An Analysis of the Effect of Females First on Cat and Dog Populations

What is Females First?

Females First is an approach to pet population control that focuses on altering female animals. It is a known fact that in non-monogamous animal populations, the rate of population growth is almost entirely dependent on the number of fertile females – i.e., the number of fertile males has almost no effect. [Shaw, Pierce et al., Pheasants] This assumption breaks down when you have more than 10 fertile males for every fertile female, but it is very difficult to achieve this in practice. Concentrating spay/neuter efforts on female animals results in much more cost-effective population control.

In this paper, we analyze the effect of such a program on feral and domestic cat and domestic dog populations using a simple exponential growth model to give a rough idea of the potential implications of a population control policy.

The Model

We will track changes in total size of a typical population based on three scenarios:

- No human intervention
- A spay/neuter program that does not distinguish between males and females
- A spay/neuter program with increased rates of spay/neuter for females

We will also track the sex ratio of the fertile population to make sure our assumption that there is at least one fertile female for every ten fertile males remains true.

Our model uses discrete time periods, distinguishes between sexes, and tracks both the altered and unaltered populations. Altering happens at the beginning of each period and the time increment is one year.

Parameters

d_m = male death rate (fraction of the male population that dies during one year)

d_f = female death rate (fraction of the female population that dies during one year)

b_m = male birth rate (number of males produced by a single female during one year)

b_f = female birth rate (number of females produced by a single female during one year)

a_f = female alter rate (fraction of female population that is altered during one year)

a_m = male alter rate (fraction of male population that is altered during one year)

$P_{am,t}$= population of altered males at time t

$P_{um,t}$= population of unaltered males at time t

$P_{af,t}$= population of altered females at time t

$P_{uf,t}$= population of unaltered females at time t

Difference Equations

$$P_{am,t*} = P_{am,t-1} + a_m P_{um,t-1}$$
$$P_{um,t*} = P_{um,t-1} - a_m P_{um,t-1}$$
$$P_{af,t*} = P_{af,t-1} + a_m P_{uf,t-1}$$
$$P_{um,t*} = P_{am,t-1} - a_f P_{uf,t-1}$$

$$P_{am,t} = P_{am,t*} - d_m P_{am,t*}$$
$$P_{um,t} = P_{um,t*} - d_m P_{um,t*} + b_m P_{uf,t*}$$
$$P_{af,t} = P_{af,t*} + a_m P_{uf,t*} - d_f P_{af,t*}$$
$$P_{um,t} = P_{am,t*} - a_f P_{uf,t*} - d_f P_{uf,t*} + b_f P_{uf,t*}$$

The Model Parameters

Feral cats

According to published sources, cited in Karen Johnson's National Pet Alliance report titled "A Report on Trap/Alter/Release Programs":

- The average female feral cat gives birth to 2.1 litters per year of 4.25 kittens per litter [Pederson]
- 42% of feral kittens die by 2 months of natural causes [Berkeley]
- Average life span of a female feral cat: 3 years [Berkeley]
- Average stray female cat will have 5.25 litters [Berkeley]
- Sex ratio at birth is 6 females / 7 males [Berkeley]
- At maturity: 2 females / 3 males due to high mortality of females during first pregnancy and birth [Berkeley]
- 97% of strays are not altered [Johnson3]

From this data, we can derive the birth rates for males and females:

Birth rate: 4.3 per female cat (derived from 12.9 survivors divided by 3)

Female (b_f): 2.0 (derived from birth sex ratio)

Male (b_m): 2.3 (derived from birth sex ratio)

Death rate:

Female (d_f): 0.29 (derived from average life span of 3 years)

Male (d_m): 0.19 (derived from female death rate and change in sex ratios at year 0 and year 2)

Fraction of male cats altered at year 0: 0.03
Fraction of female cats altered at year 0: 0.03

Domestic cats

- In San Diego County, 87.1% of male domestic cats are altered and 82.8% of females [Johnson3]
- Average life span of a cat is 14 years [Waltham]
- Number of litters a female cat can theoretically produce in a year: 3 [HSUS]
- Average litter size: 4.25 kittens, 1/3 will be dead by the age of one year, with most of the deaths

occurring at birth, or shortly thereafter [Pederson]

We were unable to find a reliable actual average number of litters that an unaltered female cat produces, so we use 1.5 for a lifetime.

Birth rate: (1.5 litters * 2.85 kittens) / 14: 0.31

Female (b_f): 0.155 (derived from even birth sex ratio)

Male (b_m): 0.155 (derived from even birth sex ratio)

Death rate:

Female (d_f): 0.07 (derived from average life span of 14 years)

Male (d_m): 0.07 (derived from average life span of 14 years)

Fraction of females altered at time 0: 0.828
Fraction of males altered at time 0: 0.871

Domestic dogs

- Average life span of a dog is 10 – 15 years [Compton's]
- In San Diego County, 76.0% of male dogs are altered and 59.9% of females [Johnson3]
- The average number of dogs owned by a dog-owning household: 1.69 [HSUS2]
- Number of puppies per litter: 8 [HSUS2]
- sex ratio: 50/50 [HSUS2]
- number of litters a female dog can theoretically produce in a year: 2 [HSUS1]

Again, we were unable to find a reliable source for the actual average number of litters that an unaltered female produces, so we use 1.5 for a lifetime.

Birth rate: (1.5 litters * 8 puppies) / 12.5: 0.96

Female (b_f): 0.48 (derived from birth sex ratio)

Male (b_m): 0.48 (derived from birth sex ratio)

Death rate:

Female (d_f): 0.08 (derived from average life span of 12.5 years)

Male (d_m): 0.08 (derived from average life span of 12.5 years)

Fraction of females altered at time 0: 0.599
Fraction of males altered at time 0: 0.76

Population Projections

For each population (feral cats, domestic cats, and domestic dogs) we assume the initial population is 1000 animals, and we run 3 projections:

1. No change in current spay/neuter rates
2. Increase spay/neuter rates for both males and females
3. Increases spay/neuter rates for females only

Feral Cats

With no altering at all, the population climbs to over 100,000 in just five years:

Year	Altered males	Unaltered females	Altered females	Unaltered females	Total	# of alters
0	18	582	12	388	1000	0
1	15	1364	9	1051	2439	0
2	12	3523	6	2850	6391	0
3	10	9408	4	7722	17144	0
4	8	25381	3	20927	46319	0
5	6	68691	2	56712	125411	0

If 63.5% of all cats are altered each year, the population stops growing at about 2380 animals:

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	18	582	12	388	1000	0
1	314	498	183	384	1379	616
2	510	469	303	380	1662	560
3	655	457	386	376	1874	539
4	766	450	444	371	2031	529
5	852	445	482	367	2146	522
6	919	440	508	363	2230	516
7	971	435	525	359	2290	510
8	1010	430	535	356	2331	505
9	1040	426	540	352	2358	499
10	1061	421	542	348	2372	494
11	1076	417	542	344	2379	488
12	1086	412	540	340	2378	483
13	1091	408	537	337	2373	478

We see almost exactly the same results with less than half the number of spays by altering 63.5% of the females, and leaving the males alone. Note also that the ratio of fertile males to fertile females is still less than 5 to 1, so we are still justified in ignoring the fertile males as a factor in the population growth rate.

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	18	582	12	388	1000	0
1	15	797	183	384	1379	246
2	12	968	303	380	1663	244
3	10	1103	386	376	1875	241
4	8	1208	444	371	2031	238
5	6	1291	482	367	2146	236
6	5	1354	508	363	2230	233
7	4	1402	525	359	2290	231
8	3	1437	535	356	2331	228
9	3	1463	540	352	2358	226
10	2	1480	542	348	2372	223
11	2	1491	542	344	2379	221
12	1	1496	540	340	2377	219
13	1	1498	537	337	2373	216

Domestic Cats

If everyone stopped altering their animals, it would take until year 12 for the population to start growing again. This simulation makes it clear that the domestic cat population is not self-sustaining – it depends in an inflow of animals from animal shelters or breeders. Of course, right now there are far more than enough animals at the shelters, and until feral cat populations can be brought under control, we need to keep the inherent domestic cat population growth rate as low as possible.

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	436	64	414	86	1000	0
1	405	73	385	93	956	0
2	377	83	358	101	919	0
3	350	93	333	110	886	0
4	326	103	310	119	858	0
5	303	114	288	129	834	0
6	282	126	268	140	816	0
7	262	139	249	152	802	0
8	244	153	232	165	794	0
9	227	168	215	179	789	0
10	211	184	200	194	789	0
11	196	201	186	211	794	0
12	182	220	173	229	804	0
13	170	240	161	248	819	0

Domestic Dogs

Altering no animals, the population more than triples after just 5 years:

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	380	170	200	300	1050	0
1	350	300	184	419	1253	0
2	322	477	170	587	1556	0
3	296	721	156	822	1995	0
4	272	1058	144	1151	2625	0
5	250	1525	132	1611	3518	0

Altering 35% of both males and females every year:

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	380	170	200	300	1050	0
1	404	195	281	273	1153	164
2	435	202	346	248	1231	164
3	465	198	398	226	1287	157
4	492	189	439	205	1325	148
5	513	177	470	187	1347	138
6	529	164	493	170	1356	127
7	540	151	508	155	1354	117
8	545	139	517	141	1342	107
9	546	127	521	128	1322	98
10	543	116	521	117	1297	89
11	537	106	517	106	1266	81
12	528	96	510	97	1231	74
13	517	88	500	88	1193	68

Nearly the same results with altering only females, and the fertile male to female ratio is 5.4 to 1:

Year	Altered males	Unaltered males	Altered females	Unaltered females	Total	# of alters
0	380	170	200	300	1050	0
1	350	250	281	273	1154	105
2	322	315	346	248	1231	95
3	296	367	398	226	1287	87
4	272	408	439	205	1324	79
5	250	440	470	187	1347	72
6	230	463	493	170	1356	65
7	212	479	508	155	1354	60
8	195	489	517	141	1342	54
9	179	494	521	128	1322	49
10	165	494	521	117	1297	45
11	152	491	517	106	1266	41
12	140	485	510	97	1232	37
13	129	476	500	88	1193	34

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