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Measuring the effect of ecological factors (food waste volume changing) on the weight of cats in Tehran / 2016 - 2020

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Abstract

Humans, willingly or unwillingly, affect the lives of urban cats. Waste production is only one of the human effects on the urban cat ecosystem. The human-generated food waste provides a large portion of urban cat's food, and economic fluctuations change the quality, and content of waste bins. In this descriptive-estimation study with field monitoring, we tried to measure the weight of cats to find out how much the change in the volume of municipal food waste affects their physical condition? The results of a study conducted in Tehran from spring 2016 to winter 2020 showed that the average volume of food waste collected in this city had decreased by 26.9%. The reduction of food waste volume affected the weight of cats and caused an average of 18.71% reduction in the average weight of cats during the study. The weight loss rate intensified from autumn 2017 – to winter 2018 onwards. Male cats lost 18.68%, and female cats 18.40% of their weight from early spring 2016 to late winter 2020.

Keywords: Cat, Weight, Food waste, Tehran.

Introduction

Urbanization of humans has caused changes in the ecosystem around them, and these changes have affected the ecology of other animals[1-4]. Cats (*Felis catus*) are a group of urban animals whose lives have been affected by coexistence with humans. The effects of economic turmoil in urban communities can be seen in bins[5,6], and the economic, and living conditions of citizens living in metropolises can be measured tangibly in the contents of bins[7-9]. Although cats are predators, trash cans are alternative access to food for them[10,11], and the living conditions of citizens affect cats. To understand the magnitude of this effect, cats can be weighed at regular intervals and were informed about the impact of economic fluctuations in human societies on their ecological status.

Materials, and methods

Given the importance of the issue, and what has been said, the question was raised what is the relationship between the average weight of cats living in Tehran, and the amount of waste collected in this city? Proving the correlation between the change in cat weight (dependent continuous variable), and the change in food waste volume (independent variable) means confirming the H_0 hypothesis, and the significance of the relationship between these two components was considered as the H_1 hypothesis. Obviously, in this article, wherever are talked about waste, it means containing food waste that is regularly, and daily sent by Tehran's municipality for burial or disposal to the Arad Kooh site in the south of Tehran.

To answer the above question, and prove or disprove the research assumptions, from spring 2016 to winter 2020, the weight components of cats in 13 locations in Tehran (listed in Table 1) were randomly selected, and each of them Was within a radius of 90 to 110 meters were measured by descriptive-estimation method, and field monitoring.

Table 1: Coordinates of the studied stations (UTM)

Scope	Location
Zafaraniyeh	35.804105, 51.412755(lat/lng)
Saadatabad	35.783451, 51.369469(lat/lng)

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Davudiyeh	35.762649, 51.432133(lat/lng)
West Tehranpars	35.741498, 51.528422(lat/lng)
Central Janatabad	35.761999, 51.308244(lat/lng)
Abbasabad	35.729731, 51.435919(lat/lng)
Haft Hoz	35.733871, 51.490846(lat/lng)
Mortazavi	35.685570, 51.367043(lat/lng)
Shemiran Gate	35.696614, 51.439997(lat/lng)
Parastar	35.689377, 51.482602(lat/lng)
Shush	35.655119, 51.439517(lat/lng)
North Khani Abad	35.633956, 51.389023(lat/lng)
Firoozabadi	35.592305, 51.435659(lat/lng)

During 48 months, 4193 cats were observed. The age of 2381 cases were less than 18 months, and 1812 cats were more than 18 months (Table 2). To increase the accuracy of the study, only samples that were older than 18 months were included in the study and subsequently evaluated. It should be noted that the criterion for determining the age of cats was their teeth. This project has never been done in any country before; It is therefore unique in the world. Obviously, in the second stage of the evaluation, the cats who were older than 18 months were categorized by gender. 1377 female cats and 435 male cats were studied at this stage.

Table 2: Overview of the statistical population obtained from cats

		Lower 18	Higher 18			Total
			F	M	F + M	
2016	Spring	160	84	28	112	272
	summer	163	84	28	112	275
	Fall	165	87	29	116	281
2017	winter	162	88	28	116	278
	Spring	164	89	32	121	285
	summer	162	95	28	123	285
	Fall	147	89	30	119	266
2018	winter	140	80	26	106	246
	Spring	136	80	26	106	242
	summer	138	75	26	101	239
	Fall	145	85	26	111	256
2019	winter	150	97	25	122	272
	Spring	152	92	27	119	271
	summer	142	87	28	115	257
	Fall	133	87	24	111	244
2020	winter	122	78	24	102	224
Total		2381	1377	435	1812	4193

By referring to the Tehran Waste Management Organization's website[12], were extracted the data, and information related to the average volume of waste collected in Tehran were related to the waste sent to the Arad Kooh site (Table 3). The statistics extracted from this website were only related to the waste sent to the Arad Kooh site, and the information related to construction, and health-treatment waste was not used in this research.

Table 3: Daily average of waste accepted in the Arad Kooh processing units (tons/day)

	2016-17		2017-18		2018-19		2019-20	
Spring	5431.67	-	5842.00	-5.09%	5652.00	-4.48%	5162.67	-1.89%
Summer	5699.00	4.92%	5904.33	1.07%	4967.00	-12.12%	5078.33	-1.63%
Fall	5157.33	-9.50%	5760.33	-2.44%	5785.33	16.48%	4697.00	-7.51%

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Winter	6155.33	19.35%	5917.00	2.72%	5262.33	-9.04%	3864.33	-17.73%

Microsoft Office Excel Professional Plus 2019, and IBM SPSS Statistics 26 were used to store, process, categorize, analyze data, and draw tables, and graphs. Age, sex, weight, and number were collected as baseline data. IBM SPSS Statistics 26 software was used for Paired Sample T-test, one-way variance, Univariate ANOVA, Bivariate Correlation Spearman, and Linear Regression.

Results

The result of analyzing the cats' weight component in a certain period (research period) showed that the decrease in the volume of waste has affected their weight, and the cats' weight with the volume of waste has Is a direct relation, and thus the H_1 hypothesis was confirmed (Figure 1).

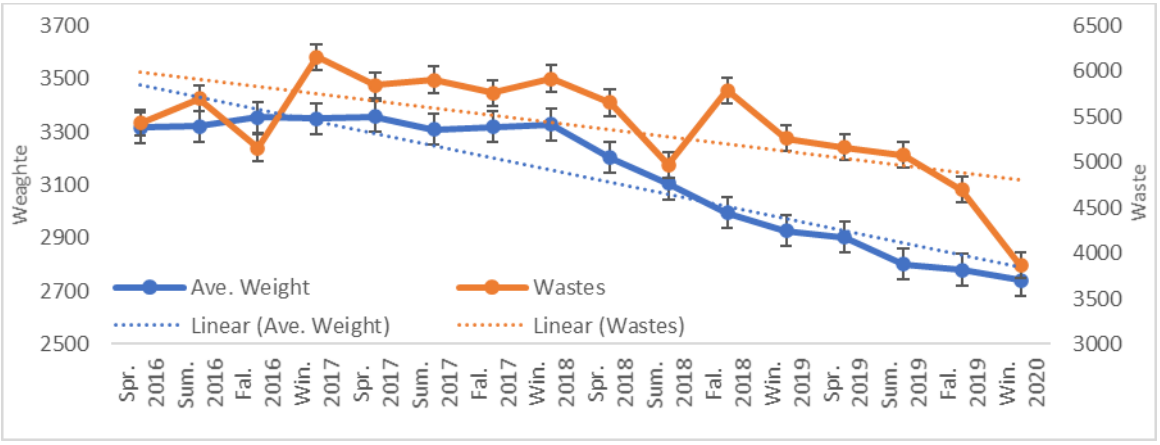

Figure 1: Comparison of the average weight of cats (gr) with the average volume of waste (tonne/Day)

The Paired Sample T-test was performed which was the criterion for evaluating the hypothesis H0: $\mu1 = \mu2$ versus the hypothesis H1: $\mu1 \neq \mu2$ (Table 4). Given that Sig for Pairs 2,3,4 was less than $\alpha = 0.05$, and the mean value was positive, then it can be concluded that the H_0 hypothesis is rejected, and the H_1 hypothesis is confirmed. That is, $\mu_1-\mu_2>0$ or $\mu_1> \mu_2$. Based on the proof of the H_1 hypothesis, it is concluded that the changes in the volume of waste from 2017 onwards have affected the change in the average weight of cats.

Table 4: The results of Paired Sample T-test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Weight2016	3330.35	340	307.974	16.702
	Weight2017	3333.03	340	312.478	16.946
Pair 2	Weight2017	3337.11	424	307.438	14.930
	Weight2018	3155.89	424	355.295	17.255
Pair 3	Weight2018	3155.89	424	355.295	17.255
	Weight2019	2843.39	424	364.943	17.723
Pair 4	Weight2019	2870.20	102	324.407	32.121
	Weight2020	2740.78	102	323.901	32.071

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Weight2016 & Weight2017	340	.224	.000
Pair 2	Weight2017 & Weight2018	424	.011	.823
Pair 3	Weight2018 & Weight2019	424	.066	.175
Pair 4	Weight2019 & Weight2020	102	.175	.079

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Weight2016 - Weight2017	-2.682	386.452	20.958	-43.907	38.542	-.128	339	.898

Pair 2	Weight2017 - Weight2018	181.222	467.306	22.694	136.614	225.829	7.985	423	.000
Pair 3	Weight2018 - Weight2019	312.493	492.264	23.906	265.503	359.483	13.071	423	.000
Pair 4	Weight2019 - Weight2020	129.412	416.399	41.230	47.623	211.200	3.139	101	.002

One Way ANOVA test was performed to characterize the weight of cats under the influence of age groups as a discrete component (Table 5). The value of Sig was calculated, and Sig≤α was obtained. Therefore, the H_0 hypothesis was rejected, and no relationship was found between the change in weight of cats with different age groups. In other words, according to the proof of the effect of waste volume changes on the weight of cats, which was examined in Paired Sample T-test (Table 4), it can be said that the weight of all age groups was affected by fluctuations in waste volume.

Table 5: One Way ANOVA test based on the weight of cats under the influence of age groups

ANOVA

Weight

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10108292454.677	1	10108292454.677	148076.023	.000
Within Groups	286027031.317	4190	68264.208		
Total	10394319485.994	4191			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Weight

	(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	18.24	24.30	-145.990*	19.553	.000	-184.34	-107.64
		30.36	-313.950*	22.013	.000	-357.12	-270.78
		36.42	-522.831*	24.185	.000	-570.26	-475.40
		42.00	-723.071*	25.618	.000	-773.31	-672.83
	24.30	18.24	145.990*	19.553	.000	107.64	184.34
		30.36	-167.959*	22.996	.000	-213.06	-122.86
		36.42	-376.841*	25.083	.000	-426.04	-327.65
		42.00	-577.081*	26.467	.000	-628.99	-525.17
	30.36	18.24	313.950*	22.013	.000	270.78	357.12
		24.30	167.959*	22.996	.000	122.86	213.06
		36.42	-208.881*	27.045	.000	-261.92	-155.84
		42.00	-409.121*	28.333	.000	-464.69	-353.55
	36.42	18.24	522.831*	24.185	.000	475.40	570.26
		24.30	376.841*	25.083	.000	327.65	426.04
		30.36	208.881*	27.045	.000	155.84	261.92
		42.00	-200.240*	30.052	.000	-259.18	-141.30
	42.00	18.24	723.071*	25.618	.000	672.83	773.31
		24.30	577.081*	26.467	.000	525.17	628.99
		30.36	409.121*	28.333	.000	353.55	464.69
		36.42	200.240*	30.052	.000	141.30	259.18

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Weight

	Age	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a,b]	18.24	588	2892.11				
	24.30	466		3038.10			
	30.36	315			3206.06		
	36.42	239				3414.94	
	42.00	204					3615.18
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 310.419.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

One-Way ANOVA test for cat weight index was also calculated under the influence of years of research (discrete component) (Table 6). The calculated Sig value was less than α, and thus the H_0 hypothesis was rejected. Thus, it was found that the weight of cats was not affected by time, while these changes occurred over time. Because of according to the Mean, and Sig components, the weight of cats decreased continuously from 2018 onwards. However, the Paired Sample T-test was previously

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performed, and its results are shown in Table 4, and the relationship between the weight of cats, and the Volume of waste was proven.

Table 6: One-Way ANOVA test based on cats' weight under time interval

ANOVA

Weight

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	84420930.535	4	21105232.634	189.167	.000
Within Groups	201606100.783	1807	111569.508		
Total	286027031.317	1811			

Multiple Comparisons

Dependent Variable: Weight

	(I) Year	(J) Year	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	2016	2017	-2.844	23.687	.904	-49.30	43.61
		2018	174.463*	24.316	.000	126.77	222.15
		2019	475.279*	23.813	.000	428.58	521.98
		2020	589.566*	37.709	.000	515.61	663.52
	2017	2016	2.844	23.687	.904	-43.61	49.30
		2018	177.307*	22.272	.000	133.63	220.99
		2019	478.123*	21.722	.000	435.52	520.73
		2020	592.410*	36.424	.000	520.97	663.85
	2018	2016	-174.463*	24.316	.000	-222.15	-126.77
		2017	-177.307*	22.272	.000	-220.99	-133.63
		2019	300.816*	22.406	.000	256.87	344.76
		2020	415.102*	36.837	.000	342.86	487.35
	2019	2016	-475.279*	23.813	.000	-521.98	-428.58
		2017	-478.123*	21.722	.000	-520.73	-435.52
		2018	-300.816*	22.406	.000	-344.76	-256.87
		2020	114.286*	36.507	.002	42.69	185.89
	2020	2016	-589.566*	37.709	.000	-663.52	-515.61
		2017	-592.410*	36.424	.000	-663.85	-520.97
		2018	-415.102*	36.837	.000	-487.35	-342.86
		2019	-114.286*	36.507	.002	-185.89	-42.69

*. The mean difference is significant at the 0.05 level.

Weight

	Year	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a,b]	2020	102	2740.78			
	2019	467		2855.07		
	2018	424			3155.89	
	2016	340				3330.35
	2017	479				3333.19
	Sig.		1.000	1.000	1.000	.923

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 258.631.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Univariate Analysis of Variance test (Table 7) was performed, and the number of samples was counted by year, age, and season, and displayed in the Between-Subjects Factors table. The relationship between year, age, and season components with the average weight of cats was calculated. Based on the results of this test, hypothesis H_0 was rejected, and hypothesis H_1 was confirmed. Or, in other words, the average weight of cats has changed during the study. Also, the weight of cats in different age groups was been influenced by the agent or factors. Also, the weight of cats in different seasons has changed.

Table 7: The results of Univariate the Analysis of Variance test

Univariate Analysis of Variance

Between-Subjects Factors

		N
Year	2016	340
	2017	479
	2018	424

	2019	467
	2020	102
	18.24	588
	24.30	466
Age	30.36	315
	36.42	239
	42.00	204
	Fall	457
Season	Spring	458
	Summer	451
	Winter	446

Tests of Between-Subjects Effects

Dependent Variable: Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	203090435.940[a]	79	2570765.012	53.686	.000
Intercept	13902185025.068	1	13902185025.068	290325.210	.000
Year	76978119.707	4	19244529.927	401.892	.000
Age	93695204.152	4	23423801.038	489.169	.000
Season	5286192.517	3	1762064.172	36.798	.000
Year * Age	562386.846	16	35149.178	.734	.761
Year * Season	2638368.802	8	329796.100	6.887	.000
Age * Season	472090.281	12	39340.857	.822	.628
Year * Age * Season	915699.579	32	28615.612	.598	.964
Error	82936595.377	1732	47884.870		
Total	18090212733.000	1812			
Corrected Total	286027031.317	1811			

a. R Squared = .710 (Adjusted R Squared = .697)

The correlation index for both components of the average weight of cats, and the average volume of waste was calculated by the "Spearman" method, and it was α≥sig (Table 8). Therefore, according to the results of this test, the average weight of cats was associated with the average waste volume.

Table 8: Results of Spearman method analysis of cat weight index and waste volume

Correlations

			Weight	Waste
Spearman's rho	Weight	Correlation Coefficient	1.000	.688**
		Sig. (2-tailed)	.	.003
		N	16	16
	Waste	Correlation Coefficient	.688**	1.000
		Sig. (2-tailed)	.003	.
		N	16	16

**. Correlation is significant at the 0.01 level (2-tailed).

Regression was calculated by the linear method (Table 9). Because α = 0.05 was considered, and Sig = 0.000 was obtained, the sig≤α relation was established, which indicates the appropriateness of the linear regression fit.

Table 9: Linear regression analysis of the mean weight component of cats

Variables Entered / Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Year[b]	.	Enter

a. Dependent Variable: Weight

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.511[a]	.261	.261	341.725

a. Predictors: (Constant), Year

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	74662984.621	1	74662984.621	639.371	.000[b]
	Residual	211364046.697	1810	116775.716		
	Total	286027031.317	1811			

a. Dependent Variable: Weight

b. Predictors: (Constant), Year

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	346209.928	13567.916		25.517	.000
	Year	-170.030	6.724	-.511	-25.286	.000

a. Dependent Variable: Weight

Discussion, and conclusion

In a point-to-point comparison, the average weight of cats increased by 1.28% in the spring of 2017 compared to the spring of 2016. But cats lost 4.62% of their average weight in the spring of 2018 compared to the spring of 2017. In the spring of 2019, 9.33% weight loss was recorded compared to the spring of 2018. The average weight changes of cats for the summer seasons were also compared from point to point. The average weight of cats in the summer of 2017 decreased by 0.35% compared to its similar period (summer 2016), and summer 2018 showed 6.19% compared to summer 2017. Finally, in the summer of 2019, 9.77% decrease was recorded in the average weight compared to the summer of 2018. In the fall of 2017, compared to the fall of 2016, the amount of weight loss was 1.08%, and in point-to-point comparison of the fall of 2018 with a similar period in the fall of 2017 showed a decrease of 9.74%. Also, the average weight of cats in the fall of 2019 decreased by 7.17% compared to the fall of 2018. in winter 2018 The weight of cats decreased by 0.65% compared to winter 2017, and in continuation of this trend, 12.03% of their weight was reduced in winter 2019 compared to winter 2018. In comparing point-to-point winter 2020 with winter 2019, 6.35% weight loss occurred again.

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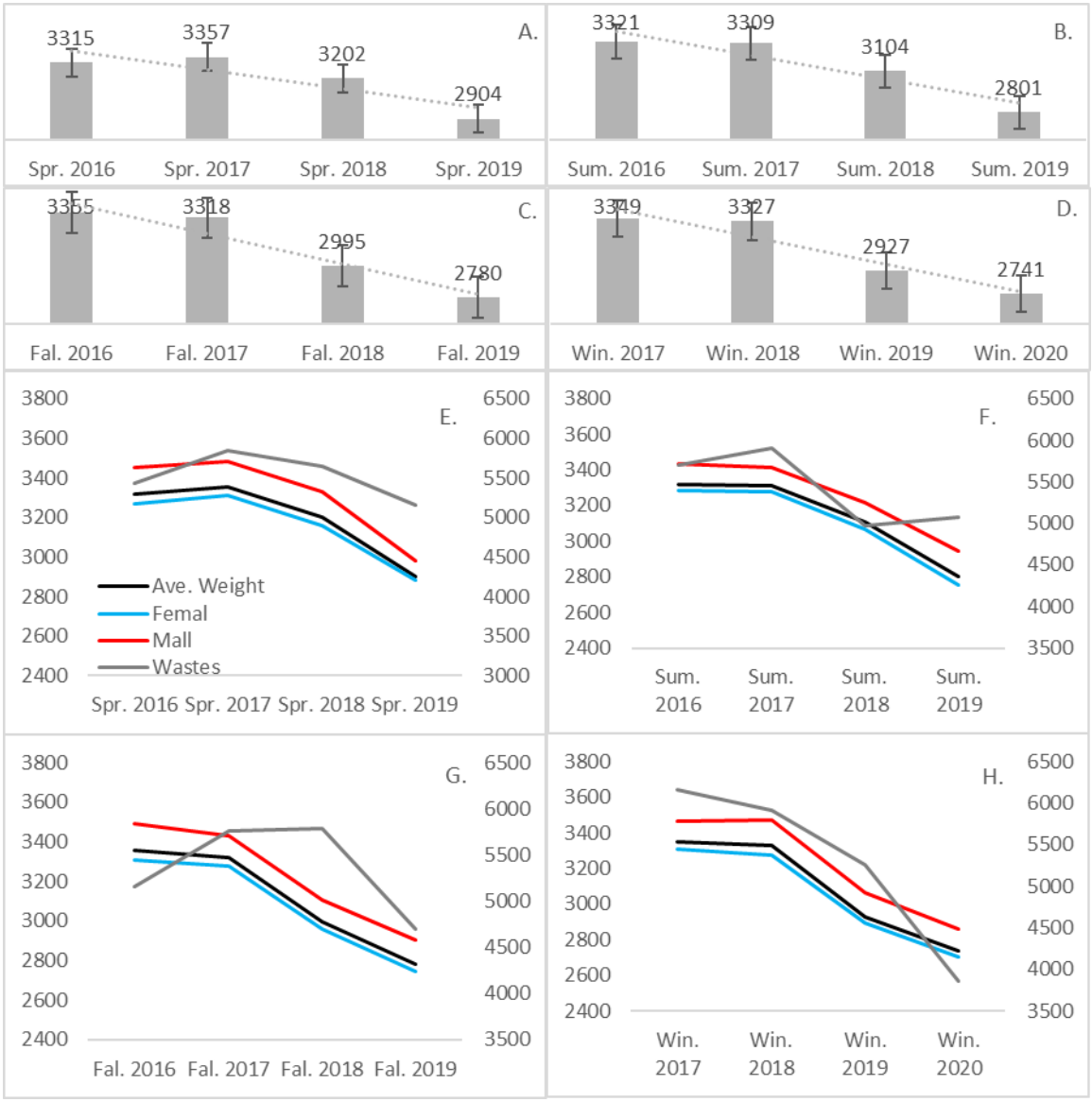

Figure 2: A, B, C & D are the point-to-point comparison of the average weight of cats (gr) in different seasons, and E, F, G & H are point-to-point relationship comparison of the weight of cats (gr) with the volume of waste (tonne/day) in different seasons

The average weight of cats did not fluctuate in spring, summer, and autumn of 2016, and the results showed that 1.2% had gained weight. While the volume of waste at the same time had decreased by 4.58% (Figure 3).

From the beginning of winter 2017 to the end of autumn 2017, the volume of waste increased by 12.89% on average, and compared to the previous year (spring to autumn 2016) also showed an increase of 8.31%. But in this period (winter to autumn 2017), the average weight of cats decreased by 1.07%. Female cats lost 0.86%, and male cats lost 1.73%. The volume of waste collected in the winter of 2017 was 19.35% higher than in the fall of 2016, which was the largest amount throughout the study (Figure 3).

During the period winter 2018 to autumn 2018, the average volume of waste had increased by 2.6%, but the average weight of cats had decreased by 10.07%. Female cats lost 10.05%, and male cats lost 9.79% of their weight during this period. The highest mean weight loss throughout the study was 3.75%, which was recorded in the spring of 2018. Male cats also experienced the most weight loss during the study in the spring of 2018, which was 4.1%. The steady decline in cat weight loss from

winter/spring 2018 onwards was visible. Until the end of the study, the weight index of both male, and female groups was always decreasing (Figure 3).

The average volume of waste in the period from winter 2019 to autumn 2019 compared to the previous year (winter - autumn 2018) decreased by 20.07%. Therefore, from winter to autumn 2019, the weight of cats was reduced by 7.34%. Female cats lost 7.47%, and male cats lost 6.71%. In the summer of 2019, females experienced the highest amount of weight loss during the study. The female cats lost 4.34% of their body weight. It is important to note that the 16.48% increasing in the average volume of waste in the fall of 2018 could not stop the weight loss of cats and the downward trend in the weight of cats continued[13] (Figure 3).

The last season was winter 2020 when the cat weight component was monitored. The largest decrease in waste volume was recorded this season. Statistics showed that 17.73% of the volume of waste collected in Tehran has been reduced. The mean weight of cats decreased by 1.42%, female cats by 1.52%, and male cats by 1.34% (Figure 3).

The average volume of waste from spring 2016 to winter 2020 decreased by 26.7%, and the trend of cat weight index from the beginning to the end of this study showed a decrease of 18.71% (Figure 3).

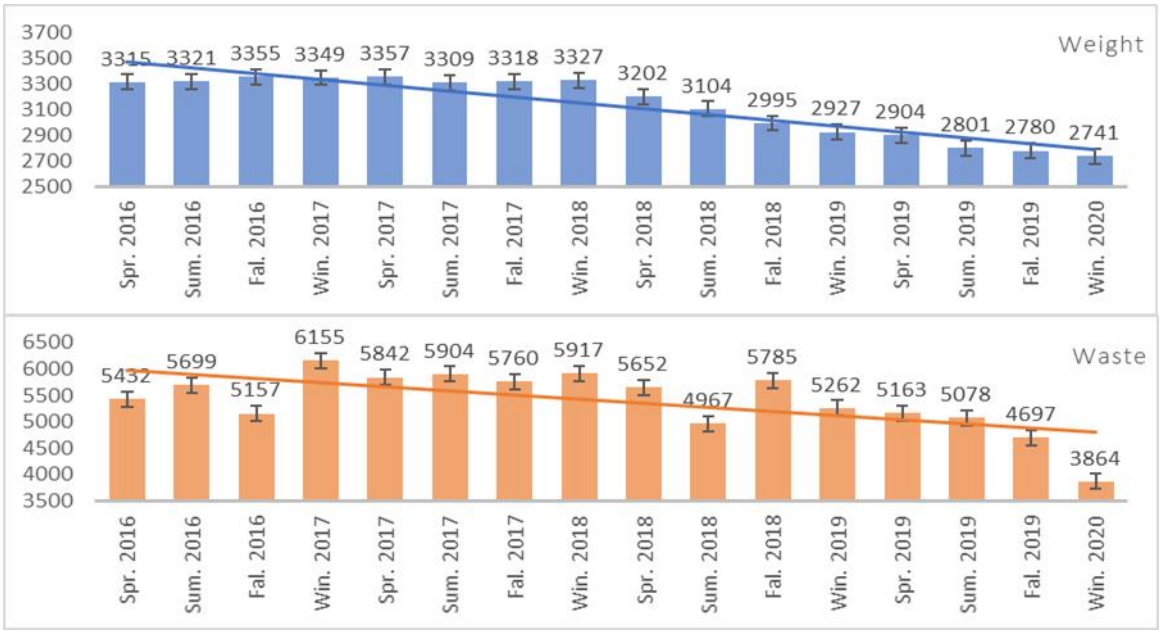

Figure 3: The average weight of cats (gr), and the average volume of Tehran's waste (tonne/day)

Given the importance of cats in controlling the rat[14] population, research on determining the share of hunt[15], and waste in the diet of urban cats is recommended to other interested researchers who have noticed the results of this study.

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