Recent American literature on Freshwater biology.

By C. Juday (Madison).

- 216) **Doolittle, A. A.**, Descriptions of Recently Discovered Cladocera from New England. Proc. U. S. Nat. Mus. 1911, vol. XLI, p. 161—170, pl. 13—19.

The author gives a detailed description of *Parophyoxus tubulatus*, which represents a new genus as well as a new species, and *Chydorus bicornutus*, nov. sp.

- 217) **Greene, C. W.**, The Migration of Salmon in the Columbia River. Bull. Bur. Fisheries 1911, vol. XXIX, p. 131—148.

In a preliminary experiment, 59 specimens of salmon, representing 3 different species (25 *Oncorhynchus tshawytscha*, 16 *O. kisutch*,

449

18 *Salmo gairdneri*) were obtained near the mouth of the Columbia river, were marked with aluminum tags, and were then liberated at the point where they were captured. Only 17 individuals, however, were retaken and reported. From the preliminary data, the author reaches the tentative conclusions a) that salmon may take from 30 to 40 days to pass through the brackish waters at the mouth of the river, considerable time being spent in swimming back and forth in tide water during acclimatization to fresh-water; b) that, after reaching fresh water, *O. kisutch* and *S. gairdneri* ascend the river at an average speed of from 9.5 km to 12.0 km per day.

218) **Hankinson, T. L.**, An Ecological Study of the Fish of a Small Stream. Trans Ill. Acad. Sc. 1910, vol. III, p. 1—8, 1 pl.

The author is studying the fish fauna of a small stream which he designates as Campus creek. Throughout most of its course the stream is broken into a series of pools with intervening narrows or broad shoals. The average depth of the pools is a little more than half a meter. Seventeen species of fish have been found in the creek; but only seven are common and permanent inhabitants.

The chief problem is to determine the type of habitat preferred by each species and its relation to the surroundings.

The author finds it difficult to determine which are the preferred habitats because there are not only annual and seasonal variations in local distribution, but also daily and even hourly ones. The more obvious factors affecting local distribution are barriers, the current, food, temperature and shore vegetation.

A barrier at the mouth of Campus creek prevents the entrance of fish from the stream into which it flows, except during unusually high water. Leaf dams sometimes form in the stream at various points and serve as barriers to upward migration. The common species of fish occupy the pools during the daytime but the shoals with rapidly moving water constitute their chief nocturnal habitats. The current also affects distribution indirectly by affecting the bottom topography of the stream. The direct effects of food and the temperature of the water on distribution, have not yet been worked out. The shore vegetation contributes to the formation of overhanging banks which afford hiding places.

219) **Morgan, Ann. H.**, May-flies of Fall Creek. Ann. Entomo. Soc. Amer. 1911, vol. IV, p. 93—119, pl. 6—12.

Fall creek, which forms one of the boundaries of the campus at Cornell University, has an abundant May-fly fauna.

The author studied representatives of 17 different genera, especial attention being given to the life history, to the habits of both imagoes and nymphs, and to the structural adaptations of various nymphs. The change of nymphs to sub-imagoes was observed in *Blasturus cupidus* Say; the mating flight of *Ephemera simulans* Walker, *Blasturus cupidus* Say, and *Leptophlebia praepedita* Etn; the egg-laying of *Baetis pygmaea* Hagen; and the burrowing movements of *Hexagenia variabilis* Eaton.

The nymphs of the Heptageninae are found only in the rapid waters and they show structural adaptations which reduce their resistance to the current. No male specimens of *Ameletus ludens* Need were found and it is suggested that this species may present a case of parthenogenesis.

- 220) **Smith, B. G.**, The Nests and Larvae of *Necturus*. Biol. Bull. 1911, vol. XX, p. 191—200.

The eggs of *Necturus* were found attached singly to the bottom of large flat stones in Lake Monona where the water was 1 m to 1,5 m deep. The eggs averaged about 66 per nest and they hatched either the latter part of June or early in July.

In color the larvae are dark brown on the dorsal and lateral surfaces with a conspicuous light yellow dorsolateral longitudinal stripe. The ventral surface is pale yellow, almost transparent. The color pattern reaches its maximum development in specimens having a body length of about 55 mm; from this time on there is a gradual change to adult color characters.

- 221) **Forbes, S. A.**, Chemical and Biological Investigations on the Illinois River, Midsummer 1911. Ill. State Lab. of Nat. Hist. 1911, p. 1—9.

Investigations were undertaken to learn as much as possible concerning the breeding grounds and habits of the more important fishes of the central part of the Illinois river. The most important breeding ground discovered has an area of about 240 ha and careful estimates show that carp may deposit about one and a half billion eggs here during a single favorable season. A large amount of decaying organic matter is found on this breeding ground and fungous growths derived from this source cause a loss of 90 to 98 per cent. of the eggs. The largemouth black bass breeds to a certain extent on this ground also but the loss among its eggs from fungous growths is not so great because this fish builds a nest, clearing away the rubbish before the eggs are deposited.

The quantity of plankton found in the river in 1909 was between two and three times as much as it was previous to the opening of the drainage canal. Through this drainage canal and through the Des Plaines river, the Illinois river receives a very large amount of sewage from Chicago and its suburbs, and investigations were made to determine the effect of this on the dissolved oxygen content of the water. In July and August 1911 it was found that more than 40 km of the upper portion of the Illinois river served as a septic basin, containing a large amount of sewage in an advanced state of decomposition. The gases arising from this decomposing material were identical in composition with those obtained from septic tanks of sewage systems.

Only a small amount of dissolved oxygen was found in this portion of the river, the averages being from 7,5 to 9,8 per cent. of the amount required for saturation, with a minimum of 0,5 per cent., and a maximum of 21. No fishes were found in this section of the river. At the lower end of this section the water flowed over a dam about 4 m high which helped

to aerate it, yet a little more than a kilometer below this dam the water contained only 24,8 per cent. of the oxygen necessary for saturation. From this point on down the river as far as tests were made, about 108 km. below the dam, the dissolved oxygen gradually increased in amount, reaching a maximum of only 49 per cent. of saturation, however, at the point farthest down stream where samples were taken.

After the work had been in progress for some time a rain fell which was heavy enough to cause the water to rise a few centimeters. This flood water brought in a large amount of decomposable matter besides the sewage, and the decay of this additional organic matter caused a decrease of about 50 per cent. in the oxygen content of the water.

222) **Scott, Will**, The Fauna of a solution Pond. Proc. Ind. Acad. Sc. 1910 (1911), p. 395—443.

The pond on which this faunal study was made is situated near the crest of an old monadnock and is isolated from similar bodies of water, the nearest being more than 3 km. distant. It is oval in shape, being about 21 m. long by 17 m. wide, and has a maximum depth of a little more than 1 m. The basin occupied by the pond was formed by the solution of limestone; the outlet of the original sinkhole became obstructed and the basin filled with water, forming a pond. This body of water is gradually becoming extinct, the maximum depth being a little more than 2 m. in 1887. The deposition of plant debris and silt are the chief factors concerned in the destruction of the pond.

The observations on this pond were made between October, 1908 and May, 1911. Plankton catches were made by means of a pump and hose. The protozoa were represented by a number of forms, the rhizopod *Diffugia* and flagellate *Euglena* being most abundant. The former reached a maximum number of 398 per liter and *Euglena viridis*, 275. Ten species of rotifers were found, — *Anuraea aculeata*, *Hydatina senta*, and *Monostyla lunaris* being the most abundant forms. The rotifer population was small in winter and showed a marked development during the latter part of April. Cyclops showed two maxima, a slight one in April and an enormous one in August. *Simocephalus vetulus* was numerous at all seasons. *Alona quadrangularis* was present in small numbers in 1910, and a few *Daphne pulex* were found in spring and early summer.

A number of aquatic insects and aquatic insect larvae were found from time to time and three species of gastropods were present.

The summer of 1908 was very dry and during the drouth the pond dried up, thus giving the author an opportunity to study the development of its new fauna. The wind and water-birds are considered as very important factors in restocking the pond.

The food relations of the various forms were studied. Material was collected from other solution ponds for comparison, but this part of the work has not been completed.

223) **Shelford, V. E.**, Ecological Succession. I. Stream Fishes and the Method of Physiographic Analysis. Biol. Bull. 1911, vol. XXI,

p. 9—35. — II. Pond Fishes. Ibid., p. 127—151. — III. A reconnaissance of its Causes in Ponds with Particular Reference to Fish. Ibid., vol. XXII, p. 1—38.

While experimenting on the modification of the taxonomic characters of tiger beetles, the author's attention was called to the striking relations of these beetles to environmental complexes and he began to study animal ecology. The first problem taken up was the distribution of various species of fishes in several streams which differ in character and age.

Ecological succession is defined as the "succession of ecological types (physiological types, modes of life) over a given locality, due to changes of environmental conditions at that point". That is, as a stream grows older and develops a larger and larger valley, the physiographic or environmental conditions of a certain locality will change and this environmental change will be accompanied by a change in the fish fauna. In other words, fishes have definite habitat preferences. The first fishes to invade a young stream will be found at the headwaters of older streams.

The same species will be represented in substantially the same order in neighboring streams which possess a similar series of environmental conditions.

The author thinks that the migration of conditions for breeding is an important factor in causing the breeding migration of fishes, but reactions outside the breeding season may often be more important than this factor.

For ecological succession in ponds, the author studied the fish fauna of a series of ponds which are situated at the southern end of Lake Michigan. These ponds are found between a series of ridges representing old beaches of the ancient Lake Chicago, which existed in the glacial period during the retreat of the ice from this region. These ridges were formed in successive stages in the history of Lake Chicago and therefore they, as well as the ponds between them, are arranged in the order of their age, the oldest being furthest from Lake Michigan. The age of the ponds is determined by their physiographic history, by the relative amount of humus and bare bottom, and by the quality and quantity of vegetation. A study of the fishes inhabiting these ponds shows that the various species are arranged in an orderly fashion. That is, species requiring clean, pure water and little vegetation, are found in the youngest ponds, while only those species will be found in the oldest ponds which are able to live in the presence of large accumulations of vegetable debris and dense growths of aquatic vegetation, and intermediate forms will be found between these extremes.

The author reaches the conclusion that the horizontal series of fish communities represented in these ponds is ecologically representative of the succession of fish communities within the older ponds — the ponds of different ages thus representing stages in the history of older ponds.

In the third paper of this series the author considers the causes of the ecological succession of fishes and other organisms in the ponds mentioned in the second paper. For this purpose the physical character of the ponds, the substances dissolved in the water, and the biological content, were studied. It was found that size, depth, temperature, and quantity of substances naturally dissolved in the water, except oxygen, did not enter as factors

in determining the distribution and succession of fishes. Likewise the quality of the food had no influence. Two sets of observations showed that bacteria were more abundant in the older ponds than in the young ones, and six sets of plankton catches gave larger numbers of crustacea for the former.

The older ponds had a larger amount of vegetation and the decay of this organic material caused a decrease of the oxygen content of their waters. The bottom water of the oldest pond contained very little or no dissolved oxygen during the breeding season. This would cause the destruction of some of the fish eggs deposited by some of the fishes on the bottom, and other aquatic animals might be affected in the same way, hence animal succession.

- 224) **House, J. L.**, Crustacea of Winona Lake. Proc. Ind. Ac. Sc. 1910 (1911), p. 129—133.

During the months of July and August, 1908 and 1909, the author made a study of the crustacean fauna of Winona Lake, Indiana. The entomostraca consisted of 21 species of cladocera, 17 species of copepods, one of which was parasitic, and one ostracod. The larger crustacea consisted of three species of crayfishes, one amphipod, and two isopods.

- 225) **Turner, C. H.**, Ecological notes on the Cladocera and Copepoda of Augusta, Georgia, with descriptions of new or little known species. Trans. Acad. Sci. of St. Louis. Dec. 31, 1910, Vol. XXIX, p. 151—176, Pls. XXXVI—XXXVIII.

Collections of micro-crustacea were made regularly for a period of more than a year in artificial ponds, creeks, marshes, and ditches in the vicinity of Augusta, Georgia. The material yielded 39 species in all, 15 copepoda and 24 cladocera. The species, *Diaptomus augustaensis* and *Bosmia reversaspina*, are described as new. Tables are given, showing the associations of the various forms, the distribution according to temperature, and distribution according to habitat.

Not a single cladoceran was found which bore winter eggs, in spite of the fact that many of the collections were made in water having a temperature only a little above zero, the water being covered with a thin layer of ice in some instances.

- 226) **Parker, H. N.**, Note on a growth of *Synura* in Lake Cochituate. Trans. Amer. Micro. Soc. 1911, Vol. XXX, p. 141—144.

The author describes an unusual growth of *Synura* which was found in Lake Cochituate between August 6 and September 21, 1900. The organism was not found nearer the surface than 4,5 m. nor deeper than 12 m. The limitation to this zone of the lake is attributed to temperature. No specimens of *Synura* were found in water which had a temperature above 19,2° C. nor below 6,4°. The maximum number was at 8 m. to 9 m. where the temperature was 9,2° to 10,4°. The growth terminated suddenly but the cause of the termination could not be determined.

- 227) **Elrod, M. J.**, The Lakes of the Glacier National Park. Trans. Amer. Micro. Soc. December 1910, Vol. XXIX, p. 111—116, pls. IV—VI. Ibid. January 1912, Vol. XXX, p. 11—16, pls. II—IV.

Glacier National Park is situated in the northwestern part of Montana and comprises a rugged, mountainous country with some peaks reaching an altitude of more than 3000 meters. About 250 bodies of water, varying in size from mere tarns to those which have a maximum length of 20 kilometers, are found in this area. Some of these lakes were visited by the author in 1909 and 1910 and a general account of the physical and biological observations on Avalanche and Louise lakes is given in these articles.

- 228) **Howland, Ruth B.**, Migration of retinal pigment in the eyes of *Branchipus gelidus*. Journ. Exp. Zool. 1911, Vol. XI, p. 143—158.

Light and darkness produce a readjustment of the pigment granules in the eye of this crustacean rather than a proximal and distal migration. Changes in the intensity of the light had no effect on the distal pigment. When exposed to bright sunlight or diffuse daylight, the pigment granules collect closely around the rhabdoms, while in the dark the granules move laterally and become more evenly distributed through the cytoplasm of the reticular cells. It requires from four and a half to five hours to complete this readjustment. Variations in temperature from 5,5° to 17° have no appreciable effect on the migration of pigment. *Branchipus gelidus* is positively phototropic but when exposed to light after remaining in the dark for five hours it is negative.

- 229) **McGinnis, Mary O.**, Reactions of *Branchipus serratus* to light, heat, and gravity. Jour. Exp. Zool. 1911, Vol. X, p. 227—240.

The author found that *Branchipus serratus* is positively phototropic to lights varying in intensity from 12 to 280 candle power and they still remained so after being kept in the dark from 12 hours to six weeks. The vibrations of the swimming feet increase in number with increase in the intensity of the light, thus showing an apparent kinetic effect of light. The eyes appear to be the only sense organs capable of being stimulated by light. The animal responds positively to temperatures of 14° to 17° and avoids temperatures above or below this; a temperature of 28° is fatal. The geotropic reactions are positive in light and negative in darkness.

- 230) **Shull, A. Franklin**, Studies in the life cycle of *Hydatina senta*. II. The rôle of temperatures, of chemical composition of the medium, and internal factors upon the ratio of parthenogenetic to sexual forms. Jour. Exp. Zool., February 1911, Vol. X, p. 117—166. III. Internal factors influencing the proportion of male-producers. Ibid., February 1912, Vol. XII, p. 283—317.

The first paper gives an account of the results of a series of experiments which were made for the purpose of determining the effect of both external and internal factors on the relative number of parthenogenetic and sexual individuals produced. With respect to external factors, the author

found that the proportion of male-producers was practically the same at the average temperatures of 20° and 24,5° C. but at 10° the proportion of male-producers was decidedly higher in many cases than at 20°. In one case it was lower. The appearance of male-producers may be wholly prevented by employing a solution of horse-manure and boiling this solution does not affect the results. The following substances reduce the proportion of male-producers: Urea, amonium hydroxid, amonium chlorid, amonium carbonate, amonium nitrate, beef extract, and creatin. The effect of a high degree of alkalinity was not very marked and the results were not uniform but it seemed to decrease the number of male-producers sometimes.

With respect to internal factors, it was found that two pure lines, entirely unrelated, gave a constant difference in the proportion of male-producers, even when exposed to the same external conditions. When a member of one of these lines was crossed with a member of the other, the offspring gave a higher proportion of male-producers, no difference which of the original lines furnished the female parent. The zygote resulting from the mating of a member of a pure line derived from the crosses with a member of one of the original parent lines, gave rise to a line of offspring having a proportion of male-producers intermediate between those of the two parent lines of this zygote.

The second paper deals with internal factors exclusively. The author found that long continued parthenogenesis results in a progressive decrease of male-producers in some lines of these rotifers, perhaps in all, and a progressive decrease in the size of family of some lines. There seems to be no correlation between decrease in size of family and decrease in proportion of male-producers, however. The time required for the hatching of fertilized eggs varies from a few days to many weeks, but the length of time does not seem to be correlated with the proportion of male-producers in the parthenogenetic line derived from the egg. Measured by size of family, eggs requiring a long time to hatch do not produce as vigorous offspring as early hatching eggs. All fertilized eggs produce females which are all female producers. Whether a female derived from a parthenogenetic egg is to become a male-producer or a female-producer is irrevocably determined during the growth period of the egg, as far as manure solution is concerned. Sex is determined during the previous generation.

- 231) **Wodsedalek, J. E.**, Phototactic reactions and their reversal in the May-fly nymphs *Heptagenia interpunctata* (Say). Biol. Bull. 1911, Vol. XXI, p. 265—271.

The author found that practically all nymphs are negatively phototactic to daylight and to the light obtained from a sixteen candlepower lamp, but different individuals vary in the intensity of their negative response.

Various chemicals changed the response to light from negative to positive. Acids were most effective, salts less so, and alkalies are least effective in reversing the response to light.

- 232) **Coker, R. E. and Surbar, T.**, A note on the metamorphosis of the mussel *Lampsilis laevis*. Biol. Bull. 1911, Vol. XX, p. 129—182, 1 pl.

The glochidium of *Lampsilis laevis* belongs to the "axe-head" type. The larva increases markedly in size and undergoes a change in form during the parasitic stage.

- 233) **Isely, F. B.**, Preliminary note on the ecology of the early juvenile life of the Unionidae. Biol. Bull. 1911, Vol. XX, p. 77 bis 80.

The most favorable environment for the growth and early development of the Unionidae must possess the following factors: An abundance of dissolved oxygen, sufficient food, fishes which make suitable hosts, and freedom from shifting sand and accumulations of silt.

- 234) **Galloway, T. W.**, The common fresh-water Oligocheta of the United States. Trans. Amer. Micro. Soc. October 1911, Vol. XXX, p. 285—317.

The author gives directions for collecting, rearing, and making permanent preparations of oligochetes. These are followed by a description of the various structures used in distinguishing the different species and by synoptical keys to the common genera and species.

- 235) **Bean, B. A. and Weed C. A.**, Notes on the coloration of fishes. Proc. Biol. Soc. of Washington 1911, Vol. XIV, p. 69—76.

The authors describe the various color changes made by several species of fishes which were kept in aquaria for exhibition purposes.

- 236) **Cockerell, T. D. A.**, The scales of Freshwater Fishes. Biol. Bull. 1911, Vol. XX, p. 367—376.

The author studied the form and sculpture of the scales of a number of freshwater fishes representing various groups. He found that generally the scales possess characters which are of considerable taxonomic importance, but frequently the characters are deceptive owing to convergence, individual variations and difference in age.

- 237) **Jordan, D. S. and Evermann, B. W.**, A review of the Salmonoid Fishes of the Great Lakes with notes on the Whitefishes of other regions. Bull. Bur. Fish. 1911, Vol. XXIX, p. 1—42, VII col. pls.

This review of the salmonoid fishes of the Great Lakes is based on a large collection of material obtained in 1908 and 1909 during investigations by the International Fisheries Commission. Descriptions of the various species found in the different lakes are given and a synoptical key is given for the species belonging to the genus *Leucichthys*. The material shows that each lake has one or more species of the group called lake herrings or ciscoes peculiar to itself.

- 238) **Seal, W. P.**, Breeding Habits of the Viviparous Fishes *Gambusia holbrooki* and *Heterandria formosa*. Proc. Biol. Soc. of Washington 1911, Vol. XXIV, p. 91—96, 1 pl.

Specimens of these small fishes were kept in aquaria and their breeding habits were observed for several seasons. During the mating period the female resents the advances of the male and attacks him vigorously, these attacks sometimes proving fatal. The females give birth to young at intervals which may vary from several minutes to as many hours. The number of young extruded each time varies from two to 12. Two generations may be produced in one season.

- 239) Seal, W. P., Papers on Freshwater Aquiculture Presented Before the Fourth International Fishery Congress. Washington. Bull. Bur. Fish. 1910, Vol. XXVIII.

The various papers relating to freshwater aquiculture cover a rather wide range of subjects, treating more particularly of the habits, propagation, food, parasites, and diseases of fishes, and the propagation of mussels. With respect to the habits of fishes Reighard gives a very interesting account of the apparatus and methods employed by himself in studying various species. He describes a reflecting water-glass which is used in observing the fishes, and a reflecting camera which is used for photographing objects under water. The second part of the paper consists of an illustrative example of the method of observation, being an account of the breeding habits of the horned dace (*Semotilus atromaculatus*). The male builds the nest and guards it. The female may deposit all her eggs in one nest or she may deposit them in several. During the spawning act the male throws the female into a vertical position with her head up and her body is encircled by his. This spawning embrace lasts for a fraction of a second, during which time from 25 to 50 eggs are laid and fertilized. When the male has completed his nest he deserts it and it rapidly becomes covered with silt and is not easily distinguished from the surrounding bottom.

Gill's paper is a plea for observation of the habits of fishes. He calls attention to a number of errors that have been made by undue generalizations and points out that one cannot assume that closely related forms have similar habits.

Vincent, fish culturist of the Trocadero Aquarium at Paris, describes a number of devices for use in fish hatcheries and aquaria. He gives descriptions of an artificial pond with a siphoid outlet for regulating the height of the water, apparatus for cleaning hatching and rearing troughs as well as ponds and aquaria, an oxygenating and vacuum producing apparatus, and a scraper for preparing fish food.

Seal reports that experiments with various species of fishes show that a combination of the goldfish, the roach or shiner, two species of sunfishes which live among plants, and top minnows would probably prove to be more effective than other species in preventing the growth of mosquito larvae, especially of the genus *Anopheles* in pools and ponds used for the cultivation of ornamental aquatic plants.

In experiments made for the purpose of determining the best food for young salmonoid fishes, Atkins found that the young of Atlantic salmon gained much faster in weight when fed on fly larvae than when fed on chopped meat (chiefly butcher's offal), the difference being 53 per cent. in

favor of the former food. A second test showed a difference of 27 per cent. in favor of the fly larvae. A similar comparison between several lots of the young landlocked salmon showed only a slight difference in favor of the fly larvae. Several commercial foods were tested and were found to be unfit for the young of salmonoid fishes. Experiments on 18 lots of brook trout showed that those fed on chopped hearts and lungs of hogs grew most rapidly. Those fed on chopped fresh herring came next, and those fed partially on rye meal gained least.

A new method of packing fish for transportation to market is described by Sölling. The fishes are dressed, thoroughly washed in order to remove all blood, and allowed to drain a few minutes. Then they are wrapped in a special vegetable parchment paper and placed on ice. Experiments show that halibut so treated will remain fresh and firm and retain their full flavor for 31 days.

Franke found that *Costia necatrix* in salmonoid fry is prevented by abundant and constant aeration of the water. *Costia* spreads more rapidly when the fry are crowded and when the temperature of the water is above 10° C.

Vincent states that various species of trout fry are especially subject to disease of the gills and frequently are subject to the epidemic known as staggers. The most effective measures in both cases are those of prevention, the best of which is perfect cleanliness of both water and equipment.

Spencer reports that fungous growths have been killed on hundreds of fishes, belonging to many species, in the New York Aquarium by the application of hydrogen dioxide. This substance produced cures when treatments with salt solutions were unsuccessful.

Ward found that the Sebago salmon is infested with a comparatively small number of internal parasites, a total of but nine species at most. The various forms manifest a striking freshwater aspect. A new species of trematode, *Azygia sebago*, is described.

Scott found that, when fishes were transferred from sea water to fresh water, there was a decrease in the number of corpuscles per cubic millimeter, a lowering of the haemoglobin percentage, a lowering of the specific gravity, and a lessening of the depression of the freezing point, all of which showed a dilution of the blood. When put into sea water whose specific gravity had been raised by the addition of sea salt, there was an increase in the number of corpuscles, a loss in weight, and an increase in the specific gravity of the blood.

A series of experiments performed by Marsh led him to the conclusion that, for practical cultural purposes, a certain minimum of natural dissolved solids is necessary to make water suitable for fishes and that there is doubtless a maximum also, but a wide adaptability must exist. Substances not commonly found in natural waters are usually unfavorable in their action on fishes, such as copper sulphate, silver nitrate, zinc, lead, aluminum and even tin. Fishes are very susceptible to mineral acids.

Birge gives a brief account of the annual cycle of changes in the gases dissolved in the waters of Wisconsin lakes, particular attention being given to the oxygen and carbon dioxide. It is pointed out that a knowledge of

lacustrine physics and chemistry is just as necessary to the best utilization of the waters of lakes as a knowledge of soil physics and chemistry is to the best agricultural use of land.

Three papers discuss plans for promoting the whitefish production of the Great Lakes. The chief proposals made for accomplishing this end are extensive artificial propagation and a closed season covering the period when most unripe fish are caught. Only about one per cent. of the whitefish eggs are fertilized when they are deposited under natural conditions. This means an enormous loss which can be prevented by artificial fertilization and rearing.

Hoek gives a brief history of the propagation and protection of the Rhine salmon. Spawning takes place in November and December, but the different sizes of salmon enter the river and begin the ascent at different seasons. As a result they are found ascending the stream during practically every month of the year. Very few salmon escape and reach the spawning grounds to deposit their eggs in the natural way. Through an international agreement, however, the various governments concerned resort to artificial propagation.

Matsubara describes the various varieties of goldfish that are cultivated in Japan and gives the methods employed in rearing them.

Lefevre and Curtis give the results of some investigations which were made for the purpose of determining the practicability of cultivating freshwater mussels artificially. The breeding habits and life history of various species of mussels were studied. Many experiments on infecting various species of fishes with the glochidia show that five species out of the total number tried serve as excellent hosts — a single specimen of these fishes 8 cm. to 10 cm. long being able to carry a thousand glochidia through the parasitic period successfully. The results showed that various species of mussels are capable of artificial propagation and a biological station has been established by the Bureau of Fisheries for the purpose of propagating species which have a commercial value.

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