1889, I found a nest in a small oak, containing two eggs. May 4, 1894, I found a pair brooding. May 16, a pair were building in an oak, fifteen to twenty feet above the ground. May 28, the birds seemed to be through building and were flitting about warbling and apparently taking a rest before time to begin brooding. May 31, after a Blue Jay had created an excitement in the oak, the Gnatcatchers began taking their nest to pieces, and went to work putting it up in a low oak a few rods away. June 7 the birds were still building. June 11 they were brooding, changing places in the nest. June 25 the young were being fed. July 4 the young were out, being fed in the brush. From May 16, or more accurately May 14— for the nest had been begun at least two days before I found it— from May 14 to July 4, those birds were working to get one brood launched. The first nest took them two weeks, the second one about ten days. Their method of work was interesting. The nest was laid on a horizontal branch. Their plan seemed to be twofold, to make the walls compact and strong by using only fine bits of material and packing them tightly together— drilling them in — and at the same time to give the walls form and keep them trim and shipshape by moulding inside and smoothing the rim and the outside. Sometimes the builder would smooth the brim with its neck and bill like a Redstart, as a person sharpens a knife on a whetstone, a stroke one way and then a stroke the other. The birds usually got inside to work, but there was a twig beside the nest that served for scaffolding, and they sometimes stood on that to work on the outside. They both worked, flying rapidly back and forth with material. The second nest rested lightly on a horizontal limb, but was supported mainly by two twigs which forked so as to enclose it. It was a beautiful nest, covered with lichen and lined with feathers. The birds were not at all shy. They let me come so near that I saw the black lines bordering the blue forehead of the male.

Sialia mexicana occidentalis. WESTERN BLUEBIRD. — Mr. Merriam told me he had seen the Bluebirds build in the mud nests of Swallows in trees; but most frequently in knot holes and in the abandoned nests of the small Woodpeckers.

THE LAW WHICH UNDERLIES PROTECTIVE COLORATION.

BY ABBOTT H. THAYER.

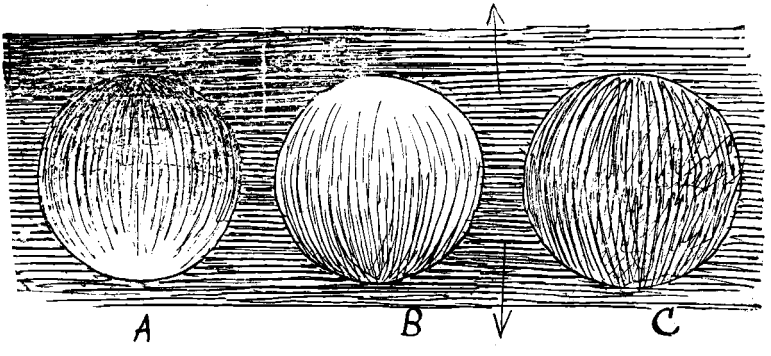
THIS article is intended to set forth a beautiful law of nature which, so far as I can discover, has never been pointed out in print. It is the law of gradation in the coloring of animals, and

is responsible for most of the phenomena of protective coloration except those properly called mimicry.

Naturalists have long recognized the fact that the coloring of many animals makes them difficult to distinguish, and have called the whole phenomenon protective coloration, little guessing how wonderful a fact lay hidden under the name.

Mimicry makes an animal appear to be some other thing, whereas this newly discovered law makes him cease to appear to exist at all. The following are some examples of true mimicry. The Screech Owl, when startled, makes himself tall and slim, and with eyes shut to a narrow line simulates a dead stub of the tree on which he sits. Certain Herons stretch their necks straight upward, and with head and green beak pointed at the zenith, pass themselves off for blades of sedge grass. Certain harmless snakes spread their heads out flat, in imitation of their poisonous cousins, and rattle with their tails in the leaves. Many butterflies have stone or bark-colored under sides to their wings, which make them look like a bit of bark or lichen when they sit still on a stone or tree trunk with wings shut over their backs.

The newly discovered law may be stated thus: Animals are painted by nature, darkest on those parts which tend to be most lighted by the sky's light, and *vice versa*.



The accompanying diagram illustrates this statement. Animals are colored by nature as in A, the sky lights them as in B, and the two effects cancel each other, as in C. The result is that their gradation of light and shade, by which opaque solid

objects manifest themselves to the eye, is effaced *at every point*, the cancellation being as complete at one point as another, as in Fig. C of the diagram, and the spectator seems to see right through the space really occupied by an opaque animal.

Fig. 1 of a Ruffed Grouse shows this arrangement of color and light. This bird belongs to the class in which the arrangement is found in its simplest form, the color making a complete gradation from brown above to silvery white beneath, and conforming to every slightest modelling; for instance, it grows light under the shelving eyebrow, and darker again on the projecting cheek.

When he stands alive on the ground, as in Fig. 2, his obliteration by the effect of the top light is obvious.

Writers say "he is so nearly like the color of his surroundings that you cannot see him." Fig. 3 is to show that they ascribe the concealment to the wrong cause. I merely took the bird shown in Fig. 2, and accurately tinted his under parts with brown to match his back, and in less degree tinted his sides, till I had reduced him to uniformity of color all over; but I did not, of course, change his upper surfaces at all. In short, I extended his 'protective' colors all over him.

Now observe the effect on replacing him in a life-like position. He is completely unmasked. The reader has but to compare the distance at which he can distinguish a bird in No. 2 and in No. 3 respectively, to see whether simple 'protective coloration,' as ordinarily defined, is the true cause of this concealment, or whether this compound gradation of color and light is the true cause.

Fig. 4 and Fig. 5 show that his colors are powerless to conceal him in any position except the upright one which he holds when alive, and Figs. 6 and 7 do the same for the Woodcock.

In Figs. 5 and 6, notwithstanding the fact that we have even the strongest 'protective' colors towards us, the bird is by no means concealed.

The Woodcock series corresponds to that of the Ruffed Grouse. Fig. 8 shows a female on her nest, very difficult to find. In Fig. 9 the bird has been treated exactly as I treated the Ruffed Grouse in Fig. 3. Observe that she is essentially more conspicuous, though not a feather of her upper parts has been artificially painted.

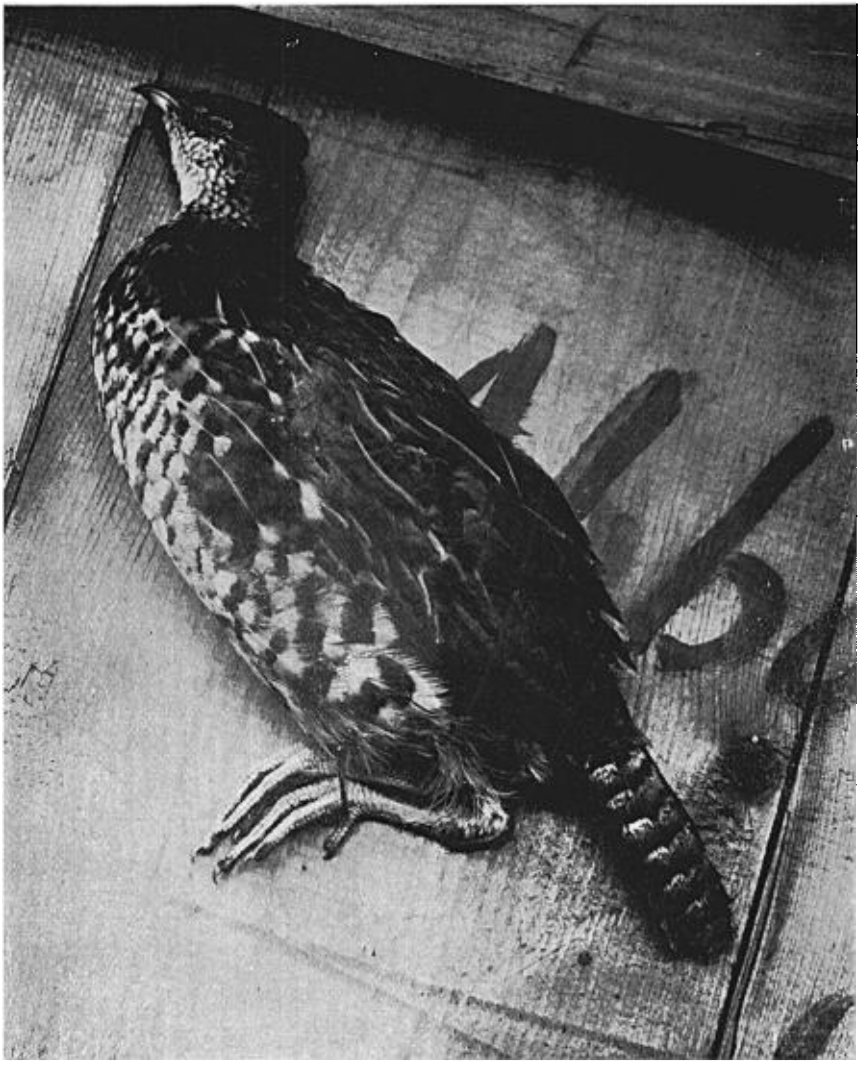


FIG. 1 .SIDE VIEW OF DEAD GROUSE TO SHOW COLOR GRADATION.

FIG. 2. GROUSE POSED ON THE GROUND AS IN LIFE.

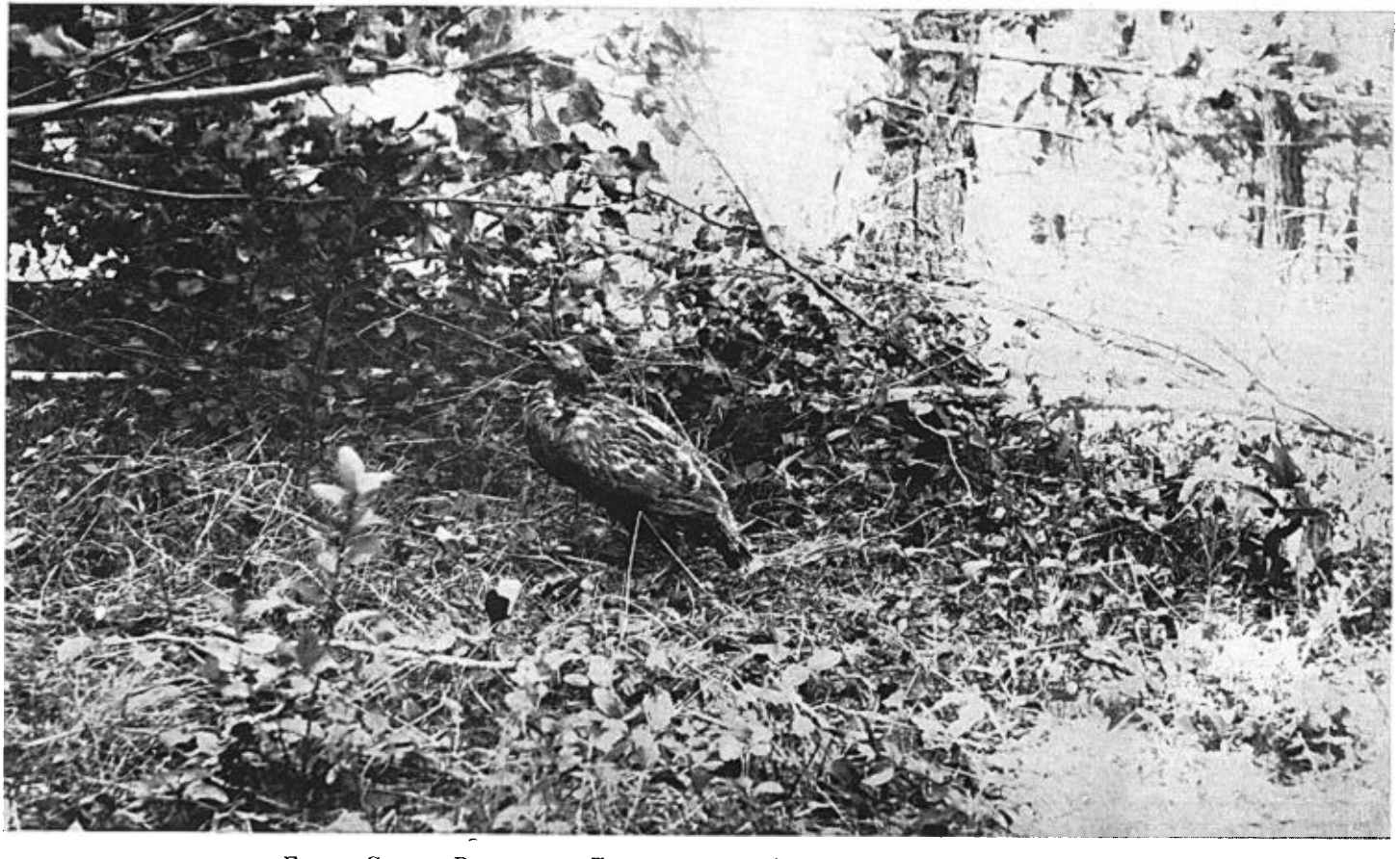


FIG. 3. GROUSE POSED AS IN FIG. 2 BUT WITH COLOR GRADATION PAINTED OUT.

Fig. 4. Grouse on Side, Exposing Breast.

Fig. 5. Grouse on Side, Exposing Back.

Fig. 6. Woodcock on Side, Exposing Back.

Fig. 7. Woodcock on Side, Exposing Breast.

FIG. 8. WOODCOCK ON NEST.

FIG. 9. WOODCOCK ON NEST, COLOR GRADATION PAINTED OUT.

The reason of her visibility is that I have artificially extended her top colors down her sides, thereby destroying her counter-gradation and forcing her solidity to manifest itself.

The reader, I think, must try these experiments for himself before he can believe that in Fig. 3 and Fig. 9 I tinted the under surfaces exactly as dark as the upper, and no darker. But I beg him to look at any horizontal branch in the woods which is either on the level of his eye or below it. He will see that although it has exactly the color of its surroundings, it is not in the least concealed, because, being of uniform color above and below, like the birds after I had painted their under sides, it wears that universal attribute of a solid, namely, a gradation of shading from its light side to its dark side.

I leave to the reader the pleasure of discovering for himself that this principle of gradation in color is almost universal in the animal kingdon. In certain classes of birds and of flying insects, however, the principle gives place, more or less, to the device pointed out by Bates; namely, the employment of strong arbitrary patterns of color which tend to conceal the wearer by destroying his apparent continuity of surface. This makes, for instance, the Mallard's dark green head tend to detach itself from his body, and to join the dark green of the shady sedge; or the ruby of the Hummingbird to desert him and to appear to belong to the glistening flower which he is searching. Yet many other cases of color applied apparently at random conform essentially to the law stated above. The dark patches are on top, the light ones beneath.[1] The dark breast-mark, so widely used by nature on birds, usually has the effect of putting out a conspicuous and shining rotundity of some bright or light color, as in the Meadow-lark and the Flicker; because it comes just where the breast, in its usual position, rounds upward and faces the sky. The dark collars of the males of most species of Duck are absolute counter-shading to the light from the sky, when the birds sit in their characteristic positions. For most female Ducks

[1] I have proved, by experiments with painted decoys, that even brilliant top-colors, however strongly contrasted to surroundings, scarcely tend to betray the wearer, if his ensemble be a gradation from dark above to light below.

nature uses the complete gradation, like that of Grouse and Sandpipers. Ground birds in general, such as Grouse, Sandpipers and Sparrows, are usually clothed throughout in colors graded according to this principle. But the males of many species of Pheasant are notable exceptions to this last statement.

Now there is still one more very beautiful phenomenon to record. If the animal itself is obliterated by this mechanism of nature, for what useful purpose beyond considerations of sexual selections do his *markings* exist, since *they* are not obliterated? The answer is that the markings on the animal become a picture of such background as one might see if the animal were transparent. They help the animal to coalesce, in appearance, with the background which is visible when the observer looks past him. In many birds, for instance, those colors, which would be seen by an enemy looking down upon them, are laid on by nature in coarser and more blotchy patterns than are the colors on their sides, so that when you look down on them you see that their backs match the mottled ground about them; whereas, when you assume a lower point of view nearer their level, and see more and more of their sides, you find them painted to match the more intricate designs of the vegetation which is a little farther off, and which, from this new stand-point of the observer, now forms the background. In this latter position, the head of the animal, being the highest part of its body, is seen against the most distant part of the background, whose details are still more reduced by perspective. To correspond with this reduction of strength in the more distant background, the details on the sides of the animal's head are likewise reduced in their emphasis, and like the more distant details are smaller in pattern.

It is a most significant fact that throughout the animal kingdom the highest development of the arrangement of color and light described in this article, and the highest development of the habit of standing or crouching motionless in full daylight to avoid discovery, seem to coincide very closely. For instance, Gallinaceous birds, most Waders, and the Cat tribe have both the color arrangement and the standing or the crouching habit highly developed. Contrasted with these, for example, are the skunks

and the bears. Neither of these quadrupeds has the gradation of color, nor the standing or crouching habit. They are both nocturnal, and therefore do not need either gradation or crouching for concealment.

It is plain, then, that while nature undeniably completes the concealment of animals by pitching their whole color-gradation in a key to match their environment, the real magic lies in the gradation itself from darkest above to lightest below, wherever this gradation is found. This is why it is so hard to see the Partridge in the tree, the Sandpiper on the mud, or the tiger crouching in the jungle.

DESCRIPTIONS OF A NEW HORNED LARK AND A NEW SONG SPARROW, WITH REMARKS ON SENNETT'S NIGHTHAWK.

BY LOUIS B. BISHOP.

THE birds upon which this paper is based were collected by Mr. W. H. Hoyt and myself in Towner and Rolette Counties, North Dakota, during the spring and summer of 1895. Both counties belong to the prairie region, are practically treeless, cultivated only partially, and dotted with lakes and sloughs of varying extent. The Turtle Mountains, part of which lie in the northern part of Rolette County, and through which passes the Manitoba boundary, are utterly different in character. They consist of hills rising a few hundred feet above the rolling prairie, contain numberless small lakes and ponds, and are covered with a dense growth of deciduous trees.

My thanks are due to Mr. Hoyt for the use of his series of skins of the races described, and to Dr. Allen and Mr. Chapman of the American Museum of Natural History, and to Mr. Ridgway of the Smithsonian Institution, for the privilege of comparing my birds with the collections of the respective museums.