THE SPLEEN DURING HIBERNATION

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FOUR FIGURES

In a study of the ductless glands during hibernation the other organs were observed routinely.¹ The most striking changes noted in the hibernating animal occurred in the spleen.

Polimanti² in his recent monograph on hibernation mentions the spleen only briefly and there are few references in his comprehensive bibliography to observations on the spleen during hibernation. It was thought that a note recording our observations might be of value.

These observations were carried out on spermophiles (*S. tridecemlineatus*). The data in regard to length of time torpid, temperature and other important factors of the hibernating animal have been given in detail in another paper¹ and will not be repeated here. Suffice to state that spleens from 30 hibernating animals and a corresponding number from active animals were studied. Of the active animals 12 were killed after varying lengths of time of activity after awakening. This number does not include the animals used in the special experiments reported in this article. The time of hibernation varied from twelve hours to one hundred and seventy-five days. Specimens of the active animals were obtained at various times throughout the year.

Unless otherwise stated, the active animals were killed by bleeding under light anesthesia. The torpid animals were bled without anesthesia. The specimens were fixed in several fluids, those most used being formalin, neutral formalin, Zenker and Zenker acetic. The sections were stained with hemotoxylin-

¹Mann, F. C. The ductless glands and hibernation. *Am. Jour. Physiol.*, 1916, vol. 41, pp. 173-188.

²Polimanti, O. *Il letargo*. Rome, Bardi, 1913, 683 pp.

eosin, Mallory's connective-tissue stain and a few other special stains such as Scharlach R.

The structure of the spleen of the spermophile does not differ essentially from that of the spleen of other rodents. The splenic nodules are prominent and the sinuses rather large. The most notable fact in regard to the histology of the organ is the relatively thick trabeculas containing a large amount of smooth muscle. In the gland of the active animal usually only a small amount of blood is found.

Within twelve hours after an animal becomes torpid the spleen presents a very characteristic appearance. Grossly and microscopically the organ is markedly congested. It is greatly enlarged and much darker in color than normal. The capsule is tense and the tissue friable. On section an increased amount of dark blood escapes. Owing to the large amount of blood present it is impossible to recognize any of the finer details of the organ grossly. Microscopically the organ presents a most intense congestion. The sinuses and venous capillaries are distended to their fullest extent with blood. In some organs red corpuscles were found in the germ centers. It appeared as if the congestion was so great as to force the cells into these centers.

The hibernating spleen reaches its maximum state of congestion within a few days after the animal becomes torpid and maintains this condition until after about forty days of hibernation. After the animal has been torpid for seventy-five days the amount of blood contained in the spleen is not greatly in excess of that found in the organ of the active animals. The blood seems to begin to decrease at the periphery of the organ first. This is probably due to the fact that the effect of the contraction of the intrinsic muscles is first exerted on the surface of the organ.

Besides the marked congestion there seems to be very little other change in the spleen. In some animals which had been torpid for many days there seemed to be a slight proliferation of the connective tissue, especially around the splenic nodules. Specimens of the spleens of both active and torpid animals were

fixed in formalin and the section stained with Scharlach R for fat. Rarely were fat droplets found in any of the cells of the organs of active animals. In several of the spleens of torpid animals, certain cells were found containing fat droplets. These cells, usually few in number, were large lymph cells which were always found in the germ centers. We have never observed fat-containing cells in any other part of the spleen.

In the spleen of the active spermophile there can always be found a considerable number of phagocytic endothelial cells containing red blood corpuscles or blood pigment. In the congested spleen of the animal which has been torpid for only a short length of time there seems to be a marked decrease in these cells. Owing to the marked congestion it may be that this is only a relative decrease or the cells are masked by the large amount of blood present. However, in some of the organs of animals which had been torpid less than forty days we were not able to find any of these cells. They reappeared in the animals which had hibernated longer and were still more numerous in the active animals which were killed within a short period after awakening. However, the largest number have always been found in the active animals.

Some of the torpid animals were killed without bleeding. The congestion of the spleen did not seem to be greater in these animals than in those which were bled.

Some experimental procedures were employed in the attempt to reproduce in the active animal the picture of the spleen found in the torpid animal. Some animals were killed with ether and about fifteen minutes after death the spleen was carefully removed and fixed. Other spermophiles were asphyxiated either in a closed jar or with illuminating gas. Some animals killed by the latter method were asleep. In some experiments the venous outflow was impeded for a short period before death. While most of the spleens in animals subjected to these experimental procedures showed congestion, it was impossible to attain completely the intense congestion noted in the organ of the animal which had been torpid for only a short period of time.

The adult spermophile usually withstands operation very well but removal of the spleen proved to be an exception. Most of the animals died within a few weeks after splenectomy, but a few lived for several months. Careful observation showed that these splenectomized animals hibernated under the same conditions as the controls.

The intense congestion of the hibernating spleen is probably due to a loss of tone and relaxation of the intrinsic muscles of both the spleen and the blood vessels. A consideration of the part this plays in the phenomena of hibernation must be purely speculative. It is possible that the spleen acts as a store room for the red blood cells in the early stages of hibernation and allows them to be added to the circulation as needed. The fact that the corpuscles in the congested sinuses appear perfectly normal and that phagocytosis of the red cells seems to be decreased and not increased as one would anticipate, strengthens this idea. However, the fact that splenectomized animals hibernate normally shows that this is only a secondary factor.

PLATES

PLATE 1

EXPLANATION OF FIGURES

1 Photomicrograph of spleen of *Spermophile* 260, a female captured in the spring of 1915. It had been torpid continuously for fifteen days, although it had hibernated for a short time also earlier in the season. Did not have access to food. Killed January 1, 1916, by bleeding. At this time it weighed 85 grams and the rectal temperature was 12°C. The photomicrograph shows the marked distention of the venous sinuses with blood. $\times 100$.

2 Photomicrograph of same section as that shown in figure 1. $\times 280$.

PLATE 2

EXPLANATION OF FIGURES

3 Photomicrograph of spleen of *Spermophile* 117, a male captured in the spring of 1915. It had been torpid for thirty-five days. Had access to food. Killed January 10, 1916, by bleeding. At this time it weighed 165 grams and the rectal temperature was 14°C.

4 Photomicrograph of spleen of *Spermophile* 266, a female captured in June, 1914. It hibernated when kept in the cold during the winter of 1914-1915. Placed in hibernating room and food withdrawn the latter part of September, 1915. Killed January 27, 1916, after hibernating about one hundred and twenty-five days. Rectal temperature at time of death 17°C. Daily observations were not made. The spleen is practically normal.