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Cost Benefit analysis of different management options for free roaming dog populations in Abruzzo, Italy

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Introduction

Free-roaming dogs consist of stray dogs, block dogs (owned by the community) and the unsupervised owned dogs. With euthanasia no longer an option by the Italian Laws and Regulations, management measures of free roaming dogs currently includes kennelling, conversion of stray dogs into block dogs and adoption of strays by new homes. The management of this animals could have high costs, in terms of money and animal welfare as well as social costs, therefore the cost optimisation is of a paramount importance.

Materials and methods

We constructed a spreadsheet model to assess the dynamics of the dog population (birth, death, migration), divided in the following five sub-groups,

1. Owned dogs (OD)
2. Free-roaming owned dogs (FreeOD)
3. Kenneled dogs (KD)
4. Block dogs (BD)
5. Stray dogs (SD)

and, according to different management options, we estimated the resulting scores in terms of (1) dog welfare (2) nuisance and health risk and (3) monetary cost.
It is a 5-year time series model from 2008 to 2012, tracking the changes in each of the dog sub-groups using year as time unit. The general equation for each group population is:

$$N_{t+1} = N_t + (B+I) - (D+E) = G\,N_t$$

Where N_t is the population size at time t; B, I, D and E are the number of births, immigrants, deaths, emigrants; G is the growth rate.
Input data were obtained from local sources when available. These included sources and studies from either Pescara or Teramo, and it was assumed that these neighbouring provinces were similar enough to extrapolate data from one province to the other. It was also assumed that the dog ownership and management patterns have been stable for the last ten years, and will be for the next five years.

Owned Dog Population (OD)
The owned dog population increases as puppies are born into the household and as new dogs are purchased, received as a gift or adopted. It decreases as owned dogs die or are abandoned.
The growth rate for OD in Teramo was recently modelled by Di Nardo et al. (2007). They found an average growth rate of 2.6%, which was in line with reported data from 1998 to 2002. The estimated OD in 2008 was based on the number of households in Teramo and Pescara, and the estimated number of dogs per household. The census of 2001 reported that Pescara province had 106.168 households, and Teramo province had 101.614. In a questionnaire undertaken in the province of Teramo in 2004 by Slater et al. (2008b), it was found that 33% of 397 households owned dogs, with an average of 1.4 dogs per dog-owning household. These figures were assumed to be representative for the two provinces and stable for the last ten years, so the OD for the two provinces could be estimated to 95.995 in 2001. Allowing for a 2.6% growth rate, OD was estimated to 114.890 in 2008, and the same growth rate was used for the following five years. The death rate was assumed to be 12.5%, based on an average life span of 8 years. The abandonment rate was assumed to be 2.2%, based on national data indicating that 150.000 out of 6.9 million dogs were abandoned in 2001 (Slater et al., 2008a). Finally, Slater et al. (2008b) reported that 13 % were allowed to roam free, 50% were identified, 62% were males. The sterilized fraction of them was 8% and 30% of the males and females, respectively.

Free-roaming owned dog population (FreeOD)
The FreeOD was calculated as a fraction of the OD population. Slater et al. (2008b) reported that, in the Teramo Province, in 2004, 13% of the dog keepers declared that they allowed their dog to roam free. Therefore, we considered that FreeOD=0.13 OD.

Kennel dog population (KD)
The KD needs to be approached differently, because it is limited by the kennel capacity. At present, kennels are full in Pescara and Teramo provinces, and the KD can therefore be approximated by the kennel's capacity, which in 2008 is approximately 1.200 units. As new kennels are built by private persons or the government, the capacity increases, and it was assumed that KD would increase accordingly. The kennel capacity and KD were assumed to increase at a base level of 10% per year.

The yearly free capacity results from KD dying or being adopted. It was assumed that KD would live on average four years, resulting in a death rate of 25%. The adoption rate was assumed to be 10% as base level, but was increased to 50% as a management option. The free space allows the immigration of dogs from other categories, and was considered filled up with following priority: 1. SD kennelled after been caught, 2. BD kennelled due to inadequate behaviour as free-roaming, 3. OD delivered to a kennel. When the capacity of the kennel was reached, the remaining dogs were considered released as BD. The number of SD converted to KD was estimated from records from the municipal dog shelter in Pescara municipality and corrected to Pescara and Teramo provinces based on the relative number of households, as reported from the 2001 census. Between 2000 and 2006, an average of 515 dogs/y were captured, of which 27 dogs/y were euthanized and 488 dogs/y were relinquished. Of these 488 dogs, 8% were kennelled (40 per year), 49% were released as BD (239 per year) and 38% were adopted (184 per year). This indicates that on average, 40 dogs/y captured in Pescara municipality are kennelled (range 18-53), which can be extrapolated to 192 dogs/y for the two provinces. It was assumed that these figures were proportional to the number of SD rather than fixed by the capacity of the veterinary services. Based on an estimated number of SD of 6261 during this period, the rate of conversion of SD to KD was estimated to 3% per year (=192/6261), as long as it doesn't exceed the kennels capacity. BD are released into the territory when considered fit for free-roaming without causing too much damage. However, they may be kennelled due to health problems or unwanted behaviour. We assumed that 5% of BD could be kennelled each year. The remaining capacity would then be available for OD delivered to a shelter.

Block dog population (BD)
BD are free-roaming dogs owned by the community. They come from SD captured by the veterinary services and released into the territory after a short stay in the municipal kennel. During this stay, they are identified, sterilized, vaccinated, tested for Leishmaniosis and medicated if needed. It is requested by law that all dogs should be identified and the public is encouraged to call the veterinary services to report for stray dogs. BD don't reproduce, since they are sterilized before release. BD may increase as SD or OD delivered to the veterinary services are converted into BD, or as KD are released into the territory for capacity reasons. It decreases as BD die or are kennelled. These dogs still remain the property of the community, so no movement of BD to owned dogs were considered. The rate of conversion of SD into BD, and the number of BD in 2008, was estimated from records from the veterinary services in the Pescara municipality, and corrected to Pescara and Teramo provinces based on the relative number of households, as reported from the 2001 census. Between 2000 and 2006, an average of 239 dogs were released yearly as BD in Pescara, which can be extrapolated to 1.147 for the two provinces. Based on an estimated number of SD of 6.261 during this period, the rate of conversion was estimated to 18% (=1.147/6.261). The resulting number in 2008 depends on the removal rate of BD, as shown below. The death rate of BD was assumed to be 25%,with an average life span of four years. A 30% removal rate was therefore assumed, adding 25% death rate and 5% kennelling rate. Given this rate and the annual number of dogs added per year, the predicted number of BD in Pescara Municipality in 2008, based on records from 2000-2006, was 751, and the corrected number for the two provinces was 3.605 BD.

Stray dog population (SD)
SD are unidentified and unowned animals and their number increases as they reproduce and as unidentified OD are abandoned in the streets. It decreases as they are converted to BD or KD by the Veterinary services, or are adopted by private persons, or die. During 2001, an estimated 150.000 dogs were abandoned in Italy, from a population of 6.9 million OD (Slater et al., 2008a). Assuming that all of these were unidentified and left in the street, rather than being delivered to a shelter, this indicates that each year, about 2.2 % of the OD population becomes SD. For Teramo and Pescara, this would represent 2.528 dogs in 2008 (2.2% of 114.890 owned dogs). Slater et al. (2008b)reported that 19% of OD in the study (33 out of 176) had been "found". With an estimated number of OD of 114.890 in 2008, this indicates that more than 20.000 OD may have been adopted from stray dogs.
There are no data available on the reproduction rate of SD in Teramo and Pescara. A fecundity of 2.25 offspring per stray fertile female per year, was assumed in stray dogs of New Zealand by Karma Rinzin (Karma Rinzin, 2007). The sex ratio of SD can be estimated from records from the Pescara municipality shelter, who report that 82% of neutered dogs in 2000-2005 were females. Slater et al. found a higher proportion of owned female dogs being neutered, compared to males (30% vs. 8%). This indicates a high proportion of females among the SD. Assuming that 80% of SD are females, 80% of those are fertile, and a sex ratio of 1:1 at birth, the birth rate for both sexes can be estimated to 2.88 (= 2.25 x 2 x 0.8 x 0.8). Assuming an average lifespan of 3 years, and the death rate therefore 33% (=1 / 3), this leads to predict a population increase rate due to birth and death of 2.55 (=2.88-0.33) per year, or an intrinsic growth rate of 3.55 (Nt+1=3.55 x Nt in a closed population). This is however very high, as Nassar and Fluke reported that the death rate is usually higher than the birth rate, resulting in a decrease in size of a closed population (intrinsic growth rate<1). To account for this, since a high proportion of SD are adopted, we assumed that reproduction and adoption would lead to an approximate stable population. The conversion of SD to BD and KD was assumed to follow a rate of 18% and 3% per year, as explained previously. Considering a yearly death rate of 33%, an 18% conversion rate to BD, a 3% conversion to KD, and a reproduction rate balanced by adoptions, this leads to a yearly removal rate of 54%. Based on 95.995 owned dogs in 2001, a 2.6% growth rate of OD and a 2.2% abandonment rate, the number of SD in 2008 was estimated to 4.578.

List of input
- Number of households (ISTAT, Census)
- Percentage of household that owns a dog (Slater et all.)
- Mean number of dogs per household (Slater et all.)
- Percentage pg owned dog that are allowed to roam free (Slater et all.)
- Estimate of stray dog population (AUSL data)
- Mean number of puppies per litter in the different sub population of dogs (Slater et all)
- Estimate of the average life span of dog (Di Nardo et all.)
- Abandonment rate (Slater et all.)
- Monetary cost to convert a stray dog into a block dog (personal communication)
- Monetary cost to convert a stray dog into a kennelled dog (personal communication).

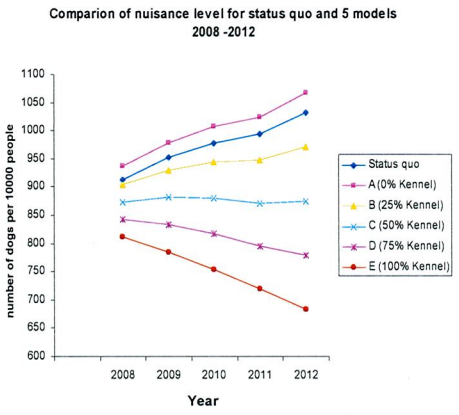
List of output
- Welfare scoring (on a scale based on an expert opinion method, an interview with 100 Veterinarians)
- Nuisance scoring (Number of free roaming dog, weighted according to the sub population of dogs, per 10.000 human population).
- Monetary cost (management cost of the whole dog population).

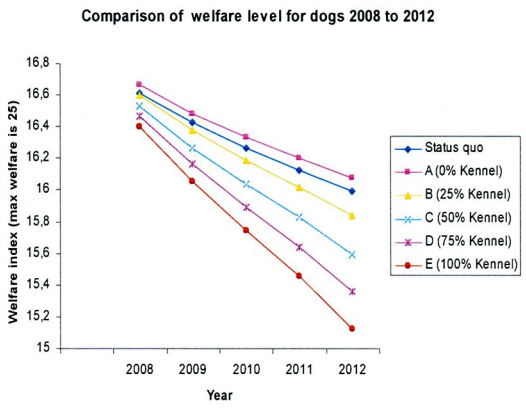
All variables characterised with a level of uncertainty have been described with a probability distribution with a Monte Carlo method using a 10.000 iterations cycle with @Risk software (Palisade Corporation ®) (Vose, 2000).

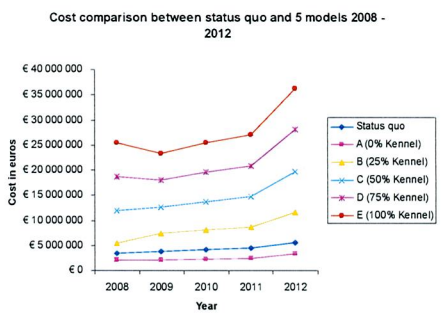
Results

Table 1. **Level of welfare in the four sub-populations based on the expert opinion**

Sub-population	Level of welfare
Owned Dog	17,67
Block Dog	15,21
Kennel Dog	13,93
Stray Dog	10,98







Discussion

From a cost benefit analysis point of view, converting as many stray dogs into block dogs without kennelling them, maximises the welfare of the animals and allows to save money. On the other hand, kennelling as many dogs as possible would greatly decrease the nuisance and the health risk, but would imply greater money investment.
The study, which is the first one of its kind, gained two main results:

- The first was to quantify with the expert opinion the level of welfare of the dogs divided in subpopulation as previously described. The best level of welfare is, as expected, in the OD sub-population, followed by BD and KD. The lowest level of welfare is in the SD sub-population. These figures, are not definitive and they need more investigation in terms of more specific "on animal" welfare indicators, both physiological and behavioural ones.
- The second one is the availability of a new and very flexible tool (the spreadsheet model) which could be used for decision makers to allocate resources. Of course, as for any predicting model, the estimates are more precise when the inputs are more accurate, for example in our model we were not able to insert any data coming from other than municipal shelter. These shelters are in fact several and differently managed according to the association which is in charge of. They surely play a role in the global picture but, in this study we missed that part of data. Nevertheless we believe that even if the main area of improvement is the data quality, the conceptual model is very useful and deserve to be further investigated.

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