in references the volume is not indicated by the boldface type as is customary.

The above-mentioned defects are not of a serious kind and can be corrected in the second edition. As it stands, the book will be very useful in awakening interest in comets among amateurs and as a reference book for professional astronomers.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

FIBER TAGS FOR WET SPECIMENS

TAGS bearing catalogue numbers or other entries for the identification of single specimens are an indispensable item in various museum and laboratory collections of objects preserved in fluid. It is obvious that such makeshifts as paper and tape labels are to be avoided, since the first requisite of a tag is permanence. The tag should be made of a durable material which withstands handling and resists disintegration in preserving fluids; the entry which it bears must be permanently clearly legible, and the attachment to the specimen must be secure.

A variety of permanent tags have been devised. Strips of sheet tin, stamped with number dies, may be seen in some zoological collections; these occasionally corrode in preserving fluids. Payne[1] seals a small paper label within a piece of glass tubing, bent into a loop at one end for insertion of the thread for tying. Robertson[2] and Pollock[3] present accounts of the employment of fiber tags in the storage of pathological specimens, at the University of Minnesota and the Mayo Clinic, respectively. Dr. Maude Abbott, in a personal communication, commends the fiber tags, stating that they have been used for some years in the Medical Museum at McGill University. Several years ago the writer, then unaware that the material had been so employed, chanced upon fiber composition for the manufacture of tags. Inquiries indicate that such tags are not generally known, and this note is presented with the aim to emphasize their desirable features. Fiber tags have been used in our laboratory over a period of several years for anatomical specimens preserved in formalin, alcohol, Kaiserling and Bouin's fluid.

Sheets of "vulcanized fiber composition" of different thicknesses and in three colors (red, black and white) are obtainable from dealers in electrical supplies. I have been using the 1/16 inch thickness (red), though a thinner stock may be as serviceable and is perhaps even more suited to tags of small size. The material is sold by weight. A sheet measuring 3 x 3 feet, 1/16 inch thick, retails for about $2.50. The sheet is cut readily with a paper cutter or heavy shears into tags of the desired dimensions (in this laboratory, about $\frac{1}{2}$ x $1\frac{1}{4}$ inches). The tags are punched at one end for tying, and stamped with dies (in this laboratory, numbers $\frac{1}{4}$ inch high) to register the accession number of the specimen. Deep, clean-cut impressions are insured if the tag rests on a block of iron during stamping.

After some hours of immersion in fluid the tag undergoes a just appreciable swelling and becomes slightly limber. Excepting this initial change no alteration can be detected.

The features of the fiber tag may be summarized as follows: (1) permanence and practicability, evidenced by actual service in at least four institutions; (2) simplicity of manufacture; (3) low cost.

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SPECIAL ARTICLES

WESTERN DUCK SICKNESS PRODUCED EXPERIMENTALLY

FOR the past two decades mortality among waterfowl in western states has attracted the serious attention of conservationists. During certain of these years losses among ducks and shore birds have been so great at some points as to make the annual toll taken by hunters appear insignificant. In 1910 untold thousands of waterfowl perished in the marshes about Great Salt Lake, Utah, and the years immediately following saw a recurrence of the sickness but, fortunately, in reduced severity. Yet even under these improved conditions it was necessary to bury the bodies of nearly 50,000 ducks at the mouth of Bear River, Utah, in the period from September 7 to 26, 1913.[1]

In 1914 the Bureau of Biological Survey undertook a study of the malady, assigning Dr. Alexander Wetmore to the task. The summer and fall seasons of 1914, 1915 and 1916 were devoted to the work and the results published in two papers, a preliminary report[2] in 1915 and a final bulletin in 1918[1] (refer-

[1] J. F. Payne, "A Permanent Tag for Museum Specimens," Intern. Assoc. Med. Mus., *Bull.* 8, 1922.
[2] H. E. Robertson, "Difficulties Encountered in the Condensation of Museum Material," *ibid.*
[3] M. Pollock, "Methods for Concentration of Museum Specimens," *ibid.*, *Bull.* 10, 1924.

[1] Alexander Wetmore, "The Duck Sickness in Utah." U. S. Dept. Agri. Bul. 672, pp. 1–26, pls. 4, 1918.
[2] Alexander Wetmore, "Mortality among Waterfowl around Great Salt Lake, Utah," U. S. Dept. Agri. Bul. 217, pp. 1–10, pls. 3, 1915.

ence above). The conclusion reached at that time indicated that the duck sickness in Utah was caused by the toxic action of certain soluble salts found in alkali and pointed to the chlorides of magnesium and calcium as two of the causative agents.

Since 1918 records of the occurrence of duck sickness have shown it to be a wide-spread yet localized malady. Roughly, the range of the disease in the United States conforms to the region of alkaline waters, yet its prevalence by no means coincides with the degree of concentration of alkali. Certain lakes of rather high alkalinity have been found to harbor waterfowl in numbers year after year with no ill effects on the birds, while other waters and marshes of nearly fresh water have experienced outbreaks of great severity precipitated apparently by such factors as low-water level and high temperatures. Under such conditions the attendant phenomenon of profuse decay of vegetable and animal matter often has been reported.

It was, therefore, with the idea of learning whether factors other than alkali might enter into the problem, particularly at points away from the influence of the highly saline conditions at Great Salt Lake, that the Biological Survey resumed its study of this malady. The area chosen was the region of Upper and Lower Klamath Lakes, Oregon, and Tule Lake, California. Preliminary work was started in 1927 when Mr. C. C. Sperry made observations and conducted experiments during August and September. No work was done in 1928, but for the past two seasons the writer has been engaged in this work.

Experiments were conducted along the usual lines of approach. There was feeding of natural and synthetic alkali both by the capsule method and through the medium of drinking water. There were attempts to transmit the disease by the feeding of body tissues of sick birds, and by inoculation in various manners commonly employed in conveying bacterial diseases. The conditions of vegetable and animal decay prevalent in duck sickness areas suggested other experiments and attempts also were made to demonstrate the possibility of certain anaerobic bacteria as a basis of the ailment. All these failed to give anything tangible or consistent in results. Birds were killed in the course of some of the experiments and now and then an isolated or fleeting symptom of duck sickness appeared, but nothing approaching the typical malady was produced or transmitted. Subsequent chemical analyses of waters and muds from sickness and non-sickness areas likewise failed to shed any light on the subject and until the middle of the present summer the whole problem seemed to be in more of a maze than ever.

About that time, however, a clew, revealed by the fortuitous circumstance that I was inadequately prepared to preserve under refrigeration certain body tissues of sick birds that were being fed to gulls in an attempt to transmit the disease, led to a series of experiments giving results wholly unexpected in the light of earlier investigations of duck sickness. Without going into detail at this time, the principal findings may be stated in the following language:

(1) Duck sickness symptoms, including the paralysis or weakness of the wing, leg and neck muscles, the paralysis of the nictitating membrane, discharges from the eyes and nostrils, difficulty in breathing, a lowered body temperature, and green diarrhea, all have been accurately and repeatedly reproduced by the feeding of the incubated body tissues of birds that have died of duck sickness after this material has been kept at a temperature of 85° Fahrenheit for 5 or more days.

(2) Allowing for variations due to the factor of individual susceptibility, the rapidity and severity of the onslaught of symptoms appears to be directly proportional to the quantity of material fed. With mallards and pintails, single doses of from 1/20 to 1/10 gram have permitted the birds to recover within four to six days in some of the cases, while doses as great as 1/2 gram to 1 gram usually have proved fatal within 12 to 24 hours.

(3) The virulence of this toxic material appears greatest when derived from birds that are the same, or are closely related to, the species being treated. Much still remains to be learned by experimentation in this direction, but up to the present time the writer has been unable to produce duck sickness symptoms in gulls by feeding material derived from any species of duck, and, in like manner, material from pintails appears more toxic to individuals of that species than to mallards.

(4) Even under the limitations of a field laboratory, it has been noted that certain batches of "incubated" tissues of birds dying of duck sickness do not become toxic. In such cases the difference in condition often is visible to the unaided eye, as, for instance, when liquefying bacteria become dominant and decomposition follows along a line quite different from that which gives toxic results.

(5) Although most of the results were obtained from incubated liver, later experiments indicate that material other than the liver may serve as a source of toxic material. Incubated blood taken from the carotid artery gave positive results in a recent experiment, and decomposed kidneys likewise have produced duck sickness symptoms.

(6) As a check against these experiments the nontoxic character of decayed liver of healthy ducks as well as of certain of the lots prepared from sick

birds (see paragraph No. 4) has been shown by experiment.

(7) The percentage of mortality among the birds made sick experimentally has been much greater than what occurs in the field. This is due partly to the excessive doses administered in early work; and partly to the fact that the great majority of sick birds brought in from the field for observation are sublethal cases. Birds given reduced doses, however, recover in the same manner and in about the same time as do those collected in the field.

(8) The faithfulness and consistency with which duck sickness symptoms are produced by this method has never been even remotely approached in any experimental work that the writer has done through the feeding of natural or synthetic alkalies.

(9) Not only have duck sickness symptoms been conveyed from the body tissues of a bird sick in the field to a healthy experimental bird by the method described, but this second bird has furnished toxic material for a third; the third in turn, for a fourth; and the fourth for a fifth. There seems to be no loss in virulence and, in fact, if any change has taken place, potency has been increased by this process.

(10) An extract of the toxic liver in normal salt solution prepared at the rate of 1 gram of decomposed liver to 5 cc of the solution, which is then filtered or allowed to settle, has permitted the injection of the toxic material into the abdominal cavity with equally typical and even more effective results. By this method material obtained from ducks has produced duck sickness symptoms in gulls, and, strange though it may seem, an extract of the incubated liver of a juvenile prairie falcon served as a means for conveying the trouble in an aberrant and mild form to a chicken and a domestic cat.

(11) Material obtained from the Bear River Marshes at Great Salt Lake has given results identical in every respect with that collected in the Klamath region.

(12) On the basis of a single experiment, it appears that boiling heat for about five minutes at this altitude (4,137 ft.) destroys the toxicity of the material.

(13) Contraction of duck sickness in the field does not establish an immunity to the symptoms as produced by this method, since birds that have recovered from duck sickness have been used two and three times in these experiments with positive results.

(14) An individual experiment performed by Mr. Sperry in 1927 in which he produced what appeared to be duck sickness symptoms by feeding liver to a duck over a period of nearly three weeks becomes explainable through the likelihood that, at some point in the feeding operations, the tissues on hand had "incubated" sufficiently in a period of hot weather.

In the foregoing the writer, an ornithologist, whom circumstances have thrust into the midst of a most baffling pathological problem, has aimed to present only such facts as have been learned from experimentation. Prudence forbids speculating at this time beyond what has actually been demonstrated, even though the results attained are highly suggestive and even though definite theories have been entertained as a help in directing the study. What has been accomplished appears to be just a beginning with much work yet to be done by specialists. Material has been gathered for histological, pathological and bacteriological studies which, as they are pursued during the coming months, may add even more startling chapters to an already intriguing subject.

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WESTERN DUCK SICKNESS AND BOTULISM

THE symptoms observed in ducks suffering from what is called "duck sickness" are characteristic of botulism as it appears in birds. Several samples of mud and water from an infected area in Tule Lake, California, were collected by one of us with the assistance of Mr. E. R. Kalmbach of the Biological Survey, during the summer of 1930, and while the outbreak of duck sickness was at its height. Bacteriological examination of the mud disclosed the presence of *Clostridium botulinum,* Type C. The primary cultures of the mud produced a toxin of rather high potency for guinea pigs (m.l.d. less than 0.001 cc for a 250 g pig); per os the m.l.d. was 0.05 cc. The m.l.d. for a domestic mallard (per os) was found to be 0.005 cc per gram of body weight.

Furthermore, *C. botulinum,* Type C, has been cultured from the tissues of wild mallards, pintails and ring-billed gulls that had died of or were killed while afflicted with "duck sickness." The clinical picture coupled with the isolation of botulinus organisms from the mud of Tule Lake and the sick birds themselves suggests that duck sickness is produced by the toxin of *Clostridium botulinum,* Type C.

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