal welfare benefits arising from foster care as cats housed within shelters are known to have poorer outcomes with increasing length of stay (Gouveia et al., 2011).

Bottle fed kittens were more likely to respond positively to carers entering the room than those who were not bottle fed. As bottle-fed kittens are younger when taken into care, this supports previous findings that positive human handling during the critical socialisation period can increase friendliness (McCune, 1995). This behaviour may represent strong associative learning, connecting the care giver with the survival critical resource of milk, and the contentment experienced during feeding. It is not known whether the behaviour in these young kittens will be predictive of future sociability as adults. Responses to all other situations for bottle fed kittens were non-significant, suggesting bottle fed kittens are similar to non-bottle-fed kittens in responses to being fed, new objects, new people and play. Bottle-fed neonates had excellent outcomes overall, with low mortality, relatively low morbidity, and good behavioural outcomes. This is evidence that these kittens are worth the extra investment needed to rear them.

Furthermore, there were no associations between singletons and any of the situation responses. This was not what we hypothesised, however it is consistent with O'Hanley et al. (2021) who found no relationship between bottle-fed kittens or singletons with later adulthood aggression. It was also hypothesised that kittens reared with their mother would have fewer negative behavioural outcomes, yet no significant association was found between queen in care and any of the situation outcomes. Notably, in this study there were fewer kittens who responded with aggression than with fear/anxiety, neutrally or positively. As fear and aggression were combined and labelled as a negative response for statistical analyses, the lack of difference between singleton and not singleton kittens might more accurately reflect no difference in fear responses rather than aggression. Nonetheless, no difference in fear or anxiety responses provides reassurance to foster care programs that the time and resources invested in bottle fed kittens, singletons and those without the queen are not wasted as there were no negative impacts on their behaviour or health when returned for adoption. Further research is required to understand how these early life behaviours reflect behaviour into adulthood.

Interestingly, kittens treated for ringworm were more likely to respond negatively to new objects. Considering treatment for ringworm consists of prolonged daily oral administration of an unpalatable antifungal paste in a syringe and baths, it follows that kittens learn to associate new objects with a negative experience, and therefore respond negatively to other new objects. Training carers to use more positive reinforcement and less aversive techniques may benefit kitten adjustment and behaviour. Additionally, this finding supports using shorter treatment courses for ringworm, especially in foster care, where there is less risk of transmission to other cats (Stuntebeck and Moriello, 2020).

The relationship between the amount of exposure kittens had to children during fostering and the kitten displaying a positive or negative response to the carer entering the room, to a new person and to play was not linear. Rather, it seems infrequent or continual exposure to children increases positive kitten responses in all three of these situations when compared to no exposure to children. It is plausible that infrequent exposure may be enough for kittens to find enrichment in the play with the child, and similarly for continual exposure the play is enriching, however, as the children are present all the time, they also allow the kitten to engage in downtime and play with other littermates. However, these unexpected findings might relate to differences in how foster carers interpreted "infrequent", "frequent" vs. "continuous" exposure in the questionnaire. This is potentially important but warrants further investigation.

The number of adults who regularly handled the kitten was not related to any outcomes. This contrasts with Collard (1967) who found 5-week-old kittens exposed to only one person were more fearful of strangers but showed more play behaviours than those exposed to five people. In our study, no question directly asked about the type of interaction or length of interactions with adults. Therefore, it is plausible that the relationship between the number of adults to which a kitten is exposed is mediated by the length of these interactions, or the type of interaction, explaining the difference in results. Further studies are warranted to clarify this relationship.

Notably, medical concerns were not related to any outcomes. Immune factors – such as the contents of colostrum which depends upon the queen's immune system, their vaccination status and the timing or absence of colostrum ingestion (Evermann and Wills, 2011) – could explain kitten medical concerns, rather than foster care variables included in this study.

Limitations of this study include the carer reported nature of the unvalidated questionnaire. Foster carer demographic variables (age, sex, experience) might also have important influences on kitten outcomes and this warrants further investigation. Future studies could also correlate these findings with more objective measures of kitten behaviour to further validate the questionnaire employed and the present findings. Additionally, as some kittens had more than one carer, it is possible some behavioural or medical concerns were not captured accurately in this study. Another limitation was the inconsistent recording of weights closest to incoming date. The 91 kitten's weights recorded to be over 1 kg could not have been intake weights as only kittens under 1 kg were included in the study. Although these were excluded from further analysis, some of the other weights included might have also been inconsistently recorded after intake. Therefore, the average weight (hence age) calculated might be an overestimate.

5. Conclusion

This study indicates that kittens do best when included as part of the household, when homes are quiet and when they spend some time alone. While bottle fed kittens were more prone to medical concerns, they do well behaviourally, responding positively to carers entering the room, and overall have relatively low morbidity and mortality. Furthermore, there was no difference in fear or anxiety responses for singletons and

those without the queen, providing reassurance to foster care programs that the time and resources invested in these kittens result in well-adjusted adoption-ready kittens. Simple changes in the foster care environment might improve kitten behaviour and influence their adoptability. Foster carers should allow kittens to spend some time alone. If possible, carers should be encouraged to keep kittens in social areas of the house, such as in an enclosure or free roaming in the lounge room. However, if their home is loud, they should slowly introduce the kitten/s to the louder and busier areas of the house before being housed there all the time.

CRediT authorship contribution statement

Gemma R Campbell: Writing – original draft, Formal analysis, Data curation. **Elizabeth R Arnott:** Writing – review & editing, Methodology, Conceptualization. **Courtney Graham:** Writing – review & editing, Methodology. **Lee Niel:** Writing – review & editing, Methodology. **Michael P Ward:** Writing – review & editing, Supervision, Methodology, Formal analysis. **Gemma Catherine Ma:** Writing – review & editing, Supervision, Project administration, Methodology, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Gemma Ma and Liz Arnott are employed by RSPCA NSW

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2024.106306.

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