Table 1. Urine/plasma ratios (U/P) for [^{14}C]inulin. Values of U/P are the ratios of ^{14}C radioactivity in 50-μl samples of urine and plasma collected 72 to 96 hours after [^{14}C]-inulin was injected. Corrections for quenching were made by adding an internal standard to each sample. After 60 hours U/P remained constant.

Species	Body weight (g)	U/P
Trematomus hansoni	180	0.040
Trematomus bernacchii	200	0.056
Dissostichus mawsoni	9966	0.031

sured into scintillation vials, and 3.5 ml of water followed by 11.5 ml of Aquasol (New England Nuclear) was added to each vial. Shaking the mixture produced a stiff gel. The amounts of radioactivity in the urine and plasma samples were determined by liquid scintillation counting (Nuclear-Chicago, Unilux II). The ratios of [^{14}C]-inulin in the urine to that in the plasma were low even after 72 to 96 hours (Table 1), indicating that these fish are indeed aglomerular. The small amounts of radioactivity in the bladder urine probably resulted from passive diffusion of labeled material into the nephron lumen, possibly in regions of cell death and renewal. Another possible explanation is that labeled inulin moved into the bladder urine by way of a localized region of irritation caused by rubbing of the catheter tip against the bladder wall.

The observed inulin urine/plasma ratios (U/P) are in marked contrast to those obtained by Lahlou *et al.* (*9*) for the aglomerular toadfish, *Opsanus tau*; these authors reported ratios as high as 0.5. Hickman and Trump (*1*) cite an average inulin U/P of 0.15 for the daddy sculpin, *Myoxocephalus scorpius*, a marine teleost described as mostly aglomerular. We interpret our low inulin U/P values as support for the findings with the light microscope.

There is strong evidence that the vertebrate glomerulus is permeable to proteins below a molecular weight of approximately 40,000 and that these filtered proteins are reabsorbed in the proximal segment of the nephron in a process that requires energy (*6, 7*). The antifreeze glycoproteins present in the blood of antarctic fish in concentrations as high as 4 g per 100 ml of serum (*2*) would be rapidly filtered at the glomerulus if such a structure were present. Because glomerular filtration is absent, no energy expenditure is required for reabsorbing the glycoproteins or other blood proteins, and thus the metabolic cost of osmoregulation in antarctic teleosts may be considerably different from that in other marine teleosts.

All the waters south of the Antarctic Convergence are near their freezing point during the winter. For fish to exploit these food-rich waters some protective mechanism against freezing must have evolved. Aglomerularism may have played an important role because it permitted the utilization of a wide range of sizes of glycoprotein antifreeze molecules without involving energy expenditures for their tubular reabsorption.

GARY H. DOBBS, III
YUAN LIN
ARTHUR L. DEVRIES
Scripps Institution of Oceanography, University of California at San Diego, La Jolla 92037

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Neighbor Recognition in Two "Solitary" Carnivores: The Raccoon (Procyon lotor) and the Red Fox (Vulpes fulva)

Abstract. *Male raccoons and red foxes were trapped alive and exposed to each other in captivity. Animals of each species trapped close to one another demonstrated a higher frequency of initial dominance-subordinance relationships and lower frequencies of more intense aggressive interactions than did animals trapped at greater distances from each other. This suggests the existence of neighbor recognition and thus a rudimentary social structure within these free-living "solitary" species.*

When considering animal sociality, biologists often categorize each species as occupying a characteristic position along a continuum ranging from solitary to highly social (*1*). This determination is generally based on observations of physical proximity and its behavioral correlates in captive or free-living subjects. However, the ability of human (*Homo sapiens*) observers to assess such characteristics in other species must necessarily be limited by our own perceptual biases and, in the case of animal social behavior, this bias may exaggerate the importance of visually apparent factors (for example, physical proximity) at the expense of other modalities, notably auditory and olfactory. Thus, in a landmark study, Weeden and Falls (*2*) demonstrated that territorial male ovenbirds are not solitary animals arrayed in independent isolation across their habitat; rather, they constitute an interlocking social network within which animals individually recognize their neighbors. The present study extends the social concept of neighbor recognition to include two species of "solitary" mammals, the raccoon (*Procyon lotor*) and the red fox (*Vulpes fulva*).

Although scattered reports of overt social groupings occur for both species, these apparently result from attraction to artificially enhanced food sources (*3*), with some evidence of occasional sociality in the raccoon, particularly during winter denning (*4*). Adult males of both species, however, are acknowledged to be asocial relative to each other, especially during the breeding season. The basic procedure for testing neighbor recognition in these two species was as follows. Free-living animals were trapped alive in eastern King County, Washington, between 23 December 1973 and 25 February 1974, during the early stages of raccoon and fox breeding seasons in western Washington. In all, 13 male raccoons and 7 male red foxes were trapped; they were maintained singly in outdoor turkey-wire cages measuring 4 by 6 by 6 feet (1 foot = 0.3 m) and fed commercial dog food. Conspecific pairs were introduced into a neutral cage and their behavior observed for a 1-hour period. Correlations of behavior patterns with the interindividual distances at which the animals were originally trapped provides an indication of the degree of neighbor recognition occurring within each species. All raccoons were tested within 2 weeks of their capture date and all foxes within 3 weeks. (This restriction made it impossible to pair all members of each species trapped during the study.) A minimum of 2 days was maintained between successive testing of any one animal and all animals had a minimum of 24 hours habituation to captivity before testing began.

Raccoons initially responded to each other by hissing and lashing their tails (see Table 1). After a variable interval of 10 to 60 seconds, a typical posture (believed to be aggressive) was assumed. This involved elevating the tail, laying back the ears, and raising the shoulder hackles, at the same time hissing almost constantly. On three occasions [when animals paired were A × B, F × G, and I × J (capital letters are designations of animals given in Table 1)] a dominance-subordinance relationship was apparent at this point, with the subordinate lowering his chin, neck, ventral body surface, and tail to the floor, and then retreating to a far corner of the cage, giving the dominant animal free access to the enclosure. In all three of these cases, the animals were trapped within 5 km of each other. When polarized social relationships were not apparent after the initial aggressive posturing, one or both animals then arched its back, revealed the teeth by posterior retraction of the lips, and growled loudly. Of the remaining three pairings between animals trapped less than 5 km apart (D × E, C × E, L × M), each revealed a polarized dominance-subordinance relationship following this behavior. By contrast, of the seven pairings involving animals trapped more than 5 km apart, only one (A × C) demonstrated clear dominance-subordinance polarity at this point.

The next stage of behavioral interaction involved actual fighting, in which the combatants grappled together for varying lengths of time, occasionally pulling large wads of fur from the opponent. Of the six pairs trapped less than 5 km apart, only one (L × M) engaged in such fighting, while of the seven pairings involving animals trapped

Table 1. Data on trapping racoons and encounter of paired animals. Italics indicate "neighbors"—animals trapped less than 8 km apart. Designations of the animals, their weights, and the dates they were trapped are as follows: A, 6.6 kg, 12/23; B, 6.0 kg, 12/31; C, 5.8 kg, 1/3; D, 6.0 kg, 1/6; E, 5.4 kg, 1/6; F, 6.0 kg, 1/19; G, 5.7 kg, 1/20; H, 5.4 kg, 1/24; I, 5.6 kg, 2/6; J, 5.9 kg, 2/10; K, 6.5 kg, 2/11; L, 5.1 kg, 2/17; M, 5.9 kg, 2/19.

Animals paired	*A × B*	B × C	A × C	*D × E*	*C × E*	*F × G*	F × H	G × H	*I × J*	I × K	J × K	*L × M*	I × M
Date	*1/4*	1/6	1/8	*1/8*	*1/13*	*1/23*	1/30	2/4	*2/13*	2/15	2/20	*2/22*	2/25
Trapping distance (km)	*1.1*	12.9	13.4	*2.0*	*1.5*	*2.5*	35	33.5	*3.5*	17	16	*3*	9
Initial dominance-subordinance relationship	*Yes*	No	No	*Yes*	*Yes*	*Yes*	No	No	*Yes*	No	No	*Yes*	No
Lip-retraction and growling	*No*	Yes	Yes	*Yes*	*Yes*	*No*	Yes	Yes	*No*	No	Yes	*Yes*	Yes
Fight (seconds per hour)	*0*	350	0	*0*	*0*	*0*	85	113	*0*	715	292	*141*	148

Table 2. Data on trapping red foxes and encounter of paired animals. Italics indicate "neighbors"—animals trapped less than 8 km apart. Designations of the animals, their weights, and the dates they were trapped are as follows: A, 5.1 kg, 1/2; B, 5.9 kg, 1/2; C, 5.0 kg, 1/19; D, 6.1 kg, 1/20; E, 5.2 kg, 2/2; F, 5.4 kg, 2/8; G, 6.0 kg, 2/16.

Animals paired	*A × B*	A × C	B × C	A × D	*C × D*	C × E	D × E	C × F	*E × F*	*G × E*	*F × G*
Date	*1/4*	1/21	1/23	1/23	*1/25*	2/4	2/8	2/9	*2/11*	*2/20*	*2/22*
Trapping distance (km)	2.5	36	34.5	39	*4.5*	67	62	55	*6.5*	*7.5*	*4.0*
Initial dominance-subordinance relationship	*Yes*	No	No	No	*Yes*	No	No	Yes	*Yes*	*?*	*Yes*
Upright display (seconds per hour)	*0*	75	45	25	*0*	54	21	0	*3*	*0*	*0*
Fight (seconds per hour)	*0*	0	0	0	*0*	4	32	0	*0*	*0*	*0*

more than 5 km apart, only one ($A \times C$) did not. Significantly, even these anomalous cases suggested the occurrence of neighbor recognition in that polarized preexisting social relationships were nonetheless apparent for the "neighbor" pair ($L \times M$) which did fight and were absent for the single "stranger" pair ($A \times C$) which did not. Neighbor pairs engaged in significantly less fighting per hour than did strangers (median test, Fisher exact probability, $P < .05$).

The results obtained for red foxes (Table 2), although differing in behavioral detail, conform to the general "neighbor-stranger" dichotomy reported above for raccoons. Thus, of five neighbor pairings (arbitrarily defined here as foxes trapped less than 8 km apart), distinct dominance-subordinance polarity was apparent prior to any further interactions in four cases—the fifth ($G \times E$) was indeterminate since one animal exhibited dominance postures while the other did not indicate subordinance. (It may be significant that these animals were trapped 7.5 km apart, a possible intermediate distance between neighbors and strangers.) The dominance-subordinance relationships observed among the foxes involved the basic postural components already described for that species (*5*). Thus, the dominant animal demonstrated a characteristic "threat gape" with mouth partially opened and vertical wrinkling of the muzzle, producing a snarl; ears lateral and forward and the head held higher than the subordinate whose mouth was more widely opened with horizontal retraction of the lips ("grin"), smooth muzzle, lateral and downward compression of the ears, and head lowered with neck extended.

Of the six stranger pairings (animals trapped more than 8 km apart), dominance-subordinance polarity was immediately apparent in only one case ($C \times F$). Neighbor pairs thus demonstrated a significantly higher frequency of initial dominance-subordinance relationships than did strangers (Fisher exact probability, $P < .05$). Five of the six stranger pairings (all of those in which no prior polarity was apparent) resulted in a characteristic "upright display"—of the neighbor pairings, only one ($E \times F$) produced an upright display, and that was the briefest of all observed (3 seconds). During the upright display, forepaws were placed on each other's shoulders with neck hairs erected. Both participants generally screamed loudly, with their mouths wide open and less than 8 cm apart. In three of these cases ($A \times C$, $B \times C$, and $D \times E$) this display was followed by a horizontal posture in which the participants lay down about 1 m apart, still screaming, with the jaws still open but less wide, ears flattened and compressed laterally, and the tail wound around the animal's side, with the tip pointing toward the other animal. Stranger pairs engaged in significantly more upright displays of longer duration than did neighbors (Fisher exact probability, $P < .05$). In two cases, upright displaying was followed by a brief fight with growls and apparent attempts to bite the opponent. Both of these fights involved strangers.

The testing conditions employed in this study were grossly unnatural and therefore the specific data reported here should probably not be treated with particular reverence. On the other hand, I believe that the general pattern reflects the real world of free-living animals from both species: for both raccoons and red foxes, neighbors showed a consistently greater frequency of initial social polarity than did more distantly trapped animals, thus suggesting some preexisting social relationships. A higher level of interactive intensity (growling in raccoons, upright displaying in red foxes) was particularly characteristic of animals trapped at greater distances, and actual fighting—the highest level—was limited almost exclusively to these animals.

In a previous study (*6*) it was suggested that a rudimentary form of social organization occurs among feral house cats; this is the first documentation of such a system among free-living, native species. The neighbor recognition described here may be achieved and maintained in a variety of ways among the free-living animals. Further research should help identify them.

DAVID P. BARASH

Departments of Psychology and Zoology, University of Washington, Seattle 98195

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Olfactory Learning-Set Formation in Rats

Abstract. *Rats trained on 16 two-odor discrimination problems showed rapid acquisition of a learning set and one-trial learning by the end of the problem series. Learning to sample odor cues before responding and adoption of a "win-stay, lose-shift" strategy probably accounts for the virtually errorless learning. Learning-set performance of rats trained with odor stimuli is comparable to that reported for primates trained on visual cues.*

Learning to learn (learning set) occurs when training on a series of discriminations of the same general class results in progressive improvement in solving each subsequent problem. Although improvement over a series of nonspatial, multiple-stimulus problems culminating in one-trial learning is usually observed only for primates, the level of asymptotic performance in learning-set tasks has been widely used by comparative psychologists to rank species for intelligence or behavior plasticity (*1, 2*). Theories attempting to relate level of intelligence with phylogenetic status on the basis of learning-set performance have been criticized because they fail to take into account species differences in sensory capacities, including "preparedness" to form specific stimulus-response associations (*1–5*). When rats, for example, are given both olfactory and visual or olfactory and auditory cues, they preferentially attend to the odors and learn little or nothing about the visual or auditory cues (*6*). Experiments in which an olfactometer was used for precise control of odor stimuli demonstrated that rats trained with odors may show very rapid acquisition of simple discriminations and significantly faster learning of reversal sets than animals trained with visual or auditory cues (*6*). In the present experiment, we examined the ability of rats to form a learning set when given a series of two-odor discrimination problems.

Subjects were trained in a modified glass funnel fitted with a response key and a water delivery mechanism. The wide end of the chamber was connected to an exhaust and the narrow end to an odorizing system (Fig. 1). A stream of air (4 liter/min) filtered through silica gel and activated charcoal (Fig. 1, main