Mathematical modeling of temporary non-surgical sterilization of dogs and cats

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Introduction

In the companion animal population management context, non-surgical alternatives for reproductive control must be effective, safe and produce permanent effect after a single treatment (Oiveira et al., 2012). Progress in this way have given rise to non-surgical methods, some with permanent but others with temporary (reversible) effect. Although reversibility is an undesired characteristic, population studies are needed to better understand the potential impact of temporary contraception in population management.
This study aimed the assessment of the impact and efficiency of companion animals temporary contraception, using a system of coupled ordinary differential equations to model fertility dynamics.

Methods: model

An hypothetical population in equilibrium was simulated. It was composed by two compartments, one of fertile X and another of infertile W animals. A fraction r of the mortality rate d was compensated by the birth rate and the complement $(1-r)$ was compensated by immigration. A fraction of immigrants z moved to X and the remaining $(1-z)$ to W. The movement of animals from X to W was given by the contraception rate e and the movement from W to X by the fertility recovery rate f. It was assumed that the proportion of infertile immigrants was equal to the proportion of treated animals per year in the population and that once they went in the population, fertility recovery rate was homogeneous for all individuals. Immigration was defined as the movement of animals from the pet market to the population and fertility as the capability to breed. All rates were defined per year (year^{-1}).
The system of equations was given by:

$$\frac{\delta X(t)}{\delta t} = rd(X+W) + z(1-r)d(X+W) + fW - (d+e)X$$

$$\frac{\delta W(t)}{\delta t} = (1-z)(1-r)d(X+W) + eX - (d+f)W$$

Table 1. State variables and parameters.

X = 950	r = 0.7, 0.2
W = 50	z = 0.95, 0.8, 0.6
l* = 6	e = 0.05, 0.2, 0.4
d = 1/l	f = 0, 0.1, ..., 0.9, 1

* Life expectancy (Ferreira, 2010).

Methods: efficiency

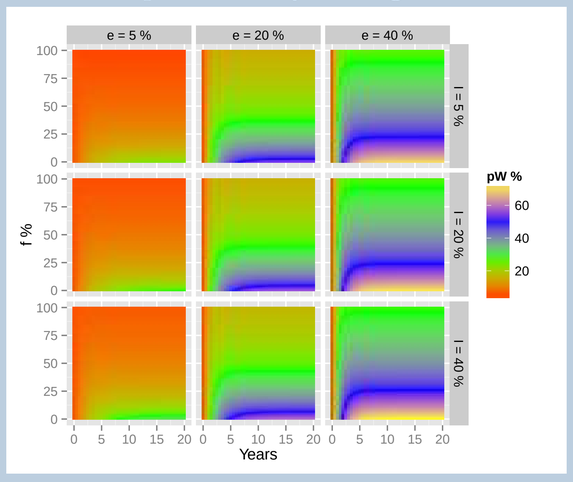
Efficiency was expressed in terms of the total of animals treated during 20 years using a given permanent contraception rate divided by total of animals treated during the same period, using temporary contraception at the same rate.

Results: scenarios

Figures 1 and 2 show the percentage of infertile animals in the population (pW) and the total of treated animals (W), conditioned by the fertility recovery rate (f), the contraception rate (e), and the proportion of infertile immigrants (I).

Figure 1. Proportion of infertile animals

30 % of the death rated compensated by immigration



80 % of the death rated compensated by immigration

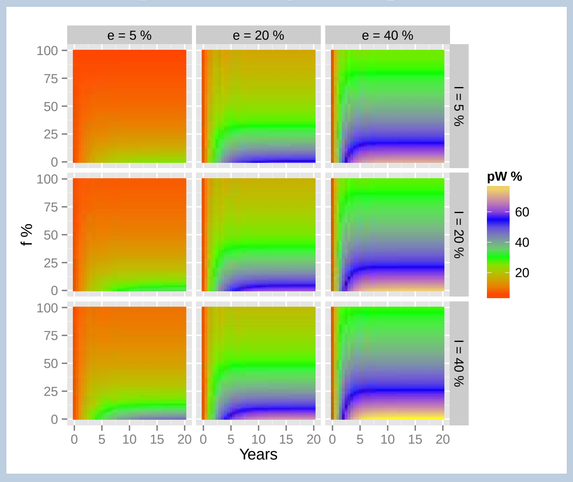
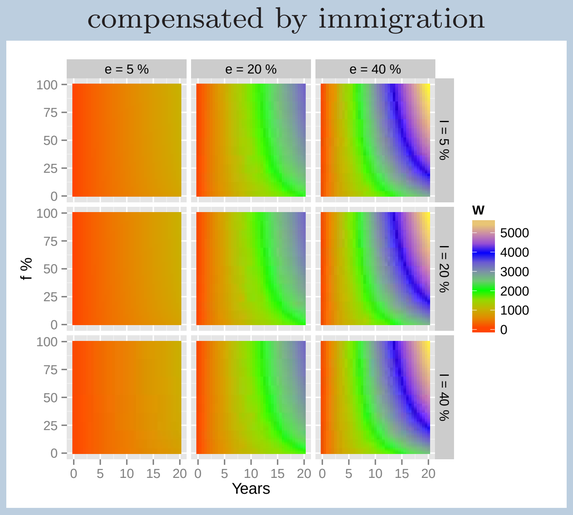


Figure 2. Total of treated animals

30 % of the death rated compensated by immigration



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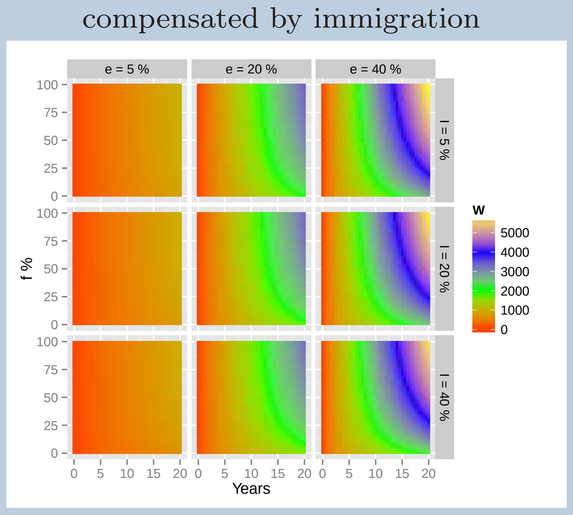
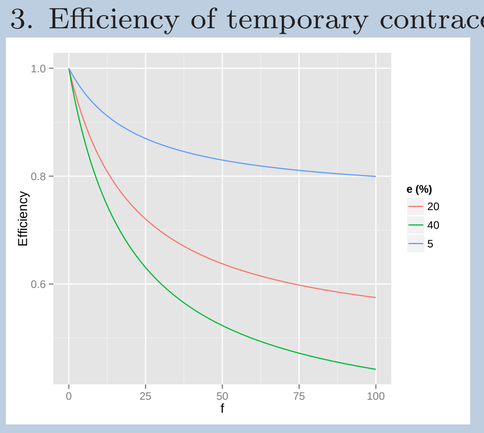


Results: efficiency

Because the percentage of death rate compensated by immigration and the percentage of infertile immigrants had little effect on the infertility of animals in the population, efficiency was tested fixing these variables at 30 %.

Figure 3. Efficiency of temporary contraception



Discussion

Temporary contraception have the potential to increase the proportion of infertile animals. In situations in which treatments are implemented at low rates, as is usual in Latin America, the effect of temporary and permanent methods are not so different. However, as contraception rate increase, the fertility recovery rate is more detrimental, thus reducing the efficiency of temporary contraception.

Discussion *(continue)*

Replacement of animals is a well known phenomenon and the reproductive control of incoming animals is a possibility for population management. The simulations showed that reproductive condition of immigrants has little effect on the fertility of the population. Nonetheless, it dose not mean necessarily that such possibility must be discarded. In fact, if it dose not interfere with the rate at which contraception is implemented, the effect of both interventions is synergistic. The specific way in which replacement happens (predominantly by birth rate or by immigration) have negligible effect on the fertility of population. However the effect of contraception tend to be better when replacement is mainly accounted by immigration, a scenario that can be facilitated by the contraception itself (birth rate reduction).
The used model is not species-specific but it must be noted that the life expectancy used to define the mortality rate is a value calculated for owned bitches.
Temporary contraception may be viable alternative of reproductive control if lost of efficiency is compensated by lower costs and easiness of implementation.

References

Ferreira, Fernando. Avaliação do impacto da esterilização e/ou sacrifício no controle de populações de cães através de um modelo matricial de crescimento poopulacional. Tese de Livre Docência. Relatório final. São Paulo. 2010.
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