TOPIC 1. SENSES

It is traditional to think of animals as having five senses. Elementary school children learn them as seeing, hearing, smelling, tasting, and touching. These are senses, to be sure, but they should be taught as five <u>of</u> the senses. Additional ones include a thermal sense, sense of pain, sense of hunger, and a gravitational sense.

An important conceptual base for defining the dimensions of the sensory environments of animals, given in Moen (1973; 19), is that the dimensions or geometries of functional environments are determined by the sensory capabilities of the animal and the characteristics of stimuli sensed. Visual environments are not spherical; an animal cannot see in all directions at the same time. Sound environments may be nearly spherical.

Taste and smell are related senses. It is difficult for humans to relate to the taste and smell capabilities of wild ruminants because their sensory capabilities cannot be described with well-defined units of measurement, and our discriminating capabilities, especially of smell, are very inferior to those of wild ruminants.

Sensory capabilities are such obvious determinants of certain dimensions of the environments of wild ruminants that the lack of knowledge of these capabilities can only be explained by the difficulties and costs associated with experiments on these animals. Their large sizes, large home ranges, and the difficulties associated with controlled experiments on wild ruminants result in the selection of smaller, easier to handle species by experimental ethologists. Subjective descriptions of wild ruminant behavior responses and patterns will have to provide the basis for most of the estimates of their sensory capabilities.

Capabilities for touch, thermal sensing, pain, hunger, and gravity are also not only difficult to measure because of the lack of suitable transducers and units of measurements, but also because animals, as living organisms, are constantly integrating all of their sensory capabilities into larger behavioral responses. We should, however, try to determine the framework within which the sensory capabilities fall.

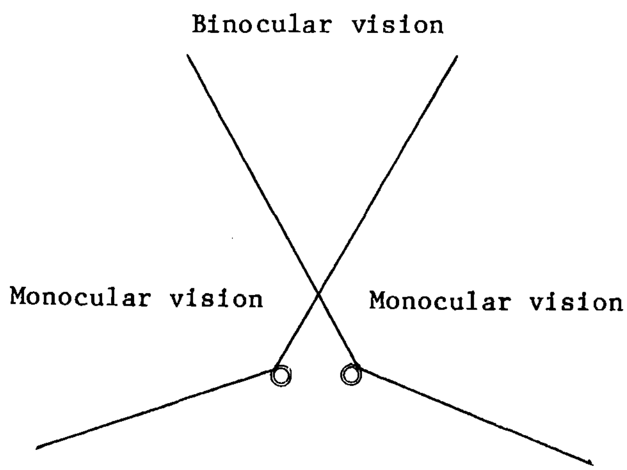
The five traditional senses plus others are discussed in UNITS 1.1 through 1.7.

LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Co., San Francisco. 458 p.

UNIT 1.1: VISION

The functional visual environment of ruminants includes a central area where the vision of both eyes overlaps, the area of binocular vision, and the lateral areas seen by only one eye, areas of monocular vision. The outer limits of the visual environment can be described by angles that describe the limits to peripheral vision.



Visual capabilities are dependent on the abilities of animals to detect certain wavelengths in the electromagnetic spectrum (see CHAPTER 14 for information on the electromagnetic spectrum) with their eyes. Visual discriminations are based on wavelengths, resulting in detection of color, and on movement. Movement is detected with or without color discrimination.

Neural processing of different wavelengths is dependent on the characteristics of the receptors in the retina, or light-sensitive part of the eye. Two kinds of receptors--rods and cones--are found in mammals. The rods are sensitive to lower light illuminations but not to color. The cones are sensitive to higher illuminations and to color (Prince 1970; 1144). Further, there are three types of cone cells (Droscher 1969). Cone types A, B, and C are sensitive to deep blue-violet, dark green, and deep yellow, respectively.

Different species have different ratios of rods and cones, and different numbers of types A, B, and C cones. The general rule given by Prince (1970, p.1145) is that those animals that are more active during the night tend to have more light-sensitive rods, and those that are more active during the day, more color-sensitive cones. Wild ruminants, especially deer, appear to be quite capable of seeing in low light. They are active during both night and day, and their color vision may be better than generally believed to be. Red deer are listed by Dröscher (1969) as one of several species of mammals with color perception.

Bighorn sheep and mountain goats are thought to have good color vision but poor night vision (Geist 1971). Geist used the technique of moving with tame or habituated sheep in order to approach wild sheep more closely, and noted that the sheep were able to spot predators "vastly better" than he was able to, especially if the predator, such as a coyote, was in shrubby habitat. Wild animals in general appear to be much better than humans in spotting moving objects in terrain. Those of us that do a large amount of field work also note improvement in our abilities to detect animals and other natural objects as our experience increases.

Think of the field of vision to consist of a near-field and far-field. The near-field includes those objects and stimuli which the animal sees nearby which allow the animal to feel secure and comfortable in its surroundings. If danger is seen nearby, the animal flees, making the source of danger in the far-field. The far-field includes those objects and visual stimuli which are distant, and which do not cause immediate concern. The line of demarcation between the near- and far-field is not absolute, and varies in time and space.

The visual environment becomes less detailed as distances from the viewer increase. There are differences in the depth of the field of vision of different wild ruminants. Pronghorns are well-known for their visual acuity at great distances, while moose have less depth of field. The former is an animal of the plains where vision is unobstructed for great distances, and the latter is much more at home in forest and brushland.

Thresholds of responses to visual stimuli vary. I have found in my field work with white-tailed deer that on some days the slightest movement some distance away triggers flight behavior, while on other days the animals can be approached much more closely. I do not know why this apparent difference exists. It may be related to both daily physiological rhythms and to transient environmental conditions. Differences in response thresholds have been especially noticable in my work in western Minnesota farmland where deer could be seen and deer could see me at distances up to a mile or more. Meagher (1973) writes that a skier in dark clothing may be detected by bison at distances of a mile or more; a far-field response.

One general conclusion concerning vision that seems to be applicable to all wild ruminants is that moving objects are quickly detected, causing alertness in the recipient animal and sometimes flight behavior, and non-moving objects are less easily detected.

LITERATURE CITED

Dröscher, V. B. 1969. The Magic of the Senses. E. P. Dutton & Co., Inc., N.Y. 298 p.

Geist, V. 1971. Mountain Sheep. The University of Chicago Press, Chicago. 383 p.

Meagher, M. M. 1973. The Bison of Yellowstone National Park. National Park Service, Scientific Monograph Series, Number 1. 161 p.

Prince, J. H. 1970. The eye and vision. Chapter 50 In Swenson, M. J. (Ed.). Duke's Physiology of Domestic Animals. Cornell Univ. Press, Ithaca. 1463 p.

REFERENCES, UNIT 1.1

VISION

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	ccth	spil	250	----	animal visi: what anim see	smythe,rh	1961
aubo	cnha	loen	132	----	vision in vertebrates	tansley,k	1965
aubo	whfr	sfca	458	----	wildlife ecology	moen,an	1973
aubo	stac	hapa	238	anam	prnghrn antlp & its mngmnt	einarsen,as	1948
aubo	qupr	oton	166	obmo	muskoxen,biol,taxon,canada	tener,js	1965

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AVCSA	18--2	152	158	cerv	the structure of cornea in	rehbinder,c; winq	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJVRA	39--4	699	702	odvi	cone, rod photo receptors	witzel,da; sprin/	1978
AMNTA	3---1	28	30	odvi	senses of sight, smell	caton,jd	1869

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	52--2	392	399	alal	observa in yellowstone prk	mcmillan,jf	1954
AVCSA	18--2	159	167	alal	lens lesions, elk, sweden	kronevi,t; holmb/	1977
MUZPA	25---	1	44	alal	moose of isle royale	murie,a	1934

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	30--4	221	241	anam	prnghrn antelp, california	mclean,dd	1944
CGFPA	3----	1	28	anam	literature review,behavior	prenzlow,ej	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	81--1	1	22	oram	obsrvtns,kootenay nt pk,bc	holroyd,jc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
APANE	1---2	167	176	dosh	sight, hear, locat, discrm	arnold,gw; bound/	1975
APANE	1---4	369	377	dosh	compr visn, hearing, lambs	shillito,ee	1975
APANE	3---1	65	81	dosh	audi & visual clues, recog	alexander,g	1977
APANE	3---2	127	136	dosh	import odor, apprnce, voic	alexander,g; shil	1977
APANE	3---2	137	144	dosh	impor, vis cl matern recog	alexander,g; shil	1977
APANE	4---1	71	80	dosh	vis, hrng, ewes fndg lambs	walser,ees	1978
APANE	4---1	81	85	dosh	vis discrm of ewes by lamb	alexander,g; wals	1978
APANE	5---3	215	232	dosh	discrim color, grey shades	alexander,g; stev	1979
APANE	6---3	221	231	dosh	maternl recog, breed ident	walser,ees	1980

CHAPTER 3, Worksheet 1.1a

Visual responses of wild ruminants

Visual responses of wild ruminants are difficult to evaluate in the field. This WORKSHEET may help you become more aware of their visual environment by calling attention to specific field observations.

Find an animal or group of animals and record the following, using a stopwatch, binoculars, and clipboard.

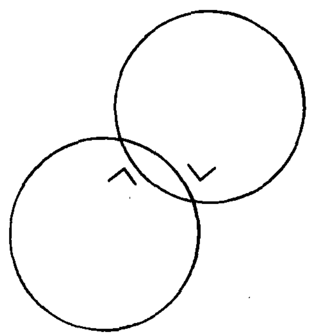
	Near-field	Objects?	Far-field	Objects?
Time:				

	Near-field	Objects?	Far-field	Objects?
Time:				

UNIT 1.2: HEARING

Hearing is a response to vibrations in air, followed by very rapid data-processing of the signal as organisms attempt to identify the kind and source of the sound. I have been quickly detected by deer as a result of a single snapping of a twig when such a noise seemed to be just one of many natural sounds. Their hearing and data-processing are acute and quick.

The dimensions of the sound environment are dependent on the loudness and frequency of the sound in relation to the animal's hearing capabilities. The geometry of the sound environment is not limited to particular angles; sounds can be heard from all directions. The shape and orientation of the ears may increase the dimension of the sound environment in one general direction, however. Ear orientation is shown rather dramatically in a photo by Paul Kelsey in Moen (1973; 1) as one deer has its ears oriented backward and other deer have theirs oriented forward.



Hearing capabilities and sound identifications include discriminations between different frequencies or wavelengths of sound energy (pitch), between different levels or intensities of sound energy (loudness), and directions relative to the receiving organism. Some frequencies are too high (wavelengths too short) and some are too low (wavelengths too long) to cause sympathetic vibrations in the auditory mechanisms of the inner ear and subsequent transmission of nerve impulses to the central nervous system for processing. Sounds must possess enough energy to activate the sympthetic vibrations in the inner ear or they are not heard.

Directional capailities for sound detection are remarkable, since the ears are really not very far apart and sound energy reaches the near ear only about 1/2000th of a second sooner than the far ear. Droscher (1969) summarizes results of experiments on humans that show directional capabilities to be dependent on special nerve ganglia that convert differences in loudness to time-differences in impulses relayed to the brain. The existence of similar neurological mechanisms in wild ruminants is certainly quite possible; deer often look in the right direction when surprised by a sound, and very quickly too.

Wild ruminants continuously receive a wide range of frequencies at different levels of loudness. Hearing may be thought of as being composed of background sounds and unusual sounds. Background sounds are those which do not alter behvior even though they are received. Unusual sounds trigger a response. Wild ruminants filter out the quiet natural background sounds, but become very alert to unusual sounds. The snapping of a twig is not an alien sound, but is an unusual sound that triggers a directional response and a new level of alertness by the animal.

LITERATURE CITED

Dröscher, V. B. 1969. The Magic of the Senses. E. P. Dutton & Co., Inc., N.Y. 298 p.

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Co., San Francisco. 458 p.

REFERENCES, UNIT 1.2

HEARING

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS------------------	AUTHORS/EDITORS--	YEAR
edbo	elpu	nyny	933	----	acoustic behavior of anima	busnel,rg,ed	1963

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				odvi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
MUZPA	25---	1	44	alal	moose of isle royale	murie,a	1934

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
CGFPA	3----	1	28	anam	literature review,behavior	prenzlow,ej	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	81--1	1	22	oram	obsrvtns,kootenay nt pk,bc	holroyd,jc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
SWNAA	9---3	118	115	----	biol acoust, sound spectog	davis,li	1964

CHAPTER 3, Worksheet 1.2a

Auditory responses of wild ruminants

Auditory responses of wild ruminants are difficult to evaluate in the field. This WORKSHEET may help you become more aware of their visual environment by calling attention to specific field observations.

Find an animal or group of animals and record the following, using a watch and binoculars as necessary.

Time	Background sounds	Unusual sounds

Time	Background sounds	Unusual sounds

UNIT 1.3: SMELL

The sense of smell in animals is commonly associated with detection of predators, selection of food, and with reproduction (Kare 1970; 1170). These are fundamental life-support activities, and it is not suprising that wild ruminants have a well-developed sense of smell. The reaction of bison to the odor of an observer is often more marked than reaction to sight or sound (Meagher 1973), and this seems to be generally true of wild ruminants. Geist (1971) states that the sense of smell is developed well enough in sheep to scent a man 350 yards away under favorable conditions.

The scent environment of wild ruminants is difficult for humans to describe because we have no good way to relate to the olfactory capabilities of animals with much keener senses of smell than we have. We do know that the geometries of functional scent environments are very much dependent on the velocity and turbulence of the wind (Moen 1973; 20); geometries change quickly as wind characteristics change.

The total areas of scent environments depend not only on wind characteristics, but also on the concentrations of molecules detected and the sensitivities of the receiving organisms for scent-detection. The closer the source of the odor, the higher the concentration of diffusing molecules and the easier the source is detected, subject to wind effects of course.

The olfactory areas in animals with a well-developed sense of smell are larger due to elongations of the nose and by internal folds in the nose, thus increasing the surface area available for scent detection. The receptor cells used in olfaction are found in the specialized epithelium which lines parts of the nasal cavities.

The molecular basis for odor is not yet fully understood, but it appears that molecular configurations and/or molecular adsorptions are involved at the cellular level. The actions of enzymes in the biolochemical reactions within the cell result in the detection and transmission of olfactory information.

Smell and taste interact, but they are distinctly different senses. Smell is a "far sense," designed to detect stimuli at very low thresholds and without direct contact. Taste is a "near sense," designed to detect stimuli by direct contact.

Smell and taste are different senses, but the interactions between smell and taste make the design of experimental studies difficult. Further, there are interactions not only between smell and taste, but also between visual, auditory, and tactile clues. These interactions involve simultaneous detections, and it is very difficult to discern between the senses which functioned most strongly in different experimental situations, especially when the subjects in such experiments cannot communicate directly with the researcher.

A wide variety of odors are given off and detected by animals. Different species of animals give off different odors, different sexes and ages give off different odors, and individuals give off different odors. The roles of pheromones in chemical communications between individuals are discussed in UNIT 2.3.

LITERATURE CITED

Geist, V. 1971. Mountain Sheep. The University of Chicago Press. Chicago. 383 p.

Kare, M. R. 1970. Taste, smell and hearing. Chapter 51 In Swenson, J. J. (Ed.). Duke's Physiology of Domestic Animals. Cornell Univ. Press, Ithaca. 1463 p.

Meagher, M. M. 1973. The Bison of Yellowstone National Park. National Park Service, Scientific Monograph Series, Number 1. 161 p.

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Co., San Francisco. 458 p.

REFERENCES, UNIT 1.3

SMELL

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	ccth	spil	200	----	molecular basis of odor	amoore,je	1970
edbo	apcc	nyny	412	----	comm, chem sig: advan chem	johnston,jw,jr; /	1970
edbo	acpr	nyny	540	----	biochemistry taste, olfctn	cagan,rh; kare,mr	1980
proc	acpr	nyny	231	rata	ecochemi studies, reindeer	bertmar,g	1975

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odvi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ANBEA	19--1	141	152	odhe	pheromones in black-t deer	muller-schwarze,d	1971
JULRA	59--3	223	230	odhe	specialized scent hair	muller-schwarze,d	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
MUZPA	25---	1	44	alal	moose of isle royale	murie,a	1934

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AZOSA	58--2	65	68	rata	sudorifr gland, hairy skin	kallquist,l; moss	1977
JCECD	1---2	275	281	rata	volat comp, tarsl scnt gln	andersson,g; and/	1975
JCECD	3---5	591	601	rata	caudal gland, histol, chem	mueller-schwarze/	1977
KPSUA	5....	654	655	rata	chem comp, interdigi gland	sokolov,ve; brun/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CGFPA	3----	1	28	anam	literature review,behavior	prenzlow,ej	1965
SCIEA	183--	860	862	anam	pher, subauric scent, male	mueller-schwarze/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	81--1	1	22	oram	obsrvtns,kootenay nt pk,bc	holroyd,jc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
APANE	3---2	151	162	dosh	ablatn olfctr bulbs,feedng	baldwin,ba; mcla/	1977

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
LLOYA	38--6	532	532	many	insect & mammal pheromones	wheeler,jw	1975
LLOYA	39--1	53	59	many	insect, mammalian pheromon	wheeler,jw	1976
PSUBA	83--4	505	539	many	scent gland mrkng, soc beh	thmessen,d; rice,	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
PZSLA	1910-	840	986	rumi	specialized subcutan glnds	pocock,ri	1910

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
AMZOA	7---3	421	429	mamm	olfaction in mammals	moulton,dg	1967
JANSA	25--S	83	87	----	smell, exteroceptiv factor	bruce,hm	1966

UNIT 1.4: TASTE

Taste is an oral sensitivity to direct contact with chemical stimulants. This sense is used by wild ruminants when ingesting and chewing forage. There seems to be a relationship between forage selection and the nutritive quality of the forage, and this relationship is likely dependent on a combination of both olfaction and taste.

Taste receptors are located in the oral and pharyngeal cavities, with the highest concentration of receptors in the tongue (Kare 1970; 1161). Their densities, shapes, and sizes have been summarized for a variety of domestic animals by Kare, but little or no information is available for wild ruminants.

Taste capabilities and preferences are usually studied by providing test subjects with two identical lots of food except for the addition of the chemical to be tested to one of the lots. The preference of the animal is then noted, and when a sufficient number of choices have been made, statistical analyses can be made to determine probabilities of the choices by chance. Non-parametric statistical tests are particularly suited to such experiments since the results are best expressed as "either-or," or ranked in order of preference. Non-parametric tests are very useful for many behavior exeriments because behavioral responses cannot be easily described with basic units of measurement like those used in expressions of mass and energy; behavioral responses are relative expressions rather than absolute quantities.

The two-choice preference test method was used by Crawford and Church (1971) to determine responses of black-tailed deer to chemical stimuli. The deer demonstrated strong preferences for sweet solutions. Responses to different salts and acids varied. No sex differences were observed in response to sweets, salts, and acids, while males showed a marrked preference for bitter solutions which females rejected. The responses of deer were compared to those of sheep.

Some taste preferences may be characteristic of a species, with avoidance or preference responses similar for individuals, and some may be learned. The difficulties and costs of such experiments have prevented compilation of tests on large numbers of wild ruminants, and an understanding of taste in this group of mammals is dependent on a very limited number of experiments and on subjective evaluations.

LITERATURE CITED

Crawford, J. C. and D. C. Church. 1971. Responses of black-tailed deer to various chemical taste stimuli. J. Wildl. Manage. 35(2):210-215.

Kare, M. R. 1970. Taste, smell, and hearing. Chapter 51 In Swenson, J. J. (Ed.). Duke's Physiology of Domestic Animals. Cornell University Press, Ithaca. 1463 p.

REFERENCES, UNIT 1.4

TASTE

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	hill	loen	760	----	the chemical senses	moncrieff,rw	1967
edbo	acpr	nyny	540	----	biochemistry taste, olfctn	cagan,rh; kare,mr	1980

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odvi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	35--2	210	215	odhe	respon, chem taste stimuli	crawford,jc; chur	1971
JWMAA	40--1	114	120	odhe	pref junipr foliag,vol oil	schwartz,cc; reg/	1980

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NATUA	183-2	345	346	doca	thresho valu, taste, twins	bell,fr; williams	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JASIA	52--1	125	128	dogo	pref threshol, tast discri	bell,fr	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	30--5	777	783	dosh	tas resp I. sug, sacc, sal	goatcher,wd; chur	1970
JANSA	30--5	784	790	dosh	II. acids, quin, urea, sod	goatcher,wd; chur	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	31--2	364	372	many	III. sucrose, sodium chlor	goatcher,wd; chur	1970
JANSA	31--2	373	382	many	IV. acetic acid, quin hydr	goatcher,wd; chur	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
SCIEA	161--	1349	1350	----	ecol chem, palatabi spectr	brower,lp; ryers/	1968
SCIEA	164--	1183	1185	----	tast nerv fib: rand distri	frank,m; pfaffman	1969
VETRA	71...	1071	1079	----	sense of taste, domest ani	bell,fr	1959

UNIT 1.5: TOUCH

The sense of touch has not been formally described in the literature for wild ruminants. They are sensitive to the stimulation of body hairs, indicated by their attempts to clear their body surfaces of insects by flicking their ears and twitching their skin. Selective foragers, such as deer and caribou, also seem to have a highly developed sense of touch around their mouths, and use this sense in orienting forage for ingestion. Less selective foragers, such as bison, may have a less well-developed sense of touch around their mouth.

Mother-young relationships are quite dependent on touch, especially during the first few hours and days of life. The licking of the young after parturition is surely important in establishing the mother-young bond. Dams also lick the hind quarters and anal region of nursing young, stimulating urination and defecation.

Observations of mother-young interactions are rather difficult to make in the wild as some species, such as bison and white-tailed deer, are very secretive at the time of parturition. Others, such as caribou, are easier to observe. Ozoga <u>et al</u>. (1982) discuss changes in areas used by white-tailed deer as parturition approaches; data are given for does who ceased social habits, withdrew to use comparatively small areas, and aggressively excluded daughters from the area selected to rear young.

The roles of touch in the development of maternal behavior are not well understood. No mention of touch or other interactions was made by Ozoga <u>et al</u>. even though they oserved deer intensively with spotting scopes from platforms. It appears that aggressive defense of fawning areas and fawns may well include forceful touching of other animals by females of several species.

A few references to the mechanisms used by wild ruminants to repel flies may be found in CHAPTER 10, UNIT 1.1. The literature on touch as a sense is obviously limited.

LITERATURE CITED

Ozoga, J. J., L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impact on neonatal mortality. J. Wildl. Manage. 46(1):1-11.

REFERENCES, UNIT 1.5

TOUCH

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS------------------	AUTHORS/EDITORS--	YEAR
aubo	macm	nyny	113	----	sensory mechanisms	case,j	1966
aubo	whfr	sfca	458	----	wildlife ecology	moen,an	1973

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
JWMAA	46--1	1	11	odvi	parturitn behav, territori	ozoga,jj; verme,/	1982

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
				anam			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CHAPTER 3, Worksheet 1.5a

Touch responses of wild ruminants

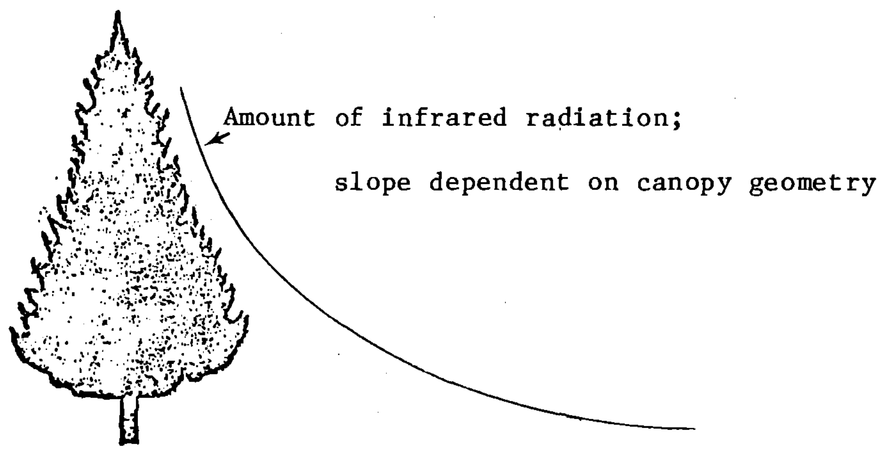
Locate an animal or a group of animals and record the times, receptors, and sources of touch responses in the columns below.

Time	Receptors	Source of touch responses

Time	Receptors	Source of touch responses

UNIT 1.6: THERMAL SENSING

It has been traditional to think of animals as having "five senses," but the list of five--sight, hearing, smell, taste, and touch--is incomplete. Animals detect heat energy with skin receptors, and are capable of detecting fairly small changes in the amounts of heat energy received. One form of energy perceived is thermal radiation. Bright sunshine is a significant source of heat energy, and wavelengths longer than the visible, called infrared energy, are also a source of heat energy. I have observed a larger-than-expected number of deer beds located next to the trunks of trees, especially in areas with few trees such as western Minnesota, and have wondered if this is a response to the larger amounts of infrared radiation present near the trunk and lesser amounts further from the trunk out to a distance about equal to the height of the tree (Moen 1968), as illustrated below.



It is important to realize that the larger amounts of radiant energy, though measurable, do not contribute significantly to the thermal balance of the deer because the amount of heat energy involved is not enough to alter the temperature profile and thermal gradient through the hair. This is discussed further in CHAPTER 16.

Thermally-sensitive bare skin, such as the nose, may be responding to the larger amounts near the tree trunks. Whitetail fawns at the Wildlife Ecology Laboratory have been observed lying in the sun with their heads in the shade on a warm summer day. This seems to indicate that their heads, probably their nose and lip surfaces, are the most thermally sensitive, and if they are in the shade, the animal "thinks" it is in a cooler environment. Thermoregulatory behavior is discussed further in CHAPTER 16.

It is well known that the warmth of the direct rays of the sun can be easily felt, and the sun's energy can add significant amounts of heat energy to the hair surface and thermal boundary region. Infrared energy, present at all times and in all places, is much less noticable because thermoreceptors at the skin surface become conditioned to this constantly-present heat energy.

Wild ruminants do adjust to changing weather and thermal conditions, and thermal senses can play a large part in determining behavioral responses under certain conditions. The literature contains essentially no information on thermal senses, however.

LITERATURE CITED

Moen, A. N. 1968. Thermal energy exchange of a birch tree and spruce tree at night. Ecology 49(1): 145-147.

REFERENCES, UNIT 1.6

THERMAL SENSING

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ARPHA	15---	357	372	----	spec sensors: therm recept	zotterman,y	1953

CHAPTER 3, Worksheet 1.6a

Thermal orientation of wild ruminants

Locate an animal of a group of animals and record your observations of their orientations in relation to the distribution of solar and infrared radiation. Further information on the radiation distribution may be found in PART V, CHAPTERS 14 and 15.

JDAY	Time	Posture	Sun	Shade	Infrared Field

JDAY	Time	Posture	Sun	Shade	Infrared Field

CHAPTER 3, Worksheet 1.6b

Bed sites in relation to solar and infrared fields

Bed sites are usually located after they have been used, especially in the winter when the beds are clearly visable in the snow. Try to determine when they were occupied, and evaluate their location with respect to solar and infrared radiation. Further information on radiation distribution may be found in PART V, CHAPTERS 14 and 15.

Time of occupancy	Solar field	Infrared field

Time of occupancy	Solar field	Infrared field

UNIT 1.7: OTHER SENSES

There are other senses in addition to those discussed in the first six UNITS. Some of the other senses are combinations of the six discussed earlier. Pain, for example, may result from too much sound (auditory), pressure (tactile), or heat (thermal).

Some senses respond to terrestrial and atmospheric stimuli. There is a gravitational sense, for example, a geometric equilibrium in relation to the earth. There may be responses to changes in barometric pressure, an atmospheric stimulus. Interesting obsevations of whitetail fawn movements in Texas are reported by Samuel and Glazener (1970). Seven fawns born and marked in lowland areas moved to upland areas prior to or during a tropical storm. The lowland areas were flooded by 1 to 20 feet of water. After the water subsided, 5 of the 7 fawns returned to their lowland areas of birth. No mortality was observed as a result of the storm, though no fawns could have survived the flooding had they not moved. Did this movement occur in response to changes in atmospheric conditions perceived by the fawns before it was too late?

Considerations of such additional senses are of potential usefulness, and an understanding of all the basic senses will help explain many ecological interactions between animal and environment.

LITERATURE CITED

Samuel, W. M. and Glazener. 1970. Movement of white-tailed deer fawns in south Texas. J. Wildl. Manage. 34(4):959-961.

REFERENCES, UNIT 1.7

OTHER SENSES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	34--4	959	961	odvi	mvt, fawns, hurricane, tex	samuel,wm; glazen	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram