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A STUDY OF BODY WATER IN ACTIVE AND HIBERNATING GROUND SQUIRRELS, CITELLUS LATERALIS LATERALIS AND CITELLUS SPILOSOMA MARGINATUS

By

Lawrence R. Klinestiver

A Thesis

Submitted in Partial Fulfillment of the

Requirements of the Degree of

Master of Science in Biology

The University of New Mexico

1962

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Stewart A. Nathrop
Dean

April 23, 1962
Date

Thesis committee

Marvin F. Riedesel
Chairman

Howard J. Whitaker

Eugene W. Rypka

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CHAPTER I

INTRODUCTION

The present studies were designed to evaluate dehydration as a factor in determining duration of hibernation. Skin temperatures were utilized to indicate the condition of hibernation. Two species of animals, Citellus lateralis and Citellus spilosoma, from two different ecological areas, were studied for the purpose of determining whether tolerance for deprivation of water would indicate changes in water content of tissues during hibernation. If hibernation is limited by dehydration of body tissues, then animals with a greater tolerance for dehydration may hibernate for longer periods. The following experiments were designed to evaluate the effects of dehydration on active and hibernating Citellus lateralis and Citellus spilosoma: (1) Animals were deprived of drinking water for 36, 48 and 72 hours. Body weight measurements at the end of each time period (final weight) were compared with the initial body weights; (2) Citellus lateralis hibernated in both humid and dry environments and the percent time in hibernation was determined by the number of days

hibernating divided by the total number of days in cold exposure; (3) Similar tissues were removed from active and hibernating Citellus lateralis and Citellus spilosoma and the water content values determined.

CHAPTER II

LITERATURE SURVEY

Mammalian hibernation has been studied with great interest in recent years. Although many of the physiological processes have been studied, more investigation is needed to understand all the controlling factors of hibernation.

The stimuli responsible for the physiological changes in animals entering into or arousing from hibernation are not well-known. Environmental stress appears to be one of the main factors inducing the hibernating response. Following the environmental stress, intricate physiological processes such as involution of certain endocrine glands, elevated serum magnesium, and lowering of the body temperature by modified activity of the heat loss center, gradually cause reduction in the metabolic activity of the animal. Arousal from hibernation involves a chain of physiological reactions initiated by physical stimuli such as pain, touch or sound. Fat depletion, thirst, full bladder and environmental light also may stimulate the natural awakening process.

Habitat of Citellus lateralis and Citellus spilosoma

The Citellus spilosoma marginatus (spotted ground squirrel) inhabits the arid regions of the Lower and Upper Sonoran Life Zones (4500-6000 feet) of New Mexico. In the White Sands area, the spotted ground squirrel obtains water from desert seeds and vegetation. Surface water is negligible (17). Citellus lateralis lateralis (golden mantled) lives at higher elevations between the Transition and Canadian Zones (8,000-12,000 feet) near meadows, creeks and rivers (19).

Body temperature during hibernation

Body temperatures of hibernating animals have been reported to be 0.5 to 3 C above the environmental temperature (30). The body temperature changes with the environmental temperature. Unless the environmental temperature changes very slowly, there will be a lag between the body temperature and that of the environment (24). Mayer (32) took rectal temperatures on arctic ground squirrels at various environmental temperatures. Animals hibernating at an environmental temperature of 19.7 C had an average rectal temperature of 18.5 C. Thirty-three rectal temperatures of animals hibernating

at an environmental temperature of 11.4 C had an average rectal temperature of 13.7 C. Hibernating animals may have body temperatures varying between 0 C and 19 C. Similar results were reported by Britton (6). Therefore, the body temperature during hibernation correlates with the temperature of the environment.

Water loss during hibernation

It is a well-known fact that the loss of water from the moist surface of the respiratory passages and through the skin may be considerable in dry air. This water loss is called insensible perspiration or diffusion water loss (1) (34) (38) (39) (40). Insensible loss of water depends on differences in temperature and water vapor pressure between the surface from which evaporation takes place and the environmental air. During hibernation, insensible loss of water through the respiratory tract is decreased for less moisture is required to saturate the expired air at cold environmental temperatures. Water loss also is decreased when the absolute humidity (mg of water/liter of air) is high. The humid environment of burrows as compared to desert environment reduces insensible water loss by 75% (39).

The air of burrows containing hibernating animals is humid and cold; therefore, insensible water loss is minimal.

Distribution of body water

The distribution of water in the animal body has been studied extensively (1) (14) (18) (26) (33) (41). Blood, lung, spleen, kidney and heart have a high water content. Muscle and intestine are intermediate in water content, while the skin, skeleton and liver have a low water content. However, the total mass of muscle and skin is relatively large and contains three-fourths of the body water. Fat tissue contains insignificant amounts of water. The tissues containing the highest percentage of water per wet weight are those concerned with the transportation. Therefore, tissues which have a greater blood flow per unit mass also have a greater water content. In different tissues, varying proportions of extracellular and intracellular water are found. However, similar tissues of various animals such as the cat, dog, rat and rabbit have about the same proportions of extracellular and intracellular water. Extracellular water comprises 27% of the body weight and intracellular

water varies from 29% to 45% of the body weight. Total body water represents 55-75% of the body weight. Blood mass represents 5% of the body weight and is approximately 82% water. Of the water in blood, 67% is in plasma and 33% is in the corpuscles (41). The proportion of extracellular and intracellular water also correlates with the volume of blood flow per unit mass to the tissue. Tissues with a higher blood flow per unit mass (kidney and lung) have a greater extracellular volume than tissue with low blood flow per unit mass.

When the animal body is subjected to artificial hypothermia (5-16 C), a shift in body water takes place from the intracellular to extracellular system, accompanied by elevated serum potassium (2) (3). As the body temperature reaches 22 C, muscle tissue and other organs increase slightly in intracellular water. At 16 C, body temperature, the hypothalamus loses reflex control to cold. At this time, the nervous system becomes depressed by cold, causing a reversal shift in water from intracellular to the extracellular system (3). During dehydration, a similar shift in body water takes place,

intracellular to extracellular, accompanied by an elevation of serum potassium (8) (9) (11) (12).

Factors that contribute to the entrance into and arousal from hibernation

The principal problem of this study pertains to water balance during hibernation. A review of studies on the subject of entrance into and arousal from hibernation indicate these processes are very complex.

Fat and food storage

Storage of energy is essential to hibernation, and most hibernators become relatively fat in the latter part of the summer and enter into hibernation in this condition. Hibernators have the capacity to increase body weight at a rapid rate by depositing fat. Animals such as the woodchuck rely on stored fat, while ground squirrels store food in burrows independent of their obese condition. Depot fats have been examined to determine their utilization during hibernation. Fawcett and Lyman (13) exposed hamsters and thirteen-lined ground squirrels to 5 C and postulated that the greater capability to desaturate fat reflects on their ability to hibernate. Depot fat in ground squirrels is more unsaturated before hibernation. They enter the torpid state rapidly when exposed to cold

as opposed to hamsters which require a longer exposure to desaturate fat (30). Fat is the main source of energy during hibernation, as indicated by the Respiratory Quotients approximating 0.7 (13). When the store of depot fat is depleted, the hunger drive may be one of the causative factors in arousing the animal from hibernation.

Brown fat

Brown fat has been described as the hibernating gland. The area between the scapula near the vertebra is a major site for deposition of brown fat in most hibernators. The vascularity of brown fat is greater than the vascularity of white fat. The difference in blood supply may account for the rapid deposition of brown fat of animals previously starved. In vitro studies, demonstrated brown fat has a greater respiration rate than other adipose tissue. The decrease in respiration in brown fat is much less than that for white fat when cooled. Brown fat has been implicated as a factor in hibernation by observations of lowered body temperature, respiratory rate and blood pressure following injections of brown fat extracts into mice (23). Extracts from the same type of gland from non-hibernators would not

produce the same effect. Johansson (23) reported similar results when extracts of brown fat were injected into hibernating animals and when extracts from other tissues were injected into non-hibernators. Popovic (35) summarizes the controversial role of brown fat in hibernation as unknown.

Endocrine system

Endocrine activity may have a preliminary function during entrance into hibernation, but positive evidence is still not available. The general agreement today is that most endocrine glands involute before and not after the hibernator enters winter sleep. As involution takes place, there is decreased resistance of the animal to low oxygen tensions, decreased mobility, and diminished food intake. Dean and Lyman (7) postulated that the ability to hibernate may be due to the unresponsiveness of the pituitary and its target organs to cold. The endocrine glands which have seasonal variations must be in the inactive state before hibernation takes place (28).

Certain biological rhythms have been reported in several of the endocrine glands of hibernators. This rhythmic activity may have an indirect response resulting

in arousal of hibernating animals. Kayser (25) suggested that the highly variable content of adrenalin in the adrenal medulla of winter hibernators could be associated with the frequency of arousal from hibernation. Injections of thyrotropic hormones and the feeding of dry thyroid glands to hibernators decreased the duration of hibernation (16) (25). Foster suggested reactivation of the thyroid causes more frequent awakenings and shorter hibernating periods (16).

Central nervous system

Prosser (36) supports the theory that entrance into and duration of hibernation involves turning down the thermostat which may be located in the central nervous system. The hypothalamus is the center of temperature control in non-hibernating animals and may control temperature of hibernating animals. There seems to be an indication of increased sensitivity in the hypothalamus, but the nature or cause is unknown. Since the sympathetic nervous system is definitely involved in waking from hibernation, Lyman and Chatfield (30) suggest this system may be of prime importance on entering hibernation.

Elevated serum magnesium has been described as a characteristic of hibernation and hypothermia (37).

Magnesium influences the hypothalamus to increase heat loss and may facilitate the onset of hibernation. Serum magnesium levels of the hedgehog, Erinaceus europeacus, were higher in the winter and lower in the summer. This may be a seasonal cycle which prepares the animal for hibernation. On the other hand, Riedesel (37) reported elevated serum magnesium in the little brown bat, Myotis lucifuqus, only when the esophageal temperature dropped to 13 C. The "Additive Influence" theory supports the idea that cold exposure initiates an elevation of serum magnesium which has an additive effect on the heat loss center, causing the body temperature and metabolism to drop to hibernating levels.

Physiological rhythms

Circadian rhythms persist during hibernation and may be a factor in arousal from hibernation. Folk (15) subjected thirteen-lined ground squirrels, Citellus tridecemlineatus, to a twelve-hour illumination period and found that more animals awoke during the second season when the light was on. Although no specific physical change has been observed to precede arousal from hibernation, Folk suggested regular arousal may be due to a speeding of the awakening process by environmental light.

Oxygen supply

Du Bois (10) related that dormancy in hibernating animals was brought about by an anoxial condition. He devised the carbonic auto-narcotic theory whereby hibernating animals breathe air containing appreciable amounts of carbon dioxide which results in an increase of carbon dioxide in the blood. The total high carbon dioxide level in the blood introduced the idea of reduced sensitivity in the respiratory center during hibernation (43). The established theory today, however, is the dependence of respiratory sensitivity on carbon dioxide tension (PCO_2) and not on the total concentration of the carbon dioxide. During hibernation, there is an increase in oxygen and carbon dioxide in blood, but the oxygen-carrying capacity of the cells is greatly increased and nullifies the effect of the carbon dioxide.

Splenic enlargement and increased storage of erythrocytes in the spleen has been reported during hibernation. Lidicker and Davis (29) postulate arousal from the dormant state results from a mass release of stored erythrocytes which influences the oxygen supply to the tissues and increases stimulation of the heart.

Water, thirst and urination

The changes in body fluids which accompany dehydration and hypothermia are similar. Dehydration and lower environmental temperatures may change chemical concentration in body fluids of the hibernator and thereby influence the onset of hibernation. The mechanism of water preservation in dehydrated animals causes a shift in body water from the intracellular to the extracellular phase, accompanied by elevated serum potassium (9),(12). Barbour (et al.)(3) reported a similar shift in body water when rats were subjected to deep hypothermia. The shift in body water coupled with elevated serum magnesium may affect the heat loss center by lowering the body temperature to the hibernating state.

Svihla (42) fed ground squirrels, Citellus tridecemlineatus, dry seeds and deprived them of water without lowering the ambient temperature. This caused a state of dormancy. He also injected distilled water into hibernating ground squirrels, Citellus tridecemlineatus, and jumping mice, Tapus trinotatus, causing arousal for two hours before reentering hibernation. Control animals pricked with empty needles remained dormant.

A decrease of fluid in the body has been reported to induce hibernation in the European marmot (10). An increase of fluid at the end of the dormant state also caused activity in the animal (10).

A number of external stimuli will arouse hibernating ground squirrels. Internal stimuli such as a full bladder, thirst, shifts or increase in body water may be factors in arousing animals from a torpid state. Hong (20) postulated that depressed renal function during hibernation caused changes in the body fluids which trigger natural arousal from hibernation. Increased body fluids resulting from metabolic water may stimulate arousal from hibernation.

CHAPTER III

MATERIALS AND METHODS

Citellus lateralis animals were captured in northern New Mexico near Red River and the Jemez Mountains. Specimens of *Citellus spilosoma* were captured on the northwest side of Gibson Boulevard near Kirtland Air Force Base. The animals were deloused with Rothrum insecticide powder (Haver and Glover Laboratory), weighed and isolated in separate cages for approximately three weeks before being placed with stock animals. Before being used for experimentation, animals were transferred from the stock animal room to the experimental animal room. The rooms were air-conditioned and maintained at 20-23 C with 40% ($\pm$10%) relative humidity. All animals were housed in separate cages with either wire or metal bottoms (H. C. Hamster-Squirrel cages, 16" x 8 3/4" x 10 1/2", Code No. 2220). Food consisted of rat pellets containing 45% water and cracked grain with 33% water content. All initial and final weights of the animals were measured on a Model E Mettler Balance (Type K).

Body temperature measurements of both sexes of *Citellus lateralis* and *Citellus spilosoma* were taken while

active and hibernating. The term "active" in this study pertains to a non-hibernating animal. A small animal temperature probe, in conjunction with the 46-TU-tele-thermometer (sensitivity 0.1 C) was used for body temperature measurements. Small thermocouples made from thermocouple wires connected to a temperature potentiometer (Leeds and Northrup, Cat. No. 8692) was used for measuring fur and skin temperatures. These temperatures were taken in the neck region. Fur temperatures were obtained by placing the probe or thermocouple lightly on top of the fur. The thermocouple was placed between the strands of fur next to the skin for skin temperature measurements. The probe was inserted 2 cm into the rectum for the measurement of the core temperatures. Exposure to room temperature was approximately three minutes during temperature measurements of the animals exposed to cold.

Three refrigerators and two constant temperature boxes were used as hibernacula. The constant temperature boxes were automatically regulated by a thermister temperature controller (Model 71, Yellow Springs Instrument Co.). Both species were subjected to the humid and dry environments at a temperature of 7-8 C. The humidity was elevated by placing wet towels on the compartment walls

with the ends of the towels draped in water pans. An electric fan was rigged with thermocouple wires to a temperature potentiometer (Leeds and Northrup, Cat. No. 8692) for the purpose of measuring the wet and dry bulb temperatures. Temperatures of 7-8 C were lethal to all Citellus spilosoma and repeated attempts to hibernate more animals were unsuccessful in July and August, 1961. Hibernation of the Citellus spilosoma was observed when cotton was supplied as nesting material and the air temperature was 12-13 C. Duration of hibernation was determined by a sawdust technique. Sawdust was placed on the hibernating animal's body. Observations were made each day to see if the sawdust had been disturbed. Movement of sawdust was considered evidence that the animal had awakened.

Water content of tissues was studied on both active and hibernating Citellus lateralis and Citellus spilosoma. After a period of ten days in hibernation, an animal was selected for tissue study. Ether was used to kill the ground squirrel by enclosing the animal in an air-tight jar. Drying of tissues during the dissecting procedure was kept to a minimum by removing the skin from only one portion of the body at a time. The tissues studied were

removed and rolled in brown absorbent paper hand towels. Evaporation from wet tissue was minimized by wrapping the tissue in tinfoil (Saratan) and weighing immediately. All tissue weight measurements were made on a chain-omatic analytic balance (Denver Fire Clay Co.). Sensitivity of the balance for loads ranging from 0 gm to 3 gm was 0.00018 to 0.00024. Two samples of each tissue were taken wherever possible. The samples were dried in an electric oven at 41 C ($\pm$ 2 C). The dried tissue samples were cooled in a desiccator before each weighing. When a constant weight was obtained, the water content of each tissue was calculated.

Throughout this study, 95% level of confidence is considered significant and 90% marginal. Methods for statistical analyses were obtained from the procedures designated by Mather (31).

CHAPTER IV

RESULTS

Body temperatures of active and hibernating Citellus lateralis and Citellus spilosoma

Fur, skin and rectal temperatures were taken on active and hibernating animals of the same species, Citellus lateralis and Citellus spilosoma. The temperatures are reported in Tables 1, 2, 3, 4 and 5. The temperatures given in the following two paragraphs are mean temperatures.

At an air temperature of 23 C, the active golden-mantleds had a fur temperature of 34.4 C, skin temperature of 36.6 C and a rectal temperature of 36.7 C. When hibernating in a cold environment of 7-8 C, their fur temperature was 17.4 C, skin temperature was 12.5 C and the rectal temperature was 11 C. For active animals, the rectal to skin temperature gradient (rectal less skin) was -0.1 C at 23 C air temperature, and for hibernating animals, the rectal to skin temperature gradient was 0.3 C.

At an air temperature of 23 C, the spotted ground squirrel had a fur temperature of 32 C, skin temperature of

33.9 C and a rectal temperature of 34.2 C. When hibernating in a cold environment of 12-13 C, the fur temperature was 16.5 C, skin temperature was 14.8 C and the rectal temperature was 13.6 C. By providing cotton for nesting material, the Citellus spilosoma hibernated readily at an air temperature of 12-13 C from August through November, whereas 7-8 C was lethal during July and August. These animals hibernated frequently during November. For active animals, the rectal to skin temperature gradient was -0.3 C (23 air temperature), and for hibernating animals, the rectal to skin temperature gradient (rectal less skin) was 1.3 C (12-13 C air temperature). Citellus spilosoma hibernating in a cold environment of 7-8 C had a fur temperature of 11.4 C, skin temperature was 10.1 C and rectal temperature was 9.6 C. The rectal to skin temperature gradient was 0.2 C.

Weight loss of Citellus lateralis and Citellus spilosoma deprived of drinking water

Three groups each of Citellus lateralis and Citellus spilosoma were deprived of drinking water. There were five Citellus lateralis and five Citellus spilosoma in the 36, 48 and 72-hour groups. The body weight at the end of each

time period (final weight) was compared with the initial body weight. The mean percent weight loss and level of significance are presented in Tables 6, 7, 8, 9, 10 and 11.

The weight loss for Citellus lateralis was 8.3% of the initial weight for 36 hours, 6.7% for 48 hours and 5.3% for 72 hours. A definite recovery in weight was observed as the period of water deprivation was extended.

The weight loss for Citellus spilosoma was 8.6% of the initial weight for 36 hours, 9.3% for 48 hours and 15.2% for 72 hours. There was no evidence of recovery of the initial weight loss during the 72-hour period.

Duration of hibernation in dry and humid environments

The percent of time in hibernation in a humid environment was determined on Citellus lateralis by calculating the ratio of number of days hibernating to number of days in cold exposure. Animals that did not hibernate were not included in the calculations of the mean percent time spent in hibernation. The values are presented in Tables 12, 13, 14 and 15. In the humid and dry environments, the mean percent time in hibernation

was 86.0% and 70.0% respectively. The percent time in hibernation also was calculated by ten-day periods. The Citellus lateralis hibernated 87.0% of the time in the humid environment and 77.0% of the time in the dry environment. These data indicate that Citellus lateralis hibernates 10.0-15.0% longer in the humid environment.

Water content of tissues taken from Citellus lateralis and Citellus spilosoma

Tissues taken from hibernating animals had a similar water content as did corresponding tissues from active animals. The percent water content of tissues is presented in Tables 42, 43, 44 and 45.

The water content of the biceps femoris taken from Citellus lateralis was 1.3% less during hibernation (70.5% active and 69.2% hibernating). A similar decrease of 2.1% in the water content of the same muscle taken from Citellus spilosoma was observed (71.7% active and 69.6% hibernating). The water content of the peroneus taken from Citellus lateralis was 1.5% less during hibernating (71.0% active and 69.5% hibernating). A decrease of 2.1% in water content of the same muscle taken from Citellus spilosoma was observed (72.4% active and 70.3% hibernating).

The water content of the kidney taken from Citellus lateralis was 3.3% more during hibernation (70.5% active and 73.8% hibernating). An increase of 3.9% in the water content of the kidney taken from Citellus spilosoma was observed (71.6% active and 75.5% hibernating).

The water content of the spleen taken from Citellus lateralis was 0.6% less during hibernation (74.0% active and 73.4% hibernating). A decrease of 1.4% in water content of the spleen taken from Citellus spilosoma was observed (74.3% active and 72.9% hibernating).

The water content of the lung taken from the Citellus lateralis was 3.5% more during hibernation (74.1% active and 77.6% hibernating). An increase of 1.8% in water content of the lung taken from Citellus spilosoma was observed during hibernation (75.1% active and 76.9% hibernating).

CHAPTER V

DISCUSSION

Body temperatures of active and hibernating Citellus lateralis and Citellus spilosoma

The core temperatures obtained in this study compare with temperatures reported by other investigators (24) (30) (32). Rectal or core temperatures have been the criterion most frequently relied upon to indicate hibernation. The measurement of core temperatures requires either implanting temperature sensing elements before hibernation or handling the animals in hibernation. The frequency with which animals gnaw or otherwise break lead wires, and the arousal which accompanies handling of hibernating animals, makes these methods undesirable. Because of the ease and reliability of skin temperature measurements, this procedure is a very desirable criterion for determining hibernation (Tables 1, 2, 3, 4 and 5).

Weight loss of Citellus lateralis and Citellus spilosoma deprived of drinking water

The availability of water in the natural habitat of these ground squirrels is quite different, as indicated in the literature survey. From observation of the

habitats, one might expect the Citellus spilosoma to tolerate water deprivation more readily than the Citellus lateralis. The data presented in this study suggest the opposite.

In interpreting these data, it is pertinent to consider the several methods utilized by animals to conserve body water: (1) behavioral responses, (2) concentrated urine, (3) excreting nitrogenous wastes in solid form, (4) dry fecal materials, (5) reduced water loss from the respiratory tract, (6) metabolic water production may exceed water loss.

When the animals were deprived of water for 72 hours, general observations revealed varied behavioral characteristics in both species. The spotted ground squirrel remained very active, but the golden-mantled ground squirrel frequently curled into a hibernating position and remained inactive. Inactivity may reduce water loss during adverse conditions.

Urinary water loss is kept to a minimum by excreting urine highly concentrated in solutes (40). Some species of desert ground squirrels have the ability to concentrate urine and eliminate nitrogenous wastes with minimum loss of water (5). Also, certain desert

mammals have specialized reabsorption filtering mechanisms in the kidney to retain the most minute quantities of water available (40).

The observations in this study suggest that the kidney of Citellus spilosoma may have a greater concentrating capacity than the kidney of the Citellus lateralis. The antelope ground squirrel, when fed dry diets, can concentrate urine, thereby losing minimal amounts of water in excretion of nitrogenous wastes. Urea concentrations of 3.3 and 3.8 M have been reported in kangaroo rats (40). Similar urea concentrations were observed in antelope ground squirrels. Although urine concentrations were not measured, Citellus lateralis appeared to eliminate larger volumes of urine than the spotted ground squirrel. This may indicate that the spotted ground squirrel can concentrate urine to a higher degree than the golden-mantled and needs less water to eliminate nitrogenous wastes. Another possible explanation for decreased urine elimination by Citellus spilosoma is a more efficient kidney than that of the golden-mantled. The antelope ground squirrel and other desert mammals have a large, elongated renal papilla which is conducive to greater water reabsorption (5) (40). Citellus spilosoma may have a kidney similar in

structure, thereby making it possible to eliminate less urine during the dehydration periods.

Water loss through fecal elimination is reduced to a minimum in desert animals (40). The water content of fecal material in kangaroo rats was 45% when they were fed a dry diet. White rats under similar conditions averaged 68% water in eliminated fecal material. Minimum water loss through fecal material is an important mechanism for conserving water and may account for the spotted ground squirrel being able to withstand water dehydration without becoming inactive. Throughout this study, it was apparent that the fecal material of the golden-mantledcontained more water than the fecal material of the spotted ground squirrel.

Evaporative water loss from the respiratory tract and through the skin can be relatively high if an animal remains active during the heat of the day. Of the total water loss, 0-5% is the estimated loss via the skin, while 95-100% is lost through the respiratory passages in kangaroo rats (39). Tennet (44) reported a 57% water loss through the skin in white rats. Antelope ground squirrels, when active at high temperatures, give up water equal to 10% of their body weight in respiration and

evaporation through the skin during the day. This is 15% of the total body water (5). It appears that the water lost through the respiratory tract in desert mammals is an important factor in maintaining water balance. The reduced activity of the Citellus lateralis reported in this study may reduce respiratory water loss by reducing respiration.

Oxidative water or "metabolic water" is an important mechanism utilized by all animals in forming water (40) (45). The grams of water formed per gram of food metabolized for starch is 0.556, fat is 1.071 and protein is 0.396. An animal deprived of water may increase its metabolic rate, thereby forming oxidative water from fats, carbohydrates and proteins. The data presented in Chapter IV, Results, indicate that Citellus spilosoma has a regulatory mechanism which stimulates activity and increases metabolic water when needed.

In summary, the activity of Citellus lateralis due to water deprivation appears to be a mechanism utilized by this species for conserving body water. By remaining inactive, metabolic rate decreases and less water will be lost via the respiratory passages. The Citellus spilosoma remained very active, thereby losing

body water in great amounts through the respiratory tract. This may account for the rapid loss in weight over the 72-hour period. On the other hand, Citellus spilosoma may not by necessity need to become inactive when subjected to a limited water supply. Elevating the metabolism by remaining active, causes the animal to increase metabolic water for water balance.

Further studies should include the following: (1) deprive animals of water for longer periods during the summer months, (2) histological studies also could be made on the kidney to positively check the anatomical structure for an elongated renal papilla, (3) replacing drinking water with different concentrations of salt solutions would provide indication of the renal capacities of both species. The antelope ground squirrel and kangaroo rats have the ability to survive while drinking isotonic saline solution (4) (5) (40).

Duration of hibernation in dry and humid environments

Water loss via the respiratory passages is determined by (1) water content of the inspired air, (2) amount of air passing over their respiratory surfaces, (3) temperature at site of evaporation, (4) temperature of the expired air.

Evaporation from the respiratory tract is reduced when the inspired air contains moisture. Although rodents do not have sweat glands, there is still some loss of water through the skin. The major loss of water will be pulmonary evaporation, and the absolute himidity (mg of water/liter of air) will determine how much water the animal will lose to the atmosphere. Schmidt-Nielsen (B.) and Schmidt-Nielsen (K.) (38) reported that higher humidity in burrows is significant for water balance. The formation of metabolic water will result in a gain in body water when the animal breathes moist air in the burrows. As determined by dry and wet bulb temperature measurements, the relative humidities in these experiments were 65% in the dry environment and 90% in the humid environment. At 8 C and 90% relative humidity, there is 6.6 mg of water/liter of air. At the same temperature with a 65% relative humidity, there is 5.0 mg of water/liter of air. The results from Tables 12, 13, 14 and 15 indicate the animals hibernated 10-15% longer in the humid environment. The difference of approximately 1.6 mg water/liter of air apparently was enough to make a significant difference in the amount of water loss from animals in the humid and dry environment. If less moisture is lost

through the respiratory tract to the environment, the production of metabolic water by the hibernating animal probably is adequate to maintain a water balance. By maintaining a water balance in the humid environment, the duration of hibernation is increased. In drier atmospheres, metabolic water production may have to be increased to maintain water balance. The increase in metabolism needed to provide adequate metabolic water may stimulate the animal to awaken. This may account for the shorter periods of hibernation by the animals in the dry environment.

Water content of tissues taken from Citellus lateralis and Citellus spilosoma

Hibernating ground squirrels from which tissues were taken for water content determinations had mean rectal temperatures of 11.3 C to 13.6 C (Tables 16, 17, 18 and 19). The skeletal muscles (biceps femoris and peroneus) had a smaller water content during hibernation. A similar response was reported during hypothermia (3). When the muscle tissues are cooled during artificial hypothermia, peripheral circulation diminishes by vasoconstriction of the capillaries. The intracellular water increases slightly until the body temperature

reaches 16 C. At this time, there is a shift of water from the intracellular to the extracellular phase. A similar shift in body water to the extracellular phase may account for the smaller water content of muscles during hibernation, as reported in this study.

The data on the kidney showed an increase in percent water content while in the hibernating state. Folk (15) observed a gain in weight in kidney tissue of thirteen-lined ground squirrels during hibernation. Due to the important excretory functions performed by this organ, a high percentage water content should be expected. Hong (20) (21) found reduction in renal blood flow during hypothermia accompanied by limited urine production. Hibernating ground squirrels at 5 C excreted only 0.001% wt/hr of urine. Depressed renal blood flow and diminished urine output may cause the increased water content of kidneys during hibernation.

The percent water content of the lung during hibernation was elevated in both the Citellus lateralis and Citellus spilosoma. Although respiration rate is greatly reduced during hibernation, the lung is an important excretory organ for gas exchange. Barbour (et al.) (3) observed an increase in total water of the

lung during hypothermia in rats. The total water content of the lung was 77.9% for the controls and 81.9% for the hypothermic animals. During hibernation, peripheral blood flow is reduced to a greater degree than systemic blood flow. Increased blood flow to the lungs for more efficient gas exchange may be the factor elevating the water content of the tissue in hibernation.

Splenic enlargement develops during hibernation in woodchucks, ground squirrels and bats (27) (29). The increased size of the spleen is due to stored erythrocytes. Folk (15) observed a decrease in spleenic weight in thirteen-lined ground squirrels during hibernation. This reduced weight may be due to species difference. The percent water content of the spleen decreased during hibernation in both Citellus lateralis and Citellus spilosoma. The loss in water was significant in the Citellus spilosoma, but not in Citellus lateralis. This may be a difference between the species or due to the small number of experimental animals. A water loss in the spleen during hibernation may be directly related to the increased erythrocytes. Corpuscles contain 33% water while plasma has 67% water (41). Decreased plasma volume in this organ during the torpid state may account

for the decreased water. On the other hand, water may shift from the intracellular to extracellular phase because of lowered temperatures. It is of interest to note that whereas the body weight loss of active golden-mantled and spotted ground squirrels deprived of water were quite different, the changes in water content of tissues during hibernation were quite similar. The explanation of these similarities during hibernation is not obvious, but may result from one or more of the following factors: (1) the difference in the body weight loss of active animals of these two species is primarily due to a behavioral difference, (2) the physiological mechanism responsible for increasing water is lost or reduced during hibernation, (3) the reduced rate of urine and feces formation and respiration during hibernation obliterates any differences that might be present in active animals of these species.

CHAPTER VI

SUMMARY

The rectal temperatures of Citellus lateralis and Citellus spilosoma were measured in hibernation and the core temperatures were 0.5 to 4 C above air temperatures. Skin temperature measurements taken on hibernating animals correlate with the rectal temperatures, and is a desirable method for determining hibernation without disturbing the animals. Body weight measurements were made on Citellus lateralis and Citellus spilosoma deprived of drinking water for 36, 48 and 72 hours. The golden-mantled became inactive and maintained body weight over the 72-hour period. Citellus spilosoma remained very active and lost an average of 15% of their total body weight over the same period.

Citellus lateralis hibernated in humid and dry environments for periods of 30-80 days. These data indicate hibernation was increased 10-15% in the humid environment when the absolute humidity was elevated 1.6 mg of water/liter of air over the dry environment.

Mean percent water content determinations were

made on various tissues taken from hibernating and active ground squirrels. The water content of muscles and splenic tissues studied was less during hibernation in both species. The kidneys and lungs increased in water content during the hibernating state.

LITERATURE CITED

1. Adolph, E. F. 1933. The metabolism and distribution of water in body and tissues. Physiol. Rev. 13: 336-371.

2. Adolph, E. F. and J. Richmond. 1956. Water exchanges of isolated mammalian tissues at low temperatures. Am. J. Physiol. 187: 437-444.

3. Barbour, H. et al. 1943. Water shifts in deep hypothermia. Am. J. Physiol. 140: 9 p.

4. Bartholomew, G. A. and J. W. Hudson. 1959. Effects of sodium chloride on weight and drinking in the antelope ground squirrel. J. Mammal. 40: 354-360.

5. Bartholomew, G. A. and J. W. Hudson. 1961. Desert ground squirrels. Sci. Am. Nov. 107-116.

6. Britton, S. W. 1930. Extreme hypothermia in various animals and in man. Can. Med. Assoc. J. 22: 257 p.

7. Dean, H. W. and C. P. Lyman. 1954. Body temperature, thyroid and adrenal content of hamsters during cold exposure and hibernation with comparisons to rats. Endocrinology 55: 300-315.

8. DeBoer, B. 1946. Water and salt exchange during chronic and acute dehydration in the dog. Am. J. Physiol. 147: 399-403.

9. DeBoer, S. C. 1949. Changes in the extracellular and intracellular fluid phases of muscle during starvation and dehydration in adult rats. Biochem. J. 44: 274-281.

10. DuBois, A. D. 1937. Hibernating ground squirrels. Nt. Hist. 39: 214-215.

11. Eichelberger, L. and A. B. Hastings. 1937. The exchange of salt and water between muscle and blood. III. The effect of dehydration. J. Biol. Chem. 118: 205 p.

12. Elkinton, J. R. and M. Taffel. 1942. Prolonged water deprivation in the dog. J. Clin. Invest. 21: 787-794.

13. Fawcett, D. W. and C. P. Lyman. 1954. The effect of low environmental temperature on the composition of fat in relation to hibernation. J. Physiol. 126: 235-247.

14. Flemister, L. J. 1941. Distribution of available water in the animal body. Am. J. Physiol. 135: 430-438.

15. Folk, G. E., Jr. 1960. Day-night rhythms and hibernation. Bull. Museum of Comp. Zool. 124: 209-229.

16. Foster, M. A., R. C. Foster and R. K. Mayer. 1939. Hibernation and endocrines. Endocrinology 24: 603-612.

17. Harris, Arthur H. 1959. A distributional check-list of New Mexican mammals. Master's Thesis. University of New Mexico. 122 p.

18. Harrison, H. E., D. C. Darrow and H. Yannet. 1936. The total electrolyte content of animals and its probable relation to the distribution of body water. J. of Biol. Chem. 113: 515 p.

19. Hill, John E. 1942. Notes on mammals of north-eastern New Mexico. J. Mammal. 23: 79 p.

20. Hong, S. H. 1955. Renal function during hypothermia. Am. J. Physiol. 183: 628 p.

21. Hong, S. K. 1957. Renal function during hypothermia and hibernation. Am. J. Physiol. 188: 137-150.

22. Hook, and Barrow. 1941. Respiration of brown adipose tissue and kidney of the hibernating and non-hibernating ground squirrel. Am. J. Physiol. 133: 334 p.

23. Johansson, B. 1960. Brown fat and its possible significance for hibernation. Bull. Museum of Comp. Zool. 124: 233-242.

24. Johnson, G. E. 1928. Hibernation of the thirteen-lined ground squirrel, Citellus tridecemlineatus. J. Exp. Zool. 50: 15-30.

25. Kayser, C. 1940. Essai d'analyse du mecanisme du sommeil hibernal. Ann. Physiol. 16: 314-372.

26. Khalil et al. 1954. Water content of tissues of some desert reptiles and mammals. J. Exp. Zool. 125: 407-414.

27. Kurtzsch, P. H. and A. H. Hughes. 1959. Hematological changes with torpor in the bat. J. Mammal. 80: 547 p.

28. Landau, B. R. and Albert R. Dawe. 1960. Observations on a colony of captive ground squirrels throughout the year. Bull. Museum of Comp. Zool. 124: 173-191.

29. Lidicker, William Z., Jr., and Wayne H. Davis. 1955. Changes in spleenic weight associated with hibernation in bats. Proc. Soc. Exp. Biol. Med. 89: 640-642.

30. Lyman, Chas. P. and Paul D. Chatfield. 1955. Physiology of hibernation in mammals. Phys. Rev. 35: 403-425.

31. Mather, K. 1947. Statistical analysis in biology. Interscience, New York. 258-267.

32. Mayer, William V. 1960. Histological changes during the hibernating cycle in the Arctic ground squirrel. Bull. Museum of Comp. Zool. 124: 131-152.

33. Painter, E. F. 1940. Total body water in the dog. Am. J. Physiol. 129: 744 p.

34. Peters, J. P. 1944. Water exchange. Physiol. Rev. 24: 491-531.

35. Popovic, Vojin. 1960. Endocrines in hibernation. Bull. Museum of Comp. Zool. 124: 105-119.

36. Prosser, C. L. 1950. Comparative Animal Physiology, Philadelphia. Saunders. Chap. 10.

37. Riedesel, Marvin L. 1960. The internal environment during hibernation. Bull. Museum of Comp. Zool. 124: 421-429.

38. Schmidt-Nielsen, B. and K. Schmidt-Nielsen. 1950. Evaporative water loss in desert rodents in their natural habitat. Ecol. 31: 75-85.

39. Schmidt-Nielsen, B. and K. Schmidt-Nielsen. 1950. Pulmonary water loss in desert rodents. Am. J. Physiol. 162: 31-36.

40. Schmidt-Nielsen, K. and B. Schmidt-Nielsen. 1952. Water metabolism of desert mammals. Physiol. Rev. 32: 135-166.

41. Skelton, H. 1927. The storage of water by various tissues of the body. Arch. Int. Med. 40: 140-152.

42. Svihla, A. 1941. The relation of water to dormancy in mammals. Murrelet 22: 15-18.

43. Svihla, A. and H. C. Bowman. 1953. Stimuli and their effects on awakening of dormant ground squirrels. Am. J. Physiol. 172: 681-685.

44. Tennet, D. M. 1946. A study of the water loss through the skin in the rat. Am. J. Physiol. 145: 359-364.

45. Vorhies, C. T. 1945. Water requirements of desert animals in the Southwest. University Arizona, Agr. Exp. Sta., Tech. Bull. No. 107. 487-525.

Table 1

Body temperatures of active C. lateralis
Air temperature 23 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal* C
4	Female	37.2	38.7	36.0	2.7
8	Male	35.0	37.1	38.1	-1.0
10	Female	36.2	37.9	35.1	2.8
11	Female	36.0	38.0	36.0	2.0
19	Male	37.0	38.4	37.3	1.1
27	Male	35.0	37.0	38.2	-1.2
29	Male	36.2	37.0	36.2	0.8
30	Female	35.6	38.1	37.2	0.9
48	Female	35.8	38.2	38.4	-0.2
50	Female	30.8	33.5	35.0	-1.5
53	Female	30.0	32.5	35.2	-2.7
54	Female	29.8	32.5	35.5	-3.0
66	Male	32.1	37.5	39.3	-1.8
Total		446.7	476.4	477.5	-1.1
Mean		34.4	36.6	36.7	-0.1
2 Sd		5.4	4.5	2.4	1.8

*Skin temperature minus rectal temperature.

Table 2

Body temperatures of hibernating C. lateralis
Temperature 7-8 C

Animal No.	Sex	Day	Fur C	Skin C	Rectal C	Skin-Rectal* D
4	Female	1	14.3	11.9	10.2	0.7
6	Male	1	18.6	13.0		
		2	17.2	12.3		
		3	15.5	11.9		
		4	18.7	10.7		
		5	17.6	9.7	10.1	-0.4
7	Male	1	14.2	14.0		
		2	18.4	14.9		
		3	18.1	12.4		
		4	17.5	10.8	10.9	-0.1
8	Male	1	18.2	15.5		
		2	17.5	13.4		
		3	17.9	14.7		
		4	19.3	10.9		
		5	17.7	10.3	10.5	-0.2
9	Male	1	18.4	11.4		
		2	17.2	13.8		
		3	14.4	9.8		
		4	18.1	10.5		
		5	18.9	10.5	9.8	0.7
10	Female	1	19.4	15.3		
		2	17.9	14.6	---	---
11	Female	1	19.0	15.8		
		2	17.8	14.3		
		3	19.0	14.0	12.7	1.3
12	Female	1	14.6	10.0		
		2	15.3	13.0		
		3	18.5	13.5		
		4	18.2	12.8		
		5	19.4	14.9	10.7	4.2
20	Male	1	16.6	11.6	13.6	-2.0
21	Female	1	13.5	10.4	11.6	-1.2
30	Female	1	15.5	10.1	10.1	0
Total			572.4	412.7	110.2	3.0
Mean			17.4	12.5	11.0	0.3
2 Sd			3.4	3.8	2.5	2.5

*Skin temperature minus rectal temperature.

Table 3

Body temperatures of active C. spilosoma
Air temperature 23 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal* C
1	Female	32.8	33.5	35.0	-1.5
6	Female	29.5	31.6	32.6	-1.0
7	Female	35.2	36.5	37.0	-0.5
24	Male	34.6	36.0	37.2	-1.2
31	Female	24.4	21.5	26.3	-4.8
34	Male	32.4	34.8	35.1	-0.3
35	Female	35.2	36.8	31.2	5.6
44	Female	32.1	34.1	35.3	-1.2
79	Male	34.5	37.6	33.5	4.1
89	Male	28.0	35.0	36.4	-1.4
94	Male	33.2	36.0	37.0	-1.0
Total		351.9	373.4	376.6	-3.2
Mean		32.0	33.9	34.2	-0.3
2 Sd		6.8	8.9	6.5	3.7

*Skin temperature minus rectal temperature.

Table 4

Body temperatures of hibernating C. spilosoma
Temperature 12-13 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal* C
1	Female	14.6	11.7	12.8	-1.1
5	Male	19.0	17.1	13.8	3.3
7	Female	14.2	13.4	12.9	0.5
21	Male	17.1	16.4	13.5	2.9
28	Male	17.6	16.2	13.8	2.4
31	Female	14.0	12.5	13.7	-1.2
33	Female	18.3	16.8	13.1	3.7
34	Male	13.9	11.8	13.5	-1.7
52	Female	18.1	17.6	15.2	2.4
67	Female	16.8	13.7	13.4	0.3
69	Female	17.3	14.4	13.6	0.8
70	Female	17.4	16.8	14.1	2.7
78	Male	16.6	14.4	13.5	0.9
94	Male	18.5	15.2	13.8	1.4
95	Male	17.2	16.5	13.5	3.0
Total		264.6	237.1	216.9	20.3
Mean		16.5	14.8	13.6	1.3
2 Sd		3.4	4.0	1.2	2.3

*Skin temperature minus rectal temperature.

Table 5

Body temperature of hibernating C. spilosoma with temperature 7-8 C

Animal No.	Sex	Day	Fur C	Skin C	Rectal C	Skin-Rectal* C
1	Female	1	10.4	10.0		
		2	12.4	10.0		
		3	11.5	10.9	9.9	1.0
7	Female	1	10.6	8.8		
		2	11.8	9.7		
		3	11.5	9.6	9.3	0.3
24	Male	1	12.6	11.5		
		2	13.6	12.0	10.3	1.7
31	Female	1	10.6	9.6		
		2	11.6	11.1		
		3	10.4	9.4	9.9	-0.5
34	Male	1	10.0	8.9		
		2	11.6	10.4		
		3	11.7	10.1	9.4	0.7
89	Male	1	11.4	9.9		
		2	13.9	12.5		
		3	9.4	7.6	8.7	-1.1
94	Male	1	9.5	8.5		
		2	12.8	11.8		
		3	10.5	8.7	9.4	-0.7
Total			227.8	201.0	66.9	1.4
Mean			11.4	10.1	9.6	0.2
2 Sd			2.4	2.6	1.1	1.3

*Skin temperature minus rectal temperature.

Table 6

Weight loss of C. lateralis deprived of drinking water for 36 hours

Animal No.	Initial weight	Final weight	36 hour weight loss	Percent weight loss	P values
					0.2
1	215.4	196.2	19.2	8.9	
2	180.5	168.2	12.3	6.8	
3	286.4	262.5	23.9	8.3	
4	281.0	264.0	17.0	6.0	
5	242.0	214.0	28.0	11.6	
Total	1205.3	1104.9	100.4	41.6	
Mean	241.0	220.9	20.1	8.3	
2 Sd	88.8	83.8	12.8	4.4	

Table 7

Weight loss of C. lateralis deprived of drinking water for 48 hours

Animal No.	Initial weight	Final weight	48 hour weight loss	Percent weight loss	P values
					0.4
1	159.0	148.0	11.0	6.9	
2	205.0	189.5	15.5	7.6	
3	265.5	252.5	13.0	4.9	
4	265.5	247.0	18.5	7.0	
5	198.8	181.5	14.3	7.3	
Total	1090.8	1018.5	72.3	33.7	
Mean	218.1	203.7	14.5	6.7	
2 Sd	93.6	89.8	5.6	2.2	

Table 8

Weight loss of C. lateralis deprived of drinking water for 72 hours

Animal No.	Initial weight	Final weight	72 hour weight loss	Percent weight loss	P values
					0.35
1	207.0	203.0	4.0	1.9	
2	235.0	208.0	27.0	11.5	
3	241.0	232.0	9.0	3.7	
4	221.0	217.0	4.0	1.8	
5	204.0	189.0	15.0	7.4	
Total	1108.0	1049.0	59.0	26.3	
Mean	221.6	209.8	11.8	5.3	
2 Sd	33.0	32.0	19.3	8.4	

Table 9

Weight loss of C. spilosoma deprived of drinking water for 36 hours

Animal No.	Initial weight	Final weight	36 hour weight loss	Percent weight loss	P values
					.013
1	167.6	158.9	8.7	5.2	
2	136.8	130.2	6.6	5.1	
3	124.5	112.1	13.3	10.4	
4	116.0	102.8	13.2	11.2	
5	155.2	136.6	18.6	11.1	
Total	701.0	640.6	60.4	43.0	
Mean	140.2	128.1	12.1	8.6	
2 Sd	42.6	44.0	12.3	6.3	

Table 10

Weight loss of C. spilosoma deprived of drinking water for 48 hours

Animal No.	Initial weight	Final weight	48 hour weight loss	Percent weight loss	P values
					.013
1	159.0	149.0	9.5	6.2	
2	134.5	123.5	11.0	8.1	
3	139.0	121.5	17.5	12.2	
4	100.0	93.5	6.5	7.0	
5	122.0	106.5	15.5	13.1	
Total	654.5	594.5	60.0	46.6	
Mean	130.9	118.9	12.0	9.3	
2 Sd	43.6	47.8	8.9	6.2	

Table 11

Weight loss of C. spilosoma deprived of drinking water for 72 hours

Animal No.	Initial weight	Final weight	72 hour weight loss	Percent weight loss	P values
					.021
1	154.0	125.0	29.0	18.8	
2	142.0	125.0	17.0	12.0	
3	133.0	113.0	20.0	15.0	
4	165.0	139.0	26.0	15.8	
5	142.0	121.0	21.0	14.8	
Total	736.0	623.0	113.0	76.4	
Mean	147.2	124.6	22.6	15.2	
2 Sd	24.8	18.9	8.7	4.8	

Table 12

Percent time hibernation of C. lateralis in humid environment (7-8 C, dry bulb 73 C, wet bulb 5.5 C)

Animal No.	Days in Hibernation	Active	Percent Time in Hibernation	P values
				.001
6	68	10	87.0	
7	69	11	86.0	
8	66	14	83.0	
9	69	9	89.0	
10	69	11	86.0	
11	11	16	80.0	
13	53	9	86.0	
14	0	62*	0	
15	71	10	88.0	
16	0	29#	0	
Mean			86.0	
2 Sd			5.7	

*Died
#Removed

Table 13

Percent time hibernation of C. lateralis in dry environment (7-8 C, dry bulb 7.1 C, wet bulb 1.1 C)

Animal No.	Days in Hibernation	Active	Percent Time in Hibernation	P values
				.001
6	21	9	70.0	
7	20	10	67.0	
8	24	6	80.0	
9	20	10	67.0	
10	17	13	57.0	
11	18	9	67.0	
12	22	3	88.0	
17	49	22	69.0	
18	31	19*	62.0	
Mean			70.0	
2 Sd			18.5	

*Died

Table 14

Mean percent time hibernation of C. lateralis in humid environment
(7-8 C, dry bulb 7.3 C, wet bulb 5.5 C)

Days	Animal No.										Mean Percent in Hibernation	P Values
	6	7	8	9	10	11	13	14	15	16		.001
1st 10	90	90	90	90	80	80	70	0	90	0	85.0	
2nd 10	80	80	80	90	80	90	100	0	90	0	87.0	
3rd 10	90	90	90	90	90	90	70	0	100	0	88.0	
4th 10	90	90	80	90	80	80	80	0	80	#	83.0	
5th 10	90	90	70	80	90	80	90	0	90		85.0	
6th 10	80	70	80	90	90	70	90	0	100		83.0	
7th 10	90	90	90	90	80	80	#	0	80		75.0	
8th 10	90	90	80	90	100	80		*	80		87.0	
Mean											88.0	

*Died
#Removed

Table 15

Mean percent time hibernation of C. lateralis in dry environment
(7-8C, dry bulb 7.1 C, wet bulb 1.1 C)

Days	Animal No.									Mean Percent in Hibernation	P Values .001
	6	7	8	9	10	11	12	17	18		
1st 10	90	40	60	80	80	90	100	90	50	68.0	
2nd 10	80	70	90	90	80	80	70	80	80	60.0	
3rd 10	100	80	80	100			100	70	80	89.0	
4th 10								90	80	85.0	
5th 10								80	*	80.0	
6th 10								80		80.0	
Mean										77.0	

*Died

Table 16

Body temperatures of C. lateralis while active
Air temperature 23 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal* C
8	Male	35.0	37.1	38.1	-1.0
50	Female	30.8	33.5	35.0	-1.5
53	Female	30.0	32.5	35.2	-2.7
54	Female	29.8	32.5	35.5	-3.0
Total		125.6	135.6	143.8	-8.2
Mean		31.4	33.9	35.9	-2.1
2 Sd		4.9	4.4	1.3	1.9

*Skin temperature minus rectal temperature.

Table 17

Body temperatures of C. lateralis in hibernation
Temperature 7-8 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal* C
4	Female	14.3	11.9	10.2	0.7
20	Male	16.6	11.6	13.6	-2.0
21	Female	13.5	10.4	11.6	-1.2
30	Female	15.5	10.1	10.1	0
Total		59.9	44.0	45.5	-2.5
Mean		14.9	11.0	11.3	-0.6
2 Sd		2.7	1.8	3.3	1.7

*Skin temperature minus rectal temperature.

Table 18

Body temperatures of C. spilosoma while active
Air temperature 23 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal * C
6	Female	29.5	31.6	32.6	-1.0
35	Female	35.2	36.8	31.2	5.6
44	Female	32.1	34.1	35.3	-1.2
79	Male	34.5	37.6	33.5	4.1
Total		131.3	140.1	132.6	7.5
Mean		32.8	35.0	33.1	1.9
2 Sd		5.1	5.5	3.5	4.5

*Skin temperature minus rectal temperature.

Table 19

Body temperatures of C. spilosoma in hibernation
Temperature 12-13 C

Animal No.	Sex	Fur C	Skin C	Rectal C	Skin-Rectal * C
5	Male	19.0	17.1	13.8	3.3
21	Male	17.1	16.4	13.5	2.9
28	Male	17.6	16.2	13.8	2.4
33	Female	18.3	16.8	13.1	3.7
52	Female	18.1	17.6	15.2	2.4
67	Female	16.8	13.7	13.4	0.3
69	Female	17.3	14.4	13.6	0.8
70	Female	17.4	16.8	14.1	2.7
78	Male	16.6	14.4	13.5	0.9
95	Male	17.2	16.5	13.5	3.0
Total		175.4	159.9	137.5	22.4
Mean		17.5	16.0	13.6	2.2
2 Sd		1.5	2.7	1.2	3.2

*Skin temperature minus rectal temperature.

Table 20

Weight and water content of tissue taken from C. lateralis No. 8 while active

Final body weight 307.8 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	1.1949	0.3457	71.07	70.92
	1.2075	0.3530	70.77	
Peroneus	0.4209	0.1181	71.95	71.70
	0.4239	0.1210	71.46	
Kidney	0.8616	0.2698	68.69	69.44
	0.8679	0.2588	70.19	
Spleen	0.1322	0.0353	73.30	
Lung	1.1889	0.3114	73.81	

Table 21

Weight and water content of tissue taken from C. lateralis No. 50 while active

Final body weight 274.0 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.8394	0.2492	70.32	70.13
	0.7845	0.2458	69.95	
Peroneus	0.4495	0.1284	71.44	71.37
	0.4449	0.1277	71.30	
Kidney	0.8247	0.2444	70.37	70.07
	0.8093	0.2446	69.78	
Spleen	0.1776	0.0478	73.09	
Lung	1.1793	0.2997	72.24	

Weight and water [illegible]
No. 3 white [illegible]

Tissue	[illegible]	[illegible]	[illegible]
Biceps femoris	1.1452	[illegible]	[illegible]
	1.2015	[illegible]	[illegible]
Psoas	0.4297	[illegible]	[illegible]
	0.4252	[illegible]	[illegible]
Kidney	0.2818	[illegible]	[illegible]
	0.86	[illegible]	[illegible]
Spleen	0.1424	[illegible]	[illegible]
Lung	1.1852	[illegible]	[illegible]

Weight and water [illegible] of tissues of [illegible]
No. 59 white [illegible]

Tissue	[illegible]	[illegible]	[illegible]
Biceps femoris	0.8194	[illegible]	[illegible]
	0.8264	[illegible]	[illegible]
Psoas	0.4431	[illegible]	[illegible]
	0.459	[illegible]	[illegible]
Kidney	0.8247	[illegible]	[illegible]
	0.8285	[illegible]	[illegible]
Spleen	0.1774	[illegible]	[illegible]
Lung	1.1751	[illegible]	[illegible]

Table 22

Weight and water content of tissue taken from C. lateralis No. 53 while active

Final body weight 310.1 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	1.3198	0.3815	71.10	71.41
	1.3612	0.3850	71.72	
Peroneus	0.5235	0.1482	71.70	71.52
	0.5421	0.1554	71.34	
Kidney	0.8538	0.2402	71.87	71.66
	0.8811	0.2416	71.45	
Spleen	0.1864	0.0466	75.00	
Lung	1.4899	0.3710	75.10	

Table 23

Weight and water content of tissue taken from C. lateralis No. 54 while active

Final body weight 273.1 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	1.0064	0.3016	70.04	69.72
	1.0709	0.3278	69.40	
Peroneus	0.4757	0.1443	69.67	69.45
	0.4807	0.1479	69.24	
Kidney	0.7754	0.2307	70.25	70.99
	0.7718	0.2182	71.73	
Spleen	0.1412	0.0360	74.51	
Lung	1.0797	0.2662	75.35	

Table 24

Weight and water content of tissues taken from C. lateralis No. 4 after 30 days hibernation

Prehibernation body weight 338.0 gm
Final body weight 229.9 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.9806	0.3114	68.25	68.35
	0.9766	0.3082	68.45	
Peroneus	0.4606	0.1449	68.55	68.97
	0.3929	0.1203	69.39	
Kidney	0.8441	0.2264	73.18	73.84
	0.8513	0.2171	74.50	
Spleen	0.5880	0.2536	74.64	
Lung	1.5630	0.3328	78.71	

Table 25

Weight and water content of tissues taken from C. lateralis No. 10 after 33 days hibernation

Prehibernation body weight 285.0 gm
Final body weight 176.0 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.7122	0.2156	69.73	69.69
	0.8019	0.2433	69.66	
Peroneus	0.3169	0.0955	69.87	69.96
	0.3342	0.1001	70.05	
Kidney	0.7637	0.2053	73.12	73.20
	0.7842	0.2096	73.28	
Spleen	0.1412	0.0378	73.23	
Lung	1.4181	0.3301	76.96	

Table 26

Weight and water content of tissues taken from C. lateralis No. 11 after 16 days hibernation

Prehibernation body weight	162.1 gm
Final body weight	136.8 gm
Sex	Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.7724	0.2393	69.02	68.88
	0.6924	0.2164	68.75	
Peroneus	0.2546	0.0754	70.19	69.80
	0.2193	0.0671	69.41	
Kidney	0.6381	0.1616	74.68	74.51
	0.6598	0.1693	74.35	
Spleen	0.1290	0.0349	72.95	
Lung	0.9461	0.2226	76.48	

Table 27

Weight and water content of tissues taken from C. lateralis No. 30 after 15 days hibernation

Prehibernation body weight	265.0 gm
Final body weight	245.7 gm
Sex	Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.9092	0.2779	69.44	69.82
	0.9137	0.2723	70.20	
Peroneus	0.4634	0.1384	70.14	69.79
	0.3754	0.1137	69.45	
Kidney	0.8789	0.2284	74.02	73.73
	0.8721	0.2316	73.45	
Spleen	0.3887	0.1051	72.97	
Lung	1.5609	0.3378	78.36	

Table 28

Weight and water content of tissues taken from C. spilosoma No. 6 while active

Final body weight 146.4 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6354	0.1824	71.30	71.36
	0.6809	0.1944	71.42	
Peroneus	0.2934	0.0808	72.47	71.94
	0.3001	0.0858	71.41	
Kidney	0.4241	0.1228	71.05	71.11
	0.4053	0.1169	71.16	
Spleen	0.3052	0.0763	75.00	
Lung	0.6746	0.1710	74.65	

Table 29

Weight and water content of tissues taken from C. spilosoma No. 35 while active

Final body weight 114.0 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6858	0.1993	70.94	71.12
	0.6206	0.1781	71.30	
Peroneus	0.2249	0.0638	71.63	72.16
	0.2862	0.0784	72.69	
Kidney	0.3585	0.0987	72.47	72.41
	0.3555	0.0983	72.35	
Spleen	0.2397	0.0602	74.89	
Lung	0.5647	0.1441	74.49	

Table 30

Weight and water content of tissues taken from C. spilosoma No. 44 while active

Final body weight 165.4 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.8254	0.2192	73.45	73.34
	0.8158	0.2184	73.23	
Peroneus	0.3364	0.0883	73.75	73.81
	0.3150	0.0823	73.88	
Kidney	0.6717	0.1836	72.67	72.67
	0.6099	0.1667	72.67	
Spleen	0.2547	0.0740	74.53	
Lung	0.9178	0.2253	75.46	

Table 31

Weight and water content of tissues taken from C. spilosoma No. 35 while active

Final body weight 147.0 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6402	0.1878	70.67	71.06
	0.6386	0.1823	71.45	
Peroneus	0.2416	0.0698	71.11	71.50
	0.2276	0.0640	71.89	
Kidney	0.5253	0.1551	70.48	70.15
	0.5796	0.1749	69.83	
Spleen	0.4900	0.1334	72.78	
Lung	0.9367	0.2277	75.69	

Table 32

Weight and water content of tissues taken from C. spilosoma No. 5 after 12 days hibernation

Prehibernation body weight 176.5 gm
Final body weight 145.7 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.7542	0.2362	68.68	69.59
	0.7134	0.2105	70.49	
Peroneus	0.3041	0.0922	69.68	69.18
	0.3042	0.0953	68.67	
Kidney	0.4698	0.1240	73.61	74.16
	0.4479	0.1133	74.70	
Spleen	0.2498	0.0642	74.30	
Lung	0.8331	0.1965	76.41	

Table 33

Weight and water content of tissues taken from C. spilosoma No. 21 after 14 days hibernation

Prehibernation body weight 179.0 gm
Final body weight 157.8 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.8031	0.2287	71.52	69.91
	0.7528	0.2386	68.30	
Peroneus	0.3172	0.0903	71.53	71.40
	0.3137	0.0901	71.28	
Kidney	0.5768	0.1414	75.45	75.84
	0.6065	0.1442	76.22	
Spleen	0.3118	0.0885	71.62	
Lung	1.2524	0.2864	77.16	

Table 34

Weight and water content of tissues taken from C. spilosoma No. 25 after 13 days hibernation

Prehibernation body weight 163.0 gm
Final body weight 158.8 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6135	0.4191	68.31	68.65
	0.5959	0.1848	68.99	
Peroneus	0.3055	0.0900	70.54	70.77
	0.2630	0.0763	70.99	
Kidney	0.6392	0.1597	75.02	75.11
	0.6832	0.1695	75.19	
Spleen	0.2182	0.0592	72.87	
Lung	0.8275	0.1861	77.16	

Table 35

Weight and water content of tissue taken from C. spilosoma No. 33 after 12 days hibernation

Prehibernation body weight 164.4 gm
Final body weight 138.0 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6005	0.1873	68.81	69.09
	0.6270	0.1921	69.36	
Peroneus	0.2725	0.0827	69.65	69.63
	0.2613	0.0794	69.61	
Kidney	0.5128	0.1207	76.46	76.47
	0.5660	0.1332	76.47	
Spleen	0.2582	0.0737	71.46	
Lung	1.0869	0.2589	76.18	

Weights and water contents of tissues, organs, and body
No. 22 after 13 days [illegible]

Tissue	Wet Weight	Dry	Water content
Biceps femoris	0.6139	0.[illegible]	[illegible]
	0.3353	0.[illegible]	[illegible]
Pectineus	0.3356	0.0[illegible]	[illegible]
	0.2658	0.[illegible]	[illegible]
Kidney	0.8382	0.[illegible]	[illegible]
	0.6882	0.[illegible]	[illegible]
Spleen	0.1218	0.0[illegible]	[illegible]
Lung	0.8213	0.[illegible]	[illegible]

Weights and water contents of tissues, organs, and body
No. 33 after 17 days [illegible]

Tissue	Wet Weight	Dry	Water content
Biceps femoris	0.8035	0.[illegible]	[illegible]
	0.6273	0.[illegible]	[illegible]
Pectineus	0.2275	0.[illegible]	[illegible]
	0.2043	0.[illegible]	[illegible]
Kidney	0.9120	0.[illegible]	[illegible]
	0.5660	0.[illegible]	[illegible]
Spleen	0.2382	0.[illegible]	[illegible]
Lung	1.0313	0.[illegible]	[illegible]

Table 36

Weight and water content of tissues taken from C. spilosoma No. 52 after 12 days hibernation

Prehibernation body weight 143.4 gm
Final body weight 115.0 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.4552	0.1346	70.43	70.11
	0.4518	0.1365	69.79	
Peroneus	0.2167	0.0626	71.11	71.06
	0.2208	0.0640	71.01	
Kidney	0.4016	0.0977	75.67	75.75
	0.4513	0.1091	75.83	
Spleen	0.1827	0.0446	74.50	
Lung	0.7627	0.1737	77.23	

Table 37

Weight and water content of tissues taken from C. spilosoma No. 67 after 11 days hibernation

Prehibernation body weight 139.0 gm
Final body weight 107.7
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.7663	0.2233	70.86	70.84
	0.7687	0.2244	70.81	
Peroneus	0.2886	0.0816	71.73	71.47
	0.3087	0.0889	71.21	
Kidney	0.5439	0.1369	74.83	74.91
	0.5402	0.1351	74.99	
Spleen	0.3468	0.0970	72.03	
Lung	0.9842	0.2208	77.76	

Table 38

Weight and water content of tissues taken from C. spilosoma No. 69 after 13 days hibernation

Prehibernation body weight 164.5 gm
Final body weight 141.5 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.7489	0.2348	68.65	68.89
	0.8374	0.2586	69.12	
Peroneus	0.3162	0.0980	69.01	69.34
	0.3286	0.0997	69.66	
Kidney	0.6611	0.1611	75.64	75.00
	0.6072	0.1557	74.36	
Spleen	0.3652	0.1018	72.13	
Lung	1.1008	0.2637	76.04	

Table 39

Weight and water content of tissues taken from C. spilosoma No. 70 after 14 days hibernation

Prehibernation body weight 157.5 gm
Final body weight 122.1 gm
Sex Female

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.6101	0.1916	68.60	68.70
	0.6075	0.1896	68.79	
Peroneus	0.2280	0.0681	70.13	70.07
	0.2383	0.0715	70.00	
Kidney	0.5832	0.1442	75.27	75.62
	0.6077	0.1461	75.96	
Spleen	0.3502	0.0912	73.96	
Lung	0.8678	0.2068	76.17	

Table 40

Weight and water content of tissues taken from C. spilosoma No. 78 after 11 days hibernation

Prehibernation body weight 162.0 gm
Final body weight 124.8 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.4447	0.1361	69.40	69.11
	0.5402	0.1685	68.81	
Peroneus	0.1622	0.0477	70.59	70.39
	0.1765	0.0527	70.14	
Kidney	0.5448	0.1344	75.33	75.80
	0.5107	0.1212	76.27	
Spleen	0.2843	0.0803	71.76	
Lung	1.1981	0.2766	76.91	

Table 41

Weight and water content of tissues taken from C. spilosoma No. 95 after 12 days hibernation

Prehibernation body weight 158.0 gm
Final body weight 131.2 gm
Sex Male

Tissue	Wet Weight	Dry Weight	Percentage Water Content	Mean Percent Water
Biceps femoris	0.5873	0.1684	71.25	71.43
	0.5897	0.1674	71.61	
Peroneus	0.2473	0.0765	69.07	69.16
	0.2575	0.0792	69.24	
Kidney	0.4705	0.1108	76.46	76.41
	0.4545	0.1075	76.35	
Spleen	0.3276	0.0842	74.30	
Lung	0.8086	0.1822	77.47	

Table 42

Percent water content of tissues taken from C. lateralis while active*

Animal No.	Tissue: Biceps femoris	Peroneus	Kidney	Spleen	Lung
8	71.07	71.95	68.69	73.30	73.81
	70.77	71.46	70.19		
50	70.32	71.44	70.37	73.09	72.24
	69.95	71.30	69.78		
53	71.10	71.70	71.87	75.00	75.10
	71.72	71.34	71.45		
54	70.04	69.67	70.25	74.51	75.35
	69.40	69.24	71.73		
Mean	70.50	71.01	70.54	73.97	74.12
2 Sd	1.68	1.98	2.16	.72	2.86

*Values taken from Tables 20 through 23.

Table 43

Percent water content of tissues taken from C. lateralis in hibernation*

Animal No.	Tissue: Biceps femoris	Peroneus	Kidney	Spleen	Lung
4	68.25	68.55	73.18	74.64	78.71
	68.45	69.39	74.50		
10	69.73	69.87	73.12	73.23	76.96
	69.66	70.05	73.28		
11	69.02	70.19	74.68	72.95	76.48
	68.75	69.41	74.35		
30	69.44	70.14	74.02	72.97	78.36
	70.20	69.45	73.45		
Mean	69.19	69.54	73.82	73.44	77.63
2 Sd	1.36	1.22	1.26	1.60	2.16

*Values taken from Tables 24 through 27.

Table 44

Percent water content of tissues taken from C. spilosoma while active*

Animal No.	Tissue: Biceps femoris	Peroneus	Kidney	Spleen	Lung
6	71.30	72.47	71.05	75.00	74.65
	71.42	71.41	71.16		
35	70.94	71.63	72.47	74.89	74.49
	71.30	72.69	72.35		
44	73.45	73.75	72.67	74.53	75.46
	73.23	73.88	72.67		
79	70.67	71.11	70.48	72.78	75.69
	71.45	71.89	69.83		
Mean	71.72	72.35	71.58	74.30	75.07
2 Sd	2.10	1.86	2.20	1.16	1.18

*Values taken from Tables 28 through 31.

Table 45

Percent water content of tissues taken from C. spilosoma in hibernation*

Animal No.	Tissue				
	Biceps femoris	Peroneus	Kidney	Spleen	Lung
5	68.68	69.68	73.61	74.30	76.41
	70.49	68.67	74.70		
21	71.52	71.53	75.45	71.62	77.16
	68.30	71.28	76.22		
28	68.31	70.54	75.02	72.87	77.16
	68.99	70.99	75.19		
33	68.81	69.65	76.46	71.46	76.18
	69.36	69.61	76.47		
52	70.43	71.11	75.67	74.50	77.23
	69.79	71.01	75.83		
67	70.86	71.73	74.83	72.03	77.76
	70.81	71.21	74.99		
69	68.65	69.01	75.64	72.13	76.04
	69.12	69.66	74.36		
70	68.60	70.13	75.27	73.96	76.17
	68.79	70.00	75.96		
78	69.40	70.59	75.33	71.76	76.91
	68.81	70.14	76.27		
95	71.25	69.07	76.46	74.30	77.47
	71.61	69.24	76.35		
Mean	69.63	70.25	75.51	72.89	76.85
2 Sd	2.24	1.56	3.64	2.48	1.21

*Values taken from Tables 32 through 41.

Table 46

Mean percent water content of tissue from active and hibernating C. lateralis and C. spilosoma*

Tissue	Citellus lateralis			Citellus spilosoma		
	Active	Hibernating	P values	Active	Hibernating	P values
Biceps Femoris	70.5	69.2	.012	71.7	69.6	.001
2 Sd	(1.68)	(1.36)		(2.1)	(2.24)	
Peroneus	71.0	69.5	.012	72.4	70.3	.1
	(1.98)	(1.22)		(1.86)	(1.56)	
Kidney	70.5	73.8	.001	71.6	75.5	.001
	(2.16)	(1.26)		(2.20)	(3.64)	
Spleen	74.0	73.4	.32	74.3	72.9	.018
	(.72)	(1.60)		(1.16)	(2.48)	
Lung	74.1	77.6	.011	75.1	76.9	.12
	(2.86)	(2.16)		(1.18)	(1.21)	

*Values taken from Tables 42 through 45.

Table 40

C. Inferential and 2. additional. Mean percent ashes content to flame test and ignition

Flame	Ashes	Hydrating	& Ashes	Ashes	Hydrating	& Ashes
	Cigarette additions			Cigarette tobacco		
Ash	2.07	.013		5.69	.001	
Remove	(.88)	(.3)		(2.54)		
Brush	2.5	5.69		1.7		
Sq	(.88)	(.3)		(2.54)		
Remove	2.07	5.69		1.7		
	(.88)	(.3)		(2.54)		
Kinds	2.5	.001		5.69	.001	
	(.88)	(.3)		(2.54)		
Brush	2.5	.32		1.7		
	(.88)	(.3)		(2.54)		
Ashes	2.07	.013		5.69	.001	
needed	(.88)	(.3)		(2.54)		
	2.07	.013		1.7		
	(.88)	(.3)		(2.54)		
Sq	2.5	.32		1.7		
	(.88)	(.3)		(2.54)		

* Mean percent ashes content to flame test and ignition

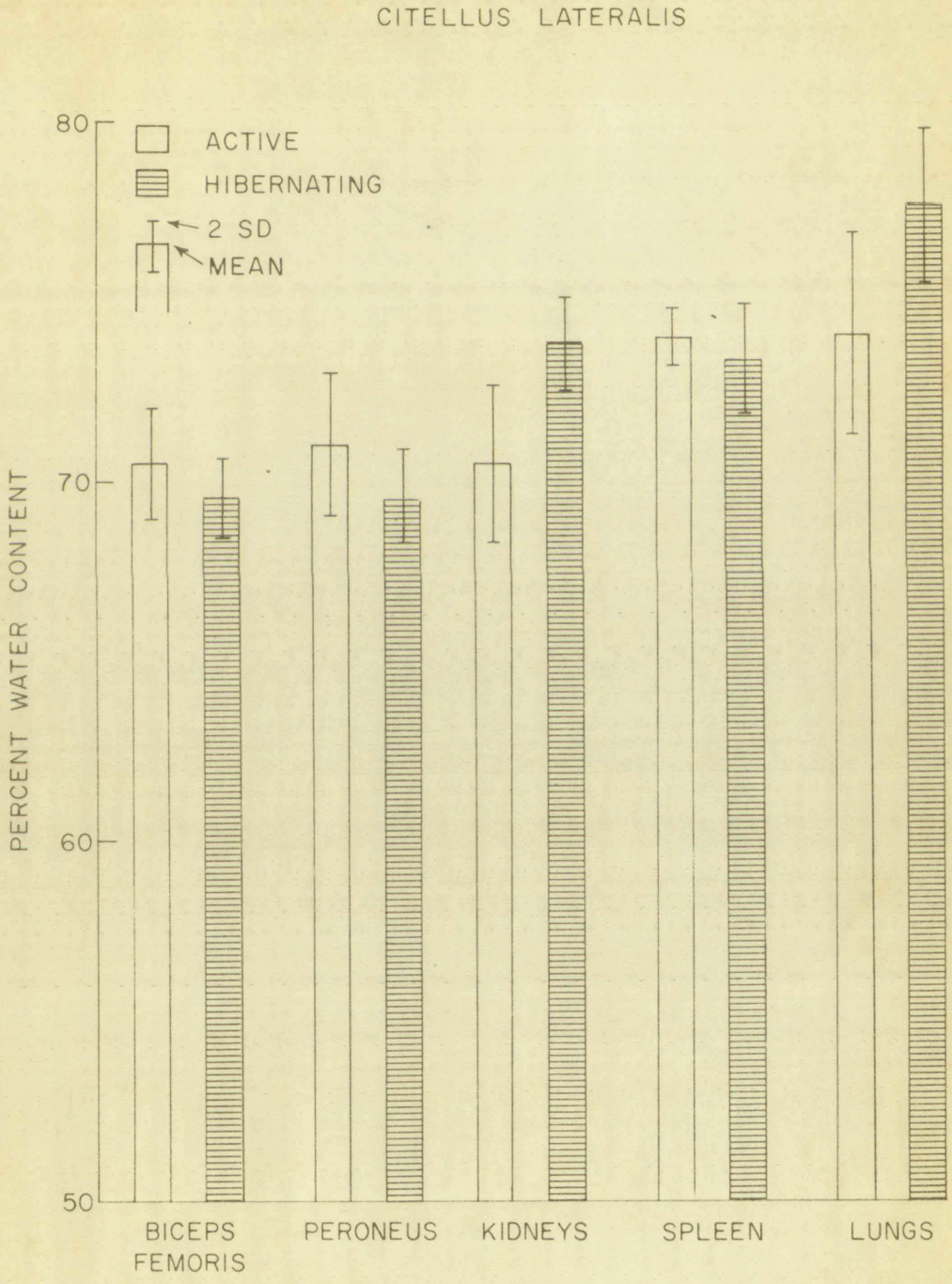

Figure 1. Percent water content of tissues from active and hibernating Citellus lateralis.

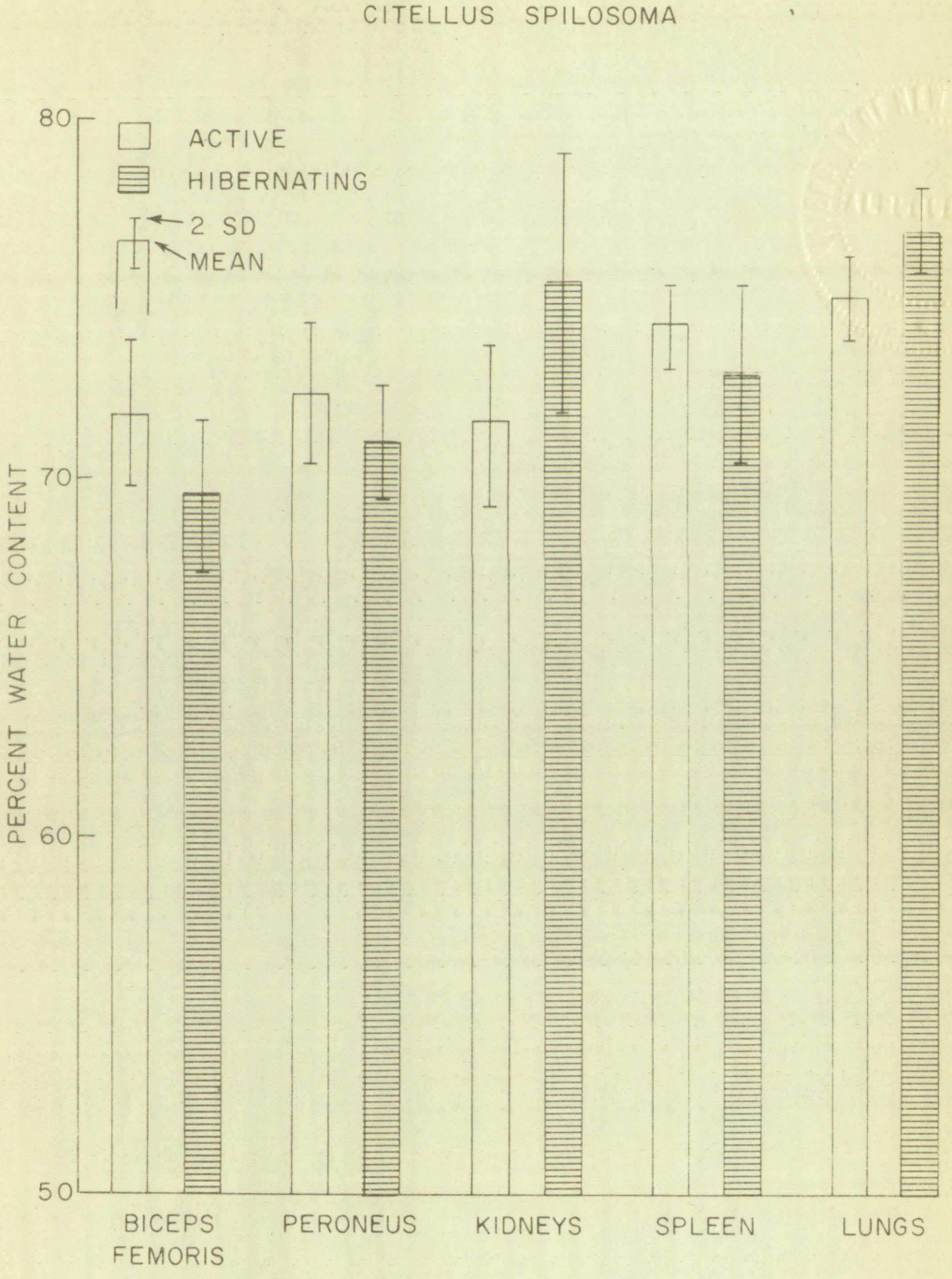

Figure 2. Percent water content of tissues from active and hibernating Citellus spilosoma.

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