STUDY OF THE STRUCTURE AND DENSITY OF A DOG POPULATION IN TEKİRDAĞ (TURKEY)

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TEKİRDAĞ'DA KÖPEK POPULASYONUNUN YOĞUNLUĞU VE YAPISI ÜZERİNE BİR ÇALIŞMA

ÖZET

Türkiye'de köpek populasyonu Tekirdağ ilinin iki kırsal bölgesinde incelenmiştir. Bu çalışma Dünya Sağlık Örgütü tarafından başlatılmış olup Türkiye'de kuduz kontrolü için uygun stratejilerin geliştirilmesine katkıyı amaçlamaktadır. Çalışmaya konu olan veriler 1992 yılı Nisan ve Mayıs aylarında toplanmış olup populasyon yoğunluğu, yapısı ve parenteral aşılama için köpeklere yaklaşılabilirlik üzerine bilgiler içermektedir. Veri toplamada anket surveyi, işaretleme ve yeniden yakalama teknikleri uygulanmıştır. Çalışmaya konu olan zaman aralığında her iki bölgede 3 aylıktan büyük sahipli köpeklerin yoğunluğu km^2'de 464 (%95 güven aralığı: 420;518) ve 211 (%95 güven aralığı: 203;224) buna tekabül eden insan köpek oranı ise 3.8 ve 6.0 olarak hesaplanmıştır. Araştırma konusu köpek populasyonunun özellikleri erkek köpeklerin baskınlığı (%75'ten fazla), başıboş köpek oranının yüksekliği (%70'ten fazla) ve oldukça düşük ortalama (yaş 3.2) olarak saptanmıştır. Çalışmanın yürütüldüğü köylerden birinde, aşı kampanyası süresince, buradaki köpeklerin yarısı tek bir merkezde aşılanmıştır. Diğer köyde ise, 3 aylıktan büyük köpeklerin %61.4'üne işaretleme işlemi için ulaşılabildiği ve bu köpeklerin evlere götürülecek bir aşılama programı çerçevesinde paranteral aşılanabileceği belirlenmiştir. Bu kategoriye dahil köpeklerin yöredeki köpek populasyonunun %42'sini oluşturduğu saptanmış ve bu nedenle bu köpeklerin yanısıra başıboş köpeklerin de kuduz hastalığının yörede kontrol altına alınması ve ortadan kaldırılması önünde en büyük engeli oluşturduğu sonucuna varılmıştır.Kuduz hastalığını diğer köpeklere, evcil hayvanlara ve insanlara temas yoluyla bulaştırma açısından yüksek risk oluşturan bu köpeklerin oral immunizasyonu ek bir korunma yöntemi olarak düşünülebilir.

SUMMARY

Dog populations were analyzed in two rural areas of the province of Tekirdağ in Turkey. This study was initiated by the World Health Organization and aimed to contribute to the development of an appropriate strategy for rabies control in Turkey. Data on population density, structure, and the accessibility of dogs to parenteral rabies vaccination were collected in April and May 1992. Questionnaire survey and mark-recapture techniques were used. Estimated density of owned dogs above three months of age was 464 (95% credibility interval (CR.I.); 420; 518) and 211 (95% CR.I.; 203; 224) per square kilometer in the two areas. The corresponding human dog ratio was 3.8 and 6.0, respectively. The dog populations were characterized by a net preponderance of male dogs (more than 75%), a rather low mean age (3.2 years), and a high proportion of free-roaming dogs (more than 70%). Ownerless dogs represented an estimated 4.5% (95% CR.I.; 0.9%; 10.2%) of the total population. During an antirabies vaccination campaign in one village, half of the dog population was vaccinated in one central vaccination point. In the second village, 61.4% of dogs above three months of age were accessible for marking and would have also been accessible for parenteral vaccination during a door-to-door campaign. Low accessibility for parenteral vaccination (40%) was observed in adult free-roaming shepherd dogs and dogs for which no specific function was indicated. This category of dogs represented 42% of the total population. Beside ownerless dogs, these animals represent the main problem for rabies control and elimination in rural areas. Oral immunization may be an additional tool to specifically target these dogs which are at high risk to contract and transmit rabies to other dogs, domestic animals and humans.

INTRODUCTION

Rabies is endemic in Turkey. Domestic dogs are the animal species mainly responsible for the maintenance of the enzootic and the transmission of the disease to humans. In the five years between 1992 and 1996 a total of 1070 laboratory confirmed animal rabies cases were reported in Turkey (Alkan, 1996; Güvener 1993 a,b; Özdek, 1993; RBE, 1992 a,b,c,d; 1993; WHO, 1996 a,b; 1997). Of these, 98.9% were in domestic animals, with dogs accounting for 78.5% and domestic cats for 4.1% of cases. Though a progressive decline in the number of laboratory confirmed rabid animals has been observed in the last few years in Turkey, this major zoonotic disease is still a source of human and animal suffering and important economic loss (Meslin et al., 1994).

In the last fifteen years, the World Health Organization (WHO) has encouraged national authorities to elaborate dog rabies control programs (WHO, 1992). It has also recommended that these programs be accompanied by specific studies of local dog populations. These studies should provide basic data to plan appropriate programs and to evaluate the rabies control activities. In the eighties, WHO published guidelines for dog ecology studies and for dog population management (WHO, 1984; WHO & WSPA, 1990). Dog populations in different countries and in various geographical and socio-demographic areas have since been analyzed by a growing number of scientists working in this field (Artois et al., 1986; Brooks, 1990; De Balogh et al., 1993; Kitala et al., 1993; Matter, 1989; Oboegbulem & Nwakonobi, 1989; Perry, 1993; Wandeler et al., 1988; 1993). The techniques used have been refined and new strategies for rabies control have been proposed (WHO, 1992; 1994).

In 1991 WHO proposed a study project for the analysis of dog populations in the Province of Tekirdağ (Turkey). It scheduled the collection of basic data on the density and structure of the local dog populations. These data should help the public health and veterinary health authorities to develop an appropriate strategy for rabies control in Western Turkey. The main purposes of the study were to determine the accessibility of dogs for parenteral and possibly oral vaccination. Special concern was given to the role of ownerless dogs. The fieldwork started on April 12th 1992 and was finished on May 29th of the same year.

MATERIAL AND METHOD

The size of the dog population was assessed by capture-mark-recapture in two rural study sites of the Province of Tekirdağ (Yağçı and Banarlı). A household census was carried out in one village. Tekirdağ province is situated in the western part of Turkey and borders the Marmara Sea.

Study areas

Yağçı is a small village with 150 households and 850 inhabitants, as indicated by the 'Muhtar' (chief of village). This site is approximately nine kilometers from Tekirdağ, the province's capital, to the East. The Yağçı village covered approximately 0.5 square kilometers.

In Banarlı, a household census revealed 254 households and a total of 1346 inhabitants including 347 children below 16 years of age (25.8%). This village is situated 25 kilometers from Tekirdağ on the road connecting Tekirdağ with Hayrabolu. The study site in Banarlı covered approximately 1.1 square kilometers.

Household census

A household census was carried out in Banarlı and every household was visited by the investigating team (Table 1). Information on the household and on the dogs belonging to the household (number, sex, age) were collected during these visits by interviewing one adult family member per household and filling in a questionnaire. The interviews were carried out in Turkish and translated into English. Households were revisited repeatedly if no household member was present when the team called. For every owned dog, it was recorded whether or not the dog was visible from outside the dog owners' premises. On a population level, this information was later used to correct capture-recapture data for unequal recapture probabilities. One month later, 102 dog owning households (69.4% of households with at least one dog) were revisited and possible loss of marker was assessed.

Table 1. Questionnaire survey and dog marking in Banarlı (Turkey).

Date	Hoseholds visited[a]	Dogs registered	Dogs marked
17.04.92	26	18	13
18.04.92	40	30	26
20.04.92	52	32	24
21.04.92	41	50	12
22.04.92	16	24	4
23.04.92	34	28	20
24.04.92	35	33	23
25.04.92	9	11	8
27.04.92	0	6	1
28.04.92	1	15	6
Total	**254**	**247**	**137**

a - First visit of the household. In some cases dogs were registered and marked at subsequent visits.

Capture-Recapture

Yağçı: A mass vaccination campaign against rabies (central vaccination point) was organized in Yağçı village. All dogs which were presented at the central vaccination point on one of two subsequent days got vaccine shots and they were marked by a collar made of polypropylene ribbon (Strapex AG, 5610 Wohlen, Switzerland). Subsequently, five reobservation passages were made by walking through the study area. Dog population density was estimated by a Bayesian model which combined the capture-recapture data from the five reobservation passages. A non-informative distribution was entered into the model as a prior for the total number of dogs. Puppies (three months or younger) were excluded from the analysis.

Table 2. Prior and posterior distributions of recapture probabilities and their components in Banarlı (Turkey).

	Confined dogs [a] marked and unmarked		Free roaming dogs [a] marked		Free roaming dogs [a] unmarked	
	prior (90% CR.I.)	posterior (mean & 95% CR.I.)	prior (90% CR.I.)	posterior (mean & 95% CR.I.)	prior (90% CR.I.)	posterior (mean & 95% CR.I.)
"Coverage"	0.500;0.800	-	0.500;0.800	-	0.500;0.800	-
"Encounter"	1.000;1.000	-	0.800;0.900	-	0.800;0.900	-
"Visibility" [b]	0.160;0.340	-	0.770;0.870	-	0.770;0.870	-
"Observer bias"	0.800;0.900	-	0.800;0.900	-	0.800;0.900	-
Recapture probability (by car)	0.041;0.203	0.105(0.083;0.129)	0.148;0.491	0.218(0.190;0.247)	0.148;0.491	0.230(0.188;0.269)
Recapture probability (by walking)	0.083;0.203	0.133(0.083;0.193)	0.295;0.491	0.331(0.257;0.408)	0.295;0.491	0.262(0.193;0.337)
Ownerless dogs	-	-	-	-	0.025;0.150	0.045(0.010;0.102)

a - lower and upper limit of the 90% credibility interval (CR.I.) are given

b - of confined and free-roaming dogs recorded during the household survey, 23.8% and 82.8% were considered visible from the re-observation line, respectively.

Banarlı: During the household census, all accessible owned dogs were marked by collars made of polyester ribbon (Meister AG, 3415 Hasle, Switzerland). A picture of every dog was taken for identification during the second visit. Subsequently, eleven reobservation passages (one by walking, ten by car) were carried out in the study area. For every dog, we recorded whether or not it was wearing a collar as well as the dog's confinement status (confined, free-roaming). Observations of puppies (three months or younger) were excluded from analysis.

The number of dogs not covered by the household census (ownerless dogs) was estimated by a binomial likelihood model. The Bayesian methodology was chosen because it gives the possibility to flexibly incorporate prior information on the parameters of interest (Lilford & Braunholtz, 1996). The a-priori estimates of the number of dogs not covered by the household census (upper and lower limit of the 90% interval) were 2.5% and 15%. These assumptions were based on experiences from dog population studies in Tunisia (Matter, 1989; Wandeler et al., 1993). Recapture probability was divided into four components:

(i) the probability of a given area being covered during a reobservation passage ("coverage");

(ii) the probability to encounter a specific dog on or near the reobservation line within the study-area covered by reobservation. This probability was set to one for confined dogs and to less than one for free-roaming dogs which may have been missed for observation because of their movements ("encounter");

(iii) the probability that a dog is visible from the reobservation line ("visibility"). These probabilities were based on the "visibility" recorded during the household census;

(iv) the probability that a dog which stays within the area covered by the reobservation line and which is potentially visible was actually recorded ("observer bias").

Recapture probabilities for confined and free-roaming dogs were defined as the product of the probabilities of "coverage","encounter", "visibility" and "observer bias". To represent prior knowledge (90% CR.I.) about these component probabilities, Beta distributions were used. Prior and posterior credibility intervals are given in table 2. For the recapture probabilities, 90% credibility intervals were computed by simulation, and prior information on the corresponding recapture probabilities was represented by Beta distributions. For reobservations by car, the lower limit of the 90% credibility interval of the recapture probability used for reobservation by walking was reduced by 50%. Posterior distributions of all model parameters were derived by the Markov Chain Monte Carlo methodology (Gilks et al., 1996). Among the different methods available, we chose a Metropolis-Hastings algorithm (Tanner, 1996).

Statistical analysis

Analytical software was used for multivariate logistic regression (SYSTAT® Version 7.0 for Windows®). Gauss® Version 3.2 (Aptech Systems, Inc.; Maple Valley, WA) was used for programming the Bayesian recapture model. For other statistical analysis and database we used SYSTAT® Version 7.0 for Windows®, Epi info Version 6.02 (World Health Organization and Centres for Disease Control and Prevention; Atlanta, GA) and FoxPro® Version 2.6 for Windows® (Fox Software, Inc.; Perrysburg, OH).

RESULTS

Dog density in Yağçı

The reobservation data of Yağçı are given in table 3. The village had an estimated total number of 232 dogs (95% CR.I.: 210; 259). This corresponds to 1.5 dogs per household, 3.7 inhabitants per dog, and 464 dogs per square kilometer (95% CR.I.: 420; 518). The number of puppies was unknown. A total of 118 dogs (50.9%) were vaccinated during the mass vaccination campaign. Of these, 78.5% were males (sex ratio: 3.7:1). Of all dogs encountered during the reobservation passages, 84.5% to 93.8% were free-roaming (neither leashed nor shut in).

Table 3. Reobservation of dogs in Yağçı (Turkey).

Date	Time	Reobservation	Initially marked dogs	Reobserved and marked	Reobserved and not marked
20.04.92	09:05-10:15	by walking	87	21	37
22.04.92	09:45-10:35	by walking	112	32	35
25.04.92	10:45-11:45	by walking	121	35	19
28.04.92	09:20-10:20	by walking	121	28	36
01.05.92	06:18-07:10	by walking	121	22	18

Excludes puppies

Characteristics of the dog population in Banarlı

A total of 247 owned dogs were counted in the study area of Banarlı (Table 4). Dogs below one year of age accounted for 22%, and 10% of the dogs were three months or younger. Male dogs were six times as frequent as female dogs. The mean age of male dogs was 3.3 years (range: 0.1 - 15 years) and female dogs had a mean age of 2.4 years (range: 0.3-5 years). According to the data obtained by the household census, the density of

Table 4. Characteristics of the owned dog population of Banarlı (Turkey).

	Number of dogs	%
Sex [a]		
male	211	85.8
female	35	14.2
Age categories		
adult	192	77.7
juvenile	31	12.6
puppy	24	9.7
Mean age (in years)		
male	3.3	
female	2.4	
total	3.2	
Origin [b]		
Born in household	67	28.9
Received from inhabitants of the village	127	54.7
Received from outside the village	26	11.2
Found	12	5.2
Confinement [c] **at time of first observation**		
Confined	67	27.4
Free-roaming	178	72.7
Confinement [d] **during night**		
Confined	54	22.1
Free-roaming	190	77.9
Location [c] **at time of first observation**		
Inside the house	22	9.0
Outside the house [e]	114	46.5
In the street	109	44.5

a -The sex was not known for one dog

b -The origin of 15 dogs remained unknown

c -Confinement status and location at time of first observation was not recorded for two dogs

d -Confinement during night was not recorded for three dogs

e -On dogs owner's premises.

owned dogs in the study area averaged 225 dogs per square kilometer. The inhabitants to dog ratio was 5.5 (6.0 for dogs above three months of age). Of 254 households, 42.2% had no dogs. The proportion of households with one, two, and more than two dogs was 40.9%, 9.1% and 7.9% respectively. Households with dogs had a significantly higher average number of adult household members (4.4; t-Test, $P<0.001$) and children (1.5; t-Test, $P=0.06$) than households without dogs (3.3 and 1.2 respectively). A specific reason for keeping dogs was indicated by the interviewees in 69.6% of cases. Most dogs were used as shepherd dogs (41.9%), for hunting (13.4%), or for guarding (44.2%). At least 83.6% of dogs originated from inside the village and were either born in the household (34.5%) or received from other inhabitants of the village (65.5%).

Most dogs were kept outside of the house during daytime. More than 70% of the dogs were free-roaming at the time of first observation during the household survey, either on the dog owner's premises (40.1%), near the household (13.0%), or further away in the streets (46.9%). According to the indication given by the interviewees, the proportion of free-roaming dogs was slightly higher by night (77.9%).

One month after the first visit, five out of 163 initially registered dogs were found dead (3.1% in one month). In one case, the dog had been abandoned.

Of 35 female dogs, 30 were considered 12 months or older. At the time of first visit, one three year old bitch was obviously pregnant and six others were suckling a total of 20 puppies. Nineteen dogs (63.3%) had had at least one litter in their life and had given birth to a total of 66 puppies (range: 0 (stillborn only) - 7). Of these, 31.8% still lived in the household, 15.2% had died, 42.2% had been given away, and 10.6% had been abandoned.

During the household survey, a total of 137 dogs (61.4% of all dogs above three months of age) were marked with a collar. Dog marking can be considered to be an indicator of accessibility to parenteral vaccination. Dogs which cannot be captured and handled for marking are probably also inaccessible for parenteral vaccine application. In order to identify which factors most influence the accessibility of dogs for vaccination, marking was entered as the dependent variable in a logistic regression model. Puppies were excluded from the analysis. Model selection was done by the likelihood ratio test (Hosmer & Lemeshow, 1989). The chosen model included a constant term and three independent variables (age, confinement status, and function). The odds ratios for these variables and for additional parameters which were part of the saturated model are given in table 5. Most difficult for marking and vaccination were adult, free-roaming shepherd dogs and dogs without any specific function. In this category, which made up 42% of dogs above three months of age, 59.8% of dogs were not marked. Among all other dogs, 20% were not marked.

Table 5. Characteristics associated with marking[a] (C.I. - confidence interval).

Variable	Dogs	Marked dogs	Odds ratio (% 95 C.I.) univariate	Logistic regression model
Age				
one year or older	178	105 (59.0)	0.17 (0.04; 0.61)	0.24 (0.07; 0.88)
below one year	29	26 (89.7)	1	
Confinement status				
confined	60	53 (88.3)	6.70 (2.68; 17.47)	3.26 (1.26; 8.46)
free-roaming	147	78 (53.1)	1	
Sex				
male	180	114 (63.3)	1.02 (0.40; 2.54)	not included
female	27	17 (63.0)	1	
Origin				
received / found	153	99 (64.7)	0.79 (0.40; 1.58)	not included
born in household	54	32 (59.3)	1	
Location				
in the streets	66	28 (39.4)	0.22 (0.11; 0.44)	not included
on or near dog owner's premises	141	105 (74.5)	1	
Function				
no function	50	28 (56.0)		0.49 (0.21; 1.13)
hunting dog	21	18 (85.7)		1.22 (0.29; 5.14)
shepherd dog	62	28 (45.2)		0.44 (0.19; 1.00)
guard dog	74	57 (77.0)		1

a - Marking (marked [1]; not marked [0]) was used as response variable

Recapture data of Banarlı are given in table 6. The estimated total number of dogs above three months of age was 232 (95% CR.I.: 223; 246) during daytime (211 dogs per square kilometer (95% CR.I.: 203; 224). Ownerless dogs represented an estimated 4.5% (95% CR.I.: 0.9%; 10.2%) of these. The posterior estimates of recapture probabilities for the different categories of dogs and the estimated number of dogs not covered by the household census (ownerless dogs) are summarized in table 2.

Marker loss was checked one month after marking and 5.3% of the initially marked dogs had lost their collar. As a consequence, the proportion of ownerless dogs may be even lower than estimated.

Table 6. Reobservation of dogs in Banarlı (Turkey).

Date	Onset of reobservation[a]	Reobservation	Reobserved and marked		Reobserved and not marked	
			confined	free-roaming	confined	free-roaming
25.04.92	16:00	by car	1	25	3	21
27.04.92	18:15	by car	2	22	1	23
28.04.92	11:00	by car	4	18	1	20
01.05.92	07:27	by car	10	17	13	27
04.05.92	11:55	by car	2	10	2	19
06.05.92	15:50	by car	3	20	5	17
11.05.92	15:28	by car	2	14	2	11
13.05.92	16:00	by car	4	18	5	12
16.05.92	08:06	by car	5	16	5	24
20.05.92	11:03	by walking	7	19	10	14
21.05.92	09:30	by car	1	23	0	26

Excludes puppies (three months and younger)

a - Mean duration of reobservation passage was 51 minutes and 77 minutes by car and by walking, respectively.

DISCUSSION

For population management and rabies control, a few basic parameters concerning the target population should be known. Data on population size and the accessibility of dogs to different control strategies are necessary to plan and implement appropriate dog rabies control programs. Supplementary information on reproduction, turn-over, habitat use etc. are also useful. It has been shown that reliable population data can be obtained by combining household surveys with techniques mainly used in wildlife research. In the past fifteen years, WHO and other organizations have promoted and funded dog ecology studies in various regions of the world. In three focal areas (Ecuador, Sri Lanka, Tunisia) local dog populations have been thoroughly investigated (Beran & Frith, 1988; Wandeler et al., 1993). These studies have contributed to the general understanding of the structure and dynamics of dog populations and the human-dog relationship in developing countries. Some of this information may also be valid for dog populations elsewhere. Bayesian statistics, as it was used in our study, gives the possibility to integrate this prior knowledge for the study of specific situations in other countries with enzootic dog rabies.

In many parts of Turkey, mass vaccination campaigns of owned dogs and the destruction of stray dogs have been applied for several years and a progressive decline in the number of animal rabies cases has been observed. However, the reasons for this decline are not fully understood. Elimination of dog rabies by mass vaccination is possible if a relatively high percentage of dogs are immunized (Wandeler et al., 1988; Coleman & Dye, 1996). However, our study showed that in two rural areas of the Tekirdağ province only 50% to 65% of adult and juvenile owned dogs were accessible to parenteral immunization. A high number of free-roaming dogs that are frequently used as shepherd dogs could not easily be handled by their owners and were not accessible for vaccination. These dogs are observed in- and outside of their villages while accompanying the sheep herds. They are never confined and frequently come in contact with other dogs, other domestic animals, and wildlife. Beside ownerless dogs, these animals represent the main problem for rabies control.

In the two rural study sites, the proportion of ownerless dogs was rather low. The high density of owned dogs and, by consequence, the low availability of unused food resources may partially explain this observation. During daytime, ownerless dogs could not be found in or near the village of Yağçı. Dogs without collar marking were identified as shepherd dogs. In Banarlı, dog population density was lower and 42% of the households had no dogs. These circumstances may favour the presence of ownerless dogs. However, their proportion was below 10%. In rural areas in North Africa the situation was similar and the proportion of ownerless dogs varied between 5% and 15% (Matter, 1989).

High proportions of inaccessible owned and ownerless dogs are not the only reason why rabies control programs may fail. Insufficient community participation as well as organizational and logistic deficiencies are as important, and further reduce the proportion of dogs vaccinated during regular mass vaccination campaigns. For countries with limited human and animal health budgets it is difficult to maintain sufficient funding, political willingness, and motivation for rabies control over a long period of time. As a consequence comprehensive dog rabies control concepts enabling the elimination of enzootic dog rabies within three to five years are needed.

Oral immunization has been proposed as an additional tool for dog rabies control. In the hope of significantly raising the overall proportion of immunized dogs within the population, preliminary trials have been implemented in Turkey and other countries. Several vaccine baits and different bait delivery systems were tested (Baer, 1976; Frontini et al., 1992; Kharmachi et al., 1992; Linhart, 1993; Matter et al., 1995; 1997; Perry et al., 1988; WHO, 1994). These trials have also shown that organization and logistics remain a crucial prerequisite for a rabies control strategy based on parenteral and oral immunization, or on oral immunization alone.

In Turkey an important proportion of dogs inaccessible to parenteral immunization actually have an owner. It may be interesting to investigate if a dog owner mediated bait delivery system would significantly increase vaccination coverage within these specific categories of dogs. Recent studies on dog owner mediated bait delivery in Tunisia have given encouraging results (Matter et al., 1997). However, before initiating large scale use of oral immunization, efficacy, feasibility, cost-effectiveness, and safety of this method need to be further investigated in the Turkish context.

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