Supporting Information

Comparative Field Study, the Fossil Record and Phylogenetic Analyses

Table S1. Species and study locations of species tested with snake, weasel and deer scent and sample sizes and proportions of individuals that applied scent for each location.

		Proportion Scent Application		
Species	**Study Location**	**Snake**	**Weasel**	**Deer**
Rock squirrel (*S. variegatus*)	Caballo Lake State Park, Caballo, New Mexico[1]	10/12	8/14	0/11
	Guadalupe Mountains National Park, Texas[1]	2/2	2/3	0/3
California ground squirrel (*S. beecheyi*)	Lake Solano County Park, Winters, California[2]	8/11	0/12	0/11
	Hamel Ranch, Davis, California[2]	0/6	0/4	0/4
Baja California rock squirrel (*S. atricapillus*)	San Ignacio, Baja California Sur, Mexico[3,4]	8/9	4/11	0/6
	San Javier, Baja California Sur, Mexico[3,4]	1/2	0/1	0/5
Golden-mantled ground squirrel (*S. lateralis*)	Lassen Volcanic National Park, California[2]	0/5	0/5	0/2
	Great Basin National Park,	0/2	0/2	0/3

	Nevada[5]			
Mexican ground squirrel (*S. mexicanus*)	Plaza di San Jose, Carlsbad, New Mexico[1]	4/5	0/7	0/4
	Pecos River Walk Park, Carlsbad, New Mexico[1]	4/5	0/4	0/5
Belding's ground squirrel (*S. beldingi*)	Yosemite National Park, California[2]	0/9	2/10	0/7
	Malheur National Wildlife Refuge, Oregon[5]	0/12	0/9	0/8
White-tailed antelope squirrel (*A. leucurus*)	San Ignacio, Baja California Sur, Mexico[3,4]	4/6	2/7	0/3
	San Javier, Baja California Sur, Mexico[3,4]	-	-	0/3
Allen's chipmunk (*Neotamias senex)*	Lassen Volcanic National Park, California[2]	0/4	0/3	0/3
Uinta chipmunk (*Neotamias umbrinus*)	Great Basin National Park, Nevada[5]	0/4	0/2	0/2
Siberian chipmunk (*Eutamias sibiricus*)[a]	Korea[6]	-	-	-
Round-tailed ground squirrel (*S. spilosoma*)[b]	Las Cruces, New Mexico[1]	-	-	-

Note: Rattlesnake species used are indicated by superscript numbers next to study locations.

[a]Kobayashi & Watanabe 1986; [b]Arrowood unpublished data

[1]*Crotalus atrox*, [2]*C. oreganus oreganus*, [3]*C. ruber*, [4]*C. mitchelli*, [5]*C. oreganus lutosus*, [6]*Gloyidus blomhoffi* and *Elaphe climacophora*

Ground Squirrel and Predator Ancestors Sympatry in the Miocene (23.8-5.3 mya) and Pliocene (5.3-1.8 mya)

The existing fossil record in western North America places the first co-occurrence between ground squirrels and rattlesnake ancestors at approximately 15 million years ago in Texas, USA (Black 1963; Holman 1977, 1979; Carrasco et al. 2005) and the first co-occurrence between ground squirrel, chipmunk and weasel ancestors approximately 16 million years ago in Wyoming, USA (Black 1963; Carrasco et al. 2005; table A2). The limited fossil records of the proposed direct ancestors of California ground squirrels, rock squirrels, Baja California rock squirrels and golden-mantled ground squirrels - *S. shotwelli* and *S. wilsoni* – was not found to co-occur with rattlesnake species. But *S. shotwelli* fossils co-occurred with weasel ancestor fossils in Nebraska, USA approximately 6 million years ago. In addition, the proposed ancestor of *S. shotwelli* and *S. wilsoni* – *S. primitus* – co-occurred with a weasel ancestor about 15 million years ago in Montana, USA (Black 1963; Carrasco et al. 2005; table A2). The direct ancestor of Belding's ground squirrel and related species – *S. mckayensis* – was not found to co-occur with either rattlesnake nor weasel ancestors, but fossils of this species' were only found at a single site in Oregon, USA, in strata laid down approximately 6 million years ago (Black 1963; Carrasco et al. 2005; table A2).

Table S2. Pliocene and Miocene co-occurrences of squirrel, rattlesnake and weasel ancestors.

EPOCH	Million Years Ago	Squirrel species	Mustela species	Viperidae species
PLIOCENE (5.3-1.8 mya)	~4-1.8	*Ammospermophilus jefferiesi*: MX[5]		*Crotalus* spp.: MX[5]
	~5.3-3.6	*Spermophilus bensoni:* AZ[2] *Spermophilus howelli:* TX, KS[2] *Spermophilus rexroadensis:* KS[2] *Spermophilus* spp: TX[2]	*Mustela rexroadensis:* KS[2]	*Crotalus viridis*: KS[3] *Crotalus atrox*: TX[4]
	~5.9-4.7	*Spermophilus shotwelli*: NE[2]		
	~5.9-5.0	*Spermophilus matthewi:* NE[2] *Spermophilus shotwelli:* NE[2]	*Mustela rexroadensis:* NE[2] *Martinogale alveodens:* NE[2]	
	~6.7-5.9	*Spermophilus mckayensis:* OR[2] *Spermophilus shotwelli:* OR[2] *Spermophilus wilsoni:* CO[2]		
	~7.5-6.7	*Spermophilus shotwelli:* OR[2] *Spermophilus wilsoni:* OR[2]		
	~8.0-7.5	*Spermophilus argonautus*: NE[2]	*Pliogale furlongi:* NE[2]	
	~9.0-7.0	*Spermophilus* spp:NE[2] *Ammospermophilus* spp: CA[2]	*Mustela* spp: NE[2]	
	~12.4-9.5	*Spermophilus wilsoni*: WA[2] *Ammospermophilus fossilis:* CA[2] *Ammospermophilus junturensis:* OR[2], NE[2] *Protospermophilus quatalensis:* CA[2]		
	~13.6-12.5	*Tamias* spp: NE[2] *Protospermophilus* spp: NE[2]	*Miomustela madisonae:* NE[2]	Viperidae: NE[3]
	~14.8-12.5	*Spermophilus primitivus:* WY[2] *Spermophilus tephrus:* OR[2] *Miospermophilus* spp: NE[2] *Spermophilus* spp: NE[2] *Tamias ateles*: NE[2]	*Mustela* spp: NE[2] *Miomustela madisonae:* NE[2]	
	~14.9-14.6	*Protospermophilus oregonensis:* MT[2] *Protospermophilus malheurensis:* OR[2] *Miospermophilus bryanti:* MT[2] *Protospermophilus quatalensis*: TX[2] *Spermophilus shotwelli:* MT[2]		
	~15.9-14.8	*Protospermophilus oregonensis:* OR[2] *Protospermophilus malheurensis:* OR[2] *Protospermophilus angusticep:* MT[2] *Protospermophilus quatalensis*: TX[2] *Spermophilus primitus:* MT[2]	*Miomustela madisonae:* MT[2]	Viperidae: TX[3]
MIOCENE (23.8-5.3 mya)	~16.6-16.5	*Protospermophilus angusticep:* NV[2]		
	~17.5-15.9	*Protospermophilus kelloggi:* CA[2], WY[2] *Tamias* spp: CA[2], WY[2] *Miospermophilus wyomingensis:* CA[2], NE[2], WY[2]	*Miomustela madisonae:* WY[2]	
	~18.8-17.5	*Protospermophilus kelloggi:* CO[2] *Miospermophilus bryanti:* CO[2]		
OLIGOCNE	~29.8-23.8	*Protospermophilus vortmani:* OR[2]		
	~37.0-30.5	*Protosciuris jeffersoni:* MT[1]		

[1]Korth 1994; [2]Black 1963, Carrasco 2005; [3]Holman 1977, Homan 1979;
[4]Brattstrom 1967; [5]Miller 1980

Table S3. Proportions of Pleistocene (1.8 million – 100 thousand year ago) fossil sites with predator fossils and proportions of current squirrel-predator co-occurrence.

Species	Historic Snake	Historic Weasel	Current Snake	Current Weasel
Rock squirrel	**5/21** **0.24**	**6/21** **0.28**	**9/9** **1.0**	**1**
California ground squirrel	**6/9** **0.67**	**5/9** **0.56**	**5/6** **0.83**	**1**
Baja California rock squirrel	-	-	**3/3** **1.0**	0
Golden-mantled ground squirrel	2/19 0.11	**8/19** **0.28**	1/8 0.13	**1**
Mexican ground squirrel	**1/2** **0.50**	0/2 0	**7/7** **1.0**	**1**
Belding's ground squirrel	0/5 0	**1/5** **0.20**	2/6 0.33	**1**
White-tailed antelope squirrel	-	-	**3/3** **1.0**	0
Allen's chipmunk	-	-	0/4 0	**1**
Uinta chipmunk	-	-	0/7 0	**1**
Siberian chipmunk	-	*	**~0.50**	*

Round-tailed ground squirrel	**2/6** **0.33**	*	**8/8** **1.0**	*

Note: Bolded values indicate which species co-occurred with the predator.

'-' = no (fossil) data available

'*' = species not tested with weasel scent

Ground Squirrel Phylogeny

Our ground squirrel phylogeny (figure S1) is modified from Harrison et al. 2003, including information from Piaggio & Spicer 2001 and Mercer & Roth 2003 for *Eutamias* and *Neotamias* species (created in Mesquite; Maddison & Maddison 2008). The divergence times are from Harrison et al. 2003 and Mercer and Roth 2003. The species we tested for scent application in this study are indicated with arrows while those tested by other researchers (Kobayashi & Watanabe 1986; Arrowood unpublished data) are indicated with an arrow and asterisk.

Figure S1. Phylogeny of ground squirrels and chipmunk outgroup species.

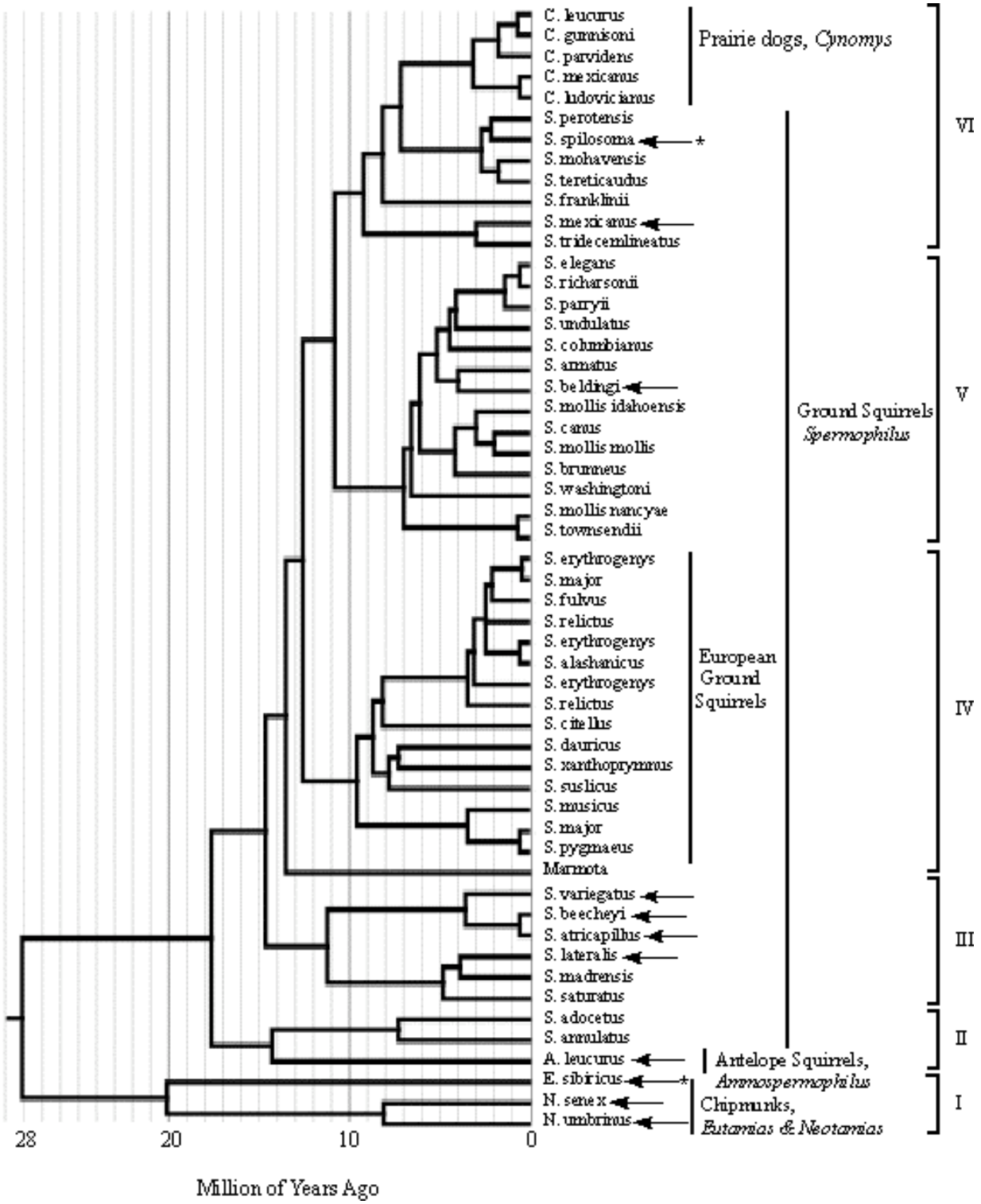

Table S4a. Transition parameters for the character states of rattlesnake presence (Pred) and rattlesnake scent application (SSA) and results for the independent and dependent correlated traits models (Pagel 1994) for rattlesnake presence and scent application.

	Transition	**q_{ij}**	**Independent model**	**Dependent model**	**Likelihood Ratio (LR)**
Gain SSA	No Pred, No SSA to No Pred, SSA	q_{12}	0.06681	0.07035	
	Pred, No SSA to Pred, SSA	q_{34}		5.46777	
Retain SSA	No Pred, SSA to Pred, SSA	q_{24}		12.26164	
	Pred, SSA to No Pred, SSA	q_{42}		0.000002	
Lose SSA	No Pred, SSA to No Pred, No SSA	q_{21}	0.04732	1.36796	
	Pred, SSA to Pred, No SSA	q_{43}		0.06255	
No SSA	Pred, No SSA to No Pred, No SSA	q_{31}	0.04732	14.32849	
	No Pred, No SSA to Pred, No SSA	q_{13}	0.06681	0.0000003	
			LI	**LD**	
			-11.5970	**-5.1190**	**12.95**
					p = 0.011

Note: Likelihood and p values are in bold.

Table S4b. Transition parameters for the character states of weasel presence (Pred) and weasel scent application (WSA) and results for the independent and dependent correlated traits models (Pagel 1994) for weasel presence and scent application.

	Transition	**q_{ij}**	**Independent model**	**Dependent model**	**Likelihood Ratio (LR)**
Gain WSA	No Pred, No WSA to No Pred, WSA	q_{12}	36.8785	43.25284	
	Pred, No WSA to Pred, WSA	q_{34}		9.333239	
Retain WSA	No Pred, WSA to Pred, WSA	q_{24}		22.76193	
	Pred, WSA to No Pred, WSA	q_{42}		17.70378	
Lose WSA	No Pred, WSA to No Pred, No WSA	q_{21}	8.1952	0.000000	
	Pred, WSA to Pred, No WSA	q_{43}	11.8486	23.33244	
No WSA	Pred, No WSA to No Pred, No WSA	q_{31}	14.8107	0.000000	
	No Pred, No WSA to Pred, No WSA	q_{13}		0.56096	
			LI	**LD**	
			-10.0118	**-8.01712**	**3.989**
					p = 0.407

Note: Likelihood and p values are in bold.

Table S5. Akaike information criterion (AIC) and likelihood values (LD) for dependent model selection.

Contingency-test models	**k**	**LD_n**	**AICc**
Unrestricted			
	8	-5.119	98.23
Restricted			
$q_{34}=q_{21}$	7	-5.127	61.58
$q_{12}=q_{43}$	7	-5.119	61.57
$q_{34}=q_{21}$; $q_{12}=q_{43}$	6	-5.119	43.23
$q_{34}=q_{21}=q_{24}=q_{31}$; $q_{12}=q_{43}$	4	-5.12	24.90
$q_{34}=q_{21}$; $q_{12}=q_{43}=q_{13}=q_{42}$	4	-5.10	24.86
$q_{34}=q_{21}=q_{24}=q_{31}$; $q_{12}=q_{43}=q_{13}=q_{42}$	**2**	**-5.203**	**15.90***
$q_{34}=q_{21}=q_{24}=q_{31}=q_{12}=q_{43}=q_{13}=q_{42}$	1	-11.79	26.02

Note: $q_{i,j}$'s are transition rates between two states, k is the number of parameters and an asterisk indicates best model.

Rattlesnake Foraging Experiment

Figure S2. Rattlesnake arena (0.63 X 0.51 X 0.80 m) a) starting chamber, b) foraging arena, c) divider, and d) video camera affixed to plexiglass arena cover. Within the arena are two artificial burrows (i and ii), one contains the stimulus prey and the other remains empty. Inset shows visual blocker and stimulus prey in wire cage.