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Types of Mammalian Hibernation*

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Mammalian hibernation is characterized by a reduction in metabolic activities and an increase in serum magnesium (1). Although these similarities exist, there are also striking differences in the patterns of hibernation among mammalian types. This study describes three types of hibernation as observed in the golden hamster, the thirteen lined ground squirrel, and the bat. The major differences recorded in these three types of hibernators were concerned with the preparation for hibernation, the survival during hibernation, and the duration of domancy in deep hibernation. Overall results suggest that hibernation is harmful to the hamster after relatively long periods of cold exposure.

Methods

The experimental animals were the golden hamster (*Mesocricetus auratus*), the thirteen-lined ground squirrel (*Citellus tridecimlineatus*), and the bat (*Myotis lucifugus*). Chemical analyses and the methods of maintaining and recording activity of these animals during control observations and during cold exposure have been described previously (1, 2). Rectal and eosophageal temperatures were taken with a copper-constantan thermocouple in a metal-tipped rubber catheter. Metabolic measurements were made by the manometric technique of Scholander (3) as modified by Grindeland.

Results and Discussion

The three types of hibernation are characterized by differences in the method of preparation for hibernation, the duration of dormancy in deep hibernation, and the survival during the period of hibernation. Our data and some obtained by other workers in this field are presented in Table I. This table compares the response of three types of hibernators during the pre-hibernation period (pre-exposure) and the period of deep hibernation. The preparation for hibernation by the hamster includes the storage of food in the vicinity of its nest. There is little storage of food by the ground squirrel and none is stored by the bat. The nutritional state of the hamster on entering hibernation differs from that of the ground squirrel and the bat in that the hamster does not accumulate excess

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depot fat. The fat that is present in the hamster and ground squirrel has a lower melting point during cold exposure than during the period in warmer temperatures (4), but the depot fat of the bat, which normally has a low melting point, does not change appreciably on exposure to cold environments (5). The duration of dormancy in the hamster is short (1-7 days) in comparison with the ground squirrel (1-18 days) and the bat (5-60 days). The hamsters remained in a dormant state for approximately 33% of the total exposure and the ground squirrel and bat remained dormant for 50% and more than 95% of the exposure period respectively. In the dormant hamster the response to external stimuli results in little or no muscular movement, although awakening usually occurs, while the ground squirrel and the bat show a reflex muscular movement as a result of external stimuli, which is not necessarily followed by awakening.

The further changes that occur as a result of hibernation and follow the same pattern in all three animals are a reduction in heart rate, respiratory rate, oxygen consumption, and body temperature, and an increase in the serum magnesium level. The serum magnesium level in the hamster shows approximately a 26.5% increase as compared with a 65.7% increase in the ground squirrel and a 62.5% increase in the bat.

The length of time before onset of hibernation after exposure to the cold is 3-265 days in the hamster, 1-7 days in the ground squirrel and the bat enters hibernation almost immediately upon exposure to reduced ambient temperature. This behavior of the bat is of particular interest; as reported by Hock (6), this animal is the only mammal in which the body temperature is a direct function of ambient temperature. Lyman has suggested that there may be some relationship between the change in melting point of the depot fat of the hamster and the ground squirrel and the difference in the time before onset of hibernation.

The storage of food by the hamster deserves further comment. It has been shown that the hamster will not enter hibernation if he is either deprived of food or not allowed to store food (8) yet deprivation of food is a common method of inducing hibernation in the ground squirrel and similar animals. When the hamster awakes from deep hibernation feeding occurs over a 12-24 hour period, probably due to the inadequate reserves of depot fat.

Hibernation has been thought to serve as a rest period among animals with overall beneficial effects. The high survival observed in the bats and ground squirrels tend to support this hypothesis. However, in the hamster a low rate of survival has been noted; this suggests that hibernation under the circumstances described is harmful rather than beneficial to this species.

Table I

Three Types of Mammalian Hibernation

Pre-Hibernation Period

	Body Temperature (°C)	Weight	Heart Rate (beats/min)	Respiratory Rate (per min)	$\dot{O}_2$ Consumption (cc/gm/hr)	Serum Mg++ (mg/100 ml)	Preparation
TYPE I Hamster (Mesocricetus auratus)	35°-38°	No change	250-300 (7)	100	1.01 (11)	4.03 ± 0.01	Storage in nesting area
TYPE II Ground squirrel (Citellus tridecemlineatus)	30°-39°	Increase	300-400 (10)	180 (10)	1.4	3.65 ± 0.41	Little storage of food
TYPE III Bat (Myotis lucifugus)	20°-40°	Increase	700	170-180	Temperature dependent	4.38 ± 0.16	No storage

Table 1 (continued)
Three Types of Mammalian Hibernation
Deep-Hibernation Period

	Nutritional State	Per Cent Survival During Hibernation	Duration of Dormancy	Response to Stimuli	Heart Rate (beats/min)	Respiratory Rate (per min)	O_2 Consumption (cc/gm/hr)	Serum Mg++ (mg/100ml)	Body Temp. (°C Above Environment)
TYPE I	Little depot fat Lowered melting point (4)	26-45	1-7 days	Little muscular response Easily awakened	4-21 (7)	0.4-15 (7)	0.06 (8)	5.1 ± 0.07	0.2°
TYPE II	Large amount of depot fat Lowered melting points (4)	77-100	1-18 days	Reflex muscular response Not easily awakened	3-15 (9)	0.3-16 (10)	0.08	6.05 ± 0.31	1°
TYPE III	Large amount of depot fat Normal low melting point (5)	83-98 (captive)	3-60 days (captive) 120 days (max. caves) (12)	Reflex muscular response Not easily awakened	28 (10)	(1)-10 (6)	0.05 (6)	7.11 ± 0.13	0-1°

Conclusion

The hibernation patterns of three mammalian forms have been presented. These animals vary in their preparation for hibernation, duration of dormancy in deep hibernation and the survival during the period of hibernation.

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