Food water, water balance and kidney health in cats

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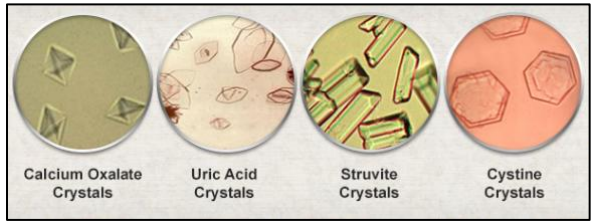
Cats Have a Problem With Hydration

What's wrong?

The original wild cat adapted to thrive in a desert climate – where water maintenance is at a premium

The price of being really good at maintaining body water is increased risk of stone formation

Solutes in urine increase, increasing urine specific gravity



Crystals form when solutes overcome urine's protective capacity

Eventually, bladder and kidney stones form from crystals

Hill’s has technologies that help hydrate cats

Cat’s “normal” urine is a stone risk

The goal is enhanced health through reduced solute concentrations

Reduce stone risk through increasing water intake

The price of being really good at maintaining body water is increased risk of stone formation

	Oxalate	Struvite
Most Common Stones		
Stone Risk Indicators	RSS and CORI	RSS

The industry has investigated increasing hydration with some success

There is limited effect of water presentation method on intake

Bowls and Fountains are similar

Table 1. Signalment, water intake, and urine specific gravity and osmolality of cats offered water from a bowl and a fountain.

Cat number	Signalment (age in years, gender, breed)	Bowl, mean water intake (ml/kg/day)	Bowl, urine specific gravity	Bowl, urine osmolality (mOsm/l)	Fountain, mean water intake (ml/kg/day)	Fountain, urine specific gravity	Fountain, urine osmolality (mOsm/l)
1	5, MC, DSH	20.9	1.051	2044	18.1	1.044	1901
2	7, FS, DSH	14.7	>1.060	2636	52.3†	1.054	1961
3	5, MC, DSH	21.3	1.056	2504	31.5	>1.060	2500
4	7, MC, DSH	11.3	>1.060	3040	25.4	>1.060	2819
5	0.5, F, DLH	41.6	1.058	2442	41.6	>1.060	3141
6	8, MC, DLH	15.8	1.053	2260	37.0	1.054	2229
7	4, MC, DSH	9.5†	1.060	2825	16.2†	>1.060	2901
8	6, FS, DSH	23.7	1.051	2206	44.1	1.051	2097
9	10, MC, DSH	18.8†	1.046	1977	14.8†	1.057	2432
10	0.5, F, DSH	38.0	1.054	2286	50.8	>1.06	3231
11	0.5, F, DSH	32.3	>1.060	3105	28.7	>1.06	2738
12	8, FS, Siamese	26.9	1.052	2302	18.2	>1.060	2502
Mean		22.9 ± 10.2 ($n = 12$) 23.3 ± 10.6 ($n = 11$)		2468.9 ± 367.3	31.6 ± 13.5* ($n = 12$) 33.1 ± 13.1* ($n = 11$)		2537.7 ± 440.8

All remaining cats received dry commercial diets. MC = male, castrated; FS = female, spayed; F = female; DSH = domestic shorthair; DLH = domestic longhair.
*Indicates statistically significant difference in mean water intake, $P < 0.05$.
†Fed dry commercial feline diet with canned diet added.

Grant, D.C., 2010. Effect of water source on intake and urine concentration in healthy cats. *Journal of feline medicine and surgery*, *12*(6), pp.431-434.

Bowl type	Daily water intake (ml/kg/day)*		
	Mean ± SD	Minimum	Maximum
S	27.483 ± 5.847	20.04	42.26
C	26.327 ± 7.342	18.71	49.16
FF	26.137 ± 6.487	17.80	40.05

S – Still water

C – circulating water

FF –freely falling water

Robbins, M.T., Cline, M.G., Bartges, J.W., Felty, E., Saker, K.E., Bastian, R. and Witzel, A.L., 2019. Quantified water intake in laboratory cats from still, free-falling and circulating water bowls, and its effects on selected urinary parameters. *Journal of feline medicine and surgery*, *21*(8), pp.682-690.

There is no effect of presentation on relative super saturation of struvite or CaOx

Urine analyte	Bowl Type									*P* value
	S			C			FF			
	Day 1	Day 7	Day 14	Day 1	Day 7	Day 14	Day 1	Day 7	Day 14	
Struvite RSS (average ± SD)	0.37 ± 0.55	0.80 ± 0.83	0.58 ± 0.68	0.30 ± 0.35	0.31 ± 0.38	0.46 ± 0.44	0.22 ± 0.44	0.48 ± 0.92	0.45 ± 0.52	0.6
Calcium oxalate RSS (average ± SD)	3.04 ± 1.93	2.02 ± 0.67	3.27 ± 1.82	1.75 ± 0.57	2.10 ± 0.63	2.61 ± 0.85	2.24 ± 0.92	2.41 ± 0.92	2.01 ± 0.88	0.3

Robbins, M.T., Cline, M.G., Bartges, J.W., Felty, E., Saker, K.E., Bastian, R. and Witzel, A.L., 2019. Quantified water intake in laboratory cats from still, free-falling and circulating water bowls, and its effects on selected urinary parameters. *Journal of feline medicine and surgery*, *21*(8), pp.682-690.

There is a significant effect of high moisture as compared to dry food

Ten cats were fed four different foods in a Latin Square Design
Each period consisted of 5 d adaption and 5 d collection.

- Dry
- Dry = 50% water
- Dry with elevated fat and protein
- Canned

	Dry	Dry + 50% water	Dry > Pro and > Fat	Canned
TWI (mL)	115.0 ± 2.4^{ab}	114.5 ± 3.5^{ab}	105.6 ± 1.3^{b}	158.0 ± 1.6^{a}
WIF (mL)	4.1 ± 0.1^{c}	52.3 ± 1.3^{b}	1.5 ± 0.0^{c}	126.2 ± 1.5^{a}
DWI (mL)	93.5 ± 2.0^{a}	45.4 ± 2.0^{b}	83.4 ± 1.0^{a}	16.8 ± 1.4^{b}
MW (mL)	18.2 ± 2.1^{a}	16.8 ± 1.8^{a}	20.2 ± 1.6^{a}	15.6 ± 0.9^{a}

TWI- total water intake; WIF- water intake from food;
DWI- drinking water intake, MW- metabolizable water

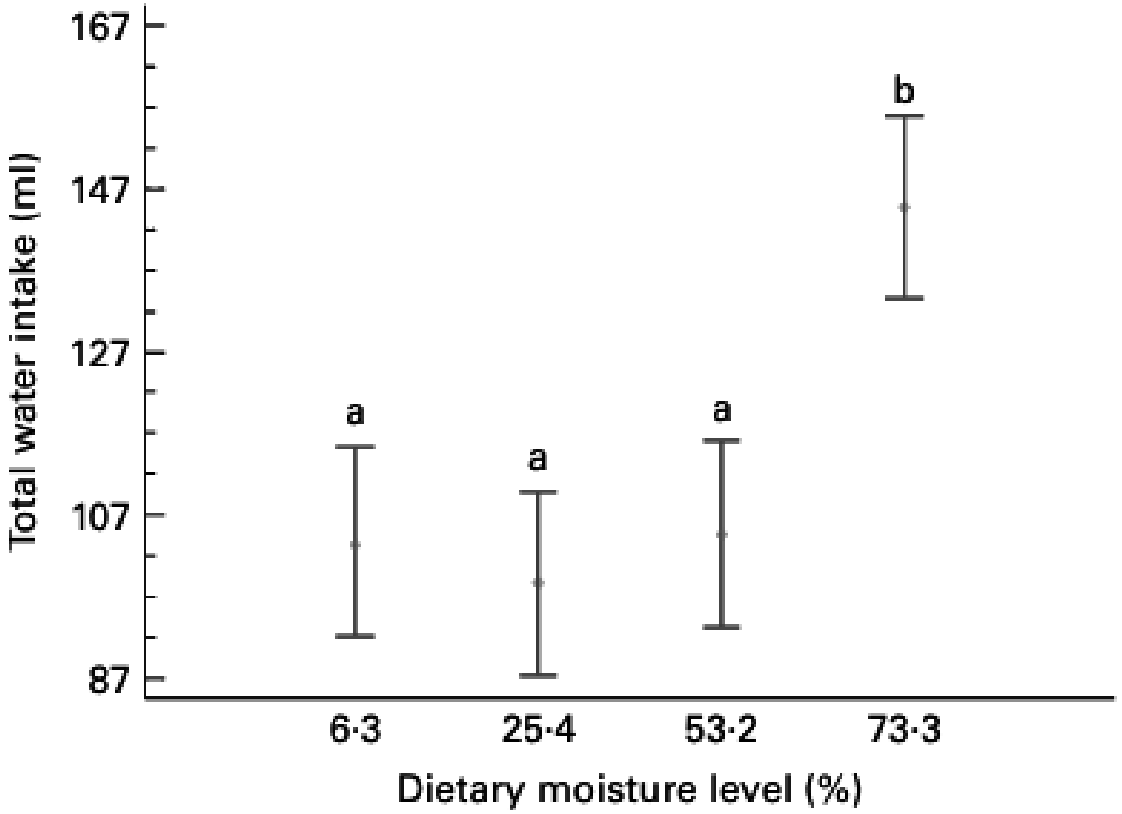
	Dry	Dry + 50% water	Dry > Pro and > Fat	Canned
Excretion				
TWE (mL)	54.0 ± 1.6^{b}	55.3 ± 2.4^{ab}	47.0 ± 1.0^{b}	91.1 ± 2.3^{a}
FWE (mL)	30.6 ± 1.6^{a}	34.7 ± 2.2^{a}	9.7 ± 0.2^{a}	22.6 ± 0.6^{a}
UE (mL)	23.4 ± 0.6^{b}	20.6 ± 0.3^{b}	29.1 ± 0.8^{b}	68.5 ± 2.1^{a}
IL (mL)	61.8 ± 5.5^{a}	59.2 ± 6.1^{a}	58.1 ± 6.3^{a}	67.6 ± 4.1^{a}

TWE- total water excretion;
FWE- fecal water excretion;
UE- urine excretion;
IL insensible losses.

Carciofi, A.C., Bazolli, R.S., Zanni, A., Kihara, L.R.L. and Prada, F., 2005. Influence of water content and the digestibility of pet foods on the water balance of cats.
Braz J Vet Res Anim Sci, *42*, pp.429-434.

Six cats were fed four different water concentrations for 3 weeks

- Dry = 6.3% water
- Dry+water = 25.4% water
- Dry++water = 53.2% water
- Dry+++water = 73.3% water



The high moisture (73.3%) food was successful

Decreased urine specific gravity

Decreased struvite RSS

Decreased CaOx RSS

Buckley, C.M., Hawthorne, A., Colyer, A. and Stevenson, A.E., 2011. Effect of dietary water intake on urinary output, specific gravity and relative supersaturation for calcium oxalate and struvite in the cat. *British journal of nutrition*, *106*(S1), pp.S128-S130.

There is a significant effect of strong ions on urine output

Fifty-five cats were used to evaluate 23 foods with different Na concentration
Food was fed for 21 days. The sodium concentrations were:

Group 1 Normal < 0.175 g/100 kcal

Group 2 Elevated - from 0.275 to 0.400 g/100 kcal

note the AAFCO min is 0.05 g/100 kcal

	Diet	*n*	Mean	SE
Water drunk (*mL/cat/d*)	Group 1	10	110	6
	Group 2	13	141	5
Urine volume (*mL/cat/d*)	Group 1	10	55	3
	Group 2	13	78	3
Urine-specific gravity	Group 1	10	1.051	0.001
	Group 2	13	1.045	0.001
Urine pH	Group 1	10	6.38	0.06
	Group 2	13	6.26	0.03
Calcium oxalate RSS	Group 1	9	2.95	0.23
	Group 2	13	2.49	0.08

Hawthorne, A.J. and Markwell, P.J., 2004. Dietary sodium promotes increased water intake and urine volume in cats. *The Journal of nutrition*, *134*(8), pp.2128S-2129S.

Thirteen cats were used to evaluate 4 foods with different Na concentration Food was fed for 10 days.

Nutrient concentrations (g/1000 kcal)

	Diet A	Diet B	Diet C	Diet D
Moisture	5.7	5.2	4.7	5.4
Crude protein	86.5	90.1	94.4	89.1
Crude fat	35.0	35.5	35.6	34.5
Total dietary fibre	15.1	19.4	26.5	16.2
Ash	13.9	15.7	17.1	20.1
Starch	66.6	61.1	59.2	66.8
Calcium	1.85	1.91	1.98	1.89
Phosphorus	1.64	1.63	1.68	1.62
Magnesium	0.16	0.17	0.16	0.17
Potassium	2.45	2.41	2.18	2.55
Sodium	0.67	1.68	2.41	3.27
Chloride	2.22	3.58	4.39	6.05
Metabolizable energy[a]	4,187	4,111	3,984	4,072

Increasing dietary NaCl increases urine volume while lowering specific gravity, CaOx and struvite RSS

	Diet A	Diet B	Diet C	Diet D	SE	*p* value
Sodium (g/1,000 kcal)	0.67	1.68	2.41	3.27		
Caloric intake (kcal/$BW^{0.71}$)	88	86	86	86	2.4	.83
Water intake (ml/kg/day)	$24.5^{\dagger}$	$28.8^{\ddagger}$	$30.3^{\ddagger}$	$36.7^{\S}$	1.38	<.001
Urine volume (ml/kg/day)	$10.9^{\dagger}$	$13.7^{\ddagger}$	$15.5^{\ddagger}$	$19.6^{\S}$	0.69	<.001
Urine specific gravity	$1.067^{\dagger}$	$1.063^{\dagger\ddagger}$	$1.061^{\ddagger}$	$1.051^{\S}$	0.002	<.001
Urine pH	$6.36^{\dagger}$	$6.51^{\dagger}$	$6.39^{\dagger}$	$6.27^{\ddagger}$	0.05	<.001
CaOx RSS	$3.39^{\dagger}$	$2.80^{\ddagger}$	$2.41^{\ddagger}$	$1.64^{\S}$	0.25	<.001
MAP RSS	$0.81^{\dagger}$	$0.83^{\dagger}$	$0.41^{\ddagger}$	$0.16^{\S}$	-	<.001

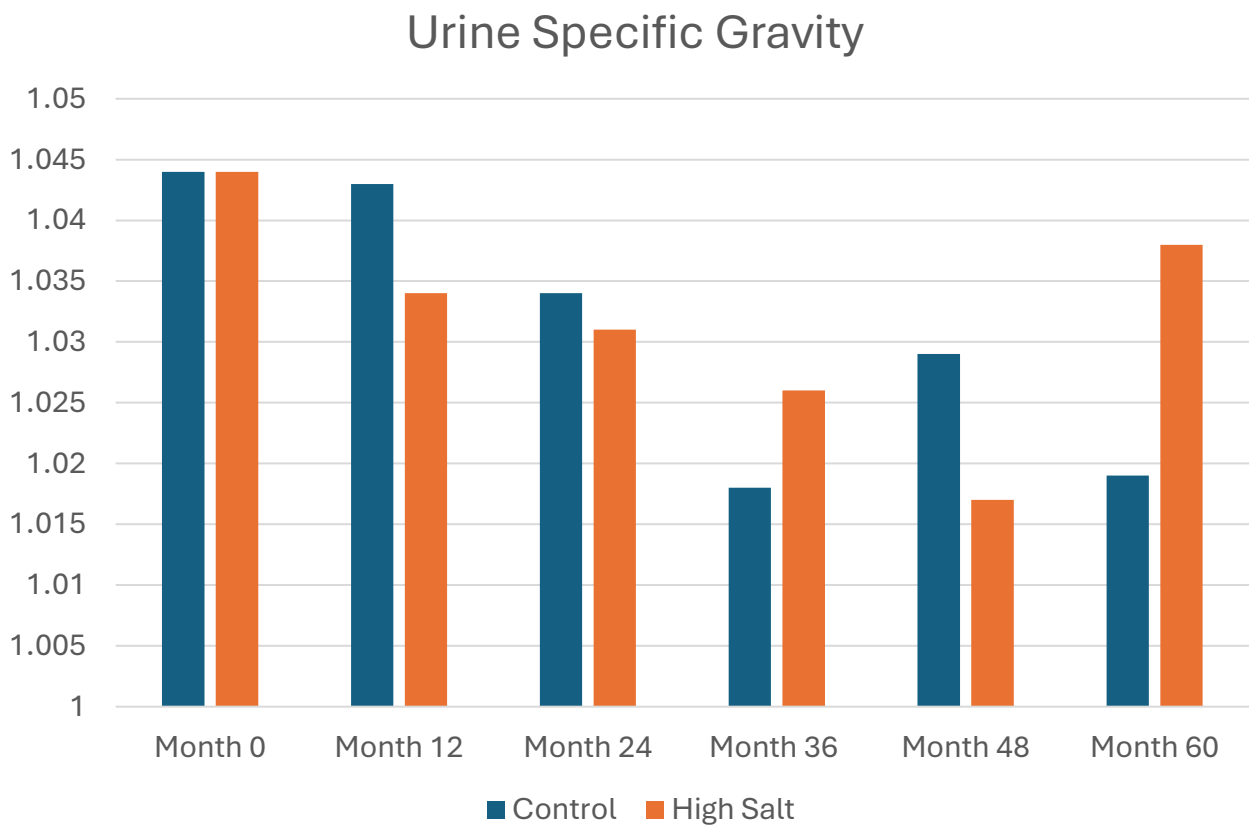
Queau, Y., Bijsmans, E.S., Feugier, A. and Biourge, V.C., 2020. Increasing dietary sodium chloride promotes urine dilution and decreases struvite and calcium oxalate relative supersaturation in healthy dogs and cats. *Journal of Animal Physiology and Animal Nutrition*, *104*(5), pp.1524-1530.

High sodium foods had no observable negative effects but lost the urine dilution effect over time

Twenty cats were used to evaluate two foods with different Na concentration fed until death or up to 5 years. The sodium concentrations were:

Group 1 Control 0.102 g/100 kcal

Group 2 Elevated 0.326 g/100 kcal



Change over time was not different between groups p = 0.29

Reynolds, B.S., Chetboul, V., Elliott, J., Laxalde, J., Nguyen, P., Testault, I., Dorso, L., Abadie, J., Lefebvre, H.P. and Biourge, V., 2024. Long-term safety of dietary salt: A 5-year ProspEctive rAndomized bliNded and controlled stUdy in healThy aged cats (PEANUT study). *Journal of Veterinary Internal Medicine*, *38*(1), pp.285-299.

Increased water viscosity increases water intake and improves CaOx stone risk estimate

Twelve cats were used to evaluate two water viscosity waters (cross over) Control and Control + 1% methylcell (a food grade thickening fiber)

	Control Water	Viscous Water	
Number of Cats, *n*	**12**	**12**	**Water Main Effect**
Body Weight (kg)			
28 days	4.63 ± 0.31	4.73 ± 0.31	0.06
56 days	4.68 ± 0.31	4.70 ± 0.31	
£ Water Intake (g/100 kcals)			
28 days	35.8 ± 3.57	45.8 ± 3.57	0.001
56 days	32.5 ± 3.57	40.2 ± 3.57	
Water Intake (g/BW_{kg})			
28 days	14.4 ± 1.27	18.0 ± 1.27	0.001
56 days	13.1 ± 1.23	15.8 ± 1.23	
Calcium (mg/dL)			
28 days	6.29 ± 0.99	4.75 ± 0. 99	0.01
56 days	5.92 ± 1.01	5.25 ± 1.00	
£ Fractional excretion of calcium (%)			
28 days	0.266 ± 0.062	0.192 ± 0.066	0.06
56 days	0.306 ± 0.062	0.215 ± 0.064	
£ Calcium oxalate titration test * (ln 1/L)			
28 days	3.59 ± 0.34	3.24 ± 0.34	0.05
56 days	3.57 ± 0.36	3.22 ± 0.35	

Hall, J.A., Vanchina, M.A., Ogleby, B. and Jewell, D.E., 2021. Increased water viscosity enhances water intake and reduces risk of calcium oxalate stone formation in cats. *Animals*, *11*(7), p.2110.

Increased dietary PUFA improves CaOx stone risk estimate

Twelve cats were used to evaluate two foods in a cross over study

Nutrient[a]	Control food[b]	Test food[c]
AA (20:4; n-6)	0.07	0.17
EPA (20:5; n-3)	<0.01	0.09
DPA (22:5; n-3)	<0.01	0.02
DHA (22:6; n-3)	<0.01	0.18

Each group of six cats were fed one of the two foods for 56 days and then “crossed over” to the other food for 56 days. Blood and urine analysis was completed on days 28 and 56.

Increased dietary PUFA reduces urine specific gravity, struvite RSS, and CaOx stone risk

	Control food	Test food
Number of animals, *n*	**12**	**12**
Specific gravity		
28 days	1.057 ± 0.002^{a}	1.052 ± 0.002^{b}
56 days	1.056 ± 0.002^{a}	1.054 ± 0.002^{b}
Struvite relative super saturation (unitless)		
28 days	12.6 ± 4.3^{a}	5.2 ± 1.1^{b}
56 days	7.1 ± 1.4^{a}	4.8 ± 1.1^{b}
Calcium oxalate titration test (1/L)		
28 days	56.7 ± 14.2^{c}	42.8 ± 9.0^{d}
56 days	52.4 ± 12.2^{c}	37.4 ± 8.5^{d}

Hall, J.A., Brockman, J.A., Davidson, S.J., MacLeay, J.M. and Jewell, D.E. , 2017. Increased dietary long-chain polyunsaturated fatty acids alter serum fatty acid concentrations and lower risk of urine stone formation in cats. *PLoS One*, *12*(10), p.e0187133.

Cats Have a Problem With Hydration

What's the solution?

Cats Have a Problem With Hydration

What's the solution?

High moisture foods with moisture exceeding 70% as fed

Increased water consumption – viscous water

Increased dietary polyunsaturated fatty acids

Decreased relative supersaturation
- strong ion inclusion
- control of dietary mineral components
- control of urinary pH (depending on stone type)