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Pet dogs home alone: A video-based study

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ABSTRACT

Many dogs are left alone at home by their owners for several hours on a daily basis. This practice is known to be a possible source of complication in dog keeping. Behaviourists and veterinarians are frequently consulted due to excessive vocalisations, destructive behaviour and house-soiling of dogs left alone by their owners. These observations are thought to be symptoms of a disorder which most authors refer to as separation anxiety or separation related behaviour. Little is known about dogs, which showed mostly inconspicuous behaviour during separation, and possible effects of the presence of conspecifics in multi-dog households, which may help coping with separation. Therefore, we videotaped 32 dogs in single-dog and 45 dogs in multi-dog households left home alone as part of their usual routine. We performed a continuous sampling of location, posture, vocalization, and various other behaviours. Calculating and comparing percentages of observation time we tested possible effects of familiar conspecifics, and investigated the effects of sex and neuter status, variables that are discussed to have an influence on the onset of separation anxiety. In general, our dogs showed low physical activity as well as a low vocal activity, independent from the time being alone. Male dogs in multi-dog households showed a significantly higher vocal activity. A further sex related difference was that male dogs were more prone to stay at the exit-door. This bias may be due to sex-specific motivations but seems to get stronger with increasing duration of separation. Dogs in multi-dog households showed a significant higher activity (single dog: 15.3 ± 14.3, multi-dog: 27.5 ± 26.1 mean ± SD). The major difference in activity was found in the first hour of being alone and interactions with other pets played only a marginal role even in multi-dog households (0.24 ± 0.6). Whining was not reduced by the presence of familiar conspecifics. Further research is needed to see if familiar conspecifics facilitate coping with separation from humans in this context. Our data suggest rather the opposite.

1. Introduction

Being separated from the owner for several amounts of time is part of the daily routine for many dogs kept as pets in modern societies. A telephone survey performed in Sweden showed that 73% of dog owners in this highly developed country left their pets at home while going to work (Norling and Keeling, 2010).

The “home alone” situation is known to be a possible source of complication in dog keeping. Undesired behaviour in this context is a common reason to get in contact with professional behaviourists (Wright and Nesselrote, 1987) and at the same time a common reason for relinquishment of dogs to shelters (Salman et al., 2000; Segurson et al., 2005). Thus, the “home alone” context is a common and crucial part of modern pet dog keeping.

The reported problematic behaviours in context with separation are essentially prolonged vocalizations, destructive behaviour and house-soiling (Sherman and Mills, 2008). On condition these behaviours are exclusively shown in absence of the owner, they are thought to be symptoms of a disorder referred to as separation anxiety (Borchelt and Voith, 1982; Voith, 1985; McCrave, 1991; Appleby and Pluijmakers, 2003; Sherman and Mills, 2008).

In a retrospective study of medical records of a veterinary clinic Bamberger and Houpt (2006) found a caseload of 14.4% for separation anxiety, which turned out to be the most common behaviour disorder after problems with aggressive behaviour. In a recent review on the topic Ogata (2016) emphasizes, separation anxiety being the most frequently discussed disorder in published studies of the past four decades, but still its aetiology and prevention remains elusive. The term ‘separation anxiety’ implies anxiety as the underlying motivation of the behavioural symptoms. Some authors use more descriptive terms, in order to avoid this attribution. Bradshaw et al. (2002) for example defined ‘separation related behaviour’ as any kind of potentially

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undesired behaviour by a dog during a period of separation from its owner. In a survey study performed as part of their work, owners stated for 50% of dogs, that it was currently showing separation related behaviour or had shown it in the past.

Video based behaviour observation studies have been performed on dogs diagnosed with separation problems (Lund and Jørgensen, 1999), and separation related behaviours (Palestrini et al., 2010) under field conditions (dogs left alone at home). These studies validated the descriptions of typical behaviour patterns in clinical reports. Vocalizations, destructive behaviour, and stress related behaviours were shown at high frequencies. These behaviours and general activity peaked shortly after owners departure (Lund and Jørgensen, 1999; Palestrini et al., 2010).

Behaviour observation studies concerning dogs not diagnosed with separation anxiety under field conditions are scarce. Scaglia et al. (2013) observed 30 dogs divided into three groups according to age in order to compare their behaviours to dogs diagnosed with separation anxiety and to investigate a possible influence of age on behaviour when left alone. While the latter was not found, the study showed that non-clinical dogs spent most of the observation time passive and showed significantly less separation related behaviour compared to the clinical dogs observed by Palestrini et al. (2010). Since some of the dogs exhibited separation related behaviours, the authors conclude, that separation anxiety may well be an underestimated disorder. Rehn and Keeling (2011) studied the behaviour of twelve dogs left home alone for three fixed amounts of time to investigate the effect of time left alone on dog welfare. In this study the dogs showed mostly passive behaviour irrespective of the duration of being alone. Differences were observed between bouts of 30 min and two or more hours in connection with behaviour during the anticipated end of separation and reunion with owners. This result indicates a certain impact of duration of separation, although it is only observable in behaviour shortly before and after owners return.

Aim of our study was to collect additional data about dogs in the 'home alone' situation. To our knowledge there is no study whether dog behaviour in this context is influenced by the presence of familiar conspecifics (except one single publication in Swedish mentioned by Rehn and Keeling (2011)). Therefore, in our study we focused on a comparison of single-dog to multi-dog households. Several studies suggest that multi-dog conditions may help coping with separation. Mariti et al. (2014) conducted an adaptation of the Ainsworth strange situation test and observed that dogs showed less whining when a familiar conspecific was present. Tiira and Lohi (2015) found fearful dogs came more often from single-dog households and conclude that the presence of other dogs may work as a stress resilience. Dreschel and Granger (2005) observed an effect of conspecifics on the physiological stress response of thunderstorm phobic dogs in reaction to a stressful event. The presence of other dogs in the household was linked to a less pronounced stress response and a more rapid recovery. Based on these findings, we may expect dogs in multi-dog households to show more passive, relaxed behaviour during separation and less separation related behaviour. On the other hand, barking and howling are discussed as allelomimetic behaviours in dogs (Adams and Johnson, 1994; Scullion Hall et al., 2017) and may be shown at higher rates in multi-dog households. The activity level may be elevated by direct interactions (e.g., agonistic conflict, play behaviour, allogrooming) with the other pets.

To investigate in which way behaviour during separation is influenced by familiar conspecifics, we decided to examine dogs that are left alone on a regular basis. We expect to observe separation related behaviour to some extend in such a sample, since previous research showed it being distributed beyond clinical detected cases (Bradshaw et al., 2002; Scaglia et al., 2013).

Furthermore, our relatively large sample size allowed us to study possible effects of sex and sexual status on dog behaviour in this context. The findings concerning the influence of these variables on the onset separation related behaviour are not consistent and partly contradicting. Male dogs are overrepresented in samples affected by separation anxiety in several studies (Podberscek et al., 1999; Overall et al., 2001; Storengen et al., 2014). In a survey study addressing Australian dog owners male dogs were rated higher on separation related behaviours, the same was true for intact dogs (McGreevy and Masters, 2008). A veterinary case review conducted by Flannigan and Dodman (2001) revealed no significant influence of sex on the onset of separation anxiety, but neutered dogs had a three times higher probability of being affected in this sample. Therefore, we included sex and neuter status in our analysis to control for possible effects of these two factors.

2. Method

2.1. Recording and analysis of dog behaviour

Owners who leave their dog home alone on a regular basis were searched via email lists and public announcement by the Akademie für Tiernaturheilkunde (ATN). Participating owners received a set of three cameras (Panasonic HCV 270) and tripods. They were instructed to align the cameras to the places where the dogs would most probably stay during separation (berths, exit-door, sofa etc.), before leaving their dog (s) alone as part of the regular routine.

The three video streams were synchronized and arranged next to each other to a combined video stream (Adobe premiere pro). The combined video files were analysed with Solomon coder (https://solomon.andraspeter.com) at a time resolution of 0.2 s. We measured activity, postures and behaviours of dogs including different kinds of vocalizations and their place preferences. A detailed description of measurements is given in Table 1. All measures are given in percentage of time the owner was absent, respectively the time it was possible to describe the dog behaviour (see below). Vocalizations given in bouts were valued as continuous behaviour. The videos were analysed by experienced observers. To estimate rater reliability, we re-analysed 26% of the videos by additional raters. The mean intra-class correlation coefficient (Cronsbach's Alpha; two-way random; absolute agreement; single measure; SPSS) was 0.92, indicating a very good inter-rater reliability.

We received video data from 69 households with 123 dogs. 14 households and 42 dogs were excluded before coding due to unfavourable camera positioning and/or inconvenient picture quality. Although we worked with three cameras it was not always possible to get a perfect view to make a reliable description of all behaviours. We decided to exclude recordings for which we had less than 75% of the time the possibility to describe the behaviour (description rate). This led to a reduction from 184 records of 55 households with 81 dogs to 167 records from 54 households with 77 dogs, with the following distribution to the different categories (dogs in type of household: single-dog = 32, multi-dog = 45; sex: males = 30, females = 47; neuter status: neutered = 47, intact = 30). The mean duration of owner absence was 157.1 ± 99.2 min (mean ± SD). Nearly half of our dogs (35) were mixed breed. The remaining 42 dogs cover all 10 FCI-groups except for group 3 (Dachshunds). See Supplemental Table 1 for further details.

For the remaining 167 records we achieved a mean behavioural description rate of 97.1% of total time being alone. We estimated the percentage of time for which we were able to describe the behaviour and used these measurements for all subsequent calculations.

Every dog owner was asked to fill out a German translation of the "Canine Behavioral Assessment & Research Questionnaire (C-BARQ)". Following C-BARQ we used the eight question (55–62) describing the separation-related behaviour of their dogs: (55) Shaking, shivering or trembling (56) Excessive salivation, (57) Restlessness/agitation/pacing, (58) Whining, (59) Barking, (60) Howling, (61) Chewing/ scratching at doors, floor, windows, curtains, etc., (62) Loss of appetite. For every question there were five possible answers which we rated with corresponding scores: Never = 0, Seldom = 1, Sometimes = 2, Usually = 3, Always = 4. This led to a total score ranges between "0" and "32″ for all eight questions. Due to some missing answers, we excluded three questionnaires, resulting in 74 complete questionnaires out of 77 dog

Table 1
Coding plan.

Terms and behavioural definitions		
Category		
Posture	Locomotion	Dog walks/runs around
	Standing	Dog is standing
	Sitting	Dog is in a sitting position
	Lying with raised head	Dog is lying, the head is held up/not resting on the ground or objects.
	Lying on elbow or curled up	Dog is lying, the head is resting on the ground or objects. The body is supported by at least one elbow, or curled up tightly
	Lying on the side or back	Dog is lying stretched out on the side or turned on the back, the head is resting on the ground or objects.
Location	On Berth	The dog is located in a place that is obviously arranged as a dog-berth (Box, dog-bed, blanket on the floor).
	Sofa/Bed	The dog is located on human sleeping/sitting – furniture.
	At exit door	The dog is located in less than double body-length distance to the exit of the space in which it is left alone. "Exit" means the door/barrier through which the humans leave and return exclusively.
	Elsewhere	The dog is located in none of the described places
Actions	Animals	The dog is obviously interacting with a conspecific or another pet. (e.g., playing/ allogrooming/threatening/fighting)
	Food	The dog is with food or chewing items/toys. (sniffing/licking/chewing/playing directed towards these objects)
	Toys	The dog is engaged with objects that are obviously designed as dog-toys, and not prepared with food. (sniffing/licking/chewing/playing directed towards these objects)
	Objects	The dog is engaged with other objects. (sniffing/ licking/chewing/playing/biting directed towards these objects)
Vocalizations	Barking Growling Howling Whining	Vocalizations given in a bout were recorded as continuous behaviours.
Calculated measures:		
Activity		Locomotion + Standing + Sitting + Lying with raised head
Corrected activity		Activity − (Animals + Food + Toys)

owners.The average age of dogs in our study was 68,0 months mean ± 38,03 SD.

2.2. Statistics

To analyse differences in dog activity related to sex, neuter status, and number of dogs in the household we fitted a linear model with sex, neuter status and 'single/multi-dog' as fixed factors. We log-transformed activity to achieve a normal distribution.

To analyse the difference in vocal activity we first calculated the mean vocalization time per dog. Because the relative high number of dogs which did not produce a certain vocal type or vocalize at all, we got zero-inflated distribution with a not normal distribution of the rest data. Therefore, we categorized the mean values in four categories (category 1 = no vocalizations; category 2 = mean percentage of vocalization = <0.1%; category 3 = vocalization between >1% and = <5%; category 4 = >5%) and run a general linear model of ordinal ordered data. We included sex, neuter status and 'single/multi-dog' as fixed factors. For same reason (zero-inflation, not normally distributed data) we made the same categorization and GLM test for the "lying" data. We used the same GLM test to test the C-BARQ scores.

To analyse differences in relation to time being alone at home we divided the total time of being alone into hours. We fitted a linear mixed model with time, sex, neuter status, and 'single/multi-dog' as fixed factors and subject (dog) as random factor. In case of significant interaction between the fixed factors we divided the data set regarding the interaction and made separated tests. Analyses were performed using IBM SPSS STATISTICS 26.

3. Results

Being alone at home the dogs predominantly lay relaxed in their preferred places. In 22% of the time dogs showed some minor activity, including lying with raised head, sitting or standing around. Only during 1.9% of the time they showed activities like walking or running around (see Table 2). To allow a less biased comparison of activity in the two types of households we additionally calculated 'corrected activity'. This parameter is corrected for interactions with animals, food, and toys, since animals are much more common in multi-dog households, while food and toys are often not provided by owners in multi-dog households to avoid resource related conflicts.

Following our C-BARQ scores we found following results regarding separation related behaviour: 31.1% of the dogs (N = 74) got a total value of "0", mean = 3.5 ± 4.3 SD, range: 0–18. We found no significant influence of C-BARQ scores in relation to sex, neuter status or whether dogs live in single or multi-dog household (GLM: sex: $chi^2 = 1.85$, $p = 0.174$; neuter status: $chi^2 = 0.15$, $p = 0.7$; single/multi-dog: $chi^2 = 0.19$, $p = 0.665$).

3.1. Difference in relation to sex, neuter status, and number of dogs in the household

We found no significant differences in the activity between female and male dogs (LM: $F_1 = 0.05$, $p = 0.823$) or neuter status (LM: $F_1 = 0.73$, $p = 0.396$) but a clear significant difference whether or not dogs living alone in a household (LM: $F_1 = 4.61$, $p = 0.035$; single dog: 15.3 ± 14.3, multi-dog: 27.3 ± 26.1 mean ± SD). Fig. 1 shows significant higher activity in multi-dog households.

The overall vocal activity of dogs was rather low (see Table 2) but we found differences dependent on sex and number of dogs per household (Fig. 2).

In relation to different vocal types, we found the following differences: Barking: Female dogs in single-dog households bark less. The same is true for males but they bark significantly more in multi-dog households (GLM: single/multi-dog: $chi^2 = 13.5$, $p < 0.001$; sex: $chi^2 = 6.2$, $p = 0.013$; Fig. 3A). We found no significant differences in

Table 2
Behaviours in percentage of total time being alone. Mean ± SD for all 77 dogs.

Categories	Behaviour	Mean ± SD total	Mean ± SD Single-dog	Mean ± SD multi-dog
postures	Locomotion	1.86 ± 2.6	1.4 ± 1.4	2.2 ± 3.1
	Standing	3.78 ± 4.9	2.7 ± 3.8	4.5 ± 5.5
	Sitting	3.3 ± 8	1.6 ± 3.3	4.5 ± 9.9
	Lying with raised head	14.8 ± 15.4	10.7 ± 10.3	17.7 ± 17.7
	Lying on elbow or curled up	49.8 ± 23	55.4 ± 22	46.1 ± 23.1
	Lying relaxed	26.4 ± 26	28.2 ± 26.1	25 ± 26.1
Locations	On Berth	27.5 ± 34.3	24.6 ± 32.6	28.9 ± 35.7
	Sofa/Bed	36.8 ± 42.5	42.6 ± 43	33 ± 42.2
	At exit door	18.6 ± 32.6	17.7 ± 31.5	19.5 ± 33.8
	Elsewhere	17.2 ± 25.1	15.2 ± 21.1	18.4 ± 27.8
Actions	Animals	0.14 ± 0.47	0.003 ± 0.012	0.24 ± 0.6
	Food	0.98 ± 3.3	0.97 ± 2.7	0.99 ± 3.7
	Toys	0.19 ± 1.2	0.09 ± 0.36	0.27 ± 1.6
	Objects	0.14 ± 0.35	0.21 ± 0.5	0.09 ± 0.19
Vocalizations	barking	0.32 ± 0.95	0.019 ± 0.05	0.54 ± 1.2
	growling	0.04 ± 0.16	0.007 ± 0.015	0.055 ± 0.2
	howling	0.16 ± 0.65	0.04 ± 0.21	0.25 ± 0.83
	whining	0.34 ± 1.3	0.5 ± 1.9	0.22 ± 0.71
Estimates	Activity	23.7 ± 23.2	16.4 ± 14.2	29 ± 26.9
	Activity (corrected)	22.4 ± 22.6	15.3 ± 14.3	27.5 ± 26.1

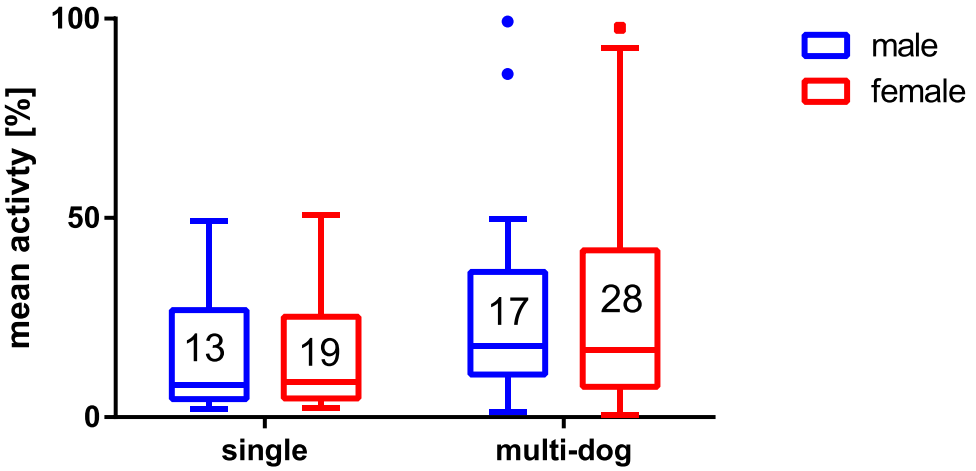

Fig. 1. "Corrected" activity of dogs in relation to sexand single/multi-dog. Boxplots with median, 25th to 75th percentile, whiskers created by Tukey method, plus extreme values. Activity was corrected for activities with conspecifics or other pets, food and toys. Numbers refer to the number of dogs per category.

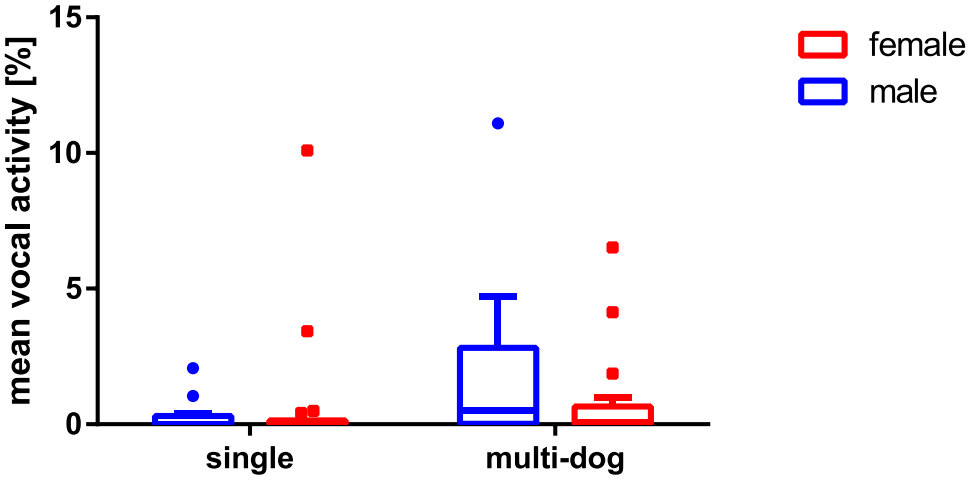

Fig. 2. Mean vocal activity in percentage of time. Boxplots and numbers of dogs as in Fig. 1.

relation to neuter status (GLM: $chi^2 = 0.71$, $p = 0.399$). Only 15.8% of female dogs and 38.5% of male dogs barked at all (Table 3). For growling, we found only sex related differences (GLM: $chi^2 = 6.9$, $p = 0.008$; Fig. 3B) and no significant difference related to single or multi-dog households (GLM: $chi^2 = 0.41$, $p = 0.523$) or neuter status (GLM: $chi^2 = 0.87$, $p = 0.768$). We also found sex related significant differences in howling (GLM: $chi^2 = 5.4$, $p = 0.02$; Fig. 3C). Males showed these vocalizations at higher rates. For whining we found no significant differences (Fig. 3D).

In addition, we found a clear sex difference in preferred lying locations. Male dogs preferred to lie in front of the door through which the owner left the home (GLM: $chi^2 = 6.7$, $p = 0.01$; Fig. 4). Neuter status and the number of dogs in household plays no significant role (GLM: single/multi-dog: $chi^2 = 0.4$, $p = 0.523$; neuter status: $chi^2 = 0.1$, $p = 0.771$).

3.2. Dog behaviour in relation to time of owner absence

We found a weak but significant negative correlation between dog activities and time of owner absence ($r = -0.28$, $p <= 0.01$, $R^2 = 0.08$). This negative trend is mainly forced by male and female dogs living together with other dogs. Single living female dogs showed a correlation of only −0.186, males a correlation of −0.018, whereas dogs in multi-dog households showed significant higher correlations (females: $r = -0.314$; males: $r = -0.326$). We found no changes of the vocal activity during the time of absence.

This result was supported by an hourly analysis of owner absence. Including all three factors (single/ multi-dog, sex, and neuter status) we found a high significant interaction in activity between time being alone and whether dogs lived in single or multi-dog households (LMM: $F_{5,137} = 3.22$, $p = 0.009$). Subsequent separated tests showed that there were no changes over time in single housed dogs but a significant difference under multi-dog conditions (LMM: "single": $F_{5,60} = 0.56$, $p = 0.733$; LMM: "multi-dog": $F_{5,77} = 4.6$, $p = 0.001$; Fig. 5A). The effect was mainly caused by differences in the first hour of absence. We found no significant changes in amount of relaxed lying over time in single or multi-dog households (Fig. 5B).

Further, we found some sex related difference in lying position (Fig. 6). Male dogs showed a clearer and earlier decrease in their amount of lying on berth than females (Fig. 6A). In addition to their general lower amount of lying on exit doors (see Fig. 4) females seem to decrease this behaviour with the persistence of owner absence, whereas male dogs increase this behaviour with time of owner absence (Fig. 6B).

4. Discussion

In order to investigate the possible influence of familiar conspecifics, sex, and neuter status on behaviour of dogs when left alone, we videotaped 77 dogs, left alone at home as part of their usual routine. We coded posture, vocalizations, location, and various behaviours to analyse the

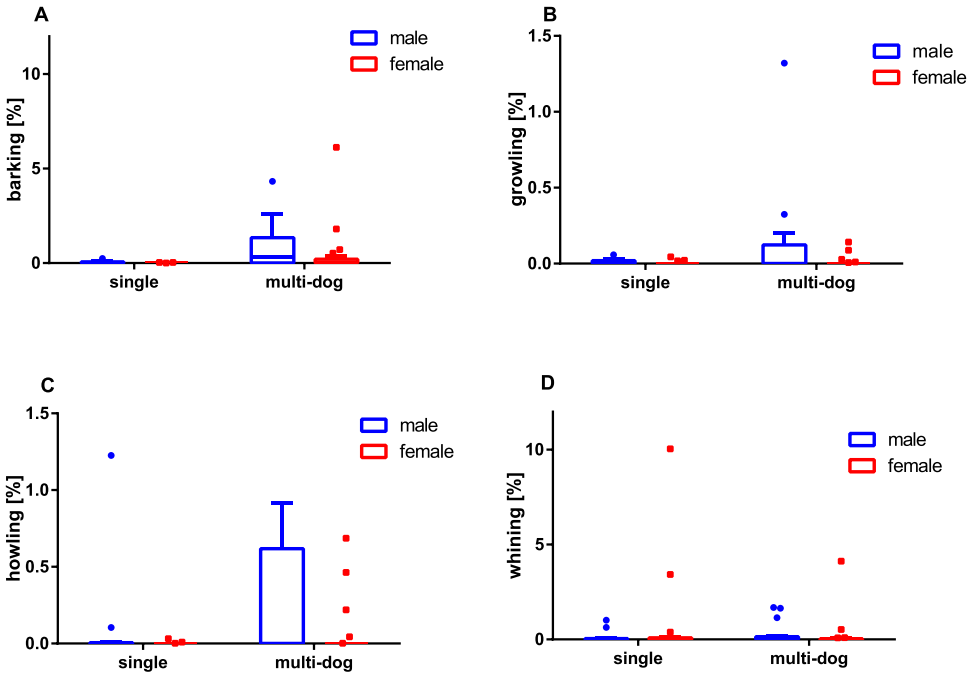

Fig. 3. Mean vocal activity per vocal type (A-D). Boxplots and numbers of dogs as in Fig. 1.

Table 3
Percentage of subject per category which at least uttered once one of the four different call types. N = Number of dogs per category. Note: The values are not corrected for observation time.

Categories	N	Barking (%)	Growling (%)	Howling (%)	Whining (%)
Male single	13	38.5	53.8	23.1	38.5
Male multi-dog	17	76.5	47.1	41.2	70.6
Female single	19	15.8	15.8	15.8	47.4
Female multi-dog	28	53.6	25.0	17.9	53.6

effects of these three factors. We found influences of type of household and sex on several observed behaviours, while no significant effects of neuter status were detected.

4.1. Activity

The observed level of activity for all 77 dogs of 23.9% is clearly lower than reported for clinical dogs by Lund and Jørgensen (1999) (58.2% awake and active) and Palestrini et al. (2010) (12% passive behaviour). Our results are between previously found values for non-clinical dogs calculated from the data published by Scaglia et al. (2013) (39.6%) and Rehn and Keeling (2011) (15.2%). The range of these values may be explained by differences in the study designs. Rehn and Keeling studied dogs in single-dog households only. Our results showed significant differences in the activity of dogs between single-dog and multi-dog conditions. Under single-dog conditions we found an activity level comparable to the results of Rehn and Keeling (see Fig. 1). The high level of activity reported by Scaglia et al. (2013) may be explained by the acquisition of the subjects. The owners of the study done by Scaglia and colleagues were random customers of a veterinary clinic, some of them reported destructive behaviour (10.3%) and house soiling (6.9%). In a survey-study conducted by Bradshaw et al. (2002) owners stated for 50% of dogs, that it was currently showing separation related behaviour

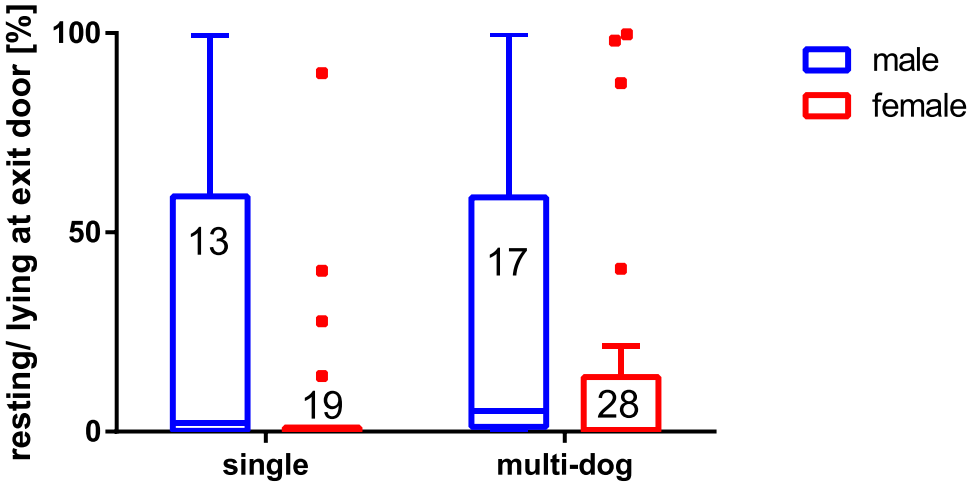

Fig. 4. Mean resting/lying duration per dog. Boxplots and numbers of dogs as in Fig. 1.

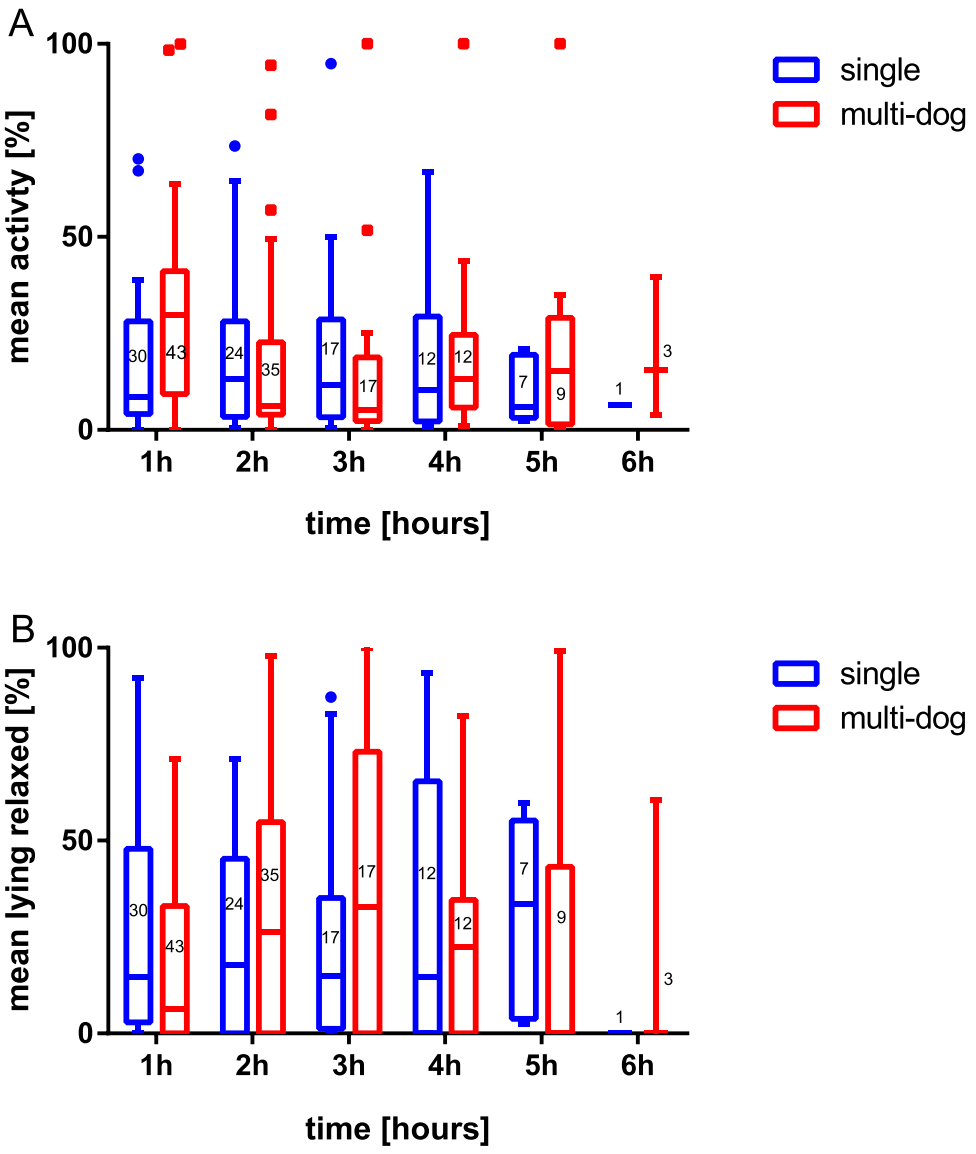

Fig. 5. A: "Corrected" activity of dogs in relation to time being alone. Boxplots with median, 25th to 75th percentile, whiskers created by Tukey method, plus extreme values. Activity was corrected for activities with conspecifics or other pets, food and toys. Numbers refer to the number of dogs per time category. B: Lying relaxed in relation to time being alone. Boxplots and numbers of dogs as in Fig. 5A. Numbers on bars refer to the number of dogs per time category.

or had shown it in the past. We acquired our probands in the surroundings of the ATN, an institution concerned with dog health and training. Thus, our participating owners may be more aware and cautious in terms of separation problems than average. In our study we did not find any destructive behaviour or soiling, and lengthy vocal activity was very rare. But even in our sample we observed individual cases of prolonged unrest and whining. Since the behaviour shown by our dogs was highly variable, we consider it generally advisable for dog owners to observe dogs left home alone using video technique.

The differences in activity remain stable, when all activities that may occur with a higher probability under single- or multi-dog conditions are excluded (Table 2, corrected activity). Time course analysis (Fig. 5A) shows that the most prominent differences between single-dog and multi-dog conditions occurred during the first hour of being alone at home. The higher activity in multi-dog households during this period may reflect a higher initial level of stimulation and a prolonged latency for relaxation. Activities directed towards other dogs are shown at remarkably low levels (0.24 ± 0.09%) only. This shows that the higher level of activity in multi-dog households is not due to social play, allogrooming or agonistic conflict, but rather a result of a higher level of stimulation and/or social facilitation. In hours 2–4 we found no significant differences in activity between single-dog and multi-dog condition. In absence of the owner dogs spend most of the time passive and do so even if familiar conspecifics are present. This observation can be explained with the central importance of humans for dogs. The dog–human relationship shows all characteristics of an attachment bond (Payne et al., 2016) while attachment seems to be clearly weaker in dog dyads (Tuber et al., 1996; Mariti et al., 2014).

Most owners did not leave their dogs alone for more than four hours. Datasets in hours 5–6 are scarce, but we did not observe any prominent increase of activity during these later hours. Such extended periods of being home alone did not lead to higher activity, which would be an expected result of emerging separation distress (Lund and Jørgensen, 1999; Palestrini et al., 2010). Since we observed dogs in their normal routine, this result indicates, that dogs are able to cope with such extended periods of separation, when they are used to.

4.2. Postures

Time course analysis of postures shows no significant changes in

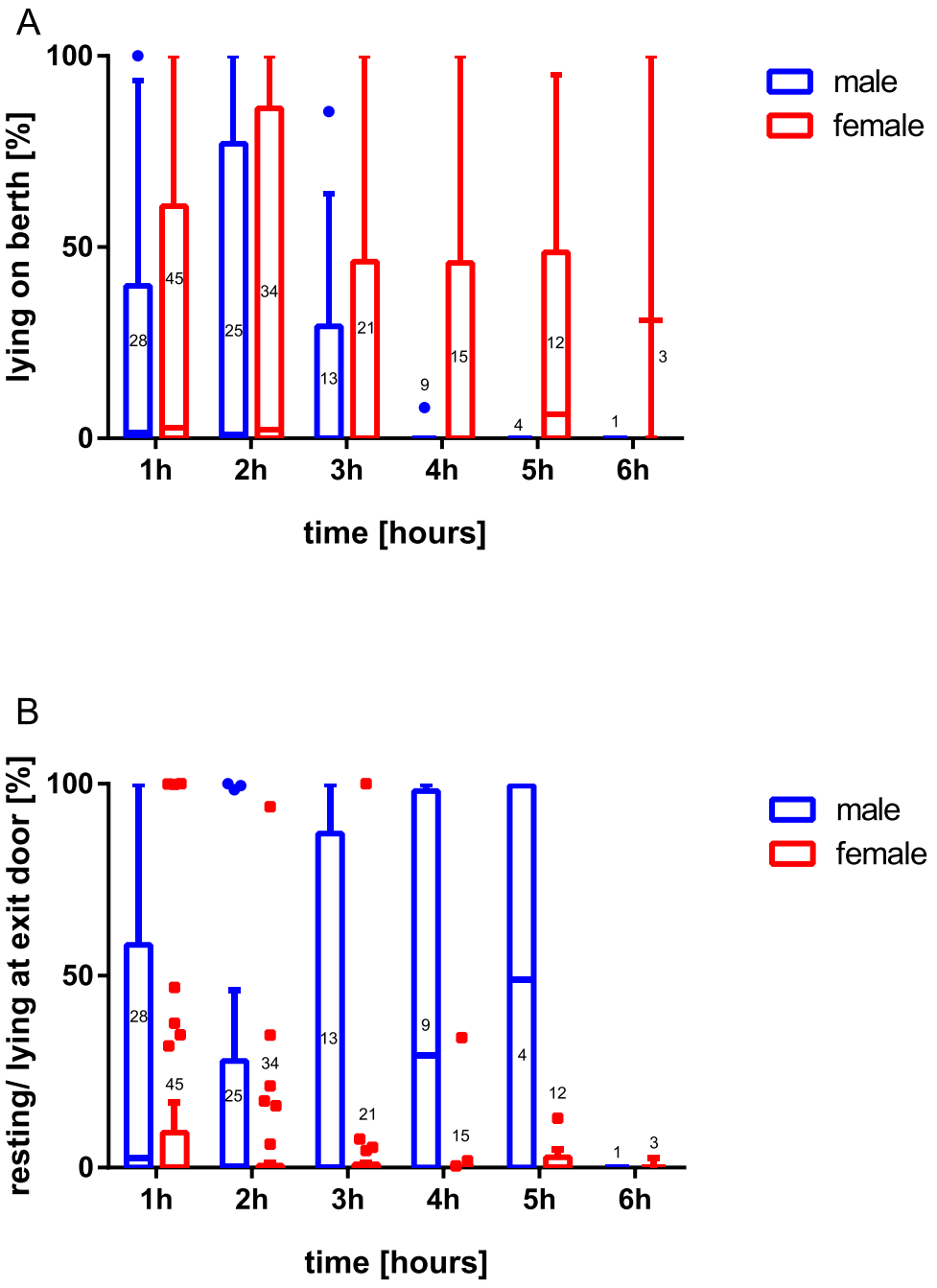

Fig. 6. A: Lying on berth in relation to time being alone. Boxplots with median, 25th to 75th percentile, whiskers created by Tukey method, plus extreme values. Numbers refer to the number of dogs per time category. B: Resting/ lying at exit door in relation to time being alone. Boxplots and numbers of dogs as in Fig. 6A.

proportion of lying relaxed for dogs left alone under single-dog conditions, while this behaviour is significantly enhanced in hours 2 and 3 compared to the first hour of separation in the multi-dog households (Fig. 5B). We assume that lying on the side/back reflects a higher level of relaxation. Thus, our results may indicate that the level of arousal is synchronized to some amount in dogs left alone under multi-dog conditions. In the first hour of separation dogs are stimulated by each other and need more time to come to rest. In hours 2 and 3 the dogs are calmer and show relaxed lying for extended periods. The proportion of relaxed lying does not decline significantly in the later hours of the observed separations. This observation indicates that at least some of the dogs remain relaxed in these prolonged periods of separation from the owner.

4.3. Locations

In respect to location of animals we found two sex-related correlations. Male dogs spend more time near the exit door. This observation is significant under single-dog conditions and a pronounced trend in the multi-dog data (Fig. 4). The space around the exit door is special in several ways. Human companions leave and return through this door, so the proximity to it may reflect the desire for their return. Furthermore, the exit door is the barrier keeping the dogs from straying and is a place where aggressive behaviour may be triggered by acoustic stimuli and expected intruders from outside. Since male dogs are more prone to show straying behaviour (Wells and Hepper, 2000) and aggression (Wright and Nesselrote, 1987; Bamberger and Houpt, 2006; Pérez-Guisado and Muñoz-Serrano, 2009) the enhanced time spent near

the exit door could be explained with these motivations. A study mentioning this special place in context with separation from the owner was conducted by Parthasarathy and Crowell-Davis (2006). In a comparison of dogs diagnosed with separation anxiety to non-clinical dogs, the enhanced proximity to the exit door in inflicted dogs did not reach significance. The authors concluded this behaviour not being diagnostic for separation anxiety. Thus, motivations to which male individuals are more prone, may contribute to the occurrence and duration of this behaviour. On the other hand, time course analysis revealed that this behaviour is on trend influenced by the amount of time being separated from the owner (Fig. 6B). The time spent near the exit door seems to increase with the duration of separation in male individuals. In contrast females show an opposite trend in respect of staying at the exit door, while resting on berth is clearly declined in hours 4–6 in males (Fig. 6A). The possible influence of the duration of separation on the preference of these locations may be a topic of further research.

4.4. Vocalizations

The overall vocal activity showed a striking difference between single-dog and multi-dog conditions in male dogs, which vocalized at significantly higher rates. In females this factor had no significant influence. To our knowledge this dimorphism was found for the first time in a study concerning dogs separated from their owners.

Barking was much more common in multi-dog households compared to single-dog condition, which is true for both sexes. Since barking is discussed as an allelomimetic behaviour in dogs (Adams and Johnson, 1994; Scullion Hall et al., 2017), the tenfold higher rates of barking behaviour in multi-dog households can be explained by social facilitation. Males were more prone to show barking behaviour (Table 3) and on trend at higher rates (Fig. 3A).

Howling seems to be enhanced in multi-dog households too and we found more howling males in multi-dog households (Table 3), but due to the small number of dogs showing this behaviour, this difference does not reach significance. Howling is discussed as a vocalization serving several functions in wolves. This behaviour is observed as a form of long distance communication in individuals separated from the social group (Theberge and Falls, 1967) as well as in context with group ceremonies on an allelomimetic basis (Zimen, 1971). In dogs howling is described predominantly in context with isolation, but the behaviour is also discussed as contagious (Zimen, 1971; Feddersen-Petersen, 2008). The increased howling of dogs left alone in canine company may reflect the contagious nature of this vocalisation. But even assuming only the initial calls being caused by separation from the owner, multi-dog condition does not seem to avert such “loneliness cries”, at least not reliably.

The significant higher vocal activity of male dogs under multi-dog conditions (Fig. 3) is tracing to the enhanced barking, growling and howling rates. Since barking and howling are relevant behaviours in diagnosing separation anxiety, our results may have important implications for the discussion of sex as a risk-factor for this disorder. Storengen et al. (2014) found male dogs being overrepresented ($p = 0.01$) in a population of 215 dogs diagnosed with separation anxiety. Wright and Nesselrote (1987) found a similar bias for separation related behaviour problems, which did not reach significance ($p > 0.05$). In other studies using medical records, researchers found sex not being a risk factor for separation anxiety (Flannigan and Dodman, 2001; Bamberger and Houpt, 2006). These contradicting results may be due to the difficulties in definition and diagnosis of separation anxiety, combined with a higher proneness for barking and howling of male dogs in this context. Bradshaw et al. (2002) reported a highly significant bias towards males in respect of separation related behaviour ($p = 0.001$). Our results are in accordance with these findings since ‘separation related behaviour’ as introduced and defined by the authors includes barking irrespectively of motivation.

Whining was the only vocalization observed in a higher percentage of female individuals, namely under single-dog conditions (Table 3). This bias was also found in respect of time spent with whining, but this enhanced duration traces to two female individuals whining at extraordinary high rates. More data is needed, but females could be more prone to whining than males when left alone under single-dog conditions. Compared to single-dog conditions, a higher percentage of individuals in multi-dog households was showing whining in at least one of the observed bouts of being left alone, which is true for both sexes (Table 3). Whining is discussed as indicative for distress in context with separation (Lund and Jørgensen, 1999; Pongrácz et al., 2017). The presence of cohabitant dogs does not have a clear reducing effect on occurrence and duration of whining. This observation is in accordance with the results of Flannigan and Dodman (2001) who did not find single-dog keeping being a risk factor for separation anxiety. We found no significant effects of neuter status. That does not mean that there are no effects. It is likely that the neuter status has a smaller effect size and together with possible interaction between sex and neuter status more dogs are necessary to find significant effects.

5. Conclusion

Most of our observed dogs showed a low vocal and physical activity, that point out that they could cope even with longer periods of separation. Being together familiar conspecifics lead to a higher level of activity, while obvious interactions between dogs in multi-dog households were remarkably rare. Under multi-dog conditions male dogs showed the highest amount of barking and howling, whereas whining was not significantly reduced by the presence of cohabitant dogs. Male dogs spent more time near the exit door compared to females.

Since dogs under single-dog conditions show more resting and less vocalizations, we could not support the view that familiar conspecifics could facilitate coping with separation stress. Although further research is needed, our data suggest rather the opposite.

Conflicts of interest

All authors declare no conflict of interest.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2021.105463.

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