

GOLDFISH BREEDS
and
OTHER AQUARIUM FISHES

A Guide to Freshwater and Marine Aquaria
Their Fauna, Flora and Management

For presentation
to the Thirty-seventh Annual Meeting
of the American Fisheries Society,
Washington D.C., U.S.A. Sept. 21^{to} 23, 1908.

Compliments of the Author,

Herman T. Wolf



Japanese Fringetail Goldfish

Carassius auratus, var. japonicus pendulibicaudalis

From Life



Japanese Fringetail Goldfish
Carassius auratus, var. *japonicus pendulicaudalis*
From Life

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Fishes

Division of Fishes,
U. S. National Museum

Goldfish Breeds and other Aquarium Fishes

Their Care and Propagation

A Guide to Freshwater and Marine Aquaria,
Their Fauna, Flora and Management.
With 280 Explanatory Illustrations,
printed with the Text.



By
Herman T. Wolf

Formerly Secretary of the Aquarium Society of Philadelphia;
Member of the Academy of Natural Sciences and the Horti-
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AUTHOR'S PREFACE

TO the lover of Nature all forms of life are interesting and there is nothing of greater charm, more diverting or restful to the mind than observations of the natural phenomena of the world about us. The habits of land animals and plants are easily observed but the fascinating study of the ever-varying beauty of aquatic life presents greater difficulty, as the denizens of the water can only be kept alive for convenient observation when the natural conditions of their existence are understood and simulated; and to those not satisfied with the dried mummy forms of the specimen cabinet or of others in preserving fluids, the aquarium and terrarium offer the best aid to that liberal education which is acquired only by personal observation.

There is, however, probably no pursuit in the natural sciences more abused by false statements, crass ignorance of the subject, trickery of trade and wilful withholding of the truth, than the care and maintenance of the aquarium, the breeding of aquarium fishes, and the cure of their diseases. Let it be here stated that these are only troublesome when not correctly understood, and the laws governing the existence of the plants and animals violated, either from lack of information or by misleading counsel.

A simple and full elucidation of the correct governing principles is greatly to be desired, as technical zoological and botanical treatment would not accomplish the purpose, nor would books of that nature reach the general public. There are a number of good American and foreign publications which severally treat of the aquarium and its inhabitants, the culture of the goldfish, and the descriptions of freshwater and marine fauna and flora, for the use of the collector, but there is none of sufficiently wide scope to cover the entire field, and by concise, up-to-date, easily comprehensible descriptions and abundant illustrations to fully familiarize the subject to all readers, the novice, the amateur and the adept.

The author's interest in aquaria and the breeding of fine goldfishes first led him to make the drawings and later prepare the accompanying

text, as an interesting study and pleasant diversion, apart from any motives of profit. He has nothing to sell, nothing to conceal, nothing to withhold. It has been his earnest effort to give as complete an insight of the subject as is possible in a book of the present dimensions. He desires to bring statements of facts before the reader in simple, practical and readable form, to incorporate all obtainable accurate information and useful precept in easily understood terms, without enthusiasm; and where possible, impart explanations of the often puzzling phenomena which tend to mislead and discourage both the novice and the expert fancier.

Though the discussions of Aquarium Societies are unquestionably the best means of acquiring information and of removing difficulties, these are usually not accessible to the masses and are patronized more especially by adepts, novices not realizing that it is inexperience which leads to their many annoyances, and so losing confidence give up a recreation which should only animate to constantly increasing effort.

It is freely admitted that the herein contained information pertaining to the breeding and care of the goldfish, aquarium hints and kindred subjects, is the consensus of opinion and the recognized best practice of the members of the Aquarium Society of Philadelphia, as elucidated by the discussions and official transactions of the past eight years. The classifications and descriptions of the goldfish breeds and varieties are those recognized as its criterion upon which awards in competitions are made; and the drawings, with but few exceptions, accurate portraits of living fishes owned by members and attested to over their signatures. The classifications of the plants are those of Britton and Brown and other recognized American authorities.

Written on a flyleaf of a book which was probably the first American publication on the aquarium and its inhabitants is the following memorandum:—

August 7, 1858.

Completed the Aquarium.

Stock,

4 Goldfish

2 Carp

1 Crawfish

1 Turtle

Mit Gott.

Though much has been learned in the fifty years since the above was written, pertaining to the physiological principals governing aquatic existence, the properly conditioned aquarium, the marvelous toy breeds of the goldfish and other aquarium fishes, there still remains much which is unexplained and which may prevent the aquarium and terrarium becoming as much a feature of almost every household as potted plants,

the canary bird, the dog and the cat; and why the same success is usually not attained with fishes as with other domesticated animals. It is hoped that this book will remove some of these difficulties and enable all to indulge in this enjoyment to whatever extent they may be inclined.

In the preparation of this volume the author has made use of every available source for information, and is personally indebted for aid in various ways to Dr. Herman Burgin, Dr. Robert Formad, Dr. Henry Skinner, Dr. J. Percy Moore, Mr. Stuartson Brown, Mr. F. G. Vanatta, Mr. Henry W. Fowler, Mr. Wm. H. Hetzel, and Mr. Rudolph H. Wolf.

THE AUTHOR



CHAPTER I.

**History and Anatomy of
the Goldfish**

THE GOLDFISH

The beauty and hardiness of the goldfish has made it a household pet for centuries, and until comparatively recently it was the only domesticated fish. Its history and origin are lost in dim and distant ages, though from the earliest descriptions to those of the present day authorities agree that the fish was derived from the golden carp or a similar member of the Cyprinidæ, and originated in a lake near a high mountain named Tsienking, near the city of Tchanghou, in the province of Tche-Kiang; and thence distributed to other provinces of the Chinese realm. It was transplanted to Japan, and then brought to Europe, in the year 1611, where it was well-known in 1728. Later it was brought to the United States, where its propagation has become an industry of considerable magnitude.

Dr. S. Watase states that the goldfish was first introduced into Japan from China at the beginning of the sixteenth century; and subsequently, at frequent intervals, from China, Loo-choo and Corea. This first imported goldfish was what is now known in Japan as the "Japanese breed" or the "Wakin," having a slender body closely resembling that of the carp and probably like the common American and European goldfish. The Loo-choo goldfish, known as the "Riukin" has a short body, rounded abdomen, and a tail longer than the rest of the fish. The Corean goldfish, known as the "Maruko" or the "Ranchiu," is characterized by a very short body, which is often almost globular, and the absence of the dorsal fin. There exist various intermediate forms; and the Japanese goldfish breeders can freely produce the "Riukin" and "Maruko" from the "Wakin"; indicating that the latter is the primitive form.

Of the European authorities Pennant, in the tenth edition of *Systema Natural*, 1751, published drawings of several breeds, descriptions of which resemble those given by Linnæus; and show individuals with double anal and bifurcated and trifurcated caudal fins, which he designated as *C. pinna ani gemina, cauda transversa bifurca*. M. Baster, in 1765, on Plate IX, Vol. II, of *Opusculus subsiciva*, also illustrated six varieties of goldfishes which he had living in basins.

George Edwards, of the Royal College of Physicians of London, in 1756, mentioned on the subject of the Goldfish that "His Grace, the late Duke of Richmond, had a large Chinese earthen vessel full of these fishes brought to England. I drew some of them for his Grace with leave to make the drawings public. The first account of these fishes being brought to England may be found in Petiver's Works, published about 1691, though

they were not generally known till 1728, when a large number were brought over in the *Houghton Indiaman*, Captain Philip Worth, and presented by him to Sir Mathew Decker; since when they have been propagated in ponds in the neighborhood of London. They may now be esteemed a domestic fish."

Edward's colored engravings show five fishes having the general conformation of the ordinary goldfish but with double anal fins; one of blue color on the back and red sides; one all red with a "spiked" dorsal fin of four rays; one red and white with a distinctly "webbed" tail; and one having a brown back, white sides and red abdomen. All have the relative length of body, head and eyes of the common goldfish.

Dr. Elieser Bloch, in *Ichthiologie*, edition of 1784, describes the goldfish and mentions some kept alive by him in Germany. Three illustrations accompany the article. In a later volume there is one other illustration of which both the description and the appearance would lead to the inference that it was a native Chinese fish and the probable progenitor of the Chinese Telescope goldfish and its kindred varieties. His is an interesting description, part fact, part fancy, but worthy of reproduction here. Of the first-named three fishes, No. 1 is described as follows:—

"The head is of moderate length, the nostrils near the eyes, which have a dark star in a golden ring, the rest of the head being of a golden color; and the operculæ consist of two blades. The back is rounded and several black spots are noticeable. On the sides it is red with gold, and the abdomen reddish mixed with silver. Large scales cover the body. The sides are narrow and straight. The fins of the sides are carmine and the tail forked. I know of no fish of which the fins are more varied, as I have one which has a small dorsal of nine spines, others with it entirely absent; another has in place of the dorsal only a hump and a third two of these humps. One of these fishes has a double anal fin and a forked tail; with another the tail is unusually long and all the other fins relatively very much longer than usual. The double anal fins stand side by side, and the superfluous lobe of the tail grows in the centre. It would appear that the tendency of the absence of one fin occasions the duplication of another, which may have given rise to the culture of the fish. Remarkable is the fact that its color changes with age. In the first year it is usually black, a color which Nature often produces in minerals and quadrupeds, more seldom in insects, birds and plants, and never with fishes except these. After the first year silver spots usually appear which gradually extend in size until the fish assumes a silver grey appearance, after which it becomes red and more beautiful the older it grows; though it sometimes happens that after the red it assumes a permanent silver color. Occasionally it is red from infancy..... The fish possesses a brilliancy which is astonishing, as it throws a lustre from the glass of water wherein I kept it, like that of a glowing coal in the dark; but my pleasure did not last long, for after death, it was in spirits but a few days before the color disappeared, a circumstance which would indicate that the color is produced by a delicate mucus (slime) which covers the fish, as the spirits assume a red color as the fish lost it; a similar occurrence to what I noticed with the Schlampitzger, which lost its fine orange color on the abdomen as in holding it the mucus came off on my hand. What further induced me to adhere to this opinion is that the fish retains its color when dried or mounted, as the mucus dries on the surface and is preserved by the varnish."

This is a strange combination of correct and of faulty observations, interesting both on account of their antiquity and of the information which they contain.

The researches of both the author and of his friends leads to the belief that all the descriptions of the toy varieties of the goldfish, subsequent to 1780, and many of those which still pass current, are based upon a monograph and series of colored plates published in Paris in 1780. The constant recurrence of allusions and reference to this work and the almost identical phraseology in describing the fishes, would indicate that the first and probably only authentic information of the goldfishes of China was this monograph which the *Manual du Libraire* mentioned as the "Histoire Naturelle des Dorades de la Chine, par de Sauvigny; gravée par M. F. N. Martinet, accompagnée d'observations. Paris, 1780, gr. in-fol. col." and briefly states "There appeared but 24 pages with the frontispiece and 48 colored plates." These represent seven distinct breeds and eighty-eight varieties of Chinese goldfishes painted from nature by Panzy-Missionnaire and sent to the French Minister of State, N. Bertin, in 1772. Most diligent search and extensive inquiry failed to produce any further information of these most important documents, of which no copy then existed in any library in the United States, nor are they mentioned in the catalogues of the libraries of Europe; but in March 1904, through the instrumentality of the author, probably the only known copy was acquired by the Academy of Natural Science of Philadelphia.

In *Historie Naturelle des Poissons*, 1803, de Lacépède describes and illustrates three goldfishes. One of these he named *Cyprin Anne-caroline*. It has the head and body of the common goldfish, a long, low, 17-spined dorsal fin, extending over the back almost to the base of the tail, narrow paired fins, a single anal fin and the short caudal fin of the common goldfish, but deeply bifurcated. It has a brilliant gold and silver color on the head, back and side and yellow fins. The back is overlaid with streaks and spots of metallic black. The second illustration shows a scaled, slightly telescopic-eyed fish, with rather long body, fins like the common goldfish, but having a distinctly double tail, deeply bifurcated. This he calls *Cyprin Gros-yeux*. The third illustration shows a fish similar to the second, with a shorter dorsal fin and a broader double tail. The eyes are like those of the common goldfish. This he calls *Cyprin Quatre-lobes*.

In the *Histoire Naturelle des Poissons*, 1842, by M. le B. Cuvier and M. A. Valenciennes, the following descriptions of Chinese goldfishes are given, which appear to be largely taken from the writings of de Sauvigny and de Lacépède:—

The Ya-Tan-Yu or Duck Eggs, so called because of their shortened form and swollen middle. It appears from the drawings that the most of the individuals lack a dorsal fin, have two anals and four-lobed caudal fins. This variety usually remains on the bottom of the water

in an overturned position, the back down and the belly upwards; but can turn readily when they wish to swim, or can move about as well in the overturned position. It seems that this is also the most richly colored fish.

The Long-Tsing-Yu or Dragon Eyes correspond with the "Telescope" and "Gros-yeux" of M. de Lacépède, a variety remarkable for the enormous development of the eyes. I have dissected them and have not found any difference in internal or external structure, the eye only is much larger. Their right or oblique muscles were very weak, but the oblique nerves did not appear smaller. This fish often holds itself overturned like the preceding. The Chinese have a singular belief as to the origin of this species, regarding it as a cross between the ordinary Kin-yu, or common goldfish, fecundated by a frog. It is however one of the rarest breeds, and are sold in Pekin for as much as twenty thalers a piece.

The Choui-Yu or Sleepers are a variety which keep themselves at the bottom of the water without motion. It would appear that to come to the surface of the vessel is a fatigue for the fish because it goes back very promptly to the sand.

The Kin-Teon-Yu or Leapers have the habit of frequently obliquely jumping out of the water, like some species of our carp.

The Kin-Eubk-Yu of Nymphs are less brilliant in gold or silver than the others; but the delicate lustre, the rich shades and the iridescence of their colorings and the quickness of their movements, make this variety highly appreciated.

The Quen-Yu or Lettered. In conclusion the missionaries mention the Quen-yu or lettered goldfish, the colors of which are so placed that one seems to find Chinese characters along their sides. The dealers in Pekin pretend that they obtained this result by a secret method. The fathers of the missions learned, but without verification from trustworthy source, that the Chinese by a method similar to tattooing cause the sides of the fish to appear as though covered by written characters. They believe that a paste is employed to leave these tracings on the fish, made of arsenic mixed with the urine of the tortoise, as skin preparations usually contain this metal; which has a very active effect; and it is natural to suppose that this metallic agent would leave marks on the horny scales of the fish.

The above constitutes the basis for probably all the more recent descriptions of the Chinese goldfish breeds; the differences being principally in the wording, errors of translation, or unfamiliarity with the toy varieties of this fish.

In the *Nouveau Memoirs de la Societé Imperial des Naturists de Moscow*, 1855, M. Basilewsky depicted five goldfishes, which he designated *cyprini aurati*, all having elongated bodies, either "tripod" tails, "web" tails or double tails; and two having "spiked" dorsal fins of three and five rays. All have larger eyes than the common goldfish but not protruding from the head.

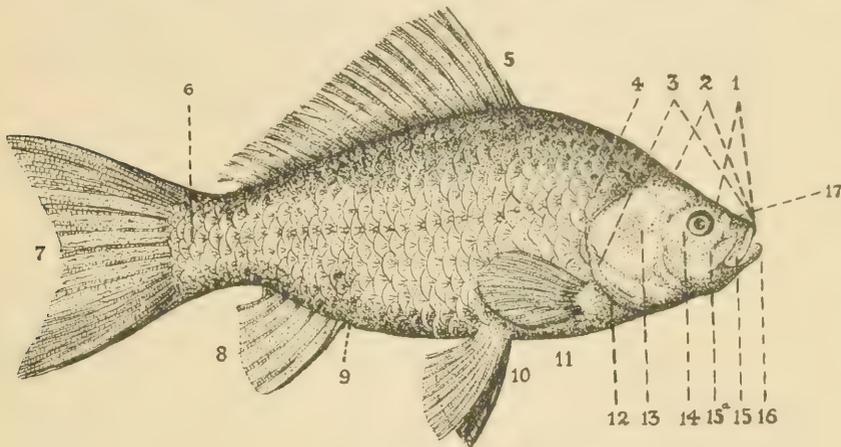
Dr. P. Bleeker in the *Atlas Ichthologique des Indes Néerlandis* 1863, describes nine breeds of goldfishes, four from Sarakarta, Java, and five from Jedo, Japan. Two of these are new, the others are based upon the descriptions and nomenclature of Bloch, Valenciennes, de Lacépède and Basilewsky.

FISHES IN GENERAL

The Pisces or fishes belong to the Vertebrata and may be defined as gilled and generally scaled cold-blooded vertebrate animals having a heart consisting of a single auricle and ventricle, limbs in the form of fins,

and a body adapted to rapid locomotion in water, and shaped to offer the least resistance and friction in swimming. The goldfish is a member of the carp family, and has been variously known as *Cyprinus auratus* and *Carassius auratus*, the latter designation being more recently preferred as more distinctive of the ornamental fish as there is a species of food carp which bears the name *Cyprinus aureus*.

ANATOMY OF THE COMMON GOLDFISH. Fig. 1. As one of the bony fishes, it has the vertebræ hollow at the ends, united by ligaments, and having the cavities filled with a gelatinous substance in order to give to the spine the mobile flexibility requisite to existence in a fluid medium.



COMMON AMERICAN GOLDFISH

Carassius auratus americanus

FIG. 1.—Parts referred to in descriptions.

- | | |
|---|-----------------------------|
| 1 Snout. | 9 Anus. |
| 2 Distance from snout to nape, or occiput. | 10 Ventral fin. |
| 3 Head. | 11 Pectoral fin. |
| 4 Lateral line. | 12 Branchiostegals. |
| 5 Dorsal fin. | 13 Operculum. |
| 6 Base of caudal fin. | 14 Eye. |
| 1 to 6 Distance from snout to base of caudal fin. | 15 Upper jaw, or maxillary. |
| 7 Caudal fin. | 15A. Preorbital. |
| 8 Anal fin | 16 Lower jaw, or mandible. |
| | 17 Nostril |

The spinal column is divided into an abdominal and a caudal region, the bones forming the arch through which the spinal cord passes. There are also transverse processes and an inferior arch below, which carries the lower caudal spine and the interspinous bones of the anal fin. The ribs are slender, curved bones each attached to a vertebra and imbedded in the muscles of the sides and abdomen. The interspinous bones in the middle line of the back between the lateral muscles, are connected with the vertebræ by ligaments, their outer ends being interspaced with the median or dorsal fin. The skull is a complicated structure consisting principally of the cranial, the maxillary and inter-maxillary, the præ-operculum, sub-operculum, and inter-operculum, mandible and other smaller intermediary bones.

The ordinary goldfish has two sets of horizontal paired fins, the anterior paired or *pectoral* fins, Fig. 2, connected with the clavicles and the skull immediately behind the gills, and the posterior paired or *ventral* fins inserted on the abdominal surface below and to the rear of the pectorals

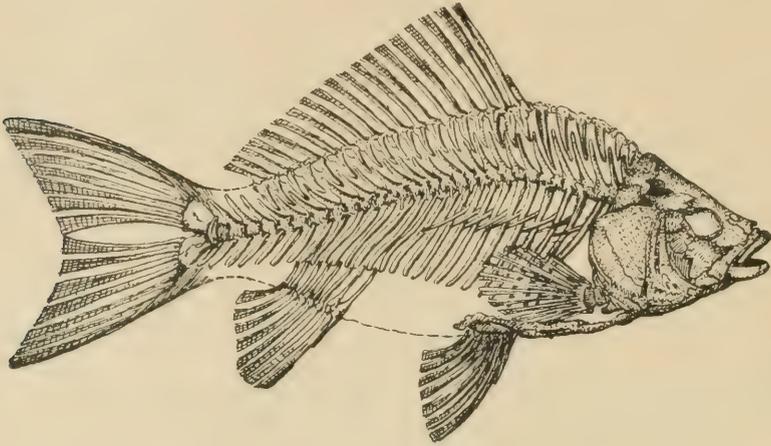


FIG. 2.—Skeleton of the Common Goldfish

and articulated to the posterior visceral arches and the pubic bone. The single median or *dorsal* fin is interspaced with the upper interspinous bones; the single *anal* fin with the lower interspinous bones, and the tail or *caudal* fin set vertically at the extremity of the spine, articulated so that it is flexible in all directions. The rays of all the fins are branched, increasing in number towards their extremities. The spinous and soft rays of the paired fins correspond with the bones of the limbs of other animals, one of their functions being to maintain the balance of the fish. Retrograde motion is principally affected by the pectoral fins which also direct the course of the fish by acting as propellers, further serving as adjuncts to the respiratory system in changing the water at the gills. The ventral fins act as a break in checking the forward motion in addition to aiding in the retrograde movement. The dorsal and anal fins balance the body, and as rudders prevent zigzag or rocking motion, while the caudal fin is the principal means of locomotion, and also, together with the anal fin, aids in steering the fish.

All the fins are organs of motion, but it is by the caudal fin that the fish is impelled forward. If the movement is to be swift, it is strongly bent to the right and left, while a gentle forward motion is effected by an undulating movement, the lobes and rays of the caudal fin, acting like the blades of a screw or an oar in sculling. If the fish wishes to move towards the left, it gives a stroke of the tail to the right, the right pectoral

fin acting simultaneously while the left remains pressed to the body; if the motion is to be checked, the ventral fins are erected and expanded vertically; if the motion is to be retrograde, a backward stroke is made with all the paired fins and the dorsal and anal fins held rigidly upright, the caudal fin being either held on a line with the body or slightly relaxed; and should the retrograde movement be in either direction, the caudal fin is flexed to the opposite side.

By observing injured fishes the purpose of the fins will be manifested. If a pectoral fin is useless or both a pectoral and a ventral fin on the same side, loss of balance will ensue, the fish falling on the opposite side; without both the pectorals, the head sinks; without the ventrals, the motion is unsteady; without the dorsal and anal fins the motion is zigzag; without the caudal fin, forward movement is labored and slow; and without any of the horizontal and vertical fins, the fish floats helplessly on its back, this being the heaviest part of the body.

The head and fins of the goldfish are naked, that is, devoid of scales; but the body is covered with an even layer of cycloid scales which consist of thin, flexible, horny discs, almost circular in form and evenly imbricated, or overlapping each other like tiles, with the posterior parts extended and free, the anterior parts being embedded in the epidermis and muscular tissue. Fig. 3. They have an enameled surface, showing a fine striation concentric to the margin with stiffening ribs radiating from the rear. Their arrangement is in an oblique transverse section across the body. On each side, reaching from the head to the caudal fin, there is a row of scales different from these in structure, which constitute the *lateral line*. Each of these scales is perforated by a tube leading to a duct connected with a sac in the head; their function being the excretion of mucus which covers the body to lessen the friction of scales and water, and to make it impervious thereto. This mucilaginous system is also provided with nerves and is the seat of a peculiar sense which corresponds to the organs of touch and hearing.

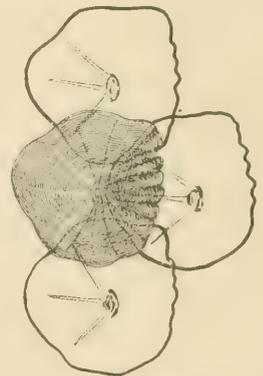


FIG. 3.—Greatly enlarged scale of the Goldfish and diagram of imbrication.

The digestive system of the goldfish is simple and adapted to its natural mixed diet. Fig. 4. Devoid of teeth, a limited mastication only takes place in the throat, which, for this purpose, is provided with a number of bony protuberances. The mouth is formed of the maxillary and the mandible bones, having labial folds or lips. The œsophagus is

capacious and opens into a well-defined stomach furnished with a valve, behind which are a number of enlargements or appendages, the pyloric cæca, which probably serve as the pancreas. The intestinal canal is a convoluted tube lined by a mucus membrane which winds in easy turns from

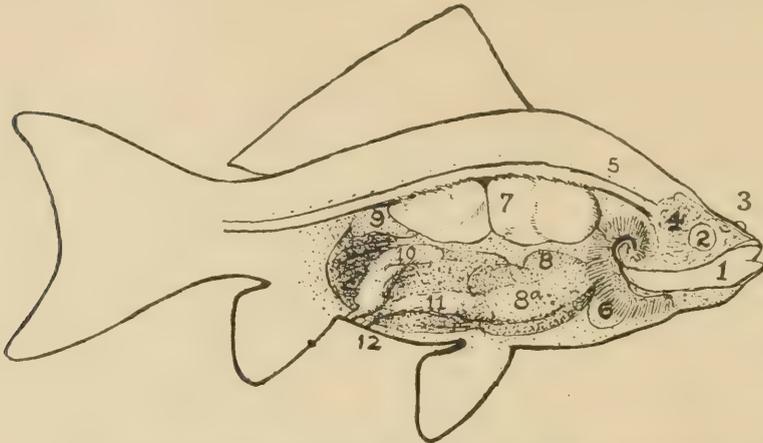


FIG. 4—Interior anatomy of the Goldfish, showing parts referred to in descriptions.

- | | | |
|---------------------|---------------------|----------------|
| 1 Gullet and gills. | 5 Vertebræ. | 9 Kidney. |
| 2 Eye socket. | 6 Heart. | 10 Milt. |
| 3 Nasal passage. | 7 Swimming-bladder. | 11 Intestines. |
| 4 Brain. | 8 Liver. | 8A Stomach. |
| | | 12 Anus. |

the pylorus to the anus. The liver is large, the gall-bladder distinct, and the kidneys, situated outside of the peritoneal cavity, form two elongated organs below the spine.

The swimming bladder is large and consists of a constricted sac divided into an anterior and a posterior portion which contains air. It is placed above the alimentary canal and communicates with the gullet by a duct. It serves to maintain the specific gravity and to change the centre of gravity of the fish and is enlarged or contracted by muscular action, whereby the air is expanded or compressed. When this bladder is ruptured, malformed or diseased the fish loses all power of changing its position except in limited motion over the bottom of the tank, or is helpless on the surface of the water.

The reproductive system of the goldfish is oviparous, the ovaries of the female being known as the roe and the testes of the male as the milt. The ovaries are placed below the spinal column on each side of the swimming bladder and posteriorly united with a Fallopian tube or oviduct which leads to an opening behind the anus. The milt of the male are similarly located, and contain a thick white fluid in which are the spermatozoa. The eggs or spawn when laid, are slightly compressed globules, about the size of the head of a pin, of semi-transparent, white or yellowish color. Fecunda-

tion takes place after the eggs are discharged, their outline then assuming a more spherical form, whereby the spermatozoa are drawn into the ova through minute orifices and the egg fertilized.

The circulation of the blood is induced by a branchial or respiratory heart consisting of two cavities, an auricle and a ventricle. Fig. 5. The venous blood, coming from the liver and the body generally, is taken

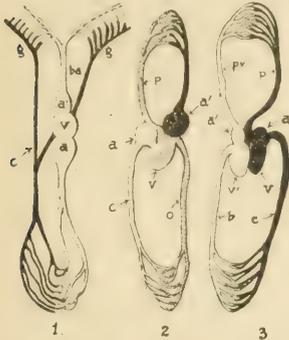


FIG. 5.—Diagram of the Blood circulatory systems of Fishes, Reptiles and Mammals.

No. 1.—Diagram of a fish.

- a'* Auricle, receiving venous blood from the body.
- v* Ventricle.
- a* Bulbus arteriosus, at the base of the branchial artery.
- ba* Branchial artery, carrying the venous blood to the gills.
- c* Aorta, carrying the arterial blood to all parts of the body.
- g* Gills

No. 2.—Diagram of a Reptile.

- a* Right auricle, receiving venous blood from the body.
 - a'* Left auricle, receiving arterial blood from the lungs.
 - v* Arterio-venous ventricle, containing mixed blood, which is driven by the pulmonary artery (*p*) to the lungs, and by the aorta (*o*) to the body.
- The venous system is left light, the arterial system is black, and vessels containing mixed blood are cross-shaded.

No. 3.—Diagram of a Mammal.

- a* Right auricle.
 - v* Right ventricle.
 - p* Pulmonary artery, carrying venous blood to the lungs.
 - pv* Pulmonary veins, carrying arterial blood from the lungs.
 - a'* Left auricle.
 - v'* Left ventricle.
 - b* Aorta, carrying arterial blood to the body.
 - c* Vena cava, carrying venous blood to the heart.
- The arterial system is left white and the venous system is black.

through the vena cava into the auricle and propelled into the ventricle, from which arises an aortic arch, dilated at the base into a cavity, the bulbus arteriosus, which has transverse rows of valves, and is covered with muscular fibres for rhythmical contraction. The blood is driven by the ventricle through the branchial artery to the gills where it is distributed by means of the branchial laminae and subjected to the action of the aerated water and thereby oxygenated. The water is taken in at the mouth, forced to the branchia by muscular action, passed over the gills, deoxydized and then emitted from the gill slits, or opercular apertures, on each side of the neck. These gill slits are closed in front and covered by the operculum bones connected by bony spines with the hyoid arch supporting the branchiostegal membrane. The aerated blood is not returned to the heart, as in higher forms of animals, but is driven from the branchia through all parts of the body by the action both of the heart and the contractions of the voluntary muscles; that is, the arterial blood returned from the gills is propelled through the systemic vessels of the body without being first sent back to the heart. The oxygen thus consumed is not that which forms the chemical constituent of water (H_2O) but that contained in the air which is dissolved or in suspension in the water. Fishes transferred to water devoid of air are speedily suffocated, but goldfishes are of low vitality and their absorption of oxygen is comparatively small, as compared with others; this, however, being also characteristic of all stillwater fishes in greater or lesser degree.

The nervous system of the goldfish is well developed but of somewhat inferior type. The brain is small and appears to consist mainly of ganglia devoted to the special senses. The eyes are large, brilliant and well developed, devoid of eyelids, and have a considerable range of vision, and probably some magnifying power as compared with the human sight. The interorbital space is wide, the eyes being placed at the sides of the head, directed somewhat forward, the angles of vision being both to the front and to the sides. The pupils are nearly round with flattened, slightly convex cornea, and are enveloped in a layer of gelatinous substance which covers the cavity of the orbit and permits of considerable movement of the bulbus. They have brilliant dark centres and white, yellowish or reddish borders.

Goldfishes are voiceless, having no lungs nor any of the auditory organs present in some species of fishes.

The nose has two erect nasal appendages below the infraorbital space with tubes leading to sacs lined with a folded olfactory membrane. Anteriorly the water is admitted into the sacs, but posteriorly they are closed and do not connect with the pharynx; the sense of smell apparently not being very acute.

The sense of taste is located in the sensory nerves of the palate, in a thick cushion of soft contractile substance supplied with nerves.

The essential portions of the organs of hearing are present but not fully developed, and consist of rudimentary organs located at the base of the cranial cavity, a labyrinth with vestibule and semicircular canals, but the tympanum and the external parts are entirely absent, though the bones in the temporal region are thin and may partially serve the purpose of conducting soundwaves.

The sense of touch is very well developed and it would appear that sensations of sound are communicated by vibrations in the water, which act on the sensory nerves of the scales, more especially those of the lateral line. On this account the fish probably feels, rather than hears, sounds.

The nerves on the surface of the fish, both of the scales and of the fins, are well developed.

The fish has a well-organized muscular system in all parts of the body. There are sets of muscles that cover the sides of the trunk, the back and the tail, composed of many tendons branching from the large lateral muscles, these being divided into dorsal and ventral halves. Each fin possesses a separate system of muscles which governs every movement. Internally, the muscles are greatly ramified and control all the organs.

The goldfish has no fixed period for slumber, apparently sleeping whenever desirable, by day or by night. It remains motionless on the bottom of the tank or rests on the plants, breathing slowly and regularly, the eyes slightly withdrawn, vacant and of a glassy stare. All the fins but the pectorals are motionless, and these have only sufficient movement to change the water at the gills. If undisturbed this rest may be for hours, but usually it is only for a few minutes at frequent intervals.

The diet of the goldfish is omnifarious, its food consisting of the minute vegetal, insectile and animal organisms found in its natural habitation, and the young shoots and tender leaves of aquatic plants, as well as smaller fishes and its own spawn and young.

The excrement, when the fish is in a healthy condition, is dark brown or black, and usually appends for some time, as a long vermicelli-like thread. From its appearance illness of the fish or constipation, may often be first detected.



CHAPTER II.

**The Freshwater Aquarium and
its Maintenance.**

THE AQUARIUM

A well-kept aquarium is unquestionably one of the most beautiful ornaments in the household, as it is both decorative and instructive, and a constant source of interest and entertainment to young and old. To the lover of the beautiful in Nature, the plant and animal life, thus brought under ready observation, affords opportunity for study and investigation that must lead to broader views and a higher appreciation of the beauties of nature.

DEVELOPMENT OF THE AQUARIUM. Of the early history of the aquarium Henry D. Butler states that "the great principle of the Aquarium was faintly indicated by Priestley, as long ago as the close of the 18th Century; Ingelhauss approached it more closely in 1778-9; Daubeny touched its verge in 1833; Dr. W. B. Ward, in 1837, suggested it with some distinction; Dr. Johnson partially demonstrated it in 1842; Dr. Lankester, in 1849, and Warrington, in 1850, rendered it conclusive; but Dr. Philip H. Gosse, in 1852, perfected all the labors of his predecessors in a series of decisive experiments that left no room for doubt or contradiction."

"An aquarium had also, about this time, established itself, by accident, at Hampton Court, England, and was described by M. Jesse. In a water tank in the open air, plants and snails made themselves unbidden confrères with the fishes. Nature did the rest, as she does in those more gigantic Aquaria, the placid lake and the majestic river."

"Next followed the grand Aquaria of London and Dublin under regal auspices. These were sumptuous exhibitions; and in a short time created such a popular interest in Great Britain that all the other curiosities of nature sank at once, into comparative insignificance."

Other authorities mention that Priestley, in 1833, discovered that growing plants, submerged in water, gave off oxygen when exposed to sunlight. In 1844, Ward succeeded in keeping fishes together with plants, but did not know the law of balance between plant and animal life. In 1849, Wm. Stimson had several aquaria at the Smithsonian Institute, but did not give publicity to the fact. But in 1850, Robert Warrington, of Manchester, England, read a monograph before the London Chemical Society on "The Relation between the Animal and Vegetable Kingdom," in which he explained the principle for the arrangement and maintenance of the aquarium. Later, he in conjunction with Dr. Gosse, continued their experiments and learned of the necessity of snails, and this finally solved the entire problem of the balanced freshwater aquarium. Dr. Gosse

also first applied the term "aquarium" to fish tanks, it having previously been used by the botanists to designate aquatic plant receptacles.

THE PROPERLY CONDITIONED OR BALANCED AQUARIUM. When properly arranged, its maintenance is very simple, but the governing principles of a balanced aquarium are not always understood. It is not realized that when the relations of plant to animal life are correctly proportioned, the aquarium is virtually self-sustaining or balanced, and the water need only be changed at long intervals, often of a year or more.

Plants in their growth liberate oxygen and take up the carbon-oxide and dioxide given off by the living creatures; the latter, in their turn require the liberated oxygen, which is either in suspension or dissolved in the water, to maintain their existence. Hence, if the plants and animals are properly balanced, the quality of the water remains fixed, and only becomes vitiated after a long period through the presence of other gases generated by the excrement of the animals and the decomposition produced by the general decay of the plants, of food, and other organic substances. Oxygen is absorbed in considerable quantity by the breathing organs of the living inmates, for the oxidation of waste carbonaceous matter, thereby producing carbonic acid gas. This, during the daytime, is absorbed by the plants, the contained carbon being required to add to the solid structure of the plants, and the oxygen is set free in the water. Thus the double action of animals and plants maintains an almost perfect balance, as the animals diminish the proportion of oxygen and add to the quantity of carbonic acid gas, and the plants increase the oxygen and diminish the carbonic acid gas.

The fishes, however, consume more oxygen than still water takes up from the air, and if oxygen-liberating plants are not introduced into the aquarium, they suffer from the lack thereof, become restless, come to the surface to breathe the air, and may finally die of asphyxiation.

It must not, however, be taken that an exact balance is ever attained, and it is better to have a preponderance of the oxygenating element, restricting the animal life to that which will live comfortably in the existing environment, and that the nearer these conditions are approached the better the inhabitants will thrive and the less often the water need be changed.

AQUARIUM PLANTS. Not all aquatic plants are equally good generators of oxygen and some information is requisite to make a selection of those which best fulfil this necessary purpose. There are quite a number of readily obtainable plants which perform this function, many of them native and others to be had of dealers. These are, in the order of their

utility, *Sagittaria* (floating arrowhead), *Cabomba* (fanwort), *Vallisneria* (eel or tape grass), *Anacharis* (water weed), *Myriophyllum* (water milfoil), *Ludwigia* (loose strife), *Fontinalis* (willow moss), *Ceratophyllum* (hornwort), *Potamogeton* (pond or stink weed), and others, of which more will be stated hereafter.

SCAVENGERS. To get rid of offal and waste matter generally, scavengers must be introduced, the best of these being frog tadpoles and those species of snails that do not attack the plants. When not overfed, they also clean the glass of the green coating of *Algæ*, the minute water plants, though these are far from objectionable, as they are one of the natural foods of the fishes.

KINDS OF AQUARIA. Any vessel will serve as an aquarium if it is clean and impervious to water, but glass better permits of observation of the contents. The cylindrical and bell forms distort the appearance of the fishes, and the ordinary globes furnish, in proportion to their capacity, too limited surface for the absorption of air. All-glass vessels are liable to fracture by uneven expansion and contraction, due to rapid changes in temperature or the effect of the sun rays, and if not soft and well-annealed, by the pressure and weight of the water. Globes and cylinders may also be so placed as to condense the sun rays, and as focusing lenses set fire to inflammable materials. Of the all-glass vessels the rectangular battery jars, though usually more expensive, give the best results. They may be obtained in two sizes made of white flint glass; having a capacity of $2\frac{1}{2}$ and 5 gallons, and are sold with or without brass or iron bases and stands. Thick pieces of felt under them are safeguards against breakage from uneven pressure on the bottoms, when set on flat surfaces, or by scratches. The brass or iron-framed aquaria are by far the best, and when properly constructed the glass sides and the bottom are so neatly joined that little or no cement is required on the inside. They are the strongest and handsomest, and can be made in any desired size. The foregoing refers to small aquaria, and it is a mooted question whether a number of these, each of distinct character, may not have more charm than one larger aquarium, if space will permit of their proper display, though the larger the aquarium the more likely is the success with fishes.

Large aquaria are usually made with heavy iron stiffening frames, slate bases and thick plate or crystal glass, the size limited only by the available space. When the tanks are of too great width they may become obscure and their contents not so easily seen. When they are of too great depth the aerating surface may not be sufficient and the water pressure too great. Consequently a tank of greater width than 24 inches and greater

height than 22 inches is objectionable. For out-of-door tanks and cisterns, any size and a variety of materials may be used; but when built of wood, they should be seasoned by a frequent change of water. Slate, soapstone and cement basins are used, of which more will be stated hereafter.

ARRANGING THE AQUARIUM. The aquarium should be set on a stable support, a stand, table or shelf, preferably facing a northern or north-eastern exposure in the summer, while in the winter it should be placed to get the sunlight two or three hours daily, preferably the morning sun; as it is essential that the aquarium should get a good light or failure will be the inevitable result. If indoors it should be placed at a window or under a skylight admitting the daylight and sunlight but without too much exposure to the direct rays of the sun during the hot summer months. The best success will be had when the light is such as to stimulate the growth of the plants without producing material changes in the temperature of the water. The position at a window also permits of the necessary ventilation and aeration; the slight draught, even when the window is closed, is a protection from excess of coal or illuminating gases and tobacco smoke; and in warm weather, it will moderate the temperature of the water if the direct rays of the sun are excluded.

COVERS FOR AQUARIA. Experts advocate glass covers for the aquarium having sufficient plant life. The plants will grow more luxuriently, dust will be kept out, froth and bubbles will not form on the surface, and the evaporation will be less rapid. The cover need not fit tightly, but raised about $\frac{1}{4}$ inch by rubber or cork discs on the upper frame of the aquarium or it may have the corners cut away. The cover will also prevent the single-tailed goldfishes, the ide, tench and other freshwater fishes, from leaping out of the aquarium, a habit which they have inherited from their wild congeners who do this at twilight, when the day enemies have retired and those of the night not yet appeared. The double-tailed goldfish cannot leap from the water. Wire gauze or cotton netting over the top of the aquarium will also serve to prevent the leaping out of the fishes.

AQUARIUM EQUIPMENT. In the equipment and maintenance of an aquarium cleanliness is the all-abiding law. The interior should be cleaned with water, the glass rubbed with table salt, either on the finger tips or on a soft rag, and then carefully rinsed; no soap or alkaline substances are to be used nor any greasy or soiled vessel employed. When placed in position, the bottom should be covered with two inches of well washed sand, or grit (small pebbles) and covered with small or larger pebbles; this depth being requisite for the proper rooting of the plants.

Next the plants should be arranged, and for the indoor aquarium *Sagittaria*, *Cabamba*, *Vallisneria*, *Nitella*, *Potamogeton* and *Ludwigia*, the best generators of oxygen, are to be recommended and should be planted in natural groups, interspersed with a few slips of *Anacharis* and *Fontinalis*, to enhance the effect; considerable opportunity being afforded for the display of individual taste either by arrangement with mathematical precision or by mingling in the graceful abandon of nature. These will grow all the year and thrive indoors; and, to permit of shelter to the fishes from too strong light, they should be arranged towards the window, leaving an open space on the inner side in which the fishes may disport themselves. If closely grouped, each kind somewhat by itself, most picturesque water gardens can be produced.

The planting is usually done directly in the sand or grit, the lower ends of the plants covered and weighted with pebbles, but it is preferable to plant in low flower pots or dishes, into which a little clean earth or pond mud has been placed, covered with pebbles, so that the plants will not be uprooted when the sand and grit are taken out and cleaned. *Sagittaria* and *Vallisneria* should be planted deeply so that the runners will be covered; the others may be set into the sand or grit without roots, as with some of the plants these will develop, or they will grow without roots. Bunches of *Cabamba* and other aquatics bound with strips of block tin, as sold by the dealers, should be separated; when planted in that way they will not thrive and soon rot at the lower ends. *Cabamba* and *Ceratophyllum* rarely root in the aquarium but grow quite as well with the ends buried in the pebbles.

A few larger pebbles scattered over the top and brook-worn stones between the plants, a pile of rockwork or a piece of turfstone make a pleasing effect, but it is surely questionable taste to introduce the grotesque submerged castles and figuresses so often seen in aquaria.

The pebbles permit the humus and precipitations to sift to the bottom, add to the cleanly appearance, permit of the growth of tiny aquatic plants, and are of benefit in many other ways.

When the plants have been put in position, the aquarium should be filled with clean water nearly or quite to the top, by pouring it on wrapping paper laid over the plants, that the contents may not be disturbed; and then the plants raised to proper positions.

The outside having been cleaned, the aquarium should be permitted to stand a few days before introducing the fishes, though it is advisable to introduce tadpoles and snails at once, so that the water may clear and the plants begin to take root and accumulate oxygen.

The use of feeding dishes is an unsettled question. Some expert fanciers claim that it is best to have the fishes hunt their food among the pebbles; but for the novice they have the advantage of showing whether the quantity given is correct and all the food consumed after each feeding, an important observation, as all excess should be removed.

STOCKING THE AQUARIUM. The number of fishes and scavengers which may be safely introduced depends upon the size of the fishes, the conditions under which they have been reared, the quantity of light, the temperature of water, the plant growth, and other circumstances; but overstocking should be avoided. A generally accepted rule for the permanent aquarium, under the most favorable conditions, is not more than one 2 or 3 inch fish per $2\frac{1}{2}$ to 3 gallons of water, with a tadpole and two snails to each three fishes. Care should also be exercised that the water is of like temperature to that to which the fishes have been accustomed, as any sudden excessive changes are injurious. If they have been kept in cold water, that of the aquarium should be of the same temperature, and assume that of the room after the fishes have been put into it. This is usually between 50° and 80° F. In the aquarium, indoors, in the winter, it is easily maintained between 50° and 60° F., and in summer between 65° and 80° F. In the open air the fishes survive almost every temperature, even freezing cold, if the ice is broken to prevent suffocation; while 100° F. is not injurious if sufficient oxygen is contained in the water and no sudden changes in temperature take place. A moderate equable temperature, between 50° and 70° F., is best for the household aquarium, and is easily attained.

It has been ascertained that for each 16 degrees of lower temperature water will absorb or hold in suspension double the volume of oxygen liberated by plants; and, inversely, a corresponding diminution will take place for each 16 degrees of rise in temperature; or that water at say 44° F. will sustain nearly twice as many fishes in comfort as will the same volume at 60° F., or three times as many as at the summer heat of 76° to 80° F.; and their number should therefore be diminished as soon as they persist in remaining on the surface sucking in the air and taking the required oxygen directly from the air itself.

In changing the fishes to the aquarium they should be gently handled, floated from one vessel to the other, if possible, avoiding violence or needless fright, as considerate treatment soon makes them less timid and more fully domesticated.

Success with goldfishes depends upon cleanliness, a vigorous plant growth to furnish abundant oxygen, intelligent treatment and proper food, sparingly fed.

FOOD. The natural food of the goldfish consists of the minute protozoans and crustaceans, algæ, insects, larvæ and worms contained in all freshwater. In the artificial conditions of domestication and in the aquarium, however, an insufficient amount of this food is obtainable, making feeding necessary; the best results being obtained when this natural food can be given to them; but in lieu thereof, artificial food may be fed, care being taken to feed in moderation, excess being more dangerous than a slight insufficiency. Not more should be given than will be immediately consumed, and if any remains uneaten, it should either be removed with the lifting-tube or no more given until it has been consumed. Animals under domestication thrive best when sparingly fed, and this also applies to goldfishes and other aquarium pets. The appetite of fishes is greatest in warm weather, as they become sluggish when the water is cold, and in their natural state take little or no food; which should be considered, and their diet regulated in keeping with their natural requirements.

During warm weather they should be fed once each day, but when the water has become cold, only on alternate days, or a smaller quantity given daily with occasional days of abstinence, that they may seek the discarded particles of previous feedings and prevent its becoming sour, with the attendant objectionable results.

For the novice, the most readily obtainable and least harmful fish food is the generally used rice wafer. Of this a piece about $\frac{3}{4}$ inch square should be fed to each 3 inch fish in summer and a smaller quantity in winter, varied at intervals of a week with other approved prepared goldfish foods or small particles of cleansed earthworms or ant larvæ, and when these can not be obtained with very small pellets of raw scraped beef, each fish receiving but one piece and care taken that none remains uneaten. Bread, cake and similar substances are not proper food for aquarium fishes.

SALTS. In an aquarium holding say five gallons of water, a half teaspoonful of table salt or a smaller quantity of epsom or glauber salts should be put about once a fortnight. It is beneficial to the fishes, who take it ravenously, as they have the same craving for saline substances as other animals. The table salt is both a mild antiseptic and a cathartic, and the other salts, cathartics, which are necessary to the fishes in their artificial surroundings, confinement, and the concentrated and highly nutritious forms of their food. Some of the prepared foods contain these salts, but their addition to the water in moderate quantity is always beneficial.

Sea shells, corals and other marine objects should not be put into the freshwater aquarium, though experts favor the introduction of a small quantity of lime in some slowly soluble form as necessary to the existence of the fish and molluscs. This will be treated of hereafter.

ADVICE TO BEGINNERS. The novice would do well to first obtain a few of the inexpensive common goldfishes, which are hardy and easily domesticated, and study their habits and requirements, before procuring the finely bred Japanese and Chinese varieties. Among the common American and European goldfishes there are many of beautiful forms and markings, ranging over almost the entire gamut of colors; from pure iridescent pearly white, lustrous silvery and golden hues, to all the shades and combinations of yellow, red, blue, brown and black. The prevailing colors of all the breeds of the goldfish are bright or dull white and yellowish tints on the abdomen, which change to a lustrous metallic yellow on the sides, and then almost imperceptibly shade into golden yellow, red, vermilion, carmine or the deepest and richest oxblood red.

When he has familiarized himself with their care, the novice could select for a five-gallon aquarium, say one Japanese Fringetail, a Fantail, a Comet and a Nymph, none over three inches; but these should not be at once put into a newly established aquarium, and only after he is assured that it will support that number in comfort. These are more easily kept than the more delicate fishes of Chinese and Corean origin.

CLEANING THE AQUARIUM. When and how often it is advisable to clean the aquarium is a matter of individual judgment. Green water, even to the extent of obscuring the contents, is not injurious; the fishes thrive better in it than in limpid water; nor is the residuum on the pebbles harmful, if objectionable substances are removed either with the dip—or lifting tube or the lower depths of water siphoned with a small rubber hose, which may be guided to all parts of the tank, removing the heavy vitiated water and most of the sediment. If the fishes continue excessively restless, persist in coming to the surface for air, and still avoid the bottom of the tank, possibly due to overfeeding, the introduction of more tadpoles and snails may be required, but should these measures not affect a remedy, thorough siphoning or cleaning is necessary and must be done at once.

DISEASED FISHES. When a fish becomes diseased, it should be immediately removed and isolated, and, dependent on the nature of the ailment, either the others quarantined, or the tank and contents cleaned and the healthy fishes returned; the latter course especially if the disease can be traced to unsanitary conditions. A clean surface on the pebbles adds to the beauty of the aquarium and also indicates healthful conditions.

It is a grave mistake to immediately introduce recently acquired fishes into an established aquarium. They should be kept for some time under observation and only introduced when full assurance has been reached that they are free of contamination. Aquatic plants should also be placed in water containing a tablespoonful of Phenol Sodique to the quart of water several hours before being placed into an aquarium; then rinsed in clean water, carefully examined, all decayed parts removed and the leaves cleared of dirt, algæ and confervæ, as serious ailments to the fishes are often produced by inattention to these particulars.

RESTLESSNESS. When the supply of oxygen is insufficient, the fishes come to the surface gasping for air. Relief may be given them by dipping and pouring back some of the water and by increasing the number of plants, selecting the best oxygenators; but if these measures do not improve their comfort some of the water should be siphoned from the bottom, refilling with fresh aerated water, poured a number of times from one vessel to another, or introduced into the aquarium in a fine spray. While the aquarium should be cleaned when the fishes persist in coming to the surface, this should not always be taken as an indication of unsanitary conditions, as they have the habit of doing this at daybreak and in the evening. The gasping of the fishes on the surface is to take in air with the water, to cause its partial absorption in the mouth before passing the water into the gills.

Excessive restlessness may also be due to a variety of causes; insufficient oxygen, the accumulation of objectionable gases in the water, impurity of the water itself, and the presence of parasites and fungi, too small to be seen. These will be treated of under ailments and remedies.

Changes from colder to warmer weather also unfavorably affect the fishes as a portion of the suspended air is thereby expelled from the water; and cloudy weather has some effect, as the plants will not liberate as much oxygen when they lack the stimulus of strong sunlight.

It is not advisable to put ice into the aquarium to furnish oxygen or to cool the water; fishes are just as liable to pneumonia as other animals; this being the ailment that kills many of them when transferred from aquaria to tanks in the open air too early in the Spring.

EFFECT OF GASES, FUMES AND ODORS. Authorities on the subject of goldfish culture disagree as to the injurious effects of illuminating and coal gases, tobacco smoke, and the dust borne by the wind or raised by sweeping. Water readily absorbs fumes and odors, and if these are excessive, they cannot be otherwise than injurious, though with care and forethought no further precautions need be taken. The hands should not

be put in the water, least of all after smoking; the aquarium should be covered when sweeping, and the room frequently aired or ventilated in mild weather. The dust may be removed from the surface of the water with a piece of clean blotting paper, but it soon settles to the bottom and serves as food for the scavengers and forms a part of the humus or residuum on the sand or pebbles. When the humus layer becomes thick, it may be injurious, and should be removed with the dipping-tube, the water siphoned, or the aquarium cleaned. In an experimental aquarium containing twenty gallons of water, this humus had formed fully half an inch thick, the water not having been changed for eighteen months, yet the fishes were perfectly healthy and contented. It is best to remove it, however, as it is the culture medium of parasites and fungi, and it is not advisable to leave it so long in the aquarium.

A piece of charcoal floating on the water or weighted and hidden among the plants serves as a deodorizer and mild antiseptic, and can be introduced to advantage.

ALGÆ. Algæ on the glass may be removed with a brush or a piece of felt on a stick or rod. It is advisable, however, to leave it on the sides which do not obstruct the view, as it aids in screening the fishes from excessive light and in keeping the water in good condition. A fish showing signs of illness, will often speedily recover when removed to a tank filled with green water, as it contains not only desirable food, but also beneficial medicinal properties. A very little permanganate of potassium will check the growth of Algæ, if this is found to be objectionable.

DESTRUCTION OF PLANTS. Even when sufficiently fed, the fishes will sometimes tear and destroy some of the aquatic plants, feeding on the younger shoots; but this is often done in sheer mischief and wantonness and the remedy is to introduce more of those plants which are unmolested. It may also be noticed that the fishes take the sand and smaller pebbles into their mouths; they do this to feed on the tiny water plants growing upon them, and it is not always an indication of insufficient feeding.

In conclusion it would be well to recapitulate the principles leading to success with the properly conditioned aquarium, any mistakes of which will surely lead to failure:—absolute cleanliness with everything pertaining to the aquarium; proper and abundant light; a vigorous growth of desirable aquatic plants; absence of decaying vegetation, a proper balance of plant and animal life, with preferably a preponderance of the former, absence of parasites and diseases, sufficient scavengers; and care in feeding the proper food.

CRUELTY TO FISHES. All admirers of the aquarium should consider it a duty to direct attention to the pernicious practise of keeping fishes in small fish globes. Millions of goldfishes have been killed by slow torture in this regrettable precursor of the modern aquarium, and by other unintentional cruelties. Many instances can be recalled of globes containing too many fishes, without a plant, hung in the glaring sun; to improper feeding and other practises which a little knowledge of the subject would prevent.

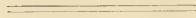
That the common goldfish is tenacious of life and will often survive abuses for a long time is no excuse for violating the laws of its nature. Other animals are protected by laws and philanthropic societies, but these seem to interest themselves but little in the fauna of the aquarium.

It is the dealer in fishes who is responsible for the survival of fish globes. They are the cheapest vessels that can be offered to purchasers, and he still has them for sale, rather than explain that the globe is an objectionable form of fish receptacle, superseded by better ones, and that success with its use is hardly possible. He would find that his sales would not diminish from candor and expressions of the truth. If he would explain the laws of balance in the aquarium, it is certain that the success which his customers will have would result in further exciting interest, while an unsuccessful attempt will discourage and may lead to the abandonment of all hope of success.

Means should be devised for placing simple correct information within the reach of everyone; then the aquarium would be much more popular than it now is, and this esthetic pleasure in the household would be within the reach of almost every one.

Experts in the keeping of the aquarium should interest themselves in this subject for the benefit of the general public. The fish globe should be used only as a temporary receptacle or hospital, but it were best if this torture chamber came entirely out of use.

CHAPTER III.



Goldfish Breeds

THE COMMON GOLDFISH

Both the American and European common goldfishes have elongated bodies slightly flattened on the sides, the latter being the slightly longer

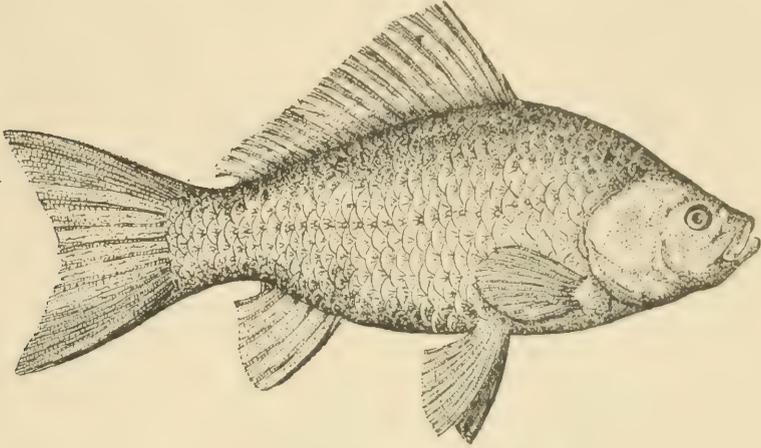


FIG. 6.—The Common American Goldfish
Carassius auratus, var. americanus

and more slender fish. Figs. 6 and 7. The scaleless head is usually short with broad forehead and wide interorbital space, blunt snout, full and well-defined lips, erect nostrils, clear eyes and the operculæ or gill covers of a burnished metallic lustre. The body has an even covering of uniformly

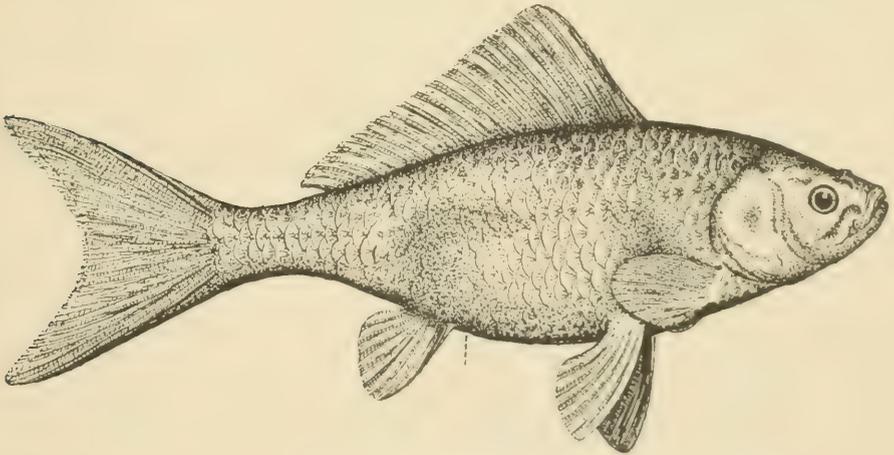


FIG. 7.—The European Goldfish
Carassius auratus, var. europænsis; as known in the eastern United States markets.

sized scales having a bright, enameled surface. There are two sets of paired and three single fins including the tail. The color varies in different fishes and may be white, silvery-grey, olivate, golden or orange-yellow,

red and brown or a combination of these colors, sometimes associated with black. It is hardy and tenacious of life, grows to large size, often attaining a length of 16 inches and reaching an age of 12 to 16 years, with reported instances of even greater size and longevity. It is prolific and will thrive under trying and adverse circumstances in any stillwater pool, cistern, tank or aquarium. It will withstand almost any temperature unless deprived of sufficient oxygen or subjected to sudden changes and may be transported over long distances. It is easily domesticated, and like its progenitor, the Crucian carp, will survive considerable periods out of the water in wet waterplants, to keep the gills moist.

When the fish has a grey or olivate hue, it is known as a silverfish, but these colorings may not be permanent and at some time either become mottled or entirely change to golden hues; though this rarely occurs with white or albinoid fishes; and when it does is usually just before or during the breeding season, thereby proving that the fish was only a dull colored, colorless or uncolored goldfish. Sometimes the color is entirely white with an iridescent or rainbow lustre. These are known as pearlfishes, their oftentimes red eyes proving them to be albinos.

When they have almost transparent scales and bodies, as sometimes happens with the white or very light-colored fishes, hybrids crossed with Japanese or Chinese stock, they are called transparent goldfishes, and these offer most interesting study in the aquarium, as all the functions of their existence may be observed through their transparent sides. Others of the goldfishes have a deep, resplendent blue-brown color on the sides and so dark a tone on the back as to appear to be black, with the scales sometimes outlined with metallic purple-bronze or bluish tints. These are commonly known as black goldfishes and are not highly prized, though a close study of the beautiful and fleeting changes of color should lead to a higher appreciation. These fishes usually lose their colors and assume those of the ordinary goldfish. All the common goldfishes are at first of a dull greyish-brown or olivate color.

Another fine distinction is in the shape of the head. When its outline, from the snout to the dorsal fin, forms an even upward curve, the head somewhat flattened on the sides, with the lower side of the body, from the gill covers to the caudal fin, nearly on a straight line, the fish is known as a Ram's nose; and when the head is very broad and rounded on the sides, with thick lips, is slightly depressed at the interorbital space and where the head joins the trunk, and the back very much rounded, the whole fish having a porcine appearance, it is known as a Hog's nose. These characteristics have been bred by the Japanese and Chinese, but

sometimes occur with the common goldfish, probably due to an admixture of an oriental strain or a variation in or from the parental type, to which this fish is particularly liable.

The desirable characteristics of the common goldfish are perfection of form, head and eye; fine, clean even and symmetrical fin development; evenly imbricated and uninjured scales; a clean and healthy general appearance, with distinct and brilliant colors.

Perfect development of the finely bred varieties are hereafter described; but the more general imperfections in these fishes consist of slight malformations of body and fins, and too great length of body in the short-bodied breeds or too short-bodies in those which should be long and slender. Some imperfect fishes of the double-tailed breeds have the upper lobe of the tail single and the lower lobe double. These are known as "Tripod-Tails". Others have the otherwise double tail joined at the top or margin and are known as "Web-tails", while when the double tail is joined at the centre and flattened on a horizontal plane, they are known as "Dolphin-tails". Another frequent imperfection of some breeds is a single instead of a double anal fin or the anal fin may be entirely absent. Some have the main ray of the dorsal fin crooked, due to the "hinge" or interspinous bone of the first ray being above the surface of the back, which prevents the fish carrying the dorsal fin erect, or the dorsal fin may be too short and consist of but three to six rays.

By careful breeding more or less fixed varieties may be produced, but none of these forms are permanent, as the goldfish is naturally inclined to variations under domestication or will revert to the original stock except under most careful breeding and selection, and what may be considered imperfections in some breeds are desired characteristics in others, as will be seen in the descriptions of the oriental goldfishes hereafter given.

Except only the Comet, the finer breeds should have very short heads, short bodies, evenly rounded backs, long pendant fins, small scales and large eyes.

THE JAPANESE AND CHINESE GOLDFISHES

The culture of the finely bred goldfishes has been conducted in the warmer parts of Japan and in China for centuries, all the varieties now known in the United States having been derived from these sources. The original parent stock was a Cyprinoid similar to the Crucian carp, with which albinism is of frequent occurrence, the colors of albinoid fishes of every species being bright orange and golden hues with occasionally white or uncolored individuals. By careful selection these colors were

made permanent in the goldfish, though the Oriental breeders did not confine themselves to this but developed combinations embracing every shade and color combination. Variations in body and head, difference in eye, fin and scale were also developed to such an extent as to produce all those strange varieties and almost incredible monstrosities which can be bred in all domesticated animals.

After the desired type had been established, breeding was carried forward generation by generation, until those wide differences were produced and perpetuated which now characterize the various breeds of Japanese and Chinese Goldfishes; but China, even more than Japan, is so truly the land of the bizarre that this is also most evident in their goldfishes; and, to the uninitiated, the forms and colors developed by them would appear like nightmares or caricatures of the fish when judged from the standard of European and American breeders. Every conceivable variation in bodily appearance, head, snout, mouth, eye, fins, tail and color has been developed and bred so as to force the conclusion that nothing is impossible to the Chinese breeder. All the varieties are not known in the United States, as some especially of the Chinese breeds, have probably never been exported or failed to survive the long journey; but the widely diversified appearance of those with which we are familiar leads to the expectation of even greater marvels as the result of that Oriental patience and perseverance which is proverbial in the Mongolian race. By methods apparently known only to themselves they have succeeded in developing and perpetuating malformations of structure which entirely change the appearance of every part of the fish. Some varieties of their goldfishes have the bodies modified in every conceivable way; shortened, elongated, rounded, curved, crescent-shaped, triangular in section or twisted and otherwise distorted into strange forms; with the dorsal fin sometimes only half its normal length or entirely absent. Others have the paired fins lengthened and abnormally shaped, the anal double or absent; the caudal of every conceivable form; the head so much shortened and the snout malformed as to produce an almost bulldog appearance, or covered by papillomatous growths, the eyes almost wholly projecting beyond the orbits, to appear like globular or tubular projections, with the pupils pointing sideways, forward or straight upward. Others have the scales raised from the sides to give an appearance like a ruffled fowl; some are so transparently scaled as to appear entirely scaleless or have a few scales on an otherwise apparently scaleless body. The marking and colors are equally fantastic and baroque and show every grotesque and fanciful design and color combination. No single detail seems to have been omitted that could produce the wierdest conceptions of what might be considered a diseased imagination.

To find beauty in this wild fantasm is surely "an acquired taste" but their rarity and singular appearance, their extreme contrast with every other kind of goldfish, led to the Chinese varieties being the highest prized of any of the aquarium fishes.

In the following descriptions and illustrations the Japanese and Chinese goldfishes will be treated of in the order in which they differ from the ordinary goldfishes and from each other. It may be here stated that the racial characteristics of the Japanese and Chinese are clearly reflected in their goldfish breeding; the innate, though often oddly expressed, appreciation of the beautiful of the Japanese race, and the search for the bizarre, the grotesque, and often to the Occidental mind the horrid, on the part of the Chinese.

It should also be premised that the illustrations are accurate, unflattered drawings from life of the most perfect fishes of their respective kinds, seen or owned by the author, except in a very few instances of those varieties which are now extinct in the Eastern States and for which descriptions and sketches were obtained from their one-time owners, to whom credit is given. Nearly all of these different breeds have been fully acclimated and most of them are American bred.

Early naturalists distinguished between the few then known toy varieties of the goldfishes, of Chinese and Japanese origin, by more or less appropriate Latin and Greek descriptive designations, which Dr. E. Zernecke applied to the now generally known varieties and added others. For instance, the Japanese double-tailed fishes were known as *Carassius auratus, varietas japonicus*, (Japanese variety of the goldfish); but which did not designate the Fringetail or Fantail and applied as well as to the Comet, Nymph or others of Japanese origin and derivation. Dr. Zernecke proposed *Carassius auratus, var. japonicus, bicaudalis*, (double-tailed Japanese variety of the goldfish); which would not include the single-tailed varieties, but could be applied to both the Fringetail and the Fantail. The following nomenclature for the toy varieties now known and bred in the United States is proposed and here adopted with the hope that it will meet with general acceptance:—

- The Common American Goldfish—*Carassius auratus, var. americanus*.
- The Common European Goldfish—*Carassius auratus, var. europensis*.
- The Japanese Comet Goldfish—*Carassius auratus, var. japonicus simplex*.
- The Japanese Fringetail Goldfish—*Carassius auratus, var. japonicus pendulibicaudalis*.
- The Japanese Fantail Goldfish—*Carassius auratus, var. japonicus erectibicaudalis*.
- The Japanese Nymph Goldfish—*Carassius auratus var. japonicus, nympa*.
- The Japanese Barnacled Goldfish—*Carassius auratus, var. japonicus verrucosus*.
- The Japanese Hooded or Lion-headed Goldfish—*Carassius auratus, var. japonicus leocephalus*.

The Chinese Telescope Goldfish—*Carassius auratus*, var. *chinensis macropthalmus*.

The Chinese Mottled or Variegated Goldfish—*Carassius auratus*, var. *chinensis variegatus*.

The Chinese Fringetail Telescope Goldfish—*Carassius auratus*, var. *chinensis pendulibicaudalis*.

The Chinese Moor or Black Telescope Goldfish—*Carassius auratus*, var. *chinensis maurus*.

The Chinese Tiger Telescope Goldfish—*Carassius auratus*, var. *chinensis tigrinus*.

The Chinese Lettered Telescope Goldfish—*Carassius auratus*, var. *chinensis scriptus*.

The Chinese Eggfish—*Carassius auratus*, var. *chinensis oviformis*.

The Chinese Blue Telescope Goldfish—*Carassius auratus*, var. *chinensis cyanus*.

The Chinese Celestial Telescope Goldfish—*Carassius auratus*, var. *chinensis uranoscopus*.

The Chinese Tumbler Telescope Goldfish—*Carassius auratus*, var. *chinensis saltator*.

The adoption of these polynomials to designate the numerous artificial variations of the Goldfish, *Carassius auratus*, is done without intention of conflicting with the codes of nomenclature of zoologists.

THE JAPANESE COMET GOLDFISH

This variety was bred from the ordinary goldfish by crossing with the Japanese Fringetail or with fishes derived of this stock, and authorities claim first known in the United States about the year 1872. The efforts of the breeders were directed to the production of a pronouncedly elon-

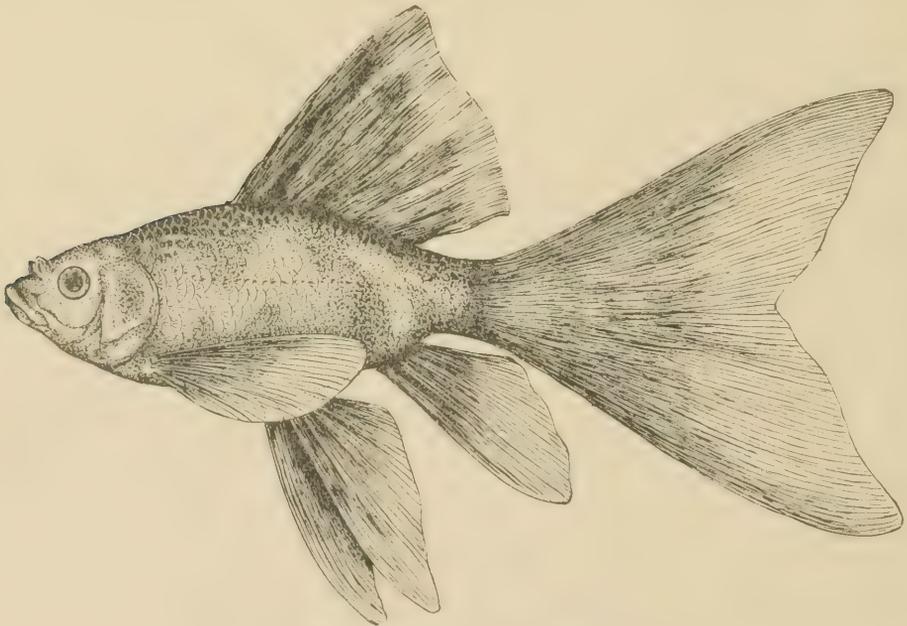


FIG. 8.—Japanese Comet Goldfish
Carassius auratus var. *japonicus simplex* Two-thirds life size.

gated body and tail, a long and narrow head with pointed snout, erect nostrils, thin lips and flat eyes; small uniform scales, long and erect dorsal

and long pendant pectoral, ventral and anal fins. Of these the pectorals and ventrals are paired and the dorsal, anal and caudal fins single; the desired characteristic being a very slender, flat-sided and long-drawn fish, as the well-applied name would indicate. The colors are those of the ordinary goldfish.

The Comet is a most elegant, graceful and dainty fish, very hardy and easily bred; the personification of grace and rapidity of movement. Since its introduction, American breeds have produced a considerable

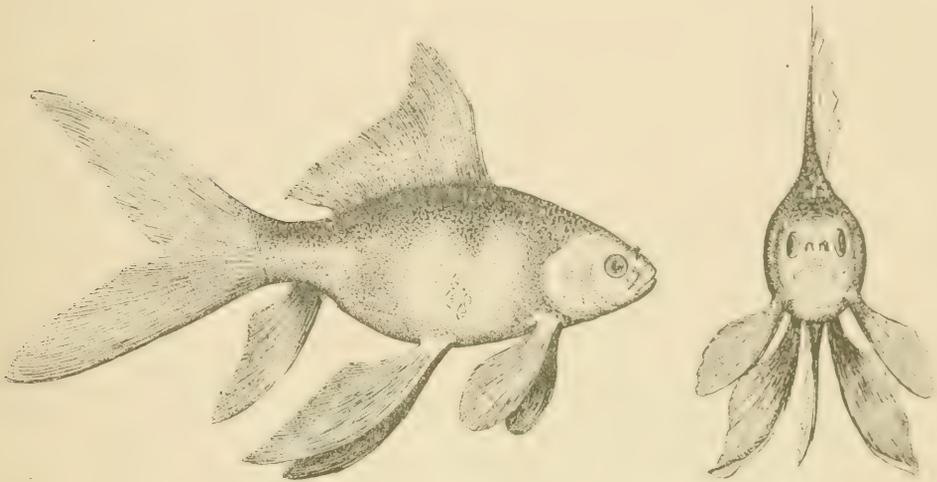


FIG. 9.—Transparently Scaled Japanese Comet Goldfish. Lateral and frontal views. Two-thirds life size.

variation of the scaled parent type, and fanciers now distinguish between Ram's nose and Hog's nose scaled and scaleless (transparently-scaled) Comets, having either full, broad tails or with the tails very considerably bifurcated and spread, the most prized and rarely to be obtained being scaleless sharp-nosed Comets of a deep oxblood red color on the body and white fins with very long pendant lower fins, erect dorsals and widely spread single tails, either full or bifurcated, carried straight out behind and considerably longer than the body of the fish. These command high prices and are in beautiful contrast to other finely bred goldfishes.

THE JAPANESE FRINGETAILED GOLDFISH

Carassius auratus, var. japonicus pendulibicaudalis. Figs. 10 and 11.

Of the finely bred aquarium fishes the beau-ideal is unquestionably the truly magnificent Japanese Fringetail. No other variety has so richly rewarded the efforts of the breeder as this wonderful specimen achieved by careful selections on the lines of beauty, symmetry, grace and elegance of

color. Patient, discriminating labor with thousands of generations has produced in the perfect Fringetail the handsomest of all goldfishes. The long, lace-like fins and tail, the rich burnished metallic lustre, the marvelous

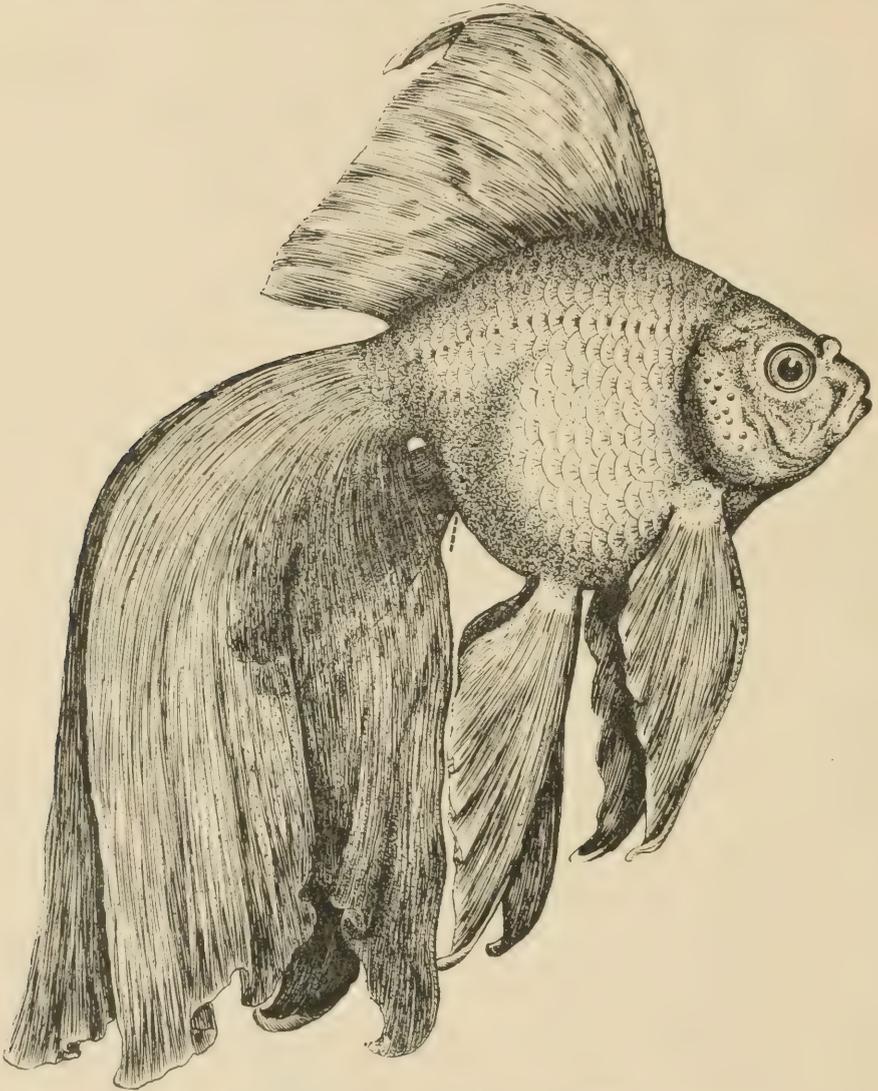


FIG. 10—Adult Japanese Fringetail Goldfish
Carassius auratus, var. *japonicus pendulibicaudalis*. Two-thirds life size.

brilliancy of color, the finely modeled form and the perfection of graceful movement are truly typified in this justly prized fish. The full development of the beauty of the species is only attained upon maturity; although the fancier can discern in quite young fishes, those that give promise of future perfect development.

The fine mature Fringetail is a small-scaled, short-bodied and short-headed, thick, almost egg-shaped fish with evenly rounded sides, having

all the very long pendant fins paired, except the long, wavy and lace-like dorsal; and an immense delicate drooping double tail, divided quite to the base and floating behind the body like a great mass of most dainty lace; much longer than the body of the fish. The two separate tails are exactly alike in conformation, length, droop and texture.

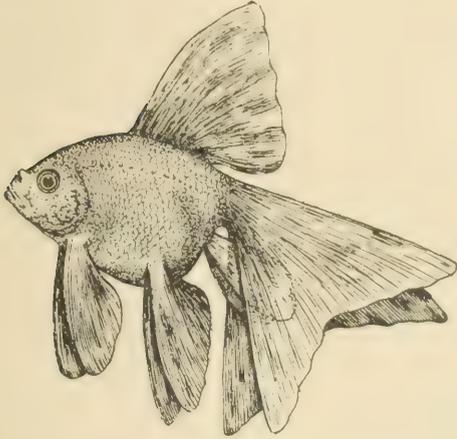


FIG. 11—Young Japanese Fringetail Goldfish.
Two-thirds life size.

By crossing with the Chinese transparently scaled fishes, American breeders have produced a larger black-eyed transparently scaled fish that is handsomer than the Japanese Fringetail, though otherwise it has all the characteristics of the imported fish; but is even more delicate and dainty in fin and tail development and more pronounced in color.

In moving through the water the stately appearance of the fully developed Fringetail is most graceful, majestic and fairy-like; the beautiful tail, floating behind and following every movement, is carried as though the fish were proud of its almost regal appearance.

THE JAPANESE FANTAIL GOLDFISH

Carassius auratus, var. japonicus erectibicaudalis. Fig. 12.

This beautiful fish has certain distinguishing characteristics which clearly mark it as a distinct variety, though in many particulars it bears a close resemblance to the Fringetail. Authorities agree on these distinctions which are recognized by fanciers. The Japanese breeders developed decided differences in conformation of body and fins which are very apparent in finely bred specimens, though these are more rare than is generally supposed, as most of the goldfishes known as Fantails are usually Fringetails with either short or imperfectly developed tails; or web-tailed Japanese fishes.

The Fantail is a scaled short-bodied fish, very thick, round-backed and deep-bellied, of almost oval outline; its body being best described as of short pumpkin-seed-form, with the horizontal longer diameter of slightly greater length than a true oval, and so formed that an imaginary line from the upper lip to the base of the tail would show the upper and lower halves of the body of almost the same conformation. It has a short, broad head, distinctly hognosed, a large mouth with full lips, erect nostrils and eyes like the ordinary goldfish, but larger. The long and erect dorsal fin sits far back on the spine, all the other fins being paired; the pectorals and

ventrals are long and pendant, the double anal fins are long and extend almost straight backward, while the broad double tail, which is the principal characteristic of the fish, is divided quite to the base and the two distinct tails stand directly vertical on the same plane and are carried straight

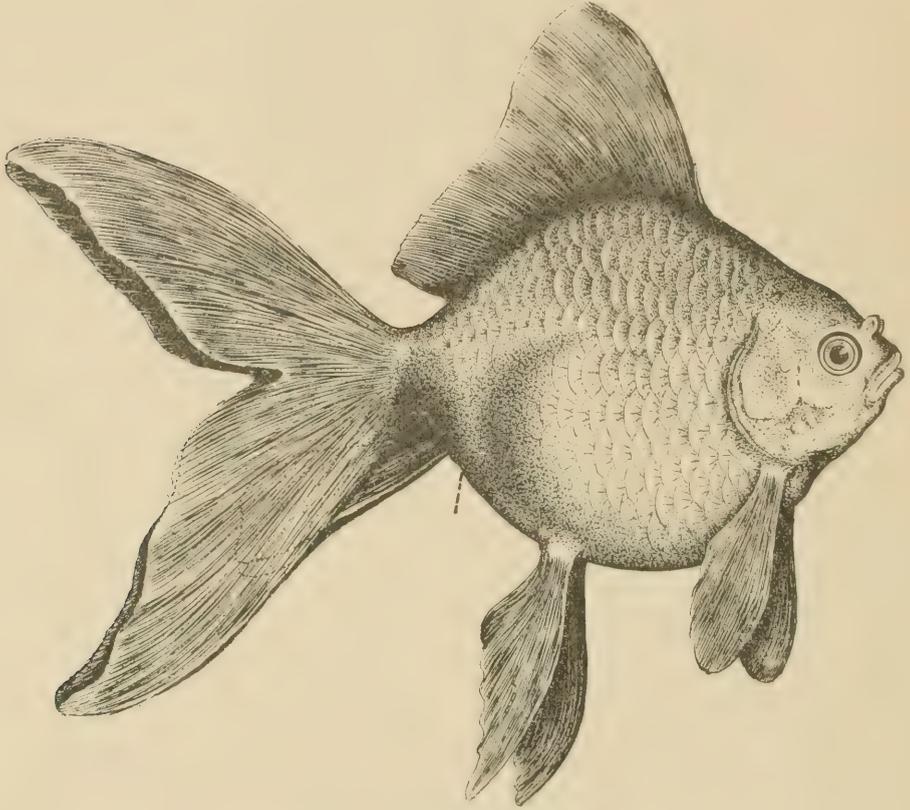


FIG. 12.—Japanese Fantail Goldfish
Carassius auratus, var. japonicus erectibicaudalis. Two-thirds life size.

out behind the body without the least drop or droop; the upper and lower lobes being of exactly the same length so that a perpendicular line from the end of the upper will exactly touch the end of the lower lobe on each side. This is never the case with the imperfectly developed Fringetail; the upper lobes are always the longer, and the relative position of the double tail is not directly vertical or parallel to each other but at a decided angle when the fish is viewed from the rear, while the perfectly developed Fantail has the appearance of having two separate single tails placed side by side. The tail of the Fantail never exceeds the body in length.

The colors are identical with those of the Fringetail, but the scales are larger and usually coarser; this variety also having no transparently scaled members, either of pure or crossed stock. It is a characteristically handsome fish though not as "showy" as the Fringetail.

THE JAPANESE NYMPH GOLDFISH

Carassius auratus, var. japonicus nympha. Figs. 13 and 14.

With all finely bred domesticated animals there are always some individuals that have a tendency to partially revert to the ancestral type. This frequently occurs with goldfishes, as many of the progeny of the

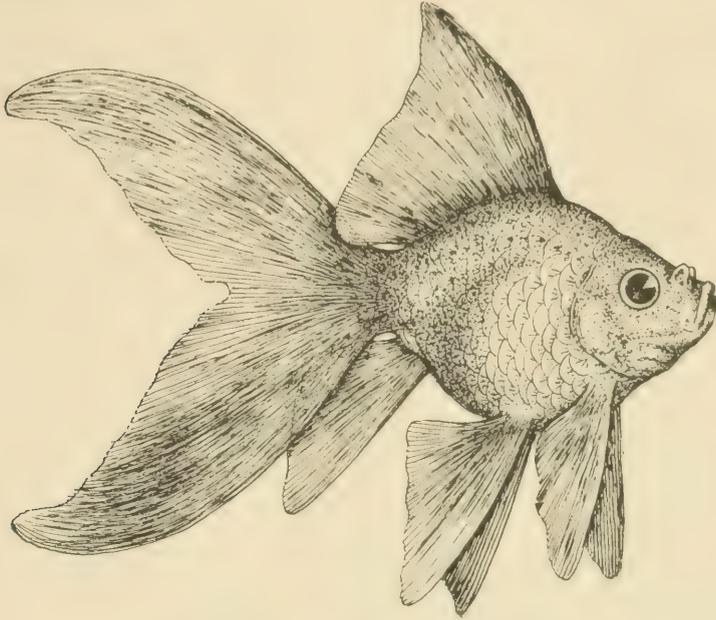


FIG. 13—Scaled Japanese Nymph Goldfish
Carassius auratus, var. japonicus nympha Two-thirds life size

finest strains develop characteristics different from their parents and clearly indicate the type from which the breed was derived. An instance of this is the Nymph goldfish, the name of which would indicate some such thought on the part of the breeders. It is now recognized as a distinct

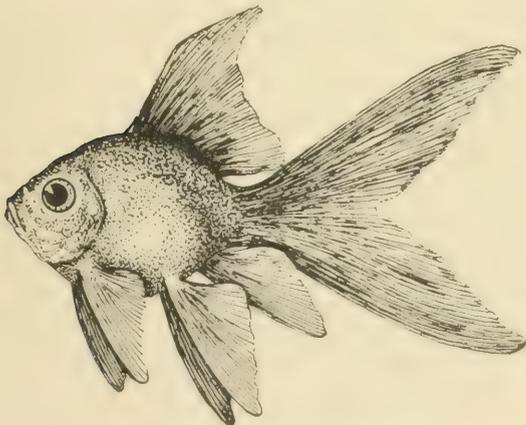


FIG. 14—Transparently-scaled Japanese Nymph Goldfish
Two-thirds life size

variety and may be bred by crossing the Comet and the Fringetail, but is more usually accidentally produced from Fringetail stock; being what is known, in the parlance of the breeder as a "sport." The finest specimens have all the characteristics of the Fringetail with a single Comet-like tail. Fine specimens of the Nymph are very handsome, having long pendant pectoral and ventral fins,

a very high dorsal and a straight single anal fin; a delicate, very long single tail, and the head, eyes, small scales and general conformation, as well as the rich lustrous colors of the Fringetail. The body is shorter, broader and fuller than the Comet, those with almost circular flat-sided bodies are the highest prized.

In the aquarium they make an agreeable contrast to the other fine breeds and have an individuality of their own which warrants their being classed as a distinct variety. Some fanciers still consider them single-tailed Fringetails, but the general consensus of opinion is that these fishes should be classed as Nymphs, the most typical having short flat-sided bodies and straight Comet-like tails, though some Nymphs have tails of such great length that they of necessity droop. These may be considered a separate variety, and are quite as much prized as the straight tailed fishes. They occur both scaled and transparently scaled.

THE JAPANESE HOODED OR LION-HEADED GOLDFISH

Carassius auratus, var. japonicus leocephalus Fig. 15.

The form, scales, fins and color of this peculiar Japanese or Korean goldfish resemble the Fringetail but the dorsal fin is absent; the distinctive difference consists of a peculiar growth on and over the sides of the head,

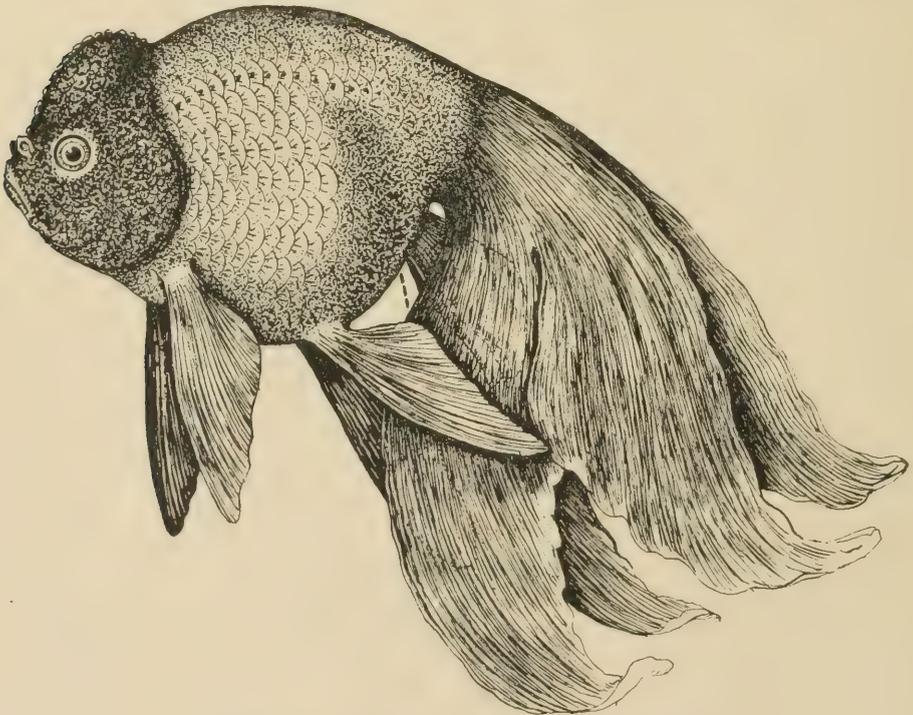


FIG. 15. Adult Japanese Hooded or Lion-headed Goldfish
Carassius auratus, var. japonicus leocephalus. Two-thirds life size

surrounding the orbits, so that the head of the fish has an appearance similar to that of the "Owl" breed of pigeon, surmounted by a hoodlike excrescence of bright pink or of crimson color. This papillomatous growth consists of rounded tubercles, about pinhead size, evenly placed and entirely covering the head.

This peculiar goldfish was described by Mr. Hugo Mulertt who imported a number from Europe, and has also recently been reintroduced into the United States. Fine specimens are of pearl-white color on the sides with occasional regularly placed single brilliant red scales; others are of golden color, but all have the characteristic crimson papillæ on and over the head. Occasional fine specimens are devoid of anal fins.

In writing of the "Corean breed," known as the "Maruko" or "Ranchiu," now largely bred in Japan, Prof. S. Watase states that it has an exceedingly short body, being in some instances almost globular in form. The dorsal fin is entirely absent and the head is distinctive of this breed in having rough-looking protuberances of the skin which often attain a considerable size and length.

Two specimens of this fish were shown in alcohol in the Japanese section at the Chicago World's Fair, as they did not survive the voyage to the United States. These had developed the peculiar growth into long and hair-like manes and were designated by the Japanese as "Lions." No others were seen by the author until recently and these had the papillomatous growths and general characteristics of the illustrated fish. Dr. Hugh M. Smith of the Bureau of Fisheries at Washington, during his visit to Japan saw and had drawings made of some remarkably developed fishes of this breed.

THE JAPANESE BARNACLED OR PARADISE GOLDFISH

Carassius auratus, var. japonicus verrucosus Fig. 16.

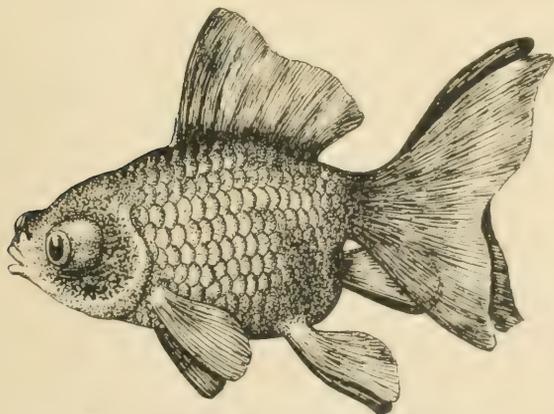


Fig. 16—Japanese Barnacled Paradise Goldfish
Carassius auratus, var. japonicus verrucosus. Two-thirds life-size

This exceedingly rare Japanese goldfish has the body and fin development of the Telescope, with the large tubular eyes pointed forward; a shortened head and long snout, moderately large paired fins and a double tail. The skin is covered with wartlike growths or papillæ, which cause the thin scales to curve and

stand from the sides as though they were ruffled, and giving to the fish somewhat the appearance of being covered with barnacles. The scales are unevenly imbricated, so that they appear somewhat scattered, like those of the mirror carp; although they entirely cover the body of the fish.

The singular appearance of these fishes led American breeders to suppose them to be diseased, but later they were recognized as a variety of the Japanese Telescope, the distinctive peculiarity being the scale formation. The colors are mottled red and white with black and white fins and tail. So far as is known, these fishes are now extinct in the Eastern section of the United States, the last importation having been received in 1897. Recent repeated inquiries and efforts to obtain breeding fishes by direct importation have been unsuccessful, leaving it an open question whether they should be recognized as a separate breed or an accidental variation which was lost.

THE CHINESE TELESCOPE GOLDFISHES

This singular breed is of Chinese origin but is also bred in Japan. In it may be observed the peculiarities of the Chinese breeder and his desire to produce abnormalities. The head and snout are considerably shortened; the body is rounded and egg-shaped, the dorsal fin erect and set far back on the spine; all the lower fins are paired; and the double tail is divided to its base and carried straight out at a downward angle. The vertebral column

is also curved downward behind in an abnormal way to produce a hunchbacked condition. There are both scaled and transparently-scaled Telescopes, the former being generally recognized as of Japanese breeding. As the name implies, the principal peculiarity is the development of the projecting eyes, Fig. 17, which have the character of spheres, ovoids, truncated cones or segmented spheres set upon the sides of the head, the eyeballs appearing to almost wholly project from the orbits, and the cornea forming a segment of a much smaller sphere than does the eyeball proper. As a result of this peculiarity, the anterior portion of the eye is more acute than the larger posterior portion. The iris is also very distinctly outlined. In addition to the abnormally

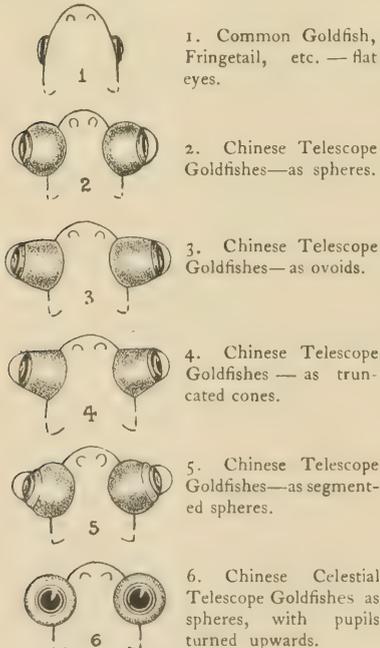


FIG. 17—The Eyes of Goldfishes.

shaped body, projecting eyes and peculiar droop of the tail, fanciers prize the remarkable colorings developed by the orientals. The prevailing colors of the scaled Japanese fish, Fig. 18 are those of the ordinary goldfish, but most oddly placed. Certain fishes have clear golden-red bodies with the backs and all the fins jet-black and have black eyeballs; others have white bodies and deep-red fins and red eyeballs

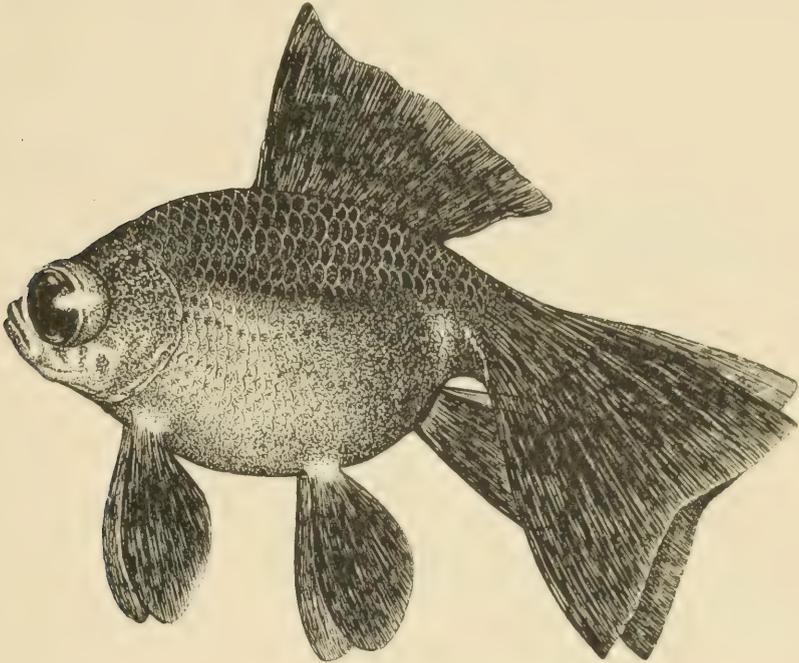


FIG. 18—Scaled Japanese Telescope Goldfish
Carassius auratus, var. japonicus macrophthalmus. Two-thirds life-size

with black irides; some have red or golden-yellow bodies and white fins with red, white and black eyes; and others pearly-white bodies, and fins mottled with red, and red and black eyes, though none of these colorings are necessarily permanent. The colors of these fishes are so fantastic that French, German and American authorities class them as much by these color peculiarities as by changes in body structure.

The following are the most generally known of the Chinese telescopic-eyed goldfishes bred in the United States:

THE CHINESE MOTTLED OR VARIEGATED TELESCOPE GOLDFISH

Carassius auratus, var. chinensis variegatus. Figs. 19, 20, 21 and 22

This variety of the Telescope is commonly known as the Calico, as best describing its fantastic markings. The body is short and thick; the spine has a decided backward curve; the snout is formed to give the short

head a pugnacious appearance ; the mouth is placed almost vertically at the front of the head ; the lips are distinct ; the nostrils small but erect, and the eyes very large and usually dislike or tubular in form. The

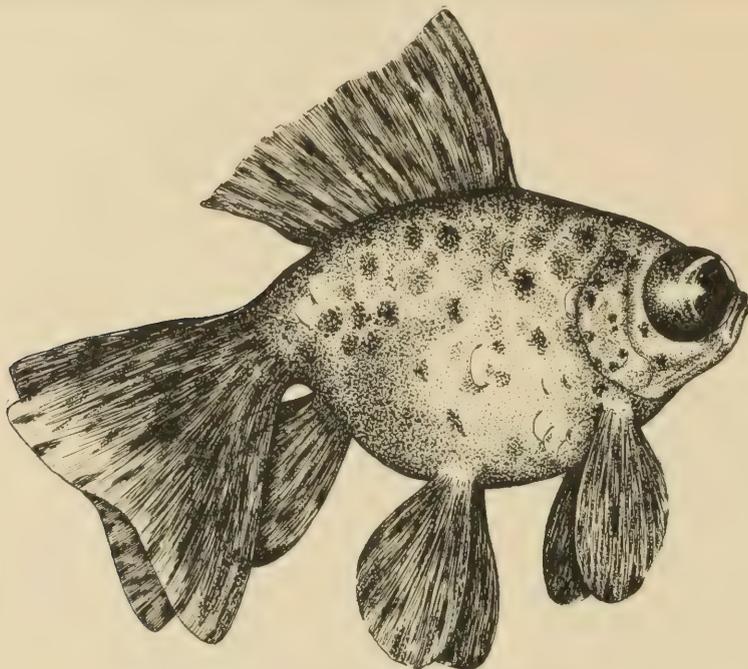


FIG. 19—Adult Chinese Mottled Telescope Goldfish
Carassius auratus, var. chinensis vertegatus. Lateral view. Two-thirds life size

dorsal fin is high and short ; all the lower fins are paired, long and very broad ; the tail is double and the two separate tails are carried at an angle

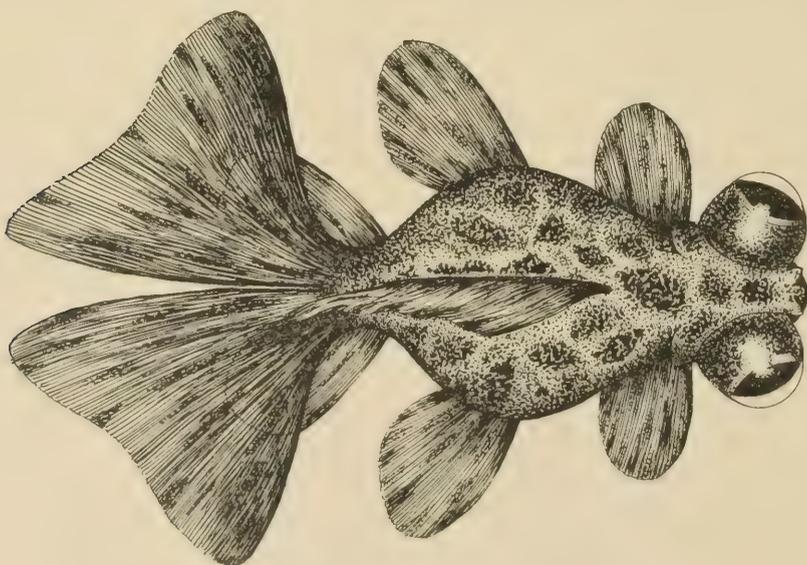


FIG. 20—Adult Chinese Mottled Telescope Goldfish
Dorsal view. Two-thirds life size

to each other, straight, drooping and at an angle with the body. Its markings are most peculiar and consist of irregular blotches of all shades and shapes, distributed at random over the entire fish, including body, fins

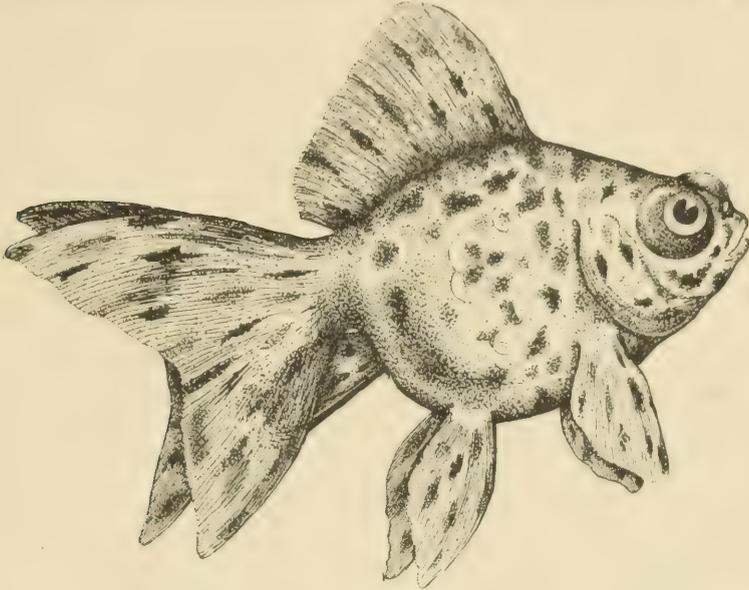


FIG. 21—Young Chinese Mottled Telescope Goldfish
Lateral view. Life size

and tail. It is so transparently scaled that the flesh tints, which are often of a pronounced bluish hue, may be seen through the skin; upon which

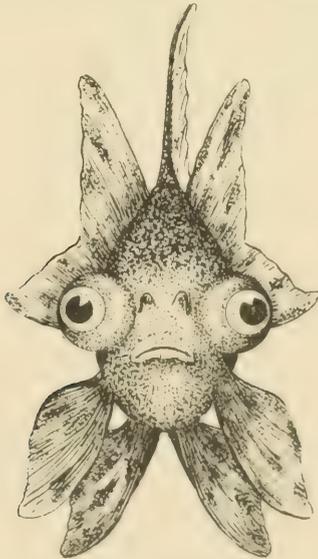


FIG. 22—Young Chinese Mottled Telescope Goldfish
Frontal view. Life size

the red, yellow, brown, blue and black mottlings show most conspicuously. This is a handsome, most peculiar and highly prized fish.

THE CHINESE FRINGETAILED TELESCOPE GOLDFISH

Carassius auratus, var. chinensis pendulibicaudalis. Fig. 23

This variety has the body, eyes and fin development of the Calico, but differs in its markings. The transparent scales are invisible and the colors are most oddly distributed in patches of beautiful oxblood red, white and bluish tints over the head and body. The long, delicate, filmy, lacelike fins and beautiful long double tail are usually white.

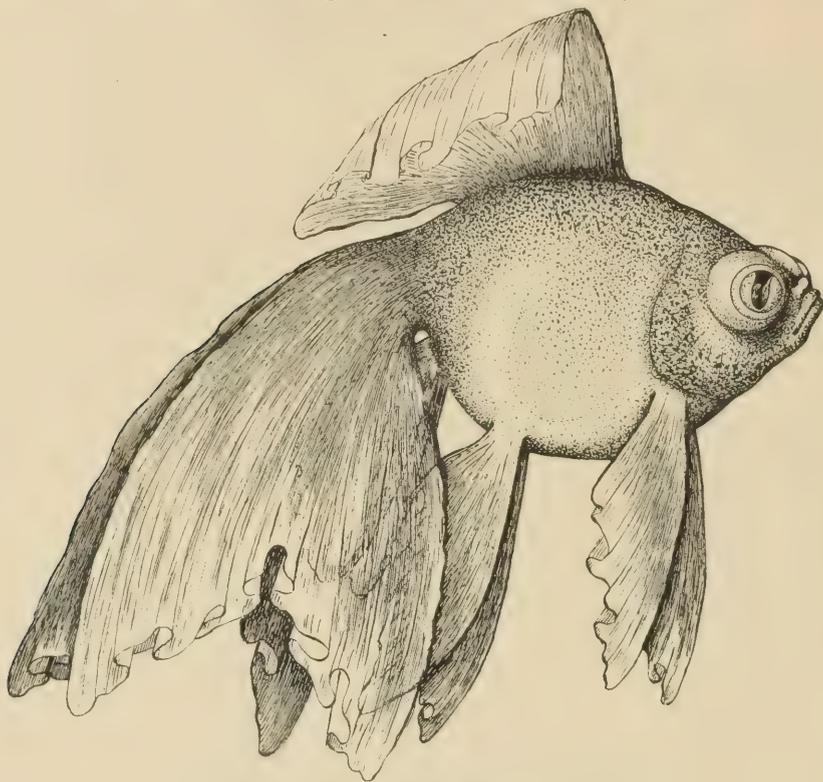


FIG. 23 —Chinese Fringetail Telescope Goldfish
Carassius auratus, var. chinensis pendulibicaudalis. Life size

Sometimes the fish is almost or entirely white, with delicate pink and blue tones, and so transparent that almost all of the internal organs and the skeleton are visible, a most interesting, curious and dainty so-called Transparent Fringetail Telescope Goldfish. These fishes are derived from the same parent stock as the Mottled Telescope and are bred from imported fishes. Oftentimes some of the young of Mottled Telescopes exhibit this character and are greatly admired, not only for their beautiful colors but also for their spheroidal eyes, which are usually deep blue in color.

The Chinese Fringetail Telescopes have most wonderful development of fins and tail, so dainty and lacelike as to seem too delicate to serve their uses. These are as long and pendant as those of the most perfect Fringetail. The illustration is of an 18 months old fish owned by the author.

THE CHINESE MOOR TELESCOPE GOLDFISH

Carassius auratus, var. Chinensis maurus Fig. 24

This magnificent variety, known as the Moor or Black Telescope, is a very rare and deservedly highly prized fish. Its general conformation is that of the Chinese Telescope, but the fins and tail are usually longer.

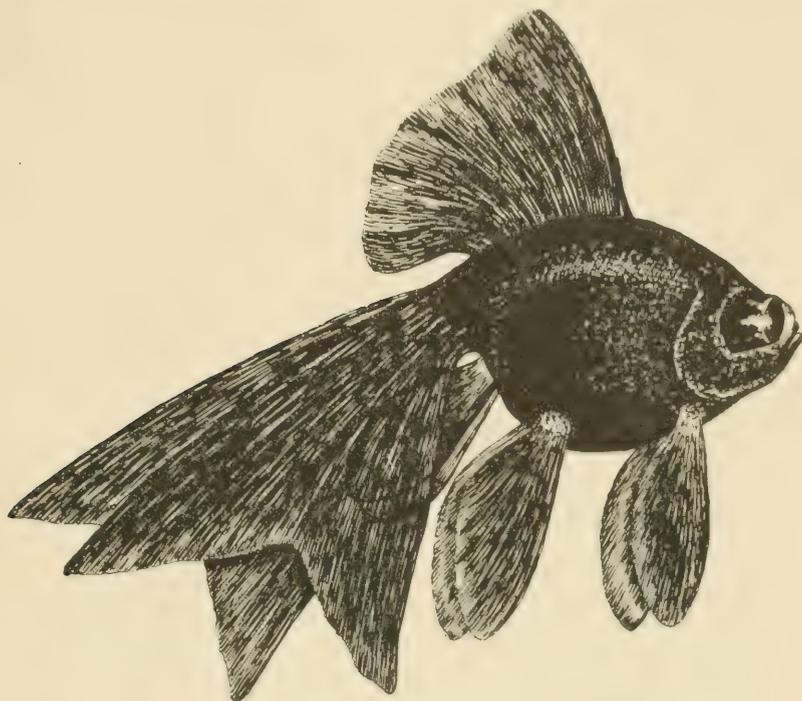


FIG. 24—Chinese Moor Telescope Goldfish
Carassius auratus, var. chinensis maurus Two-thirds life size

The distinctive coloring is permanent in purely bred fishes and consists of an even covering over the entire fish, including the eyes, fins and tail, of a wonderfully rich bluish-black hue, so delicate and even in tone as to appear as though the entire fish were covered with the richest blue-black velvet, the magnificent sheen of which is such that one could expect to feel the very texture of the fabric. With many of the American bred Moors, however, the black color is not permanent.

The Moor is always a scaled fish, though these, due to the intensely dark color, are usually invisible. Sometimes in fishes bred from Japanese stock, the colors are black on the back and sides, with a delicate bluish or reddish-bronze tone on the abdomen, these scales have the appearance of being outlined with golden-bronze. The fishes so marked never retain their black color, but at some time in their existence, assume the darker colors of the goldfish. It is accepted among breeders that young Moors

which are white on the under side of the body, between the fins, are more likely to retain their black color than those which are yellow in this region.

No fish is handsomer in the aquarium than a fine Moor, as the beautiful form and color not only contrast with the other fishes, but tend to bring their brilliant colors more prominently into notice.

THE CHINESE PIEBALD OR TIGER TELESCOPE GOLDFISH

Carassius auratus, var. chinensis tigrinus Figs. 25 and 26

This fish has a most curious appearance both in form and markings. The tubular eyes are developed to a remarkable degree, often extending

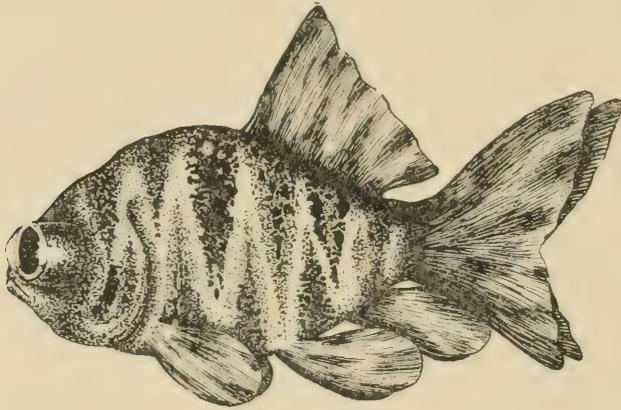


FIG. 25—Chinese Tiger Telescope Goldfish
Carassius auratus, var. chinensis tigrinus Lateral view Two-thirds life size

beyond the snout, directed sidewise and projecting $\frac{1}{2}$ to $\frac{5}{8}$ inches from the orbits. In transverse section the fish would appear almost triangular, with the flattened abdomen as the base. The body is short, thick and malformed, scant of fins and tail, and the curious markings, from which the fish derives its name, are the pink and blue tones of the flesh under the transparent scales, as the prevailing color, overlaid with streaks and patches of black, dark brown, red and dusky grey on the back, sides and fins, with a lemon-yellow abdomen. But two good specimens of this breed have been seen by the author; European authorities depict them as characteristically marked with narrow bands of contrasting colors.

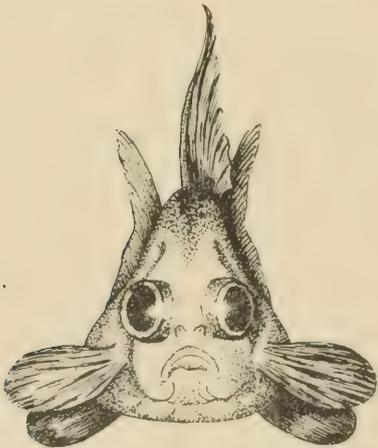


FIG. 26—Chinese Tiger Telescope Goldfish
Frontal view Two-thirds life size

THE CHINESE LETTERED TELESCOPE GOLDFISH

Carassius auratus, var. chinensis scriptus. Fig. 27

Another instance of the patient labors of the Chinese in developing desired characteristics in the goldfish is evident in the Lettered Telescope, a very rare fish, as but two specimens, both females, have come to the knowledge of the author, both owned in Philadelphia. No recent authority describes this fish, the following is a description of the two mentioned specimens.

The form and eye development is similar to that of the Tiger Telescope, though the body is rather more rounded and not so triangular in section. The eyes are distinctly tubular and directed forward at each side of the snout with a slightly upward trend, and the cornea is also directed forward and slightly upward. The head and snout are very short, the

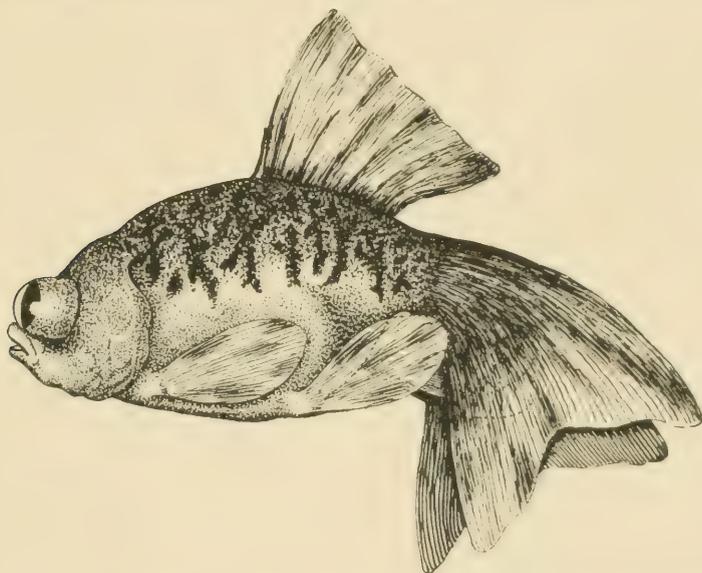


FIG. 27—Chinese Lettered Telescope Goldfish
Carassius auratus, var. chinensis scriptus. Two-thirds life size

body thick and quite as broad as high, with the fins and double tail fairly well developed, and the pectorals and ventrals extend almost straight out at the sides of the fish. The anal fin is double, as is also the tail, which is distinctly spread and divided to the base. The anal fins are used like the ventrals in swimming.

The chief peculiarity of this fish consists of the colors and markings. The transparently scaled body is dark olive-green on the back, citron-yellow on the sides, and yellowish-white under the abdomen; covered with brown markings which have the appearance of Chinese characters written in sepia.

It is a most curious, almost repulsive fish and odd-looking aquarium inmate, rather more remarkable for oddity than beauty. See Cuvier and Valenciennes description of this fish, the *Quen-yu*, and also that of de Sauvigny.

THE CHINESE BLUE TELESCOPE GOLDFISH

Carassius auratus, var. chinensis cyaneus

The fish is described as a scaled Telescope, silvery on the abdomen flushed with rose-pink, a rich azure blue on the back and sides, the whole fish having a metallic lustre. Those seen or owned by the author are transparently scaled, with a velvety, ultra-marine blue color on the back, reddish-blue transparent lower sides and a blue-white or greyish abdomen, with a dark bluish-brown or black dorsal fin, white or grey lower fins and dusky-grey or brownish double tail. The eyeballs are prominent and of a blue color, the whole color tone being bluish and bluish brown with local tones of pinkish blue and bluish-white.

This is a handsome Chinese goldfish and is greatly admired. The author has never seen one sufficiently perfect to serve as a type. The colors are best seen when the fish is viewed in a strong light, together with brilliantly colored goldfishes.

THE CHINESE CELESTIAL TELESCOPE GOLDFISH

Carassius, auratus, var. chinensis uranoscopus. Figs. 28 and 29

The most curious of the highly bred Oriental goldfishes is the Celestial Telescope or Stargazer. This fish has an extremely shortened snout,

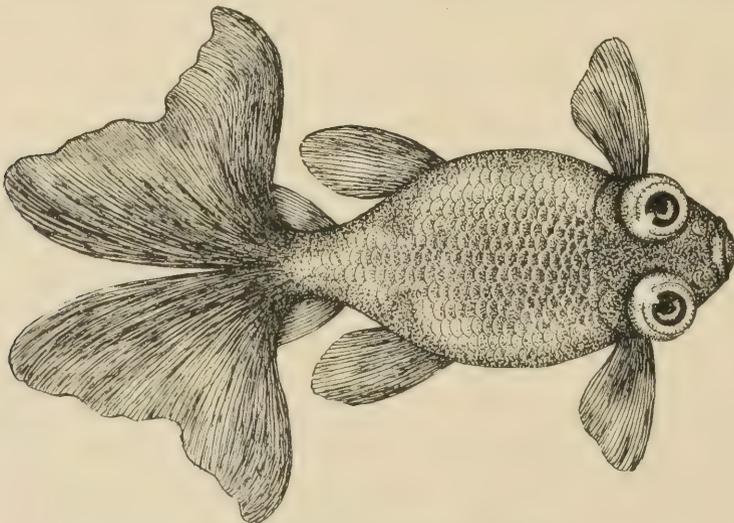


FIG. 28— Chinese Celestial Telescope Goldfish
Carassius auratus, var. chinensis uranoscopus. Dorsal view. Two-thirds life size

with the large spheroidal projecting eyes, having very small irides, turned upward over the head, so that the gaze of the fish is always directed to the surface. Its eyesight is very defective. The dorsal fin has been entirely eliminated, as the scales are evenly imbricated over the back and sides. The body is egg-shaped, very tapering at the tail. The fins are broad and pendant, and the tail is carried at a slight downward angle and very widely spread to maintain the balance of the fish. Its movements are slow and languid. Due to its fixed upward gaze, the fish has acquired the habit of carrying its body at an angle, with the snout and eyes usually the highest points of the plane. European authorities depict this fish as

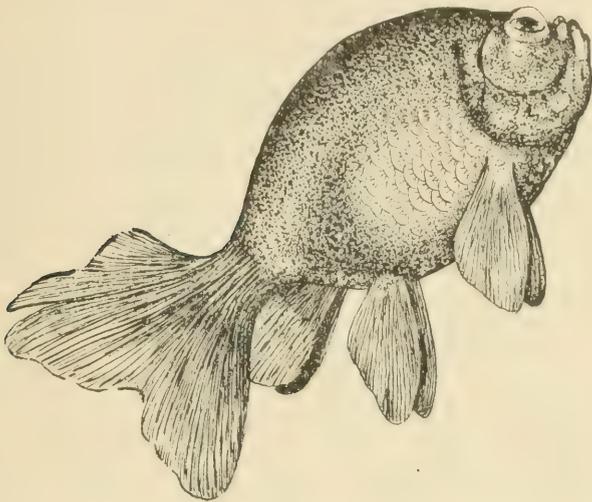


FIG. 29—Chinese Celestial Telescope Goldfish
Lateral view. Two-thirds life size

“dolphin-tailed,” and without anal fins. These would not be as highly prized by American fanciers.

It is stated that this fish is bred in jars to which the light is admitted through a slit in the lid or cover, thus inducing the fry to gaze upward for both light and food. It is considered to be sacred and is kept in many of the Oriental tem-

ples, probably on account of its constant heavenward gaze.

The Celestial Telescope is the most difficult of the imported goldfishes to rear or to keep alive in the aquarium, the author having no information of its successful breeding in the United States for successive generations and knows of but three authenticated instances of a long survival of the imported fish.

THE CHINESE EGGFISH

Carassius auratus, var. *chinensis oviformis*. Fig. 30

Several recent German authorities mention the Chinese Eggfish, a variety of the scaled goldfish which resembles the YA-TAN-YU or Duck-egg of Cuvier and Valenciennes and of de Sauvigny. It is described as having a perfect eggshaped body, very evenly convexed and rounded on all sides, from the head to the base of the tail; with flat eyes like those of the Fringetail, which very seldom incline to the telescopic. The dorsal and anal fins are absent, the pectoral and ventral fins are normal and the

narrow double tail droops directly downward from the back. Those of a white color are most highly prized and are considered to be the most perfect and preferable to mottled or red fishes, as they more nearly deserve the designation of Eggfish.

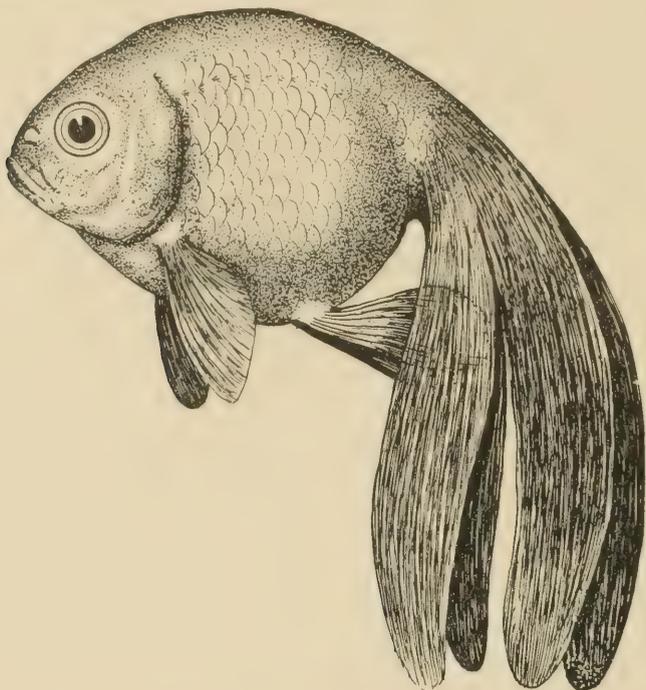


FIG. 30—Chinese Eggfish
Carassius auratus, var. chinensis oviiformis. Two-thirds life size

None of these are bred in the Eastern States, the author having seen but one imported specimen; but young fishes of scaled Telescope parentage often exhibit some of the described characteristics, which by careful breeding and selection would in time produce this breed. At the time of this writing attempts in this direction are being made in Philadelphia.

THE CHINESE TUMBLER GOLDFISH

Carassius auratus, var. chinensis saltator. Fig. 31

This singularly developed goldfish is one of the most curious of the Chinese varieties as yet known in the United States. The accompanying illustration was made from the description and sketch obtained through the courtesy of Mr. Hugo Mulertt.

The curvature of the spine, the development and position of the pectoral, ventral and dorsal fins; the large anal fin and the peculiar double tail make this fish so out of balance that its only method of progression is by a series of backward somersaults, similar to the gyrations of the Tumbler pigeon. It is described as a scaled, telescopic-eyed fish of blue color flushed with orange, and is now extinct in the United States. In

1901, a Philadelphia breeder accidentally obtained several fishes in a hatching of fry of imported Chinese mixed parentage, which had many of

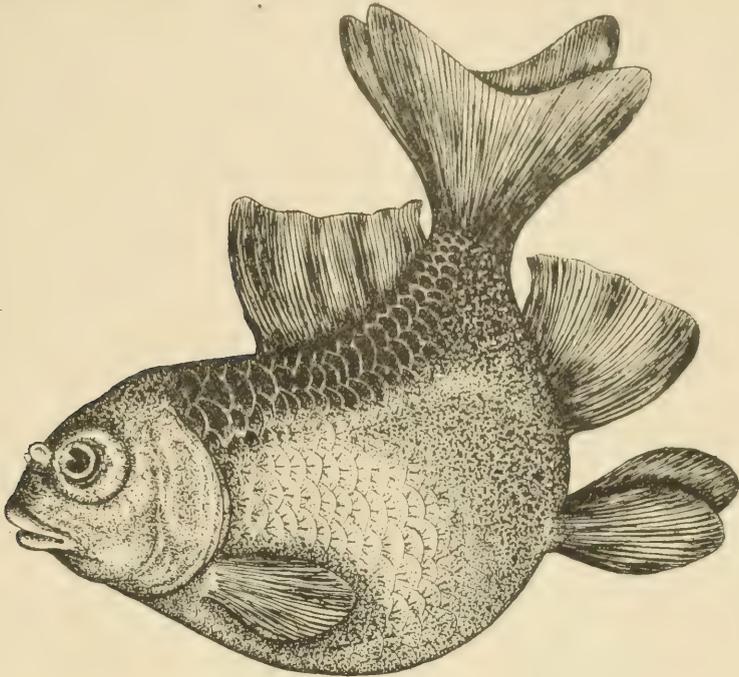


FIG. 31—Chinese Tumbler Goldfish
Carassius auratus, var. chinensis saltator Two-thirds life size

the described peculiarities of this variety, but none survived to maturity. See de Sauvigny's description of the Kin-teon-yu.

OTHER VARIETIES OF THE GOLDFISH

The early authorities writing on the goldfish mention a number of other varieties not here described because they are still unknown to the author. The data concerning them is meagre and not sufficiently explicit for their certain identification. There are probably many with which the American fancier will become familiar later, as the appreciation of the finer goldfishes is of rapid growth so that the attention of Oriental breeders will be directed to this market for their, at present, very perishable wares. With increased interest, however combined with improved facilities of transportation, better accommodations upon arrival and rest before shipment across the Continent, as well as with a fuller understanding of their requirements for acclimatization, breeding and treatment of ills and ailment upon arrival, the mortality will be so materially lessened as to make their importation and propagation a profitable industry. When this has been accomplished, all the wonders in goldfish culture now only known through the insufficient descriptions of travelers not fully conversant with the subject, will be familiar to the American and European breeders.

HYBRIDIZATION. Hybridization is easy with the goldfish, as its evident by the many singular crosses produced by breeders. Fig. 32 is an accurate drawing of a goldfish, known in Philadelphia as Agard's Wonder,



FIG. 32—Agard's Wonder
Two-thirds life size

the product of crossing a transparently scaled Comet and a similarly scaled Telescope, which resulted in the production of this singular hybrid. It has the short hunchbacked body, the depressed snout and the paired fins and protruding eyes of the Telescope, together with the dorsal fin and long vertebral column of the Comet; to which is attached a very long deeply bifurcated double tail. Another peculiarity is the entire absence of the anal fin. This singular fish is so out of balance, due to the long spine and the great mass of tail,

that it rests upon the water plants balanced on the tail, and the elongated spine is so mobile that when it is curved under the body, the head of the fish is sometimes wrapped into the folds of the tail.

Another abnormality is shown in Figs. 33 and 34. This white fish has the body shaped like an egg, and when viewed from above, has very much the appearance of a white rat.

Many other singularities could be cited, and when it is remembered what faithful copyists both the Chinese and Japanese are, there can be no doubt that the goldfishes depicted on their ceramics and

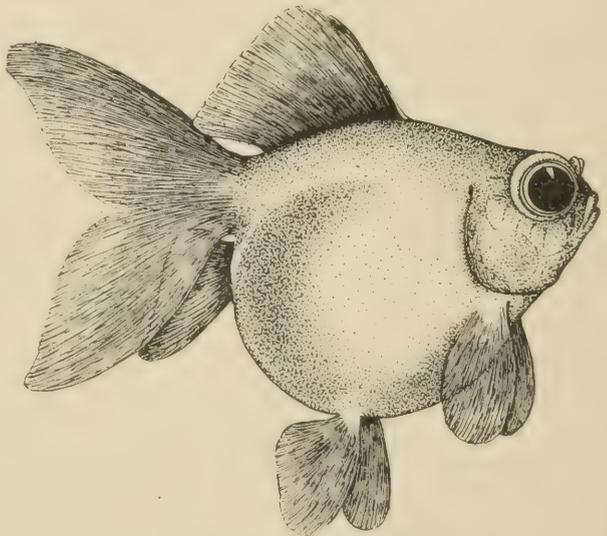


FIG. 33—Lawson's The White Rat
Lateral view Two-thirds life size

bronzes are accurate re-productions of fishes bred by them. Some of these are so astonishing in form and colors that to the layman they would appear to be willful exaggerations or caricatures, but to the experienced goldfish



FIG. 34—The White Rat
Dorsal view Two-thirds life size

culturist are easily within the range of possibility and may be accepted by him without question. This tendency to variation on the part of the goldfish is one of the principal points of interest in its culture, as any

alevin may have a distinct character of its own and be either a wonder in its way or a "sport" not worth the trouble of raising. It should be stated that young fishes of marked abnormality do not usually survive which is very often also the case with those considered the most perfect by the fancier.

Description of the Goldfishes Depicted by De Sauvigny

This illustrated memoir of Chinese goldfishes is in the possession of the Academy of Natural Sciences of Philadelphia, and is entitled

Histoire Naturelle Des Dorades de la Chine,

Gravées par M. F. N. Martinet, Ingénieur et Graveur du Cabinet du Roi,
Accompagnée d'Observations et d'Anecdotes relatives aux Usages, aux
Mœurs et au Gouvernement de cet Empire,

par M. De Sauvigny,

Chevalier de l'Ordre Royal et Militaire de Saint Louis, Censeur Royal, &c.
a Paris,

De l'Imprimerie de Louis Jorry, reu de la Huchette, près du
Petit-Châtelet.

MDCCLXXX

Avec Approbation et Privelege du Roi.

It consists of forty-eight finely colored plates, and of twenty-four pages of text principally descriptive of the Chinese realm, government, laws and literature. The brief mention of the goldfishes occurs in the Preface and in the short article proper, a literal translation of which follows.

"Of the different species of goldfishes of China the one known in Europe is the least thought of there. The stories of our travelers and the history of Pere du Halde have only given a very imperfect idea and in several respects even a false one."

“These memoirs were made in Peking by a very able Chinaman, and have been sent to the Minister in France, who has allowed us to make use of them.

“All the fishes, redrawn and colored in France, have come to us with these memoirs and we are safe in saying that the burin and colorings of M. Martinet have made the copies better than the original drawings.

Only one species of goldfish is known in Europe; the Chinese recognize seven to which they have given the common name of KIN-YU, and they distinguish each by a particular name. We have taken the precaution of adding to the Chinese names the French equivalents because it must be remembered that all the names in the Chinese language, as in the greater number of the Oriental languages, have a descriptive significance and ordinarily take to themselves the principal qualities of the thing described.”

“There are then seven species of goldfishes or KIN-YU.

1. The KIN-YU, properly so called; this is the most common of all, first known in China, towards the year 950, and in the 18th Century brought to Port de l’Orient, to l’Hotel de la Compagnie des Indes.

2. The YA-TAN-YU, or Duck Eggs.

3. The LONG-TSING-YU or Dragon Eyes.

4. The CHOI-YU or Sleepers.

5. The KIN-TEON-YU or Tumblers.

6. The NIN-EUBK-YU or Nymphs.

7. The QUEN-YU or Lettered Fishes.”

“The habits of life, the development, the different changes, the manner of propagation and the increase of these fishes are no less marvelous than their external form and their brilliant colors.”

“It is a noteworthy fact that they have been given the name of a sea fish, with which they appear to have nothing in common. However, they may have originally come from the sea; indeed they were first known in the province of Tche-Kiang which extends as far as the sea on the Oriental coast. They may have ascended the rivers by which this province is watered, following the habit of the salmon, the shad, the sturgeon, the sole and many other species of fishes.”

“We know how actively Chinese industry is awakened by cupidity, but is it able to influence the Works of Nature? Is it able to change, so to speak, their habitation? However, if man has been able to transplant plants and quadrupeds from the northern meridian and from the old to the new hemisphere, what law prevents him naturalizing in the rivers some of the inhabitants of the sea? Some of the provinces abound in salt waters of which fish ponds can be made; would it then be impossible to people them with sea fishes? These questions, more interesting because

of the benefit which they present than because of the curiosity which they excite, open a vast field of research for naturalists, which have not yet sufficiently attracted their attention.”

This meagre and unsatisfactory description is all the mention which the memoir makes of the goldfishes, but the plates are so interesting and curious that brief descriptions of the eighty-eight fishes of the mentioned seven breeds shown are only omitted on account of lack of space. The book is open to the inspection of the public in the library of the Academy, Cor. 19th and Race Streets, Philadelphia.

None of the plates show transparently scaled fishes or an absence of the dorsal fin which leads to the inference that these characteristics were of later development than the publication of this book.



CHAPTER IV.

Some Freshwater Aquarium Fishes

SOME FRESHWATER AQUARIUM FISHES

Many of the readily obtainable native freshwater fishes, and some of the foreign forms, make interesting aquarium inhabitants, living in perfect amity with and harmless to goldfishes. There are others, however, which are best kept by themselves; but all serve as interesting studies to the lover of fluvial life in the household. These will be described, together with the methods for their care and maintenance, beginning with the nest-builders and following with the ordinary pond and river fishes. Mention of a good part of the freshwater Ichthyic fauna is omitted, these being forms that cannot be kept alive in smaller aquaria.

THE INDIAN PARADISE FISH

This beautiful and interesting aquarium fish, *Macropodus venestrus*, is most singular and curious in all its habits. In the Orient, it is bred for the same purpose as the game chicken and contests are arranged upon which considerable sums are often staked. This fish is of such a belligerent disposition that the males will attack each other, and also their mates out of the breeding season, the strong lips and sharp teeth being formidable weapons with which fatal wounds are inflicted.

The appearance of the fish is novel, the curious form, brilliant markings, evasive colors and marvelous fins and tail, differing from any other domesticated fish. In the breeding season the males are of lustrous,

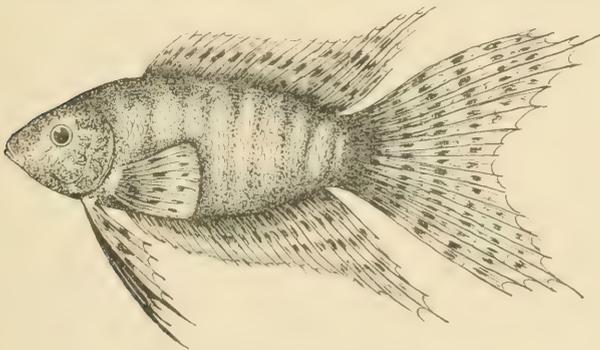


FIG. 35—Indian Paradise Fish
Macropodus viridi-auratus Two-thirds life size

dark olive-green color, overlaid with fleeting, prismatic color flashes which seem to be under control of the fish. The fins and tail are outlined with most brilliant red, yellow and brown. The females are lighter in color and of a more greyish or light-brown hue, which becomes a greyish-white during the breeding period, and all the fins are shorter and more rounded than those of the males. The illustration, Fig. 35, is the male of the domesticated variety, *Macropodus viridi-auratus*, in nuptial garb.

The Paradise Fish is easily reared and prolific, and will thrive in any

receptacle and water, much plant life and frequent changes of water being unnecessary. The fish is an air-breather and is not dependent upon the oxygen liberated by aquatic plants. It will live in temperatures to 100° F., but, on account of its tropical origin, succumbs to those under 38° or 40° F. It is of such lively habit that the aquarium should be kept covered to prevent its leaping out of the water. The sexes should also be separated except in the breeding season, as the full-grown pugnacious male frequently kills its mate and will exterminate any other fish in the same vessel.

The nest-building habit of this fish is most curious. The spawnings occur a number of times during the season, the floating nests being formed of air bubbles coated with gelatinous matter expelled from the mouth of the male. The eggs are deposited by the female, fecundated by the male, carefully placed in the fairy nest and permitted to hatch, he guarding and caring for them until the fry make their appearance. Then the nest is destroyed and the young fishes are carefully tended until they are old enough to care for themselves; the male assuming the whole duty and keeping the female away from the young. When of sufficient age, the fry should be fed with the same food as young goldfishes and later will thrive on the prepared fish foods together with a frequent diet of earthworms or small particles of raw meat and liver, though the fish prefers and thrives best on living food. Daphnia, small worms, young snails, gnats, small houseflies, moths and other insects are generally fed.

THE STICKLEBACK

This most interesting little fish inhabits streams which reach the ocean, some forms frequenting brackish and salt water. It is one of the most belligerent of freshwater fishes and may be bred in the aquarium, but should

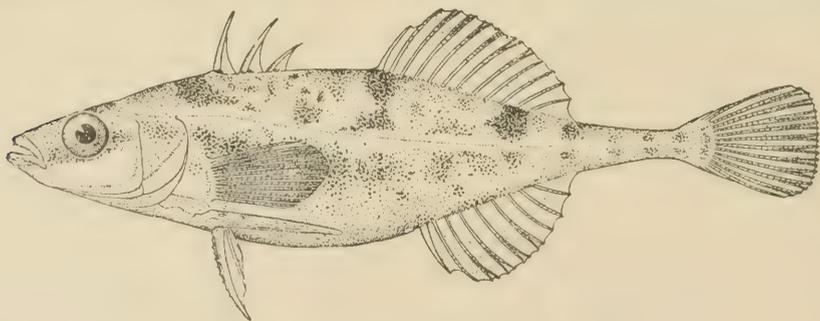


FIG. 36—Four-spined Stickleback, *Apeltes quadratus*

be isolated from other kinds. Its nest-building is very interesting and varies considerably in the natural state. Some build upon the bottom of

the streams hidden among the weeds and water plants, others under submerged boughs to which the nest is attached, or upon stones and projecting ledges. The building is done solely by the male who assumes bright colorings at this period. All kinds of material are collected and are matted together to form the bottom, and held in place by sand and small pebbles. Leaves, stems, twigs and other available materials are glued together with a mucilagenous substance which is exuded from the body of the fish. Next the sides and roof are formed, leaving only a circular opening through which the female deposits the spawn. The male guards the young fishes, not even permitting the female to approach the nest after spawning. He assaults every living thing that comes into the neighborhood with his sharp dorsal and ventral fins and teeth. About the tenth day after the spawn has hatched, he begins to demolish the nest but keeps vigil over the young for a month or more until they are able to take care of themselves, when both he and the young disappear together.

There is nothing more interesting in an aquarium than a pair of sticklebacks. They should be supplied with an abundance of building material in the form of aquatic plants, especially myriophyllum, nitella and vallisneria, the long leaves of the latter being especially desirable for the foundation of the nests.

Three species are generally distributed, the Two-spined Stickleback, *Gasterosteus bispinosus*; the Four-spined Stickleback, *Apeltes quadratus*; Fig. 36, and the Ten-spined Stickleback, *Pygosteus pungitius*. The Four-spined form is abundant in the Delaware river.

Daphnia, earthworms, small particles of fresh meat, insects and any of the boiled cereals, sparingly fed, is the best food for the Stickleback in the aquarium.

THE SUNFISH

The ordinary sunfish, *Eupomotis gibbosus*, is one of the most widely distributed of the freshwater fishes. There are many well-known species which differ principally in their really beautiful markings and the shape of the ear or gill-flap. Nearly all the sunfishes are nest-builders; their spawning beds may be recognized by the clean appearance of the gravelly bottoms of streams and ponds, from which all vegetal matter, mud and pebbles have been either carefully removed by agitation with the fins and tail, or carried away in the mouths of the fishes. Often the stems of the surrounding aquatic plants are trained over the beds to form a perfect bower. After depositing the spawn it is carefully watched by the parent fishes,

which become bold and belligerent during this season and will attack all approaching enemies.

The sunfishes acquire the unpleasant habit of nibbling the fins and tails of the goldfishes, if not plentifully fed, for which reason it is best to

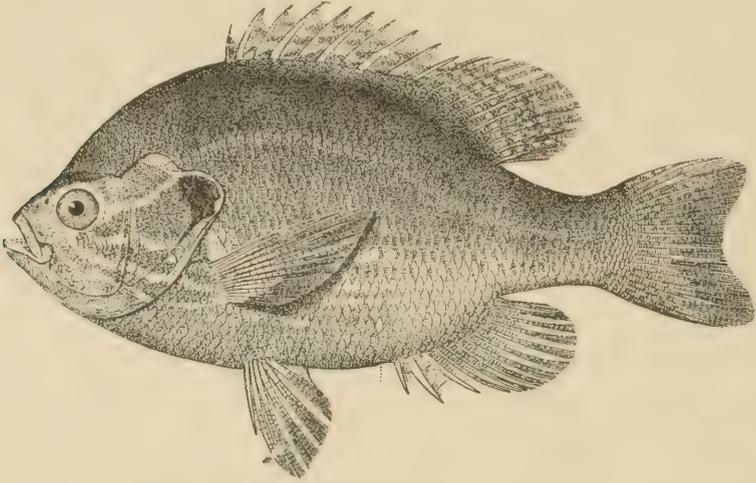


FIG. 37—Common Sunfish, *Eupomotis gibbosus*

keep them separate or to introduce very small ones only into an aquarium in which goldfishes are kept.

The most generally distributed species of sunfishes (Centrarchidæ) are the following: The Common Sunfish, *Eupomotis gibbosus*; Fig. 37, the Blue-spotted Sunfish, *Enneacanthus gloriosus*; the long-eared Sunfish, *Lepomis*

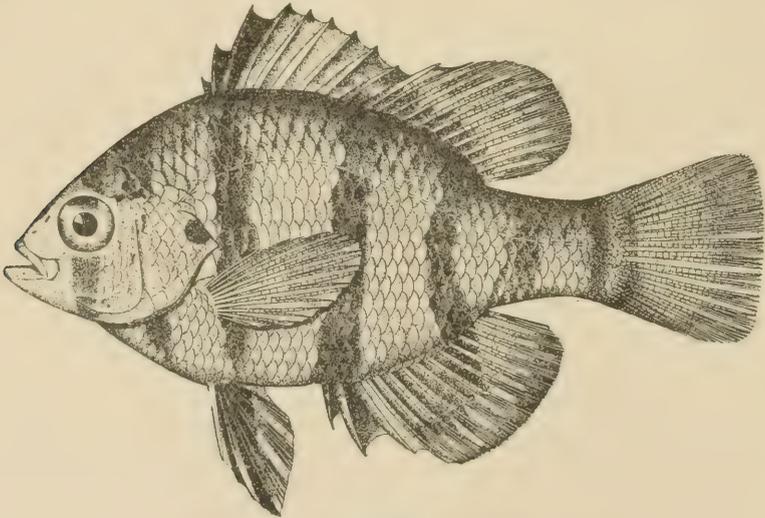


FIG. 38—Black-banded Sunfish, *Mesogonistius chætodon*

auritus; the Black-banded Sunfish, or Chætodon, *Mesogonistius chætodon*, Fig. 38, and other forms popularly known as the Green and Blue Sunfish,

Red-bellied Bream and Crappie. All will survive in the aquarium, and those enumerated occur in the Delaware River. The Chætodon is an especial favorite with aquarists on account of its beautiful markings and lively habits. The sunfish should be occasionally fed with live food, flies, worms, etc.

THE AMERICAN DACE

The Black-nosed Dace, *Rhinichthys cataractæ*, Fig. 39, is a native of all swift-running streams, preferably those of cold water. There are two varieties most generally distributed which usually inhabit the same streams and rivulets. The Black-nosed Dace, the most abundant form in the valley of the Delaware, is easily distinguished by the black line extending from the

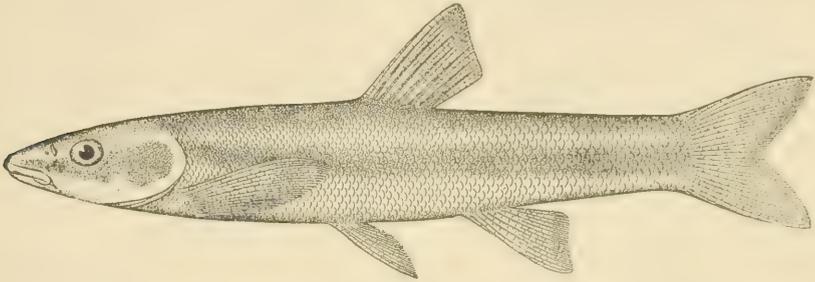


FIG. 39.—Black-nosed Dace, *Rhinichthys cataractæ*

snout along the sides to the tail. It is most remarkably rapid in its movements and in the aquarium is a veritable finny jester. Its movements are so rapid and erratic that it appears like a silvery streak as it darts about in bewildering confusion. In every way it is entirely harmless and may be kept with goldfishes, especially with the fine breeds of sluggish habits, to whom it is of direct benefit in agitating the water.

The spawning season begins early in June, when both the male and the female take to nest-making in some rapid running brook or trout stream, the clearing sometimes being over two feet in diameter. All waste-materials are carefully removed and when the spawn has been deposited it is covered with clean pebbles which the fishes bring down stream in their mouths, the alternate deposits of spawn and pebbles often forming mounds eight inches high. This is done not only to protect the young from enemies, but also to prevent the eggs from washing away in the rapid flowing streams.

The dace will thrive on the usual goldfish foods. Live food should be occasionally fed.

THE CHUB

That species of the Chub popularly known as the Fall-fish, Silverchub, Wind-fish and Corporal, *Semotilus corporalis*, is a most interesting aquarium fish but thrives best in larger tanks, as it often grows to be 15 inches in length. It has the habit of building nests for the spawn and

young, which, in a locality in which the fishes are abundant, measure 4 to 10 feet in diameter. Pebbles and stones, often several pounds in weight, are heaped up to form conical mounds, and, as the fishes are gregarious during the breeding season, quite a number use the same spawning place, which is added to year by year. The purpose of these elaborate structures is to protect the young from their predatory enemies, the Rock and Black bass, perch, catfish, eel and water-snake. In the aquarium they are timid and entirely harmless and will thrive satisfactorily when not overstocked.

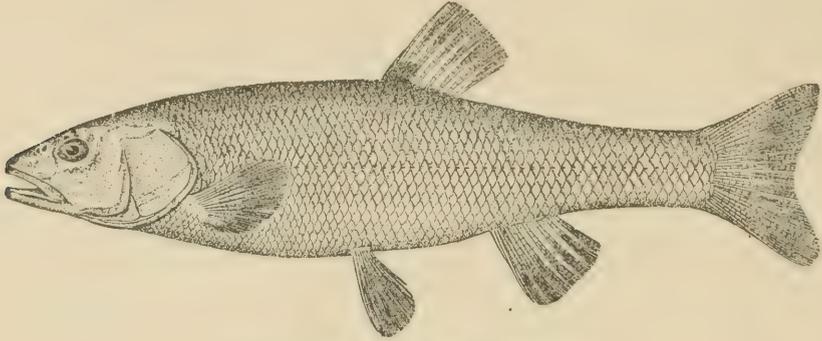


FIG. 40—Creek Chub, *Semotilus atromaculatus*

The Horned-dace or Creek-chub, *Semotilus atromaculatus*, Fig. 40, is abundant chiefly in small brooks. It is more lively in the aquarium than the Corporal.

The chub prefers a vegetable diet, and should be fed on boiled cereals, and occasionally a little of the boiled yolk of an egg.

THE GOLDEN ORFE OR IDE

This fish, Fig. 41, is one of the Carp family, the *Cyprinidae*, developed in Germany from the albino Orfe, *Idus idus*, a handsome, hardy fish but not fully domesticated, its probable migratory habit and consequent restlessness causing it to leap from the water, on which account the tank should be screened or not filled to the top. This applies more to the

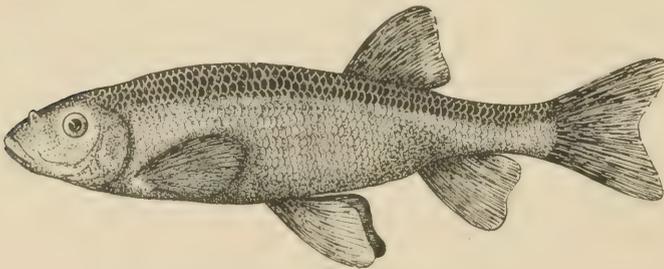


FIG. 41—Golden Ide, *Idus idus*

American bred fish than to the imported German Orfe, *Idus melanotis*; the latter having lost its wild habits by many generations under domestication. Its propagation has been

very successful in the fish ponds at Washington, where an abundant supply is kept, and though a food fish of fair quality it has not been bred for

this use in the United States. Tenacious of life and easily reared in shallow ponds of about 3 feet depth, of either spring or running water and containing abundant plant life, its propagation should be encouraged because it is a very ornamental fish. It is of handsome form with rich salmon-yellow color on the back and silvery white sides, and a very conspicuous inhabitant for the pond or basin as it has retained its habit of swimming in schools and appears to be constantly in motion.

Spawning takes place in April or May, the eggs, being about 1-10 inch in diameter, adhere to the aquatic plants, on which they hatch in 5 or 6 days. Success in hatching depends upon an even temperature of about 56° F.; and should be conducted in shaded ponds. With a healthy plant growth feeding need not be resorted to until the fry is a month old, when they should be given a small quantity of cooked corn-meal mixed with flour and boiled oatmeal, with an occasional ration of finely divided fish flesh, bivalve, crayfish or other animal food. The young attain a length of 3 inches in six months, growing in natural waters to 12 to 15 inches in a year and to a weight of 1 to 1½ pounds. In the aquarium the growth is slow, not over an inch a year.

The Golden Orfe is a beautiful aquarium inhabitant and is harmless to goldfishes. For pond culture, on country estates, it is preferable to the common goldfish, as its habits are more interesting.

THE TENCH

This handsome freshwater food fish, *Tinca tinca*, is one of the most generally bred of the European pond fishes, especially in England, whither it was introduced from the Continent, as it is not indigenous to the natural waters of Great Britain. It has also been successfully cultivated in the United States, the breeding fishes and fry having been distributed by the U. S. Commission of Fish and Fisheries.

It belongs to the carp family, (Cyprinidæ) but differs from the other members of this numerous family both in body conformation and its very small scales. All the fins have a rounded outline, the dorsal is without a spine and the male possesses a thick outer ray on the ventrals which serves a sexual purpose. The tench thrives best in enclosed preserved waters having a clay or mud bottom with abundant vegetation, is extremely prolific and grows to a weight of 3 and 4 pounds. It is a food fish, the meat being of a sweet and pleasant flavor and it will thrive in any fresh water pond,

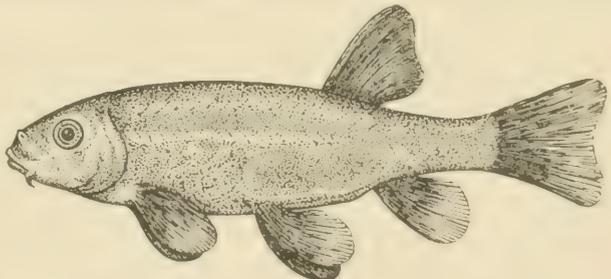


FIG. 42—Young Golden Tench. *Tinca auratus*.

lake or pool which never seem to be too thick, muddy or fetid for it to inhabit. Like the carp it buries itself in the mud during the winter months and there remains in a semi-torpid state until the advent of warm weather.

The young are most beautiful aquarium inmates though more timid than goldfishes. Their colors are so delicate and fleeting as to be almost prismatic, when the fishes are viewed in a strong light. In form they are long, slender and rather flat-sided; the mouth is narrow, the eyes large and the small nostrils are erect. The fins are clear transparent white in fine contrast with the handsome colors of the body. Two forms are generally bred, the Green and the Golden tench.

The Common or Green Tench, *Tinca caruleus*, is a finely scaled handsome fish, especially the young when about 2 to 3 inches in length. The colors are rich olive-green on the back and abdomen with a fine metallic golden-green lustre which fairly scintillates with prismatic colors when viewed in the aquarium with the light at the back of the observer.

The Golden Tench, *Tinca auratus*, is an albino variety of the Common Tench originally bred in Silesia, and is of bright orange color, spotted with brown dots on the sides, fins and tail. The small fishes, Fig. 42, are so nearly transparent when viewed towards the light that all the interior organs and the very functions of life may be seen through the transparent substance of the skin. When viewed with the light at the back of the observer, the colors are most charming and resemble an opal more than any other object. With the exception of the Goldfish and the Paradise fish, the Tench is probably the handsomest aquarium fish, very hardy, easily kept, and perfectly harmless, and should find a place in every aquarium. It may be fed with the usual goldfish foods. Its culture should be encouraged, as it is a very fine pond fish of lively habit.

THE CARP

The Carp, *Cyprinus carpio*, is one of the most widely distributed of the pond fishes. A number of forms have been produced by European breeders of which the following are the more interesting.

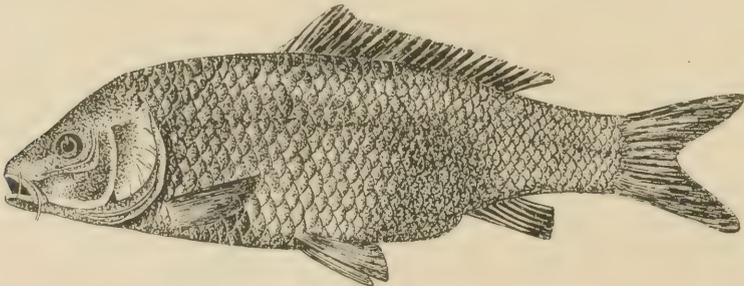


FIG 43—Young Scaled Carp, *Cyprinus carpio communis*

The Scaled Carp, *Cyprinus carpio communis*, Fig. 43, was originally introduced into Europe from Central Asia, and has been extensively cultivated in natural and artificial ponds and slow-flowing streams. It is distinguished from its kindred breeds by its regular concentrically arranged scales. The color is variable but is usually brownish with a bluish tinge along the back and a golden or coppery reflection along the scales.

The Mirror Carp, *Cyprinus carpio specularis*, Fig. 44, has very large irregularly disposed scales. Some forms have very few scales, sometimes restricted to one row along the lateral line, or in others to a line along the back with a few large scales scattered at random over the sides. Some have a dorsal, a ventral and a lateral line of scales on an otherwise scaleless body, these differences being produced by the careful selection and propagation of breeders.

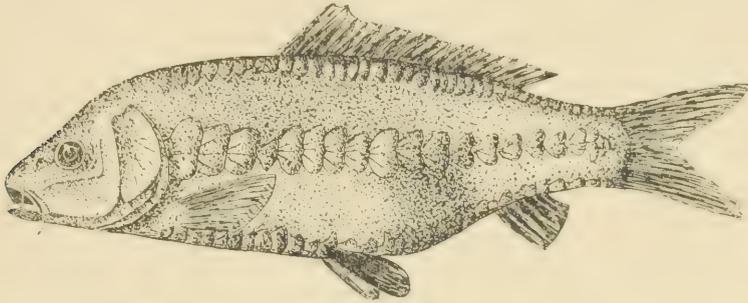


FIG. 44—Young Mirror Carp, *Cyprinus carpio specularis*

The color of the back is a decided bluish tone tinged with green and grey, which extends over the sides. The abdomen and the fins are white.

The Leather Carp, *Cyprinus carpio coriaceus, sive nudus*, Fig. 44A has either a few scales on the back or none at all, and possesses a thick soft

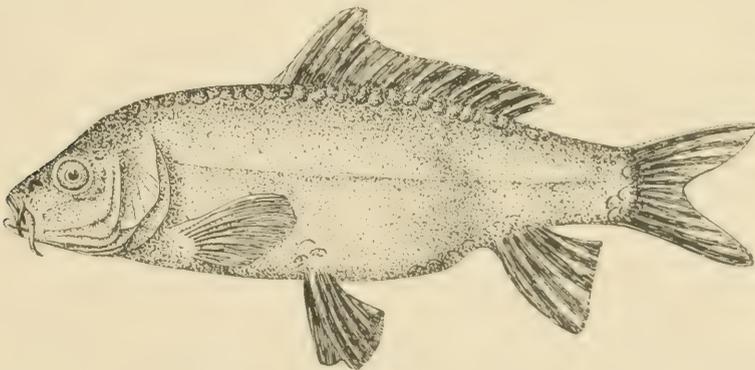


FIG. 44A—Young Leather Carp, *Cyprinus carpio coriaceus*

leathery skin, which feels velvety to the touch. Those of golden-brown, color and devoid of scales are most highly prized by European breeders.

The Golden Carp, *Cyprinus carpio aureus*, is an albino form of the Scaled Carp, at one time extensively bred in Germany for ornamental purposes but has been largely superseded by the Common goldfish.

The Crusian Carp, *Carassius carassius*, Fig. 45 is a variable form closely related to *Cyprinus carpio* and differs somewhat in form and in the absence of barbels. It is a shorter fish of more hunch-backed appearance. Its habits are also similar to the common carp, and it will live in localities wherein the impurities are sufficient to destroy most other of the fresh-

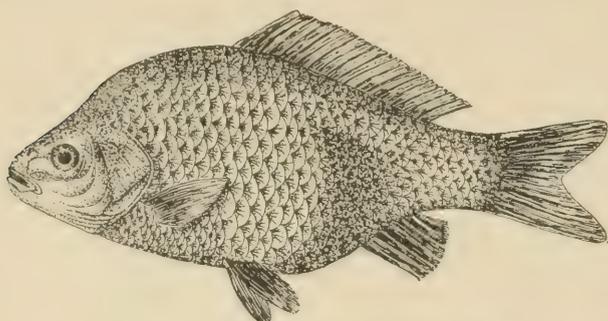


FIG. 45—Young Crusian Carp, *Carassius carassius*

oblongus and *C. humilis*, all variations produced by domestication, selection and breeding.

water fishes. It is considered to have been the form from which the goldfish, *Carassius auratus*, was derived, this fish being of Chinese and Corean origin and extraction. Other forms of the Crusian Carp are *C. moles*, *C. gibelio*, *C.*

Small specimens of all the Carp breeds make interesting aquarium fishes. In 1877, and for some years thereafter, attempts were made to generally introduce the Scaled and Leather Carp in the United States, as their easy propagation recommended them for regions remote from a supply of better-flavored fishes, but the results were not satisfactory and in the past years the attempt has been abandoned. The introduction of carp into many streams is now forbidden by acts of state legislation.

All carp will excavate the banks of ponds in search for food which consists of the tender shoots and roots of aquatic plants and the tiny entomostraca and insects of fresh water, for which it burrows into the mud and the banks of streams and ponds. In the aquarium it will thrive on goldfish foods. The carp is destructive to the spawn of other fishes.

THE TESSELLATED DARTER

The Tessellated Darter, *Boleosoma nigrum ohmstedti*, Fig. 46 is a most singular and beautifully marked small fish of belligerent habits. The name is derived from its habit of lying motionless on the bottom of clear streams and suddenly springing upon its prey with marvelous rapidity. In the aquarium it is best kept with such freshwater fishes as are able to

take care of themselves, like the sunfish, catfish, tiny eels, the young of the spiny-rayed fishes, etc.; and should be fed on small live food and boiled cereals.

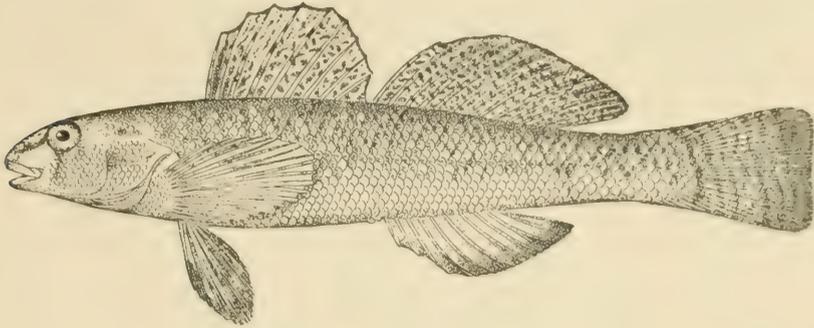


FIG. 46—Tessellated Darter, *Boleosoma nigrum olmstedii*

THE SUCKER

The Common Sucker, *Catostomus commersonnii*, Fig. 47, will also thrive in the aquarium. Its habits are similar to the Carp, and the young

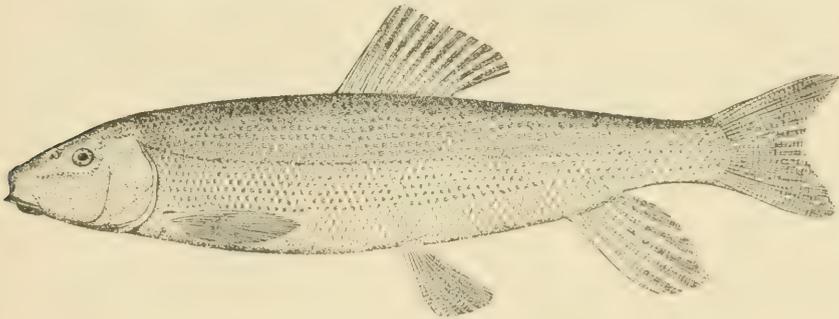


FIG. 47—Common Sucker, *Catostomus commersonnii*

may be kept with goldfishes. Any of the goldfish foods may be fed, boiled oatmeal, flaked rice, or fine corn meal mush being the usual food, varied occasionally with small particles of earthworms, mussels and small snails.

THE KILLIFISH

Two species of the Killifish are vivacious little aquarium inmates. These are the Common or Green Killifish, *Fundulus heterochtus*, and the Barred Killifish, *Fundulus diaphanus*, Fig. 48, which inhabits brackish water. Both thrive in the aquarium. The Barred form is marked with steel-blue and silvery-white bars, and has a peculiar metallic lustre. It is entirely harmless and very lively in its habits. Its food should be a mixed animal and vegetable diet, sparingly fed.

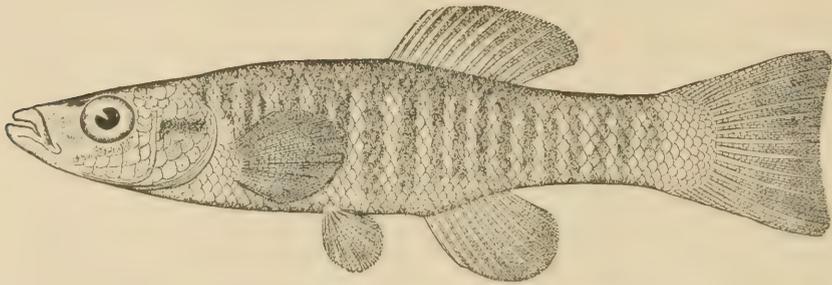


FIG. 48—Barred Killfish, *Fundulus diaphanus*

THE BRILLIANT CHUBSUCKER OR MULLET

This fish is known as the Chubsucker, *Erimyzon sucetta*, Fig. 49, and may be recognized by its clear green back, lemon-yellow sides, and white

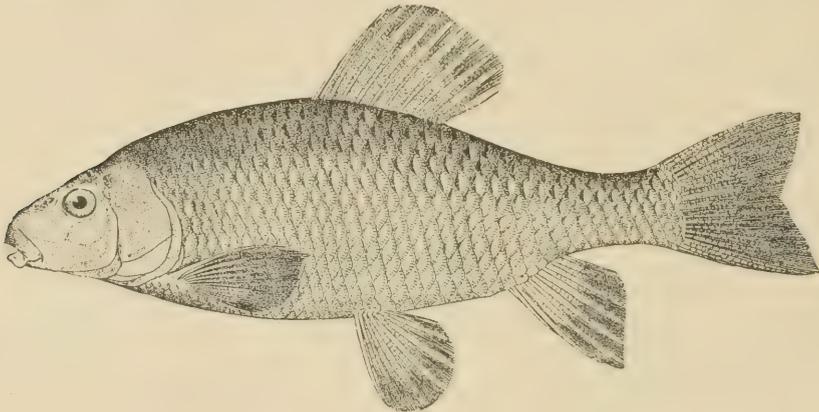


FIG. 49—Chub-sucker or Mullet, *Erimyzon sucetta*

abdomen. It is quite generally distributed in flowing water in most of the river systems of the Eastern, Middle and Southern states. It can be kept with other freshwater fishes and thrives satisfactorily in the aquarium. Its food is the same as that of the Sucker.

THE MINNOWS

The Minnows or cyprinoids are among the smallest of freshwater fishes. There are many well-known species some of which thrive in the aquarium, but others, whose natural habitat is swift-running water, are difficult to keep alive except in tanks in which the water is constantly changing. Some of the hardy forms are easily tamed and soon learn to come to the surface of the water to be fed. The most generally distributed species are the Black-striped minnow, *Notropis procne*; the Silver-fin, *Notropis analostanus*, Fig. 50, and the Red-fin, *Notropis cornutus*.

These are all abundant in the small tributary streams of the Delaware, and when young are difficult to identify as they all look much alike. The adults, however, are different and develop brilliant colors during the

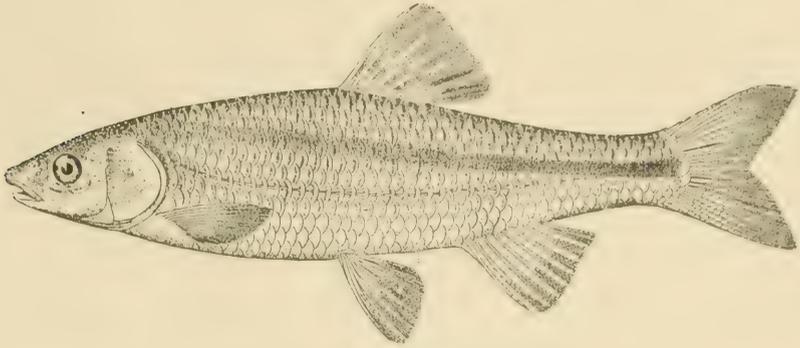


FIG. 50—Silver Fin, *Notropis anaoostanus*

spring or breeding season. The young of almost all species of freshwater fishes are often called minnows. The minnows thrive best on boiled cereals and small particles of earthworms, dessicated meat, shellfish, etc.

THE SHINER OR ROACH

This beautiful fish, *Abramis crysoleucas*, Fig. 51, may be kept in the aquarium and is perhaps the most hardy of all of our Minnows or Cyprioid fishes. Instances of a long survival of this fish in the aquarium are

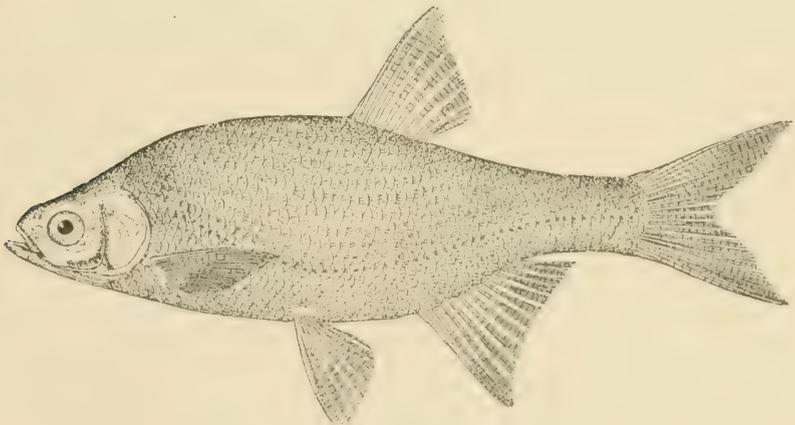


FIG. 51—Shiner or Roach, *Abramis crysoleucas*

frequently mentioned, and, as it is of interesting habit, it will reward the fancier to introduce it, but not together with the finely bred goldfishes, as it tears their tails and fins. Its food is like that of the minnows.

THE CATFISH

This fish is so well-known that little need be said in its description. Several species are most generally distributed, the White Catfish, *Ameiurus*

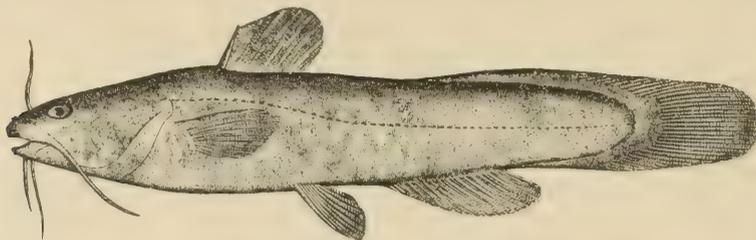


FIG. 52—Stone-catfish or Little Mad Tom, *Schilbeodes insignis*

catus, the Horned Pout or Common Bullhead *Ameiurus nebulosus*, and the Little Mad Tom, *Schilbeodes insignis*, Fig. 52. They are very annoying to goldfishes and should not be put into aquaria with them. Small particles of animal food, dessicated meat, mussels, etc., together with boiled cereals are the best food.

THE EEL

Eels abound in all the waters of the temperate and torrid zones, but it has been established that they always visit brackish and salt water to spawn. They are very tenacious of life, a modification of their gills enabling them to go considerable distances overland in their Spring migrations or in search of food. The Common American Eel, *Anguilla*

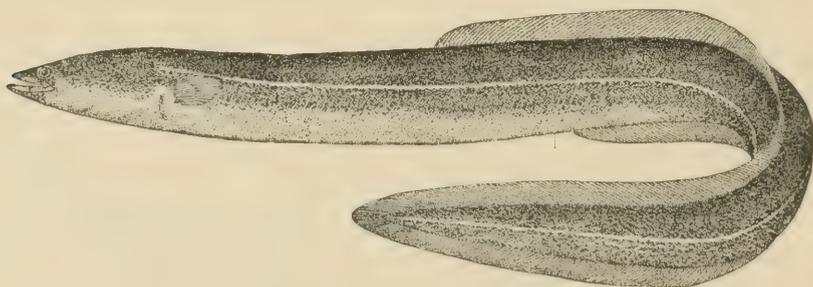


FIG. 53—Common Eel, *Anguilla chrysypa*

chrysypa, Fig. 53, is of slow growth, rarely exceeding 12 inches during the first year, but attaining a length of over 4 feet and a weight exceeding 5 pounds. Its food consists of all insect and animal life as well as putrescent vegetal and animal substances. They are good scavengers but destructive to the spawn of all fishes. In the aquarium they will nibble at the fins of other fishes and should not be kept with goldfishes unless they are of very small size. Eels will eat almost anything and everything fed to them.

THE SPINY-RAYED FISHES

The Bass, Perch, Pike, Pike-perch, and other predaceous spiny-rayed fishes need not receive mention here, as their belligerent habits preclude their being kept in aquaria with other fishes. They thrive only in large tanks having a constant flow of fresh water. Very small specimens are sometimes kept in aquaria, but it is difficult to keep them alive.

COLLECTING IN STREAMS AND PONDS

One of the chief pleasures incidental to the household aquarium for other than goldfishes, is the collecting of the plant and animal inhabitants of running streams and standing water for home study, observation and classification, and the pleasant outings with congenial companions which this occupation affords. Very few and simple appliances are required; these being a close-meshed pond net with a long sectional handle, upon which a small garden hoe and a wire scoop may be fastened, a collapsing dredging net, a fishing line and minnow hooks, a can of two gallons capacity, a number of small tin cans with perforated lids and small bottles for catching and holding the water inhabitants; and, for the collecting of plants otherwise out of reach, a wire dredging hook or grapple fastened to a strong cord. Larger cans are required to transport fishes, covered with gauze, not with a lid, and if ice is necessary it should be put into the gauze cover, not into the water.

In collecting, a certain indication of abundant animal life is the presence of a considerable plant growth, and a careful examination of the floating and submerged leaves, the overhanging foliage, the bottom and the stones is advisable before rendering the water muddy with nets and scoop, which should be turned out on a clear space rather than in the grass, as the contents can then be better searched and the catch seen. The route should also be up-stream that the water may be clear. In addition to identifying the plants and preserving such as may be desired, a thorough examination of them, as well as of the mud and gravel, should be made as these are the home of many insects, larvæ, and molluscs. The dredge will also yield many of the latter not otherwise readily obtained.

The late summer and fall months are the best for making collections for the household aquarium, as those collected in the spring may not survive the summer heat.

The lower forms of life are present in all bodies of water but in rapid streams minnows, shiners, sunfishes, dace, chub, suckers, newts, salamanders and crayfishes will be found; and in springwater streams trout, troutlets, sticklebacks, dace, pickerel and bass; also fontinalis, chara, and sometimes anacharis of the long-leaved variety. In ditches many insects and their larvæ abound; also catfishes, sunfishes, killifishes, carp, eels, tadpoles, mussels and some varieties of the snails; while the ponds afford sunfishes, catfishes, chub, carp, eels, frogs and tadpoles; and in these latter two most of the desired aquatic plants will be found, and a great variety of bivalve and univalve molluscs, together with many of the insects and their larvæ. In ponds, ditches and pools the tiny entomastrea, which form the natural food for young fishes, may be found.

PHOTOGRAPHING FISHES. The photographing of the ichthyfauna in the natural element and surroundings is a recent achievement of the instantaneous processes but the difficulties are so many that good results are extremely rare. Probably the best work in this line was done by R. W. Shufeld, of the Medical Corps, U. S. Army. The usual conditions are unfavorable to proper light, the incessant movements of the fishes makes focusing difficult, the refraction of the glass front of the aquarium is troublesome and the reflection produces a mirror as likely to show the camera and operator as the contents of the aquarium. By the use of a glass plate behind the fish, to restrict its movement, one element of difficulty may be partially obviated; but a specially constructed very narrow miniature aquarium, fitted to a tripod and backed by a screen will lead to more satisfactory results, as it may be set in the open air and in favorable light. The apparent plant life, to form a natural background, may consist of a sepia drawing secured to the back of the aquarium; the front being constructed of the thinnest portrait glass; but even this interposes a slight screen to the contents and sometimes interferes with a perfectly clear picture.

The constant, almost imperceptible movement of the fins and the rarity with which they are all fully expanded compelled the abandonment of this method of illustrating this volume and forced the author to adopt the considerable labor of making accurate pen drawings. The restlessness of the subject prevented the taking of snapshots with every detail of form and fin at their best so as to serve as types of the most perfect fishes of the recognized breeds.

CHAPTER V.

The Propagation of the Goldfish

THE PROPAGATION OF THE GOLDFISH

As previously stated, the goldfish is oviparous and the spawn is fecundated after extrusion. Figure 54. The almost transparent white or yellowish eggs are about one-sixteenth inch in diameter and when first ex-

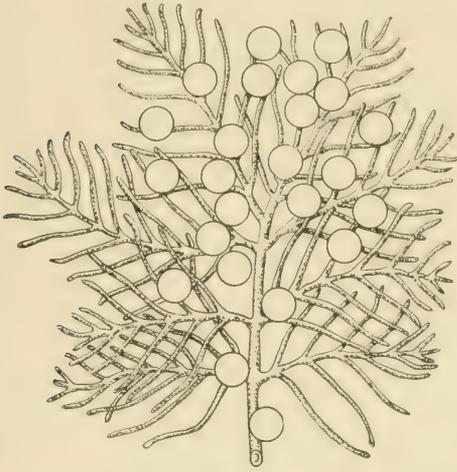


FIG. 54—Goldfish spawn attached to the leaf of an aquatic plant. Enlarged about two and a half diameters.

truded have a slightly flattened, lentel shaped appearance but upon fecundation assume a globular form. Fertilized eggs retain their translucent appearance, but the unfertilized eggs become opaque or milky. The hatching of the ova takes place in from three to seven days, dependent upon the season of the year and the temperature of the water; and consists of the germination of the yolk, the development of the embryo, and the final evolution of the alevin or tiny fry still attached to the yolksac, upon which it nourishes for some

days after hatching. Figure 55 will explain the metamorphosis of the egg and the development of the fry, the greatly enlarged illustration being that of a June hatching of spawn of a mottled male and a red and white female Chinese Telescope goldfish; and is (1) the newly exuded unfecundated ova, full and lateral views; (2) the ova four and ten hours after fecundation, showing germination and formation of the membrane; (3) the development of the embryo and plasmic processes at the edge of the membrane, twenty-four and thirty-six hours after fecundation; (4) development of the alevin and yolksac, fifty and fifty-six hours after fecundation; (5) free-swimming alevin attached to the yolksac, four days old; (6) alevin five days old; (7) the same seven days old; (8) the fully developed young fry ten days old.

ARTIFICIAL IMPREGNATION. The author knows of no successful attempts at the artificial impregnation of the spawn of goldfishes, though this is successfully done with the eggs of the larger food fishes, and has increased the number of fertile eggs from 50% to 80% or 90% over the natural method of fecundation. Attempts in this direction would be most interesting, and there is no doubt of its being practiced by the Oriental breeders.

MATING. The mating season of the goldfish is during the warm spring and summer months, when the water is at 60° or over, and spawnings occur at frequent intervals, as with this species of Cyprinidæ all the

FIG. 55. Embriology of the Goldfish.

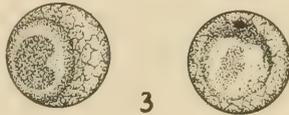
1. Newly exuded egg, not fecundated, wrinkled and unexpanded surface covered with vesicles. Full and lateral views.



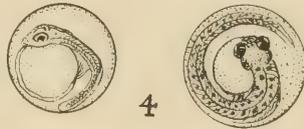
2. Egg, four and ten hours after fecundation, showing germination and formation of membrane.



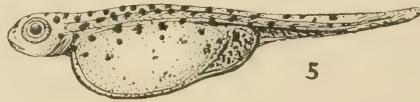
3. Development of embryo and plasmic processes at edge of membrane, 24 and 34 hours after spawning.



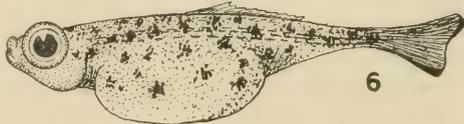
4. Development of alevin and yolk-sac, 50 and 58 hours after spawning.



5. Free-swimming alevin attached to the yolk-sac, showing skeleton, partly developed digestive organs and surface colors. Four days old.



6. Alevin five days old; dorsal and caudal fins partly developed.



7. Alevin seven days old; pectoral and anal fins developed.



8. The fully developed Telescope fry, ten days old.



Greatly enlarged. Actual size, No. 8, |———|

eggs do not mature at the same time. During this period the distinguishing characteristics of the male are developed and consist of wartlike protuberances or papillose tubercles on the operculæ and main rays of the pectoral fins, Fig. 10 (page 46), which have distinct sexual purpose. Another

means of discriminating the sexes is the appearance of the fishes near the anal region. The female shows a slight protuberance above the anus, the



FIG. 56 Difference at anal region of female and male Goldfishes, for determining the sex.

protrusion of the oviduct; while the male has a depression in this region as though a tiny piece of the flesh had been pinched out with the nails of the finger and thumb, Fig. 56. These latter differences are noticeable at all times.

The conduct of the male in pursuit of the female shows unmistakable evidence of courtship; swimming beside and around her, rubbing her sides and pressing on the ovaries with the head and tubercles, aiding her in depositing the spawn, often fairly forcing her on the spawning bed.

At this season the enlarged ovaries of the female give to her a decidedly fuller and more distended appearance and also aid in the discrimination of the sexes, though the otherwise general conformation of body and fin may be alike. It is generally recognized, however, that the males of finely bred goldfishes incline to longer bodies than the females.

The female deposits the spawn, Fig. 54, on the leaves and roots of aquatic plants, its mucilaginous covering causing an adhesion thereto, where it is covered and fecundated with spermatic corpuscles by the male. To the breeder the preferable plants for spawning are *Myriophyllum*, introduced in loose bunches, and the Water Hyacinth whose finely spiked floating roots are well adapted to this purpose. Previous examination is advisable that they harbor no snails, insects, larvæ, or other enemies that may devour the spawn or injure the fry, if introduced with them into the hatching dishes. Preferably the plants should be placed in water for some time so that the larvæ will hatch and then thoroughly cleaned in a weak solution of Phenol-sodique before use for spawning.

When the fry has reached the stage of development that the yolk sac entirely disappears, feeding is necessary and this consists of the tiny water plants known as Algæ, and of minute aquatic animalculæ which abound in quiet pools and still water, entomostraca of the genera *Daphnia*, *Polyphemus*, *Ceriodaphnia*, *Sida*, *Cyclops* and *Cypris*; also mosquito larvæ and those of harmless insects, of which more will be stated hereafter. Great care must be taken in the selection of this food that injurious insect spawn and larvæ, or the protozoa and fungi which produce diseases, and parasites are not introduced with it into the rearing tanks. This will also be treated of elsewhere.

If the breeding is undertaken in a small way, a fine net of cheese cloth and a jar containing a little pond soil and a water plant are required

to collect the animalculæ which constitute the entire requirements of the fry; but breeders usually employ a tank in which to store and propagate them under careful supervision.

When the fry have reached an age of about three weeks a few particles of clean, crushed earthworms, finely scraped liver or powdered prepared fish food may be occasionally fed, their diet being as described until they have reached an age of two or three months and are able to subsist on the food of mature fishes. Rice flour, oatmeal broth and finely powdered barley malt starch have also been fed to very young fishes with success; but the best results and most vigorous growth are obtained by feeding them their natural pond food two or three times daily; when this can be obtained it should be fed exclusively.

The common goldfish is easy to propagate but considerable experience, skill and knowledge are required to successfully rear fine specimens of the Japanese and Chinese breeds; of which the Comets, Fringetails, Fantails and Nymphs are more likely to reward the efforts of the amateur culturist than the very abnormally developed Telescopes and Celestials. There are but few breeders who have successfully done this on a commercial scale, though the requirements as to equipment are few and simple. A light, sheltered room, a greenhouse, conservatory, or in the open air during mild weather; a number of rearing tanks or other vessels of various sizes and depths of water; hatching dishes, jars or tanks; the proper aquatic plants and water supply; some few simple tools, patience, cleanliness, good eyesight, some little experience and a careful attention to minor details are required.

A prime factor in the successful propagation of the goldfish breeds is a judicious selection of the breeding stock, so that the desired characteristics of the parents may be transmitted to their young. The breeder should carefully select and mate those which most markedly exhibit the recognized perfections of strain, type, color and conformation, or such which are derived from known fine stock, as the constant tendency of the finely bred Japanese and Chinese fishes is toward reversion to the original stock or ancestral type; nor is this probably as much due to inbreeding as to the fact that the fishes, under the changed condition of existence, differences in treatment, climate, food etc., from generation to generation undergo a gradual variation from the direct parent stock, acquire a different form or become hybridized; and perfect specimens of the fine Oriental fishes are exceptionally rare. There is a general belief that all the methods employed by the Japanese and Chinese culturists, in developing and maintaining the pure strains and in producing the wide diversity of form, color and appearance of the different breeds are not known or fully understood by

the American breeder, goldfish culture being a comparatively recent industry in the United States, but has been a science in China and Japan for centuries and an occupation of very considerable magnitude, to which must be added the endless patience and perseverance which is characteristic of the Oriental. It is also known that they only retain those young fishes which are the most perfect of their respective kinds, as with all animals even the most careful breeding will produce many variations from the parent stock, which in the goldfish leads to the hatching of imperfect fishes and "sports."

The breeding of the fine varieties is best conducted in tanks where the fishes may be kept under constant inspection and supervision, but the common goldfish multiplies rapidly in the pond; requiring only moderate attention, some little protection from natural enemies and sufficient food.

None of the early writers mention or illustrate the so-called scaleless goldfishes. These really are thin or transparently scaled fishes. The young of these breeds show a change from the dull to the bright colors almost as soon as the umbilical sac is consumed and when the fish is still very small. Under the microscope both the embryo and alevin show a mottled appearance different from the dull olivate color of the heavily scaled goldfishes. These thin-scaled fishes are the most sensitive to cold water and low temperatures, as they are derived from fishes bred in the warmer parts of China.

In breeding for color both parents should have the desired markings or have been derived from highly colored stock. To produce scaleless (transparently scaled) Japanese Fringetails a female Fringetail should be crossed with a transparently scaled male Chinese Telescope; as when the female is transparently scaled and the male scaled, a smaller percentage of the young will be transparently scaled. A scaleless (crossed) female Fringetail and a male scaleless Telescope will produce the telescopic eye and the Fringetail body and large fin development; and when both parents are scaleless (crossed) Fringetails, they are most likely to produce scaleless Fringetails with smaller and flat eye development than the Chinese Telescope, but larger than that of the common goldfish. These are the handsomest and most highly colored fishes, superior to the Scaled Japanese Fringetail stock.

Prof. John A. Ryder stated that experiments in shaking apart the cells produced by the first cleavage in the egg led to the development of two separate embryos from the same egg, as well as the production of monstrosities in both invertebrate and vertebrate animals. He mentioned experiments in producing double monsters by violently shaking the re-

cently fertilized ova of the pike, of almost entire broods of salmon composed of fry developed as double and triple monsters, each from a single yolk, by rough and careless handling or shaking of the ova during the early stages of their development; and the production of double monsters of the lobster and of birds by these and similar treatment of the eggs; which led him to the conclusion that the double-tailed goldfishes were produced by this or similar simple practices. The Orientals, by taking the eggs of the normal species and either by shaking or disturbing them in other ways produced some complete double monsters, some with two heads and a single tail, and some with duplicate caudal and anal fins. Of these the double monsters did not survive, but those with duplicated fins may have been kept alive and selections in breeding would continue the tendency to double fins.

It is known that crustaceans, batrachians, reptiles and fishes also have the power not only to reproduce lost parts, but of their regeneration in duplicate and triplicate, diverging from the point of mutilation. In tadpoles it has been observed that when the tail is cut off at right angles to the body, the new tip grows straight backwards in normal form, but when the cut is at an acute angle the development is, according to the inclination, either upwards or downwards; and that, if the growth of new material is interfered with across the narrow line of the stump, the growth will be to each side, producing a duplication of the part in diverging directions.

It has also been noted that this regenerative power diminishes in the higher animals, the last evidence being the reproduction of extremital parts; and that the rarity of the production of monstrosities, due to disturbance during the development, also diminishes, so that the continuation of these aberrations in successive generations becomes less frequent in the higher animal forms.

With fishes, however, the hereditary tendency to duplication of parts is a marked characteristic; and the goldfish and other Cyprinidæ tend to the retention of abnormalities; but which, in the natural state of pond existence would be lost, as fishes encumbered with duplicate fins, especially tails, would be less likely to reach maturity than those normally developed, though this sometimes occurs. Under the care of the breeder, however, these are fostered and by selection and careful propagation still further developed, until this tendency becomes a characteristic of the breed, and a considerable portion of the young continue the desired inherited peculiarity.

How this tendency is transmitted to the ova of the parent it is difficult to trace, but it is certain that the partially double bodies of the parents have some influence, and that the artificial interference with the ova or

with the normal processes of development, influences the first generation and these may transmit the effect and continue the peculiarity in the future generations.

Abnormal modifications in the goldfish breeds are not restricted to the fins, but affect the body, head and other organs, but in some respects the type is fixed, as in the number of scales in the lateral line and the number of transverse rows of scales on the body, though a displacement of the organs, a shortening of the body muscles and of the segments of the vertebra, is evident in the shortened body; to compensate for which the overlap of the scales and of their surface varies very considerable in the different breeds. Variations of the head consist most largely in a shortening, by compression, of the snout and of the position of the mouth, which in some breeds is modified to an almost vertical position. The form and position of the nostrils are also changed on the short snout.

The degenerative changes are not alone due to careful selection, but are also attributable to the restraint of an aquarium existence; the enforced disuse of the muscles producing an exaggerated growth of all the fins, as "the material saved from expenditure in muscular effort may be expended in growth in another direction, and culminates in a lengthening of all the fins, so that they are an actual hindrance in swimming."

The highly bred varieties have become entirely unfitted to existence other than in the aquarium under the fostering care of the breeder, and the young of such breeds, if they survive at all, revert more and more to the ancestral type with each succeeding generation when deprived of this supervision.

A sluggishness of habit has also been developed by the Oriental breeders, as both the descriptions of authorities on the propagation of the goldfish and the observations of fanciers prove; and with some of the highly developed varieties has been carried to such extent that harmless fishes of other species must be kept with them in the aquaria to agitate the water and prevent suffocation.

Some of the races are so monstrously developed and the displacement or the crowding of the swimming bladder so extensive that they cannot maintain their equilibrium in the water, but assume a position as though standing on their heads or tails, or partly or entirely reversed.

Professor Ryder prepared tables of measurements, in millimetres, of the three breeds of goldfishes obtained from Philadelphia breeders in March, 1893, which are here given in condensed form; but it should be stated that at this writing more varieties and even more wonderful developed fishes are successfully bred.

THE PROPAGATION OF THE GOLDFISH

RACES	Total length of head and body.		Length of body.		Length of head.		Length of intestine.		Width of the trunk behind the body cavity, between it and the base of the caudal fin.		Length of caudal fin.		Distance from vent to caudal fin.		Ratio of head to length of intestine.		Ratio of total length to length of intestine.		Ratio of total length of head and body to the length of the caudal fin.	
Common Goldfish.	90	62	28	364	15	36	25	1:13	1:4.45	2.5:1										
Two long bodied Japanese long-tailed Goldfishes.	74	51	23	213	10	80	19	1:9.25	1:2.85	1:8.3										
Three short-bodied Japanese double-tailed Goldfishes.	47	28	19	226	7	36	10	1:11.75	1:4.6	1:33:1										

He also pointed out that “the large number of capillaries in the huge tail of fine specimens of the ‘Kinyiki’ and KIN-YU races indicate that the caudal fin may possibly serve in a very important way as an adjunct to branchial respiration”, and that “the immense fins of the Japanese double-tailed goldfishes have been developed partially in physiological response to artificial conditions of respiration, that were not as favorable as those enjoyed by their wild congenitors”, and, “that the dorsal, anal and caudal fins may be so modified as to minister in an important way to the needs of respiration.” Also, “the fact that the very long fins are only fully developed at a very late period of the growth of the animal, is in harmony with the view that the hypertrophy of these organs is associated with a correlative degeneration of the muscles of the trunk, and possible use of these structures with their great amount of surface as respiratory organs, in the restricted and badly aerated tanks and aquaria in which they have been bred for centuries.”

The very red color of the blood in the arteries and capillaries of the fins would indicate the correctness of this hypothesis.

The comparisons of the telescopic-eyed goldfishes are equally interesting. Professor Ryder states that “the eye-ball becomes greatly elongated in the direction of its optic axis. Sometimes the difference between the axial and equatorial diameter is as much as three millimetres, constituting an extremely myopic form of eye-ball. The form of the eye-ball in the common races is flat or hypermetropic in character. A gradual passage from the hypermetropic to the myopic form is shown in the following table, as based upon actual approximate measurements of the eye-balls of individuals of the three races. The size and shape of the globular lens is not appreciably different from that of the other races with smaller eye-balls. It would therefore, seem impossible for the image formed by the lens

of a distant object to be thrown on the retina at all, consequently the condition is one of near sightedness, or of an optical adjustment for very near objects. The conditions of life * * * would in their restricted quarters actually foster the development of near sightedness, and any variation in that direction would actually tend to be preserved. * * * The name telescope fish in allusion to the protruding eye-balls becomes a misnomer, as the form of the eye is distinctly myopic and short-sighted, and not hypermetropic or far-sighted, as required of an optical organ having telescopic capacity." The Chinese designation "Dragon-eyes," would better apply to these breeds of goldfishes.

RACES	Total length	Equatorial diameter of eye-ball	Axial diameter of eye-ball
Common Goldfish.	130	7	5
Double-tailed Japanese Goldfish.	55	5	4
Telescopic-eyed Goldfish. No. 1 - -	63	6	6
No. 2 - -	70	6	9

All measurements in millimeters.

Dr. S. Watase, in writing "On the Caudal and Anal Fins of Goldfishes" states that in his opinion, artificial selection has produced the abnormal forms of all the fins, and that in all goldfishes, irrespective of what breed, the tail fin is above all other parts subject to the greatest variation.

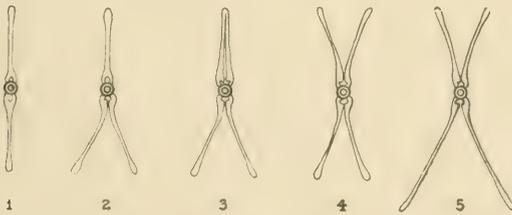


Fig. 57. Diagram of the vertebra and tail-rays of Goldfishes.

- 1 Single tail of the Common Goldfish.
- 2 Tripod tail of the Chinese and Japanese Goldfishes.
- 3 Webbed tail of the Chinese and Japanese Goldfishes.
- 4 Double tail of the Japanese Fantail Goldfish.
- 5 Double tail of the Japanese and Chinese Fringetail and Telescope Goldfishes.

of what breed, the tail fin is above all other parts subject to the greatest variation.

It is found in one of the following states: 1, it has three lobes, one median and two lateral; 2, it consists of two separate halves (*paired*) giving rise to a four-lobed tail (the "Yotsuo-wo;") and 3, it is vertical and normal. In the first

two classes, the lobes are more or less horizontally spread. The simplest transition state from single to double, is seen when the tail, normal in all other respects, has the ventral edge slightly furrowed by a median groove.

The greater part of it is vertical and median, but its lower portion occurs double (the *tripod tail*) which in some cases extends further upwards (the *web tail*). In other instances the furrow may reach the dorsal edge of the tail and thus divide it into two halves, which then expand right and left. These halves may or may not be connected at the median line, at the dorsal edge; in the former case, the tail is represented by a more or less horizontally expanded single piece (the *dolphin tail*) in the latter case it is distinctly paired (the *double tail*). Fig. 57.

Next to the caudal fin the anal fin undergoes a remarkable variation. It is either median and normal or distinctly paired. In the former case, especially when the caudal fin is also normal, the goldfish closely resembles the carp. In the double form of the anal fin, bony structures similar to those of the single fin are present in pairs. These double fins often make a flapping motion serving the same function as the ventral fins. Examination of the embryos of these breeds of fishes show that the double caudal and anal fins are laid out as two longitudinal folds or thicknesses along the ventral side of the post-anal section of the body, which diverge at a later period and form paired caudal and anal fins. The internal structures of these parts are also paired. In some of the breeds the anal fin is entirely absent and others have been developed which are devoid of dorsal fins, while the Egg-fish has neither dorsal nor anal fins.

BREEDING. It is proposed to treat of tank culture first and later of the basin or pool and pond or lake culture, these latter terms being applied to the smaller brick or cement basins and pools or those with earthen or boarded sides, and the larger natural or artificial ponds and lakes.

When the breeding is conducted indoors or in a greenhouse the season is earlier than in the open air and spawnings may begin in February, while out-of-doors or in the pond, in a temperate climate, the fishes may not mature the spawn till April, May, or June, after which it may be continuous, at short intervals, until the advent of cold weather. Spawning is also dependent upon the temperature of the water and rarely begins until it has reached 60° F.

The period of rest between spawning varies with the fishes and may be but a few days or several weeks, dependent upon their vigor and the temperature of the water. Spawning may occur two days in succession, or at an interval of several days, if the weather becomes colder, to be resumed when the water becomes warmer. Of this the surest guide is the appearance of the female and the action of the male, and trials with the latter should be undertaken, the fishes being again separated if no spawn results in a day or two. An occasional change of males is also advisable. Stimu-

lating food and the frequent addition of well-aerated water also greatly aid the spawning. As soon as the spawn is deposited and fecundated, which usually takes place early in the morning, the plants to which it adheres should be placed in the hatching dishes or the parents removed from the tank or rearing trough, to prevent their devouring both the spawn and later the young fishes. The fry also prey on each other, and hatchings of different dates should be isolated until the fishes have acquired considerable growth and are of equal size; those of slower development and smaller size to be either put by themselves or with the next younger hatch; where their chances of obtaining food are improved, or the larger and more vigorous ones removed. In breeding fine fishes it will be noticed that the single-tail "sports" always make the most rapid growth, as they are better able to get about than their finer double-tailed brethren. They are also the natural cannibals and prey upon the smaller more perfect fishes.

The depth of water for hatching and for the fry should best not exceed 6 to 8 inches and when transfers are made, the dishes and their contents should be submerged and the fry permitted to make their exit at will. Change in the temperature of the water is also usually fatal and must be guarded against in making transfers and at other times.

If there are no facilities for separating the parents and spawn, as in the small way in the house aquarium, a movable partition will serve; but it is best to hatch the spawn in separate vessels which can be placed in good but not too strong light, where eggs and fry will remain undisturbed. Shallow glass, porcelain or enameled dishes, fruit or candy jars, or other similar receptacles will fully answer the purpose, and are generally employed.

The relative size and vigor of the fishes regulate the number of males and females mated, to which individual judgment is the best guide. With the facilities at hand each female ready to spawn should be placed in a separate compartment with one, two or three males, dependent upon their size; but when the spawning has begun, selection of the finest male should be made, if he is of sufficient size, and the others removed to prevent too great exhaustion of the female. Care should also be exercised to prevent inbreeding by mating fishes of different strain or parentage. Where the number of fishes to be bred is large and of the same breed, it is advisable to select two or three males to one female, when she is the larger, three females and four males when of one size, and six females and four males when the latter are the larger fishes; but this, like much else relating to the culture of the goldfish is a matter of experience and applies more to the breeding of the ordinary than the finely bred varieties. A change of males is also advisable at different spawnings.

Should the rearing of the fishes be conducted in the open air, on a large scale or in pools or lakes, much that has been stated will apply; as with whatever method adopted the results are always more certain when the hatching is done in dishes or shallow tanks and the fry only transferred to the rearing ponds when sufficiently developed to find their own nourishment and too large to readily fall a prey to their numerous enemies. The temperature and condition of the water is thus under control, the spawn and fry better protected, feeding can be regulated, and a closer supervision had of all the details which lead to success.

Attention should also be given to the selection of such breeding fishes, especially with the common goldfish, which evince rapid growth and soonest develop color, as this may vary considerably, some fishes being very vigorous, growing to a length of 4 to 6 inches in a few months and assuming the desired colors when quite small, while with others this may have been delayed until the following season; and as these and other tendencies are likely to be transmitted to the progeny, a study of the parents is necessary to insure satisfactory results.

In pond or lake culture, where the fishes are turned in and permitted to breed at will, few precautions other than those of water supply, abundant food, protection from freshets and the larger predatory animals are possible; but when the breeding is done in prepared basins or pools, a very considerable supervision and control of the essential features are possible. A careful supervision, even from a business point of view, is advisable, as both the returns and the quality of the fishes are so greatly increased and better as to repay the additional care and labor involved.

Should the breeding stock have been sheltered indoors during the winter months, which with the facilities should be done, care must be taken not to transfer them to the open air tanks or basins too early in the spring as serious mortality may result. The fishes have lost much of their hardiness, and are liable to congested colds, affecting the gills and circulatory system. Such fishes should be placed in tanks or spawning beds protected by hotbed sash to moderate the temperature during the night and early morning, until they have once more become acclimated to out-of-door conditions.

Though spawning early in the season has a number of advantages from the commercial standpoint, as the young fishes may mature sooner and will be ready for sale when they command better prices, their enemies less numerous, as many of them will not yet have appeared, and thereby assure the arrival at maturity of a greater number, very early spawnings are usually not as robust and vigorous as those of later hatching.

Where the breeding is done in protected tanks, in the open air, it has been proven that better results are obtained by delay than by forcing, as these later fishes often outstrip the earlier ones in size and number of survivals at the selling season, which is usually after the month of September; but late spawnings are not advisable, as the young must then be carried over the winter.

The age as well as the probable maturity of the goldfish cannot always be determined by the size, the rate of growth not only varying with the individual but is also greatly influenced by the conditions under which it is, or has been, kept. When the surroundings are nearest the natural, growth and development are most rapid; indoors and in the small aquarium the conditions of existence are artificial and unnatural and may considerably stunt, dwarf or arrest development; but when transferred to larger tanks or basins in the open air, the growth is often surprisingly rapid, the increase in size being usually greater in a few weeks than during previous months in the aquarium or greenhouse.

The size, however, does not impair the fecundity of the fishes as those of small size and but eight (8) months old will spawn, though, naturally, developing less and apparently smaller eggs than the larger more robust fishes. Some individuals of the imported varieties are dwarfs and never attain a size over three inches; these are particularly desirable for small aquaria. They are fertile and breed as well as larger fishes. Aquarium rearing almost always dwarfs the fishes, but they are usually of finer appearance than those reared in the pond, for reasons already given.

Under favorable conditions, the goldfish attains to maturity during the spring and summer following that in which it was hatched, and large, vigorous fishes will spawn 1500 to 2000 eggs in a season. It has been established that fishes of the finer toy breeds under two years old have more rounded fins than older fishes, whereby their age may be determined. Also that fishes under four years old are the best for breeding, producing a larger number and more robust young.

Though, as stated, any well-lighted room will serve for the culture of the goldfish, especially a properly constructed and equipped greenhouse, having out-of-doors facilities for the young fishes, on a mercantile basis the industry is usually conducted in the open air, either in specially equipped hatching and rearing establishments or in basins and pools fitted for the purpose. There are a number of small and larger plants of this kind in the Eastern Section of the United States, principally devoted to the culture of the common goldfish; but some of the breeders have turned their attention to the more profitable industry of rearing the finer breeds and

with varying success, as the results of a season's labors depend upon many conditions not yet fully understood but which longer experience may remedy. Success with directly imported Japanese and Chinese goldfishes is equally uncertain; the mortality before arrival, from diseases, contracted during transit and before acclimatization, being in such proportion as to make this also a precarious business venture. Importations are made during the most favorable season, the late fall, winter and early spring months, but the results are usually such as soon to discourage many enthusiasts who otherwise would become profitable customers. The survivors in the home aquarium are so very few that American bred fishes of the choice imported breeds are more desirable and command higher prices, as the percentage of fatalities of imported stock is so considerable as to prevent a profitable venture.

The greatest discouragement to the breeder is the failure to raise a large proportion of the fishes hatched. This may be due to easily explained reasons or possibly caused by mistakes made in remote stages of the development of the eggs or of the parent fishes; and when the fry perish in unusual numbers, it is not sufficient to seek the cause in recent occurrences but all the conditions of feeding and care of the parents as well the young should be considered and corrections made in the future. At best, the survivals are usually small in proportion to the number hatched and even the most experienced breeders do not expect a greater survival than 20 to 25 per cent. of the most promising hatches which have arrived at an age of two or three weeks, after which he should separate the finer developed fishes from the less desirable ones, and of these rarely over 5 per cent. will be fishes which will be considered perfect in conformation and development by the expert fancier.

The least touch will affect the mucous membrane of the alevin and may lay the foundation for a future fungus development, and the fry from very young fishes or those which have not received a sufficient supply of oxygen by overcrowding, or those of parents which have not had a frequent change of water to act as a stimulant some little time before spawning, are usually weaklings and do not survive. Young fishes should be handled with a spoon and never taken out of the water.

The constantly growing demand for goldfishes is such that extensive cultivation is certain to be remunerative. In the Eastern States, at some seasons of the year, the supply is often exhausted and dealers complain that fishes are hard or impossible to get; which applies to both the common and the fine breeds and assures a ready market to breeders having the facilities for keeping their stock until times of greatest demand, usually at the Christmas season and in the spring when the breeding fishes are sought.

As it is the purpose of this volume to treat the subject not from the business point of view only but to interest the amateur and professional breeder alike, it is desirable to describe the breeding methods separately beginning with the simplest. The suggestions given should be modified to suit the conditions.

AQUARIUM AND TANK CULTURE. This method is usually employed by amateurs and fanciers with limited facilities, and undertaken as a pleasant diversion. The requirements are an open space, good light, one or more tanks, sawed-off barrels or similar clean and seasoned vessels of varying depth of water, which have been thoroughly scalded, scoured, frequently watered, filled and left standing for one or more months, and on which a growth of algæ has formed, success always being surer the longer they have been in use for this purpose. They should be placed in a bright and sunny location, accessible to water; clean potted plants placed therein and permitted to stand to accumulate oxygen and the minute animal life which is not only beneficial in removing the refuse, decayed particles of plants and excrement, but also serves as food; care being necessary in the establishment, seasoning and maintenance of the spawning and rearing tanks, which often require more than one season's use to be in perfect condition. When let into the ground they maintain a more equitable temperature, but set above the ground are not so accessible to some of the enemies, frogs and cats among the number. It is advisable to cover the tanks with wire screens as a protection from the larger enemies.

As elsewhere stated, either the parent fishes may be placed into the tanks to spawn and then removed, or the plants to which the spawn adheres placed therein and permitted to hatch, the former being the better method as then none of the eggs will be lost.

BASIN AND POOL CULTURE. Basins and pools may be built of bricks laid in cement or mortar and lined with cement, of cement concrete, or on a good clay bottom with the sides of boards backed by well puddled clay. Their proportions should be such that a careful observation of the entire contents is possible and when based on a factor of 4 or 5 feet many advantages will be manifest; that is, a breadth of 4 feet and a length of 4, 8 and 12 feet; or a breadth of 5 feet and length of 5, 10 and 15 feet, so that glass sashes, wire covering, etc., are interchangeable, the capacity and the number of fishes for each size easily kept in mind, and the available space well occupied by this systematic arrangement.

An easily constructed basin is one of circular form with sloping sides, as the earth may be evenly excavated, the bottom leveled off, and brick or concrete sides built directly against and upon them. The action of frost

is also less severe on circular than rectangular basins and a basin of this kind is more likely to be lifted off the bottom than to break the sides by the pressure, and is easily repaired by filling in the bottom crack with liquid cement. All tanks should be seasoned before the fishes are introduced by a thorough soaking and frequent changes of water, to remove all traces of soluble lime or acid substances.

When not in use, it is a mooted question whether they should be kept dry in winter or partially filled with water to equalize the pressure of the frozen ground. Good results have been obtained by filling with water and floating logs in them to relieve the sides of ice pressure, while freezing will destroy fungus and disease spores.

GREENHOUSE CULTURE. Experience has taught breeders of the goldfish that the principal purpose of the greenhouse is the wintering of the breeding fishes, keeping over young fishes for better prices when the general supply is exhausted, and for spawning, hatching and rearing of the fry during the early weeks of the spawning season, when the possibility of late frosts may endanger them out-of-doors, though early spawning is not to be generally recommended.

Another purpose of the greenhouse is the facilities it affords in continuous growth of the young during the winter months, as aquaria and small household tanks tend to arrest development; also for the preservation of the necessary aquatic plants over winter. Young fishes, however, thrive best in the open air.

Compartment tanks and cement basins, should be arranged to place as many as possible in the available space, and to permit of ready access and inspection. When the weather has become settled, the rearing should be done out-of-doors. Great care must be exercised in seasoning these receptacles.

The illustration, Fig. 58, is a greenhouse for goldfish propagation designed by the author, which may be erected in a back yard or garden. All the sash of the sides and roof are hinged, to permit of raising or removal in warm weather for the free circulation of air, a prime essential to success. The spawning and hatching tanks are arranged at the sides, to permit of a central aisle, and the overflow connections led to the drainage by pipes with union joints. The water supply is by a hose. The rearing tanks are shown adjoining the greenhouse but may be located within convenient distance and should be provided with portable glass sash as covers on cold nights and mornings and with wire screens to keep out enemies. If the screens are of galvanized iron, they should be thoroughly cleansed and seasoned, to remove the acid.

All the openings are protected by screens, those of the roof by gauze netting and the sides by $\frac{1}{4}$ inch-mesh wire screens to exclude obnoxious

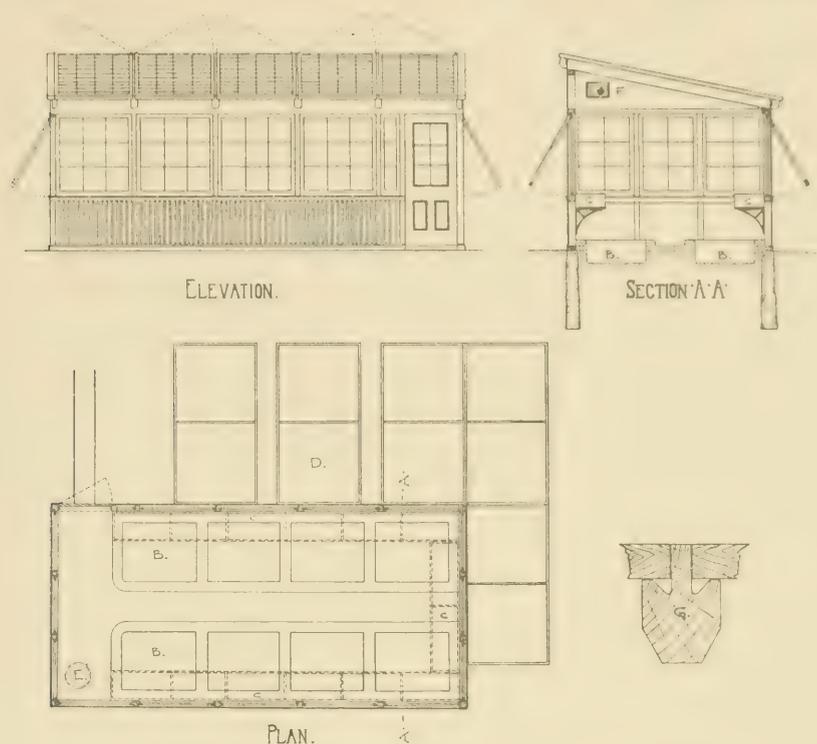


FIG. 58 Elevation, plan and section of a Greenhouse for Goldfish propagation.

- A-A Line of section.
- B Cement basins, 3' 9" x 3' 0" x 1' 4".
- C Shelves and Hatching tanks, 2' 10" x 1' 6" x 1' 2".
- D Rearing tanks, 4' 0" x 8' 0" x 1' 3".
- E Oil or gas stove.
- F Ventilator.
- G Detail of Roof supports to prevent dripping.

insects but to permit small flies, gnats, mosquitoes and other harmless insects to enter and deposit their eggs, the larvæ serving as food for the young fishes.

Heating arrangements other than a portable odorless oil stove or a small coal stove are not required, and these need only be employed in the most inclement weather; experience having proven that goldfishes thrive best when not kept in too warm temperature, 45° to 50° F. being better than higher, and if no rapid changes take place those just above freezing are not injurious, except to the transparently-scaled Chinese breeds developed in a warm climate. Warmer water is necessary during the breeding season.

The sash of the greenhouse should be arranged to open in the direction of the prevailing summer winds.

The principal reasons for failure to rear many young fishes, apart

from improper feeding and other evident causes, are too much light, particularly strong sunlight, which should be guarded against. Daily ventilation is also required, especially when the heating apparatus is in use.

POND AND LAKE CULTURE. Figs. 59 and 59A. With this method, the rearing ponds should not be of the same depth of water, but vary from 3 or 4 feet near the outlet to a few inches at the inlet, that the fishes

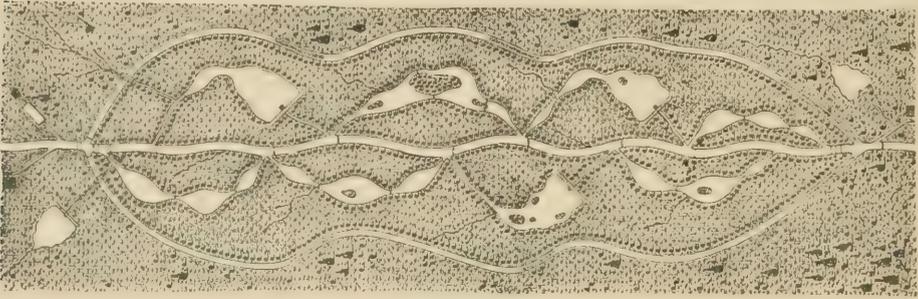


FIG. 59. Plan of a Fish Farm.

may seek any desired depth and relieve themselves of the water pressure, but constructed that they may be entirely drained when necessary, and free from obstructions that they may be seined. Each should have independent inlet and outlet, but also arranged to connect in series, when desired. Ponds should not be formed in streams, but at a safe distance and the water led to them through sluices which can be closed in case of freshets or too muddy water.

Each season the ponds should be drained, thoroughly cleaned and the upper layer of soil removed from the bottom. It is also advisable to leave them exposed to frost for a time to exterminate insects and other enemies.

One or more small isolated emergency ponds, containing a plentiful growth of plants and arranged for draining, should be established; into which fishes may be placed in case of mishap, serve as reserve ponds for temporary storage, utilized for fishes of retarded growth, or for the separation from the general stock of selected future breeders.

A small basin dug into the soil or having a soil bottom, thickly grown with aquatic vegetation, to supply the water with oxygen and for the propagation of the live food, should be arranged between the water supply and the rearing ponds; and if the water is derived from a spring it should not be too near the ponds, that it may not be of too low temperature and also in flowing over stones or artificially constructed ripples absorb a large quantity of air, as spring water is deficient in oxygen. The water of a shaded cold-water brook is preferable, river or pond water is not as desirable on account of its rising temperature in the hot summer months.

Ponds dug into the earth or constructed by dams are less expensive than those built of bricks or concrete, but the latter are more easily supervised, as the perpendicular sides offer a clear view of the contents and protection from the direct rays of the sun during hot afternoons. However constructed, shrubbery and shade trees should be planted along the banks and a luxuriant growth of water plants encouraged in them, restricted to localities where they will be under control. For this purpose Cabomba, Myriophyllum, Giant Anacharis and *Ludwigia mullertii* are best and will find a ready market; but floating bunches of watercress will root and thrive on the surface, furnish oxygen and offer convenient hiding places and shade for the fishes and homes for the small aquatic fauna constituting the natural food; having the additional advantage of ready removal when desired. No plants other than these and lilies should be introduced or permitted to grow. Sagittaria will not grow out-of-doors. All sod should be removed from the bottom

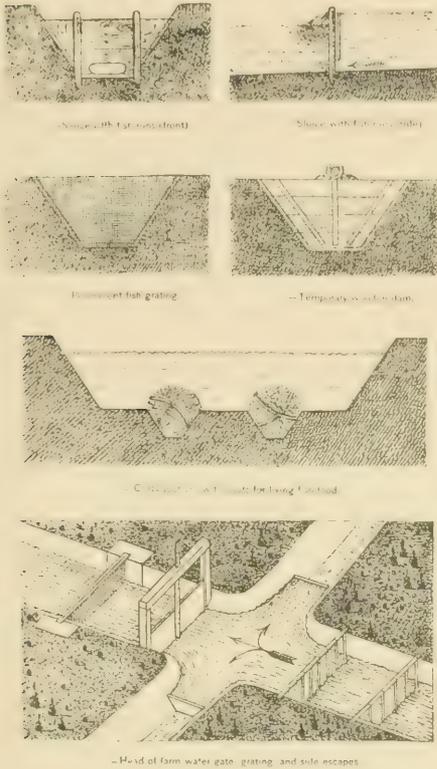


FIG. 59A Sectional views of Sluices and Ponds.

and the sides at the water level to prevent the injurious decay of vegetable matter.

Feeding tables in the water are not advisable as they may become foul from decaying matter, culture places for parasites and safe retreats and lurking places for enemies which shun the light of day. The fishes soon learn to congregate in the desired localities at the regular feeding time and will keep the bottom clean and clear of food, if not overfed.

Let it here be again noted that goldfishes of the fine breeds become more course in large bodies of water than those reared in small tanks and basins.

SPECIALLY EQUIPPED GOLDFISH BREEDING ESTABLISHMENT. The illustration, Fig. 60, is an ideal arrangement for a large artificially constructed breeding establishment for fine fishes. Its location would best be in the country near an abundant supply of clear, moderately cold-water,

derived from a constant spring or shaded brook; the best site being a sunny location, a natural valley or a hollow, sheltered by hills or woods in the direction of the prevailing cold winds.

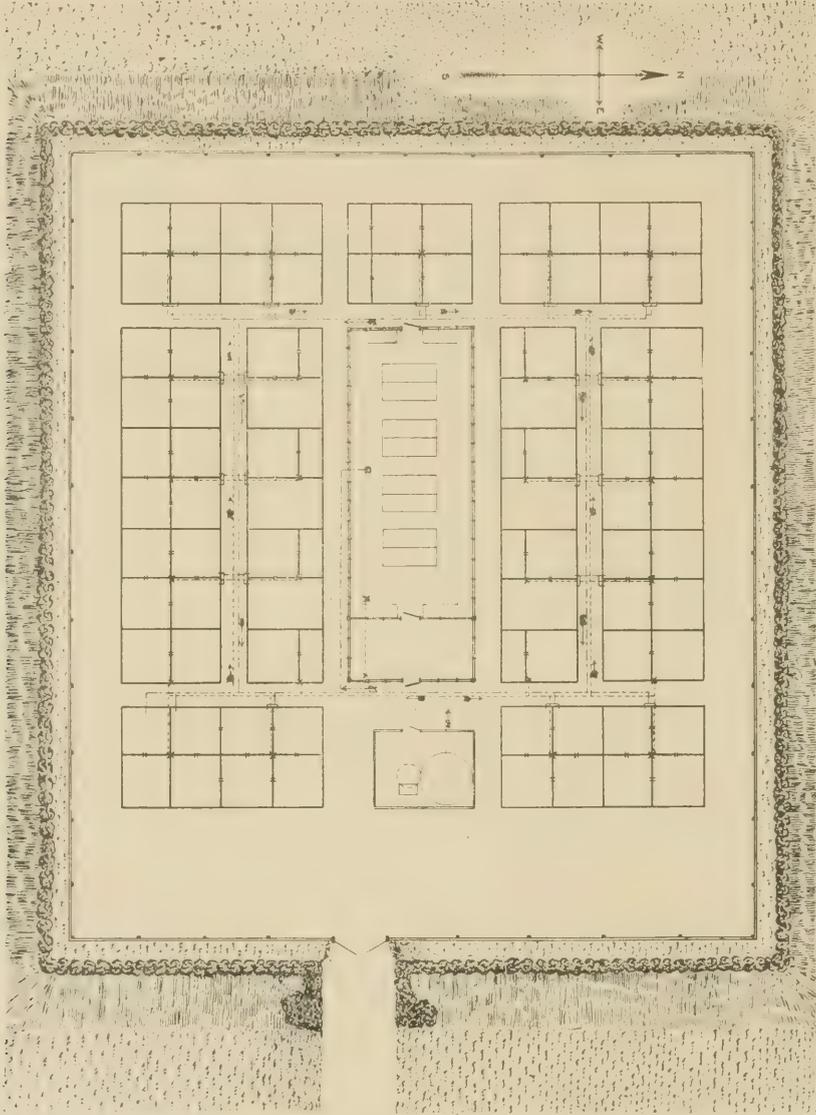


FIG. 60 Arrangement for a large Fish-culture Establishment for the propagation of the Goldfish.

A central greenhouse is surrounded by rearing and breeding basins; a shed containing the water collecting tank and a pump; the water supply and drainage system is indicated, and the premises surrounded by a board fence, sheltering embankment and shrubbery.

An establishment of this size with sufficient breeding fishes, after a

successful season, should produce many thousands of goldfishes of both the common and the highly prized Oriental breeds, for which there would always be a constant and remunerative demand. The Paradise Fish, Ide and Tench could also be cultivated.

POND AQUARIA. Vol. VII of the Bulletins of the U. S. Fish Commission, 1887, gives two excellent suggestions for pond aquaria which are here reproduced and no better explanation can be given than to quote the accompanying article by Mr. Wm. P. Seal:—

“With this idea in view I offer the following suggestion for the consideration of those interested in the establishment of large aquaria, hoping for further development through interchange of ideas.

The plan or principle herein suggested might be termed not inaptly Pond-Aquaria, it being essentially a combination of the pond and the aquarium; the aquaria being constructed on the margin of the pond or reservoir used, as shown in the accompanying illustration, Fig. 61; the

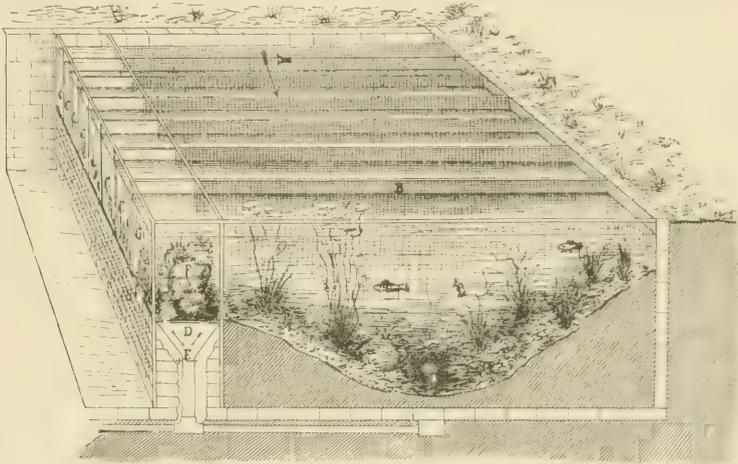


FIG. 61 Pond Aquarium.

idea being to have a water-pen or pond-garden (A) extending back from each aquarium front, and to be surrounded by a wire or other fence or partition (B) of sufficiently small mesh to prevent the escape of the occupants, but large enough to allow the smaller fry, which would furnish them with food, to pass through freely. (C) represents the glass fronts. (D) the upper or perforated aquarium bottom, which allows the escape to a lower funnel-shaped bottom (E) of all sedimentary deposits. (F) represents rocky eminences containing pockets, in which could be planted aquatic vegetation at depths adapted to their needs. The whole creating a close approximation of natural conditions. An arrangement of wire gates would keep fishes in close confinement for short periods for observation, or would keep some, while others were allowed to roam at will in their domain.

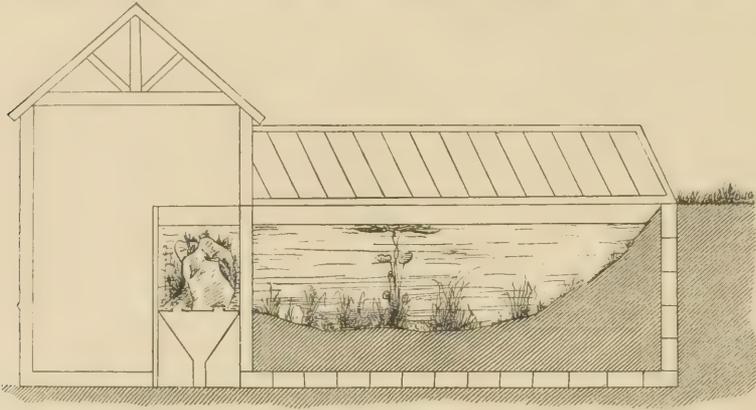
Fig. 61A represents a cross-section of the same, showing building over the aquaria, and greenhouse roof to pond-gardens.

The advantages of some such plan will, I think, be apparent to all who have experience on the subject at least. It is simply imitating nature more closely and getting rid of artificialities.

The conditions would afford natural vegetation, sunlight, mud, sand, and rocks, with abundance of room in which to move about freely and seek for natural food.

By such a plan also the necessity for circulatory apparatus is dispensed with, the circulation caused by the movements of the fishes, changes of temperature and evaporation, together with the aeration or oxygenation affected by the plant life being ample, as in the pond.

It might be argued that, with so large a space, fishes would keep hidden from view. The experience of the writer has been that when the fear of danger is removed and animals become confident of an ability to escape at will when threatened by danger they lose their timidity and



ENCLOSED POND AQUARIUM.

FIG. 61A Section of Enclosure for a Pond Aquarium.

become both bold and curious, and are more easily and satisfactorily viewed than when under the influence of fear in close confinement. The deer, the most timid of animals, when confident of safety, becomes perfectly content, and without desire to escape except to seek its kind for company.

The experience of the writer in the care of fishes and reptiles and other animals as well, is to the same effect."

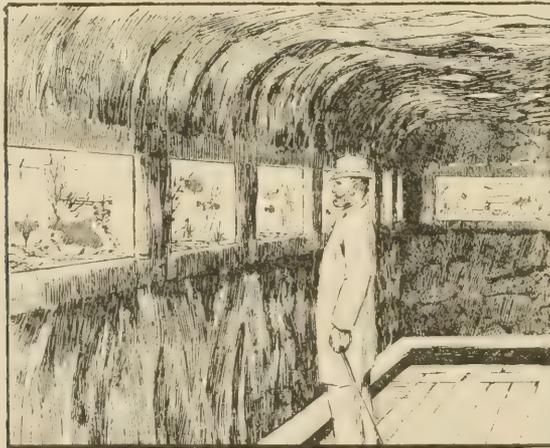


FIG. 62 Grotto at the Central Station of the U. S. Fish Commission, at Washington, D. C.

AQUARIUM GROTTTO. The same authority describes the aquarium grotto attached to the Fish Commission building at Washington, of which the herewith reproduced illustrations give an adequate idea. Figs. 62 and 63.

WINTERING GOLDFISHES. In the household the fall, winter and spring months are the seasons when the aquarium is the most appreciated, and considerations for wintering are for the surplus fishes and breeders, or for

THE PROPAGATION OF THE GOLDFISH

such as have been kept in outdoor tanks and basins in favorable weather but which must be otherwise accommodated during the rigors of cold weather. The best success is had when fine fishes are kept only about four months in household aquaria, after which they should be placed out-of-doors.

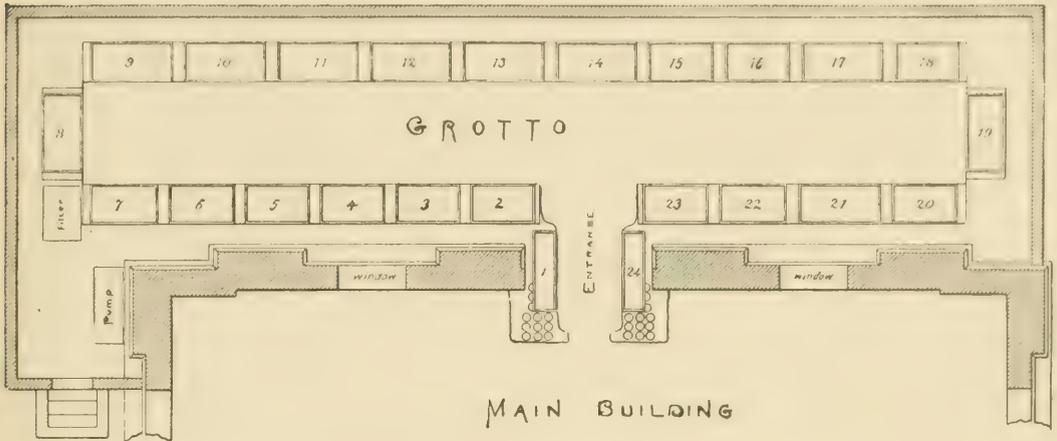


FIG. 63 Plan of Grotto at the Central Station of the Fish Commission, at Washington, D. C.

The ordinary goldfish will survive out-of-doors, if the ice is broken to admit air. The tanks should be of sufficient depth so as not to freeze solid, and straw or other materials should be packed about them for protection. A board cover, with straw spread over it, should also be provided, to moderate the cold. An approved method is to permit an inch of ice to form, after which a hole should be cut and sufficient water removed to make a space of two inches between the ice and the water, and the hole closed with a cloth and a board. If the sides are protected, the cold will not cause a further freezing, and the air space will prevent suffocation. The top of the tank may also be covered, after which the fishes will be in comfort until the advent of spring. Feeding is only necessary at long intervals.

The fine breeds should be wintered in a greenhouse or in the cellar. Tanks or similar vessels will serve, but the best receptacles are fibre wash-tubs. These should be set upon supports near a window, for occasional ventilation, but no plants introduced unless the light is such that they will grow. The fishes should have ample water, five gallons per fish, if possible, and once a week a pail or two of water should be siphoned from the bottom around the edges, where the excrement will accumulate, and a like quantity of fresh water added, which has been moderated in temperature. Feeding should be light, once a week, and but a small quantity of nutritious food given. Fishes so wintered will remain in fine condition,

the only danger being a possible lack of aeration in the absence of plants, which should be guarded against by the occasional partial change of water.

Where there are facilities for water supply and drainage an excellent plan is to arrange an overflow pipe and a constant very small inflow of fresh water. A sheet of glass suspended vertically over the tank, to which a very small hose is attached, will occasion a constant dripping to both aerate the water and moderate its temperature. A very considerable constant water supply has been found to be objectionable, as the low temperature of the water direct from the mains in winter is injurious to the finer goldfishes, which have been bred and kept in a warm climate and lack the hardiness of the common goldfish. Snow water is usually fatal to the finer breeds.

Goldfishes are sometimes kept over in tubs in moderately warm cellars without any attention or food, and though they have survived, this is an inadvisable practice and an unnecessary cruelty.

Wintering in large aquaria and tanks is best, and should be adopted wherever the facilities are to be had. Any unoccupied light room will serve, and temperatures above freezing are not injurious, except possible to the transparently scaled fishes, if no sudden changes occur. Under these conditions aquatic plants can usually be kept in growing condition to supply the required oxygen. The water should be occasionally partially changed.



CHAPTER VI.

Food and Feeding

FOOD AND FEEDING OF GOLDFISHES AND OTHER FRESHWATER FISHES

One of the fundamental principles of dietetics is that the chemical composition of food should conform with the chemical composition of the body and that those which furnish this in the best proportion are not only the most nutritious but also best maintain the animal organism in its most perfect condition. For this reason the diet of coldblooded animals should consist most largely of vegetal substances and of coldblooded animals, their natural food, as having no body temperature to maintain they do not require as large a proportion of the rich hydrates of carbon and other heat-producing foods necessary to warmblooded animals. Experiments with food fishes have demonstrated that with this natural food the fry will grow seven times more rapidly than on a diet of mammal flesh.

Dietaries for mature goldfishes may be divided into several classes: Barely subsistence diets, leading to semi-starvation, stunting and deformities; healthy diets, producing normal growth, vigorous health and fine development; fattening diets, leading to coarseness of appearance, insufficient fin development, indolence and predisposition to disease; overfattening diets, producing disturbances of the digestive system and a suppression of the reproductive organs; and overfeeding, which leads to water contamination diseases, asphyxiation and death.

Barely sustaining diets usually occur from the dread of overfeeding or from overstocking, and reduce the fishes to a point below healthy development. When the fishes are starved in infancy they become permanently stunted, the bones hardening so that no subsequent care or feeding will cause them to expand sufficiently to permit of normal growth; for which reason the early feeding stages are the most important in the rearing of fine fishes and require intelligent understanding of their wants and requirements. Healthy diets imply not only a sufficient quantity of food, but those composed of the proper constituents to stimulate active assimilation, to supply all the needs of the animal organism in proper proportion and to produce a vigorous growth, fine development of both body and fins, a clean and elegant appearance, and robust health. Fattening diets are such as cause overstimulation and excessive nutrition by their too considerable richness of composition and produce fishes lacking in vitality, and the elegance of appearance and fine fin development, noticeable in those more carefully reared. This is sometimes attributed to pond culture, but is as often due to

highly nutritious food excessively fed, so that the labor of procuring a livelihood is reduced to a minimum and by constant gorging the fishes become coarse and misshapen. Excess of food also produces disorders of the digestive system and the consequent liver affections. Overfattening diets will produce in the goldfish the same results as in other animals and an overaccumulation of flesh or fat will invariably be followed by a partial or total sterility, just as the removal of the genital organs will produce a rapid accumulation of flesh. Overfeeding is a most serious evil as very many of the diseases may be directly or remotely traced to this cause and its attendant results. Sufficient food should be given, as much as will be at once eaten, and to fully satisfy the hunger, all additional feeding is a source of danger to the fishes.

It was formerly supposed that the carp subsisted on vegetal food only, but it is now known that its principal diet consists of snails, crustaceans infusoria and other small aquatic fauna, it also deriving albumen and soluble hydrates of carbon from the minute aquatic flora and the young shoots and roots of plants; and this applies to all the Cyprinidæ, including the goldfish.

In the aquarium, fully developed goldfishes should not be fed oftener than once a day in warm weather and on alternate days or intermittently when the weather is cold or the temperature of the water low, receiving less than one per cent. of their judged average weight of nutritious food, regulated that it will be immediately consumed, not carried off and later disgorged to contaminate the water. All fishes can live a long time without food and experience enables the culturist to judge from general appearances when they are sufficiently fed. Whenever they are crowded in a small space feeding should be done with additional care or the equilibrium may be disturbed, even with a very considerable plant growth. Inferior, stale or sour food should never be fed, and the feeding and care of the fishes should be vested in one reliable person.

FEEDING THE FRY. The foregoing more particularly applies to growing and mature goldfishes; the important considerations of feeding the alevin and fry require special mention, as this greatly influences the development of the finely bred forms. When too sparingly fed or at long intervals, the exertion of procuring food necessitates an activity detrimental to the development of the desired short bodies and large fins, while sufficient nutrition tends to slothfulness, an easy existence and the consequent fuller development of these desired characteristics. A short rotund body also requires a shortening and crowding of the alimentary organs together with a partial displacement of others; the double tail and long fins further hampering the movements of the fish, so that any active strug-

gle for food can only tend to the elimination of the finest fry and the survival of the better adapted but undesired long-bodied, single-tailed fishes.

To achieve most certain results, a careful observation of the following suggestions is advisable:—Experience has proven that it is best to take the spawn and the plants to which it adheres from the spawning bed or tank and place them into filtered water to hatch, thus largely avoiding the danger of the presence of fungus spores and enemies; but it is well to introduce a few pots of clean growing plants to supply the necessary oxygen and prevent the asphyxiation of the hatching fry. Immediately after hatching, the alevin is still attached to the umbilical sac and requires no other food than is furnished by it and that present on the plants and in the water; but after its absorption young fishes may be fed on rice flour scattered on the surface of the water, or a little of the broth of oat meal, but the best food is the natural pond-life food, and this should be continued until it is $\frac{3}{4}$ to 1 inch long, when prepared foods may be fed, if natural food is no longer to be obtained.

Together with the plants a small dish containing clean soil should be introduced, as it contains substances necessary for nutrition and will stimulate the development and propagation of infusoria, the minute animal life which is the natural first food of the newly hatched alevin. This is manifested by the greenish color of the water, which is also in part due to the presence of tiny vegetal life, the diatoms and other small algæ. After the fry have reached the age of a week, a half pint of water of pronouncedly green color, taken from a tank in which a considerable growth of algæ has collected, should be added every few days, then after a week live food should be fed.

It should be here repeated that a low temperature of the water and insufficient light will seriously affect the survival of the fry, as the generally accepted opinion that fishes do not feed freely when the weather is cloudy and the water cold applies to young goldfishes; but strong sunlight must be avoided, as that also is injurious.

When the stage of feeding live food has been reached, it should be given in liberal quantity about three or four times a day, carefully screened that only the smallest entomostraca are introduced into the rearing tanks; and though it has been observed that when very abundant the larger may prey upon the young fishes, it is always the weaklings which are attacked and these can be dispensed with; the healthy and vigorous young fishes escape these attacks or but few succumb.

paired and one central single eye. It has two pairs of threadlike antennæ. Under the shell there are 60 pairs of gilled legs, of which the first pairs are developed into antennæ-like feelers. It swims on the back and steadily moves through the water by rapid undulating strokes of the legs. The periodic appearance of this Crustacean may be due to the fact that the eggs must be subjected to a period of incubation in the dry earth. The food consists of water animalculæ and decaying vegetation.

It is the larvæ and young of these Branchiopods which constitute the food of the mature goldfish, the adult being of too large size to be readily taken. It is principally the Crustaceans of the following sub-order Cladocera which constitute their live food.

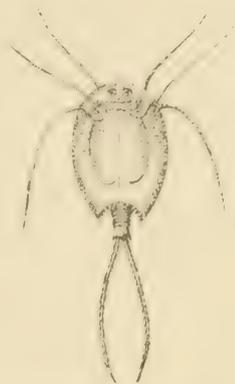


FIG. 65. *Apus cancriformis*. Greatly enlarged.

SUB-ORDER CLADOCERA. Compressed body small, indistinctly segmented, enclosed in a bivalve carapace, four or six swimming feet, and the posterior antennæ developed as longer swimming feet. The most general forms are *Daphnia*, *Polyphemus* and *Leptodora*. *Daphnella*, *Sida* and *Ciriodaphnia* also belong to this sub-order.

DAPHNIA. Fig. 66. Four or five species of *Daphnia*, known to the goldfish breeder by their light green, dark green, red and reddish colors, abound at different seasons in almost every still or stagnant water. Their size is from .75 to 1.5 millimeters. The segmentation of the body is imperfect, the Crustacean being covered by a folded carapace. The head is distinct and the abdomen is turned downward and is in constant movement. The long antennæ are moved at longer or shorter intervals, making the progress a series of rapid starts and stops. Between the abdomen and the carapace of the female is a large brood pouch in which the eggs are stored and hatched and the larvæ only make their escape when they have reached the free-swimming stage. The paired eyes have fused into a single organ. There are five pairs of swimming legs on the thorax. The re-



FIG. 66. *Daphnia pulex*. Greatly enlarged.

production of the *Daphnia* is most curious. During the summer the female develops spores, which, without fructification by the male, develop in the brood pouch to perfect *Daphnia* in four days, and which, when they have become liberated, in a few days reproduce in the same manner. In the fall of the year the much smaller males appear and the sexual reproduction takes place. Winter eggs are produced, the thick shells of which protect them through the cold season. The food of the *Daphnia* is de-

caying vegetation, organic offal and small infusoria. They are the best food for the goldfish. It has been noticed that the tiny newly hatched alevin will follow *Daphnia* to feed upon the young as they are released from the brood pouch of the female. The most generally distributed forms are *Daphnia laevis*, *D. pellucida*, *D. pulex*, *Daphnella branchyura*, *Ceriodaphnia pulchella* and *Sida crystallina*.

POLYPHEMUS. Fig. 67. One species of Polyphemus is quite generally present in still and stagnant water. This is *P. pedeculus*, of which the body is of most grotesque form, owing to the peculiar humplike brood pouch. It is smaller than the *Daphnia*, about .65 to 1 millimeter in length.



FIG. 67. Polyphemus pedeculus. Greatly enlarged.

LEPTODORA. Fig. 68. One form of Leptodora is quite generally present in larger bodies of freshwater, and may be taken on the surface on bright days. The body is long and is covered by a faintly segmented carapace. There are two long swimming legs and the very long antennæ branch at the ends and are furnished with swimming bristles. *L. hyalina* is the most generally distributed form. Its length is about 1 to 1.5 millimeters.

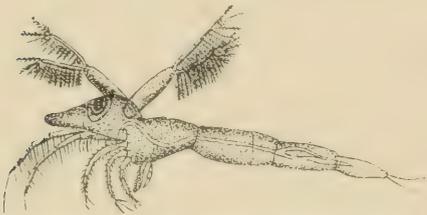


FIG. 68. Leptodora hyalina. Greatly enlarged.

SUB-ORDER OSTRACODA. Compressed body small, indistinctly segmented, in a bivalve shell, five pairs of feet adapted to swimming and creeping. The freshwater form is *Cypris*.

CYPRIS. Fig. 69. Several species are very generally distributed and may be taken from almost every water which contains the other entomotraca. The body is unsegmented and is enclosed in a carapace articulated at the dorsal edge to form a bivalve shell. At the anterior end is a median eye, and there are seven pairs of swimming appendages. Its size is 1 to 1.5 millimeters, and its movements are slow and leisurely either in swimming or in crawling over the bottom. The young are developed in the brood pouch but are expelled in the larvel condition. This Crustacean propagates even more abundantly than the *Daphnia*, and will prey upon the eggs and embryos of fishes, a number of them may attack an alevin, fastening themselves to its surface and devouring it in spite of efforts to free itself. Goldfishes eagerly eat the *Cypris*. The generally distributed forms are *Cypris virens*, *C. pubera*, *C. pellucida*, *C. fusca* and *C. ornata*.

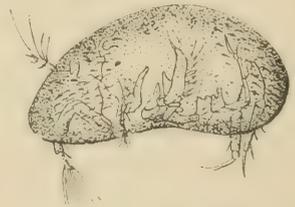


FIG. 69. Cypris virens. Greatly enlarged.

SUB-ORDER COPOPODA. Body small, distinctly segmented, the foremost segment fused with the head; antennæ, mandibles and maxillæ well developed, six pairs of swimming feet in the free-swimming freshwater forms, which consist of the Cyclops and Canthocamptus.

CYCLOPS. Fig. 70. Ten or twelve closely allied forms abound in still and stagnant water. Their size is 1 to 1.5 millimeter. The segmentation of the body is perfect, the Crustacean being covered with a carapace of which the first segment is fused with the head. Two long antennæ are present and but a single eye. The swimming legs are attached to the thorax, and the lengthened abdomen is provided with caudal appendages. Their food is organic substances, infusoria and algæ, and their movements are steady and regular as though propelled by driving wheels. The most

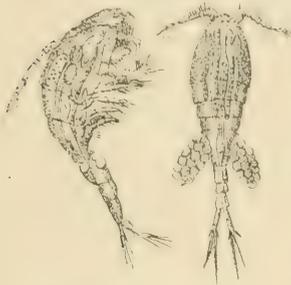


FIG. 70—*Cyclops thomasi*.
Greatly enlarged.

generally distributed are *C. thomasi*, *C. gyrinus*, *C. agilis*, *C. edax*, *C. modestas*, *C. ater* and *C. viridis*. *Canthocamptus* is rare in the Eastern and Middle states and occasionally occurs as an unrecognized species.

These Copopods possess extraordinary fecundity. In the winter they seek the bottom and hibernate, but when the water reaches a temperature of 45° to 50° F. they revive, their increase being greatest at 65° to 70° F.; when the female every two days develops two egg sacs or external uteri, wherein 16 to 32 eggs are hatched. In two days these become detached, fall to the bottom where the young, almost globular cyclops, having four legs but no tail, undergo a molting in about 15 days, when the other feet and the tail form. In another 15 days they mature and reproduce. Carbonate of lime is necessary in the formation of their shells. They thrive in water infused with vegetal matter in decomposition, but as it does not contract any odor of decomposition it is probable that they live on the infusoria. Potamogeton, Ceratophyllum and Fountain cress, upon which algæ and voucheria will form are usually present to sustain the infusoria. Young goldfishes usually reject Cyclops when they can obtain Daphnia. It has also been observed that some species of Cyclops feed upon fish spawn and will attack very young fishes.

MALOCOSTRACA. These highly organized Crustacea have the thorax of eight and the abdomen of seven segments. The sub-order *Amphipoda* are shrimplike forms with stalked eyes; the *Isopoda* have depressed or flattened bodies and gills borne on the abdominal appendages; and the *Decapoda* have the thoracic segments united with the head in a carapace,

the three anterior pairs of limbs as foot-claws and the five pairs of posterior limbs as walking legs. The eyes are stalked and the gills thoracic.

SUB-ORDER AMPHIPODA. This sub-order includes the Water-fleas and the marine Sand-hoppers, of which one genus is present in both running and standing fresh water.

GAMMARUS. Fig. 71. This freshwater Crustacean, known as the Water-flea and Fairy Shrimp, *Gammarus pulex*, has a flattened form, the anterior portion consisting of the head and thorax covered with a carapace, and the posterior portion with six segments and a terminal flap ending in a short bristle. The anterior three pairs of legs serve for swimming and the posterior legs for swimming and the hopping motion by which it moves more rapidly through the water. The color is a translucent dusky grey. It is found in muddy streams among half-rotten brush wood and other litter, usually hidden under stones or aquatic plants, generally feeding at dusk or at night, when it either swims leisurely through the water or hops by rapid strokes of the posterior legs. Its food is decaying vegetation, small animals and spawn; and will serve as an effective scavenger in tanks for larger fishes and amphibia but should not be introduced with young fishes.



FIG. 71. *Gammarus pulex*.
Greatly enlarged.

SUB-ORDER ISOPODA. This sub-order includes the Water-Asel, Wood Louse and a number of marine forms.

ASELLOPUS. Fig. 72. This freshwater Crustacean is known as the Water-Asel, *Asellopus tenax*, and has a compressed or flattened form and a segmental body covered with an olivate armor marked with lighter spots. It reaches a length of 1 to 1.5 centimeters, and inhabits still and slow-flowing water containing considerable vegetation. Its movements are slow and it is usually secreted in the mud or on the under side of the leaves of aquatic plants; feeding on decaying vegetal substances, smaller animals and spawn, and is an active enemy of very young fishes. Another more slender and longer-limbed form is *Asellus communis*, a New England States species.

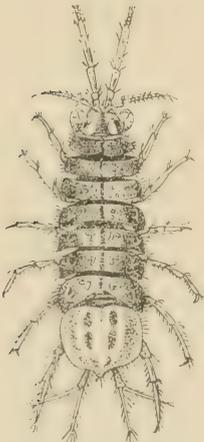


FIG. 72. *Asellopus tenax*.
Greatly enlarged.

SUB-ORDER DECAPODA. This sub-order includes the freshwater Crayfishes, marine Prawns, Shrimps, the true Crabs and Lobsters. These will be treated of elsewhere.

The minute Crustaceans are of the greatest benefit to the growth and survival of the young brood of

goldfishes. Another abundant form of live food is Mosquito larvæ, which should be here mentioned but is more fully described in another Chapter. Too strong light and changes in the temperature of the water seriously affect the survival of this live food. Experienced breeders guard against these by keeping the pails or tanks in secluded places and provide protecting covers. For Goldfishes *Daphnia*, *Cypris*, and Mosquito larvæ are the best food, preference being given to the former. For the other freshwater fishes all the mentioned Crustacea serve as food; they may be fed on any of them small enough to be swallowed.

CRAYFISHES. These largest freshwater Crustaceans occur abundantly in most lakes and streams except in the New England states and the Great Plains region. They resemble the Lobster in miniature. The head and

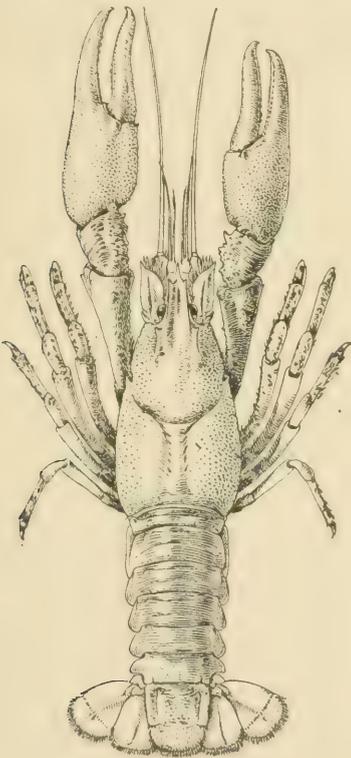


FIG. 73. Freshwater Crayfish,
Cambarus blandinii.

thorax are amalgamated in one mass covered with a carapace. The abdomen is divided into seven segments, six of which bear swimmerets and the seventh a divided flattened tail-fin or telson. The compound eyes are borne on long movable eye-stalks, behind which are two long jointed antennæ and a second pair of short antennules. The mouth is on the under surface and is provided with one pair of mandibles, two pairs of maxillæ, and three pairs of maxillipeds or foot-jaws. The segments of the thorax under the carapace bear a pair of prehensile limbs with chelæ or claws, two pairs of ambulatory or walking legs with smaller claws and two pairs of legs ending in simple pointed extremities. These, together with the swimmerets and telson, constitute twenty pairs of appendages. Most localities have several species, difficult of identification, as they all exhibit considerable variation.

The distribution of the 79 species of *Cambarus* is limited to the Atlantic water shed and of the 7 species of *Astacus* to the Pacific water shed. The species most abundant from New York to Alabama and south to Virginia are *Cambarus blandinii*, Fig. 73, *C. propinquus* and *C. affinis*; but the greatest number of forms occur in the southern and central portion of the United States. Crayfishes hide under stones or in holes excavated in the banks, where

they sit with the head toward the opening and the claws ready to grasp any smaller creature or dead animal matter. They should not be introduced into the aquarium with fishes but kept by themselves and when acclimatized can be fed on small particles of meat or the flesh of mussels or oysters.

ROTIFERA. The Trochelminths, of which the wheel-animalcules form one group, consist of *Rotifera* and *Gastrotricha*, generally fresh water forms, and *Dinophilea* of salt and blackish waters. About 25 species of Rotifera occur abundantly in the United States in almost all bodies of freshwater. They are of small size inclosed in a cuticle to form a stiff shell. At the anterior end are cilia by which the animal swims and brings food to the mouth, and at the posterior end is a small separate joint, the foot, to which two bristle-like structures are attached. The internal organs comprise an alimentary canal, and nervous, reproductive and excretory systems and mucus glands. They have dorsal antennæ back of the anterior end of the head. Reproduction is by eggs which are developed under the carapace. The genera most generally distributed in the United States are *Branchionus rubens*, *Diurella tigris*, *D. tenuior*; *D. weberi*, *D. porcellus*, *Rattulus gracilis*, *R. longiseta*, *R. bicristatus*, *R. carinatus* and *R. rattus*. Fig. 74. In the author's vicinity Dr. Joseph Leidy also identified *Acyclus inquietus*, *Apsilus lentiformis*, *Limnias socialis* and a very considerable number of less common forms. Some of the parasitic forms on fishes resemble the free-swimming larvæ of Annelids and Crustaceans.

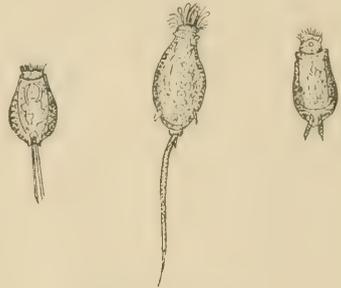


FIG. 74. Rotifera,
1. *Branchionus rubens*.
2. *Rattulus longiseta*.
3. *Diurella tigris*.

GASTROTRICHA. This small group of minute freshwater Trochelminths have spindle-shaped bodies with two longitudinal bands of cilia or swimming hairs on the ventral surface and the mouth surrounded with a circlet of hooked hair-like appendages. *Chaetonotus maximus* is the most common form. They are harmless to fishes and spawn.

COLLECTING NATURAL FOOD. For the collection of the minute water fauna a mull net attached to a pole and a covered tin pail are usually employed. During the breeding and rearing season of the goldfish almost any ditch, pool or pond contains them in greater or lesser quantity; but the keeping of a supply is difficult as they may soon die and rapidly decompose, making frequent excursions to the pond necessary. To avoid this, breeders prepare a breeding tank in a shaded locality and a collection of what might be called pure cultures for propagation are made with a pipette or lifting tube, which closed at the upper end may be placed in the water

between the plants and more clean catches made than with the mull net. The tank should be prepared with a layer of garden soil mixed with a little liquid manure covered with pond mud, on this a thin layer of dead leaves, and then filled with water to reproduce pond conditions. Some algæ, voucheria, wolffia and other small aquatic plants will be introduced with the pond mud; and, after stocking, in a short time colonies of shell insects, flea lobsters, water multipedes, infusoria, algæ etc. will develop which should be occasionally replenished by catches in the ponds.

In a small way a candy or battery jar containing a little pond soil and rooted plants, preferably anacharis, will serve; but with ponds or ditches nearby, the mull net will usually be all that is required. Care should be exercised to prevent introducing predaceous insects and their larvæ, parasites or other enemies together with this food.

PRESERVING NATURAL FOODS. It is the practice of breeders to collect the entomostraca in quantities when they are plentiful and preserve them in a dried state for periods of scarcity. This is done by dipping them from the ponds with the net and filling cans with them in almost drained condition, adding table salt to prevent their rapid decomposition. They are then parboiled, strained and evaporated to dryness at low temperature or by spreading in the sun in hot weather. This food contains all the essentials of the pond animalculæ, and will keep almost indefinitely, further eliminating all danger of introducing enemies into the rearing tanks. In its dried state it is used in the best prepared fish foods.

PROPAGATING NATURAL FOOD. The artificial propagation of natural food has received considerable attention from the culturists of food fishes. These consist of the minute fresh water fauna together with the larvæ of mosquitoes, gnats, mayflies, dayflies, smaller bugs and beetles. Ditches in the vicinity of the fish propagating basins, for the cultivation of natural food, are prepared with a layer of cow manure in which water plants, including potamogeton, anacharis, cress and confervæ are grown, and partly filled with brushwood, bricks, stones, etc.; in which the animalculæ may secrete themselves; and from which they are let into the ponds with the water supply.

FEEDING IN THE AQUARIUM. To assure success with the aquarium, it must not only be in natural balance but the food should be either the natural small pond life, or simulate that of nature, and prepared to furnish to the living inmates the proper constituents in correct chemical proportion and easily digestible form. Natural live food should be fed when it can be procured, and which may consist not only of the tiny water entomostraca, but of the larvæ and pupæ of mosquitoes, fly maggots, particles

of worms and other living creatures; but when this cannot be procured or its condition is such that it may be unclean, or that parasites or disease fungi might be introduced with it; then surrogates in the form of prepared foods should be fed. One of the first requirements in feeding artificial food is frequent change of diet and care taken that only such quantities are fed which will be at once consumed, and not a particle left over 15 minutes after feeding.

Substitutes for the natural live food are prepared of the following animal and vegetable substances:—Scalded and dried earthworms; lean raw or dried meat and liver; fish roe and flesh; ant-eggs; raw and boiled eggs; milk curds; dried daphnia; dried prawns (fresh or saltwater shrimp) or lobster; rice wafers, rice flour, pea flour, fine corn meal, dry or boiled oat meal, vermicelli, egg noodles, water crackers, dog biscuit and other hard biscuit. For very young fishes the best substitute foods are rice flour sprinkled on the surface of the water, and oat meal broth. Blood has also been tried but has been found to be objectionable, except for pond feeding.

RAW MEAT FOOD. Any kind of lean meat may be finely scraped, slightly rinsed in cold water and carefully fed to the fishes.

EARTHWORM FOOD. The worms should be kept a few days in moist moss, to clean themselves, then immersed a few minutes in scalding water, quickly rinsed with cold water, finely chopped, and either immediately carefully fed or dried for future use.

DRIED LIVER FOOD. Liver is boiled and either dried in a low heat and scraped from the piece when perfectly dry; or finely minced and dried. Care must be exercised in its feeding.

FISH ROE AND FLESH FOODS. The roe of the sea-bass, smelt and shad is an excellent fish food. It should be freed from the membrane, parboiled, dried at low temperature, and fed either in this form or rubbed into and fed with boiled oat meal. Finely desiccated boiled fish flesh, prepared in similar manner, is also used.

ANT EGG FOOD. The pupæ of ants, known as ant eggs, may be obtained of dealers, and if crushed and mixed with oat meal or with boiled corn meal, salt, and the yolks of hard-boiled eggs, make a most nutritious and readily digestible food. They may also be fed in the dry state.

EGG FOOD. The yolk of boiled eggs, mixed with any of the farinaceous foods, preferably oat meal, is an often used food. Also granulated water crackers into which beaten raw eggs are mixed and thoroughly dried, make a good food.

MIXED FOODS. Milk curds, corn meal, boiled rice flour and eggs, with their finely crushed shells, together with hard biscuit or water-crackers, make a nutritious food. It should be perfectly dry, and crumbled when fed.

STARCHY FOODS. Of the farinaceous foods, vermicelli, egg noodles, and the breakfast cereals are all to be recommended and when varied with those containing animal substances, all sparingly fed, will not only nourish the fishes but produce growth and vigor, and furnish the necessary variety of diet.

Many combinations may be prepared from the foregoing list; the best being those which contain animal, crustaceous and starchy ingredients, together with some digestible form of lime, preferably, the cuttle-fish bone used in bird cages, or finely powdered egg-shells, table and epsom or glauber salts; which, in combination, will furnish all the chemical constituents necessary to the health, growth and full development of animal life, together with a mild laxative necessary to animals in confinement and deprived of the laxative salts abundant in the natural environment. Some successful fish culturists supply the salts and lime to the aquarium water by adding an occasional pinch of a powder composed of $\frac{1}{3}$ table salt, $\frac{1}{3}$ epsom salt and $\frac{1}{3}$ plaster of paris.

A considerably used German goldfish food consists of these ingredients: 5 ounces of pea flour; 4 ounces of rice flour; 2 ounces of dried and powdered fish flesh, (herring); $\frac{1}{2}$ ounce of finely desiccated dried meat fibre, (beef heart); $1\frac{1}{2}$ ounces of ant-eggs (pupæ); 1 ounce of dried powdered prawn, (shrimp) or lobster; 2 ounces of dried daphnia; two raw eggs, together with the powdered shells; $\frac{1}{4}$ ounce of table salt; $\frac{1}{8}$ ounce of epsom salt and sufficient gum arabic in boiling water to bind the mass; thoroughly kneaded into a thick dough, dried at low temperature, and crushed into convenient small particles. This makes about a pound of dried food. In feeding, the granules are steeped in lukewarm water and immediately fed; or they may be forced through a colinder, or other device to produce a vermicelli form. In the opinion of the author this food has rather an excess of animal substances.

It must always be kept in mind that a variety of food is beneficial, fed only in sufficient quantity to satisfy the hunger of the fishes, and none left over after the meal to cause contaminations in the water, or to form a culture medium for the ever-present spores of Saprolegnia, the fungus which produces the most general external disease of fishes, or breeding places for other external and internal parasites.

When Daphnia can be obtained they should be fed to the exclusion of any other form of live or artificial food, not only to the goldfish but to almost all the other freshwater fishes that can be kept in the aquarium. By their use the most vigorous growth will be obtained and the least trouble had with the aquarium and its contents. This is the unanimous opinion of expert aquarists.

CHAPTER VII.

**Ailments and Diseases of the Goldfish
and Other Freshwater Fishes**

AILMENTS AND DISEASES OF THE GOLDFISH AND OTHER FRESHWATER FISHES, AND THEIR REMEDIES

As already stated, the appearance and conduct of the goldfish and other fishes are the surest indications of health or illness. A bright color, clean appearance, expanded fins, lively disposition, good appetite and active digestion are indicative of good health; while a dull color, coated or inflamed body and fins, a congested appearance, drooping or fraying fins and tail, apathy, loss of appetite, and disturbances of the digestive system indicated by the unusual appearance of the excrement, are equally certain indications of illness.

The goldfish is not only subject to the usual ailments of fishes but to others incidental to the unnatural conditions under which it is propagated, marketed and kept in captivity. Many of the diseases are the result of unsanitary conditions due to inexperience, neglect or overkindness; others are due to infection and the presence of external and internal parasites. These diseases may affect the surface and the fins, the respiratory organs, the digestive, pulmonary and muscular systems, and the swimming bladder. This important subject will be treated of at large, as investigations of the diseases of goldfishes and their remedies have not had the careful attention which has been devoted to other domesticated animals, and on account of the meagre data it is difficult to classify them other than on general lines.

At all stages of their existence fishes are subject to a variety of diseases. The spawn is attacked by a white fungoid growth which covers the exterior with a mat of fine hair like filaments, first visible on unfertile eggs but which spreads to others with which it comes in contact. A similar fungus attacks the umbilical sac of the alevin. Numerous other diseases also afflict the fry, while the organic and parasitic diseases of goldfishes may be classed as systemic, surface, gill, fin, fungus and parasite, the origin of which may be traced either to simple or to more complex and obscure causes; all more or less fatal to these beautiful household pets of which fine specimens are probably more difficult to rear than any other domesticated animal.

DETECTION OF ILLNESS. In good health, the goldfish swims with a slow and regular motion, with the dorsal fin erect and the pectorals moving easily and regularly. When startled it darts to the bottom by a vigorous stroke of all the fins. When ill or out of condition, the movements are languid or the fish will remain motionless near the top or on the bottom of the aquarium, the dorsal fin folded on the back and the movement of the pectorals listless, as though the fish were unwilling to make exertion.

When startled it will slowly sink to the bottom, soon to return to its former position, or when on the bottom will seek to secrete itself.

This appearance is sometimes due to improper water conditions, which may be easily remedied. But when the body becomes coated and the fins pointed, then frayed, ragged, congested or inflamed, as these are certain indications of advanced illness, it behooves the fancier to investigate the cause or to consult an experienced breeder. Let it be stated, however, that it is not well to accept of promiscuous advice.

TREATMENT OF DISEASES. In treating the diseases of goldfishes the natural self-remedies of freshwater fishes should be applied under similar conditions as far as practicable. In a state of nature the fishes seek brackish or salt water, saline deposits or salty earths for some of their illnesses; or darkness, light, deep or shallow water, abstinence from food, natural purgatives and rest for others. These conditions should be imitated by the aquarist when his pets become afflicted with such ailments that in his judgment would be benefited by their application. In addition the remedies hereafter mentioned should be tried.

SANITARIUM AND HOSPITAL. Where many fishes are kept, it is advisable to have an aquarium or battery jar in reserve in which a luxuriant plant growth has been developed, to serve as a sanitarium in which fishes of doubtful appearance may be isolated and quarantined, to prevent the spread of diseases, and which would also serve as a "snail farm" as young snails are one of the best articles of diet for sick fishes. In such sanitarium the plants should be grown in pots or dishes that they may be removed without disturbance when it is necessary to thoroughly clean both the jar and the plants. It may be well to here mention that a $\frac{1}{2000}$ solution of bichloride of mercury can be used for cleaning purposes, but plants and receptacle must afterwards be thoroughly washed with clean water.

As a hospital a well seasoned tank, if possible one having an active growth of algæ on its sides, is best. It should contain considerable well developed plant life and the water should have a bright green color, indicating an active growth of the smaller algæ. The plants should be rooted in clean soil in pots with a slight covering of grit, because earth and mud are beneficial to sick fishes. The tank should have a large surface area as compared with its depth; the latter not to exceed 12 inches. In the summer, it should be partially protected from the sun, but in winter it should get the full sunlight, and should be kept at a temperature of 60° to 70° F. One end may be covered with a board when fishes are introduced, for rest and shade.

All vessels for fishes having contagious and parasitic diseases should be of glass, so that they may be thoroughly cleansed. A sick fish does

not require a large receptacle, but it should be of large diameter in proportion to its depth, or else the depth of water so regulated. The sides should be screened or curtained when necessary to permit of rest for the patient.

Breeders, dealers and others having a large number of fishes, should have a hospital for fishes "out of condition"; but which is not used for those in the active stages of contagious and parasitic diseases though it may be used later for such patients when the danger of contagion has passed and they are convalescing. From this receptacle they may later be transferred to the sanitarium and only returned to the aquarium when fully recovered.

At all times when a fish gives indications of being out of condition, it is best to remove it from its companions for the following reasons; first, it prevents the well and stronger fishes from annoying it, second, while the illness may be only slight, it may also be a contagious affection; third, it gives opportunity for the required treatment or for experimentation with the view of a cure, which could not otherwise be undertaken. A sick fish should have nourishing food offered to it, for if it will eat the chances of recovery are greatly increased.

REMEDIES. Beneficial remedies for the ills of fishes are but few, and the medicaments of the aquarist should consist of the following:

- Common table salt and rock salt, frequently required.
- Phenol-sodique, frequently required.
- Peroxide of hydrogen, frequently required.
- Epsom and Glauber salts, as laxatives, frequently required.
- Castor oil, as a cathartic, occasionally required.
- Boracic acid solution.
- Saturated solution of Monsell's salt.
- Permanganate of potassium solution.
- Gypsum and plaster of paris.
- Coal Oil.
- Tincture of aloes and myrrh.
- Turlington's Balsam.
- Antigyrodactylin.
- Bichloride of mercury, as an anticeptic and parasiticide.
- Salicylate of soda, " " " " "
- Chlorate of potassium, " " " " "
- Formalin, " " " " "

NOTE: A few drops of Monsell's salt, less than 10 to the gallon, will clear turbid water, due to the decomposition of chlorophyll, and 15 to 20 drops to the gallon will destroy many of the lower organisms. It is also fatal to the snails, which should be removed before it is used. A few drops of a weak solution of permanganate of potassium in the aquarium will remove the green color, when objectionable.

FUNGUS ON SPAWN. The spawn of fishes is attacked by a fungus which manifests itself by short hairlike growths on the surface. Fig. 75. It is usually one of the species of the Saprolegniaceæ, *Saprolegnia ferax* or *Dictyuchus polysporus*, the spores of which are present in all natural waters, and are more fully described hereafter.

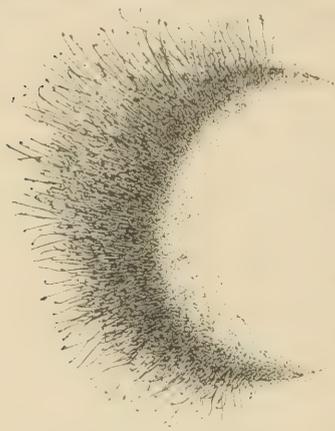


Fig. 75. Fungus on Spawn.
Saprolegnia ferax.
Greatly enlarged.

TREATMENT. There is little to be done for this diseased condition other than to pick out the affected eggs with tweezers. Even then more fertile eggs may be injured than would be saved. Under good conditions only the unfertile opaque eggs are attacked; and if the parents are healthy and the water conditions good, these are not likely to be present in sufficient number to warrant the removal of the affected spawn. If the fishes are weak or over-

spawned, at times nearly all the eggs are unfertile or the fry hatches weak, and on such occasions all the eggs and fry may be attacked by the fungus. When in a day or two the spawn shows a majority of affected eggs, it is best to destroy both it and the spawning plants, to prevent a further spread of the fungus and the diseased condition.

It is probably always best to take the spawn and the plants to which it adheres from the spawning bed and place them in filtered water to hatch, thus largely avoiding the danger of the presence of fungus spores and those of parasites; but a few pots of growing plants should be introduced to supply the necessary oxygen and to prevent the asphyxiation of the fry. A small dish containing clean soil should also be furnished as it contains substances necessary for nutrition and will stimulate the development of minute plant and animal life, the first food of the young fry. The presence of these low forms is manifested by the greenish color of the water. After the fry are a week old, a half pint of water of pronouncedly green color should be added every few days, and then live food should be fed.

WHITE FUNGUS. One of the most frequent diseases of the goldfish and other aquarium fishes is manifested by the appearance of a white coating on the tail and fins which spreads to the body, operculæ and into the gills of the fish, destroying the fins, covering the body with a threadlike scum and finally causing the death of the fish from exhaustion, asphyxiation and interference with the proper functions of the skin by obstruction of the surface pores and the induced inflammation. Figure 76.

The disease is most often introduced into the aquarium by newly acquired fishes that may have been shipped long distances in cans containing

such numbers that the water is not sufficiently aerated, or which have been bruised and otherwise injured, enfeebled from lack of food, or have suffered from constant excitement. Carelessness of their comfort, lack of

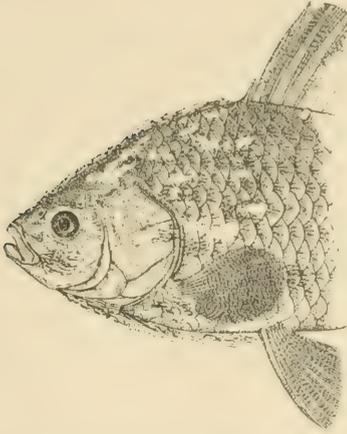


FIG. 76.—Head of a Goldfish affected with the so-called White Fungus. Usually *Saprolegnia* and *Dictyuchus*.

proper care while in the hands of dealers, unsanitary conditions, insufficient plant life, decay of the plants and food, overstocking and similar causes, will also produce the disease; as under these conditions the ever-present micro-organisms attack the weaker fishes and spread to healthy ones with which they come into contact. Another cause is sudden changes of the temperature of the water by injudiciously adding thereto, or its continued low temperature. This is a most frequent reason for outbreaks of the disease in the spring, as the above conditions often prevail during the winter and the vitality of the fishes has become low, so that they succumb to this fungus when it becomes more

active owing to the rise in temperature. A very large proportion of the mortality among aquarium fishes is due to this cause.

This White Fungus is one of the most common diseases which the amateur is likely to encounter. When neglected, it is serious in its effects and results, but if taken in time, proper care exercised and remedies applied, death losses will be reduced or prevented. Owing to the general natural or surgical contingent, in advanced stages, destruction of fin and tail development and much loss of beauty may occur, with a probability that the fish will never entirely recover its former beauty.

TREATMENT. When a fish shows fungoid tendency it should be removed from its fellows and placed in a hospital jar, containing $2\frac{1}{2}$ gallons of water, to which a teaspoonful of table salt, the same quantity of epsom salt and 10 or 12 drops of Phenol-sodique have been added. The jar should also contain a partially opened inverted earthen flower pot, or similar vessel, in which the fish may hide and rest. It should be kept out of the sun, at a temperature of about 65° to 70° F. During two days the fish should not be fed, as the disorder may be the result of overfeeding; but, if at the end of this period there is no improvement, it should be taken out and all the fungus spots painted with coal oil, the fish being then placed for a short period in another receptacle to allow the excess of oil to float off, when it may be returned to the jar. Penciling with or dipping into a 50 per cent. solution of peroxide of hydrogen is also an approved remedy.

If the fungus has extended and the fins and tail become ragged, it is necessary to cut off the affected parts, painting the cut edges with Phenol-sodique, tincture of aloes and myrrh or with the peroxide of hydrogen solution. If the spots are extensive on the body they should be cleansed with a table salt or peroxide solution and also painted with the tincture of aloes and myrrh. Immediate attention is necessary as soon as the disease is detected, then a cure is almost always possible.

If the fish improves, the white appearance disappears and a dark edge shows on the fins and tail. It may then be transferred to the hospital tank to acquire strength on a light mixed diet, sparingly but frequently fed, but if it becomes weaker, the fungus extending over the sides and into the gills, unless it is very valuable, it is best to destroy it, because little more can be done for its benefit. A final recourse is to place it in the greenest water procurable and leave it there. Sometimes it recovers, but it may be subject to a recurrence of the disease, or may present only a wreck of its former appearance and beauty.

A recently introduced and approved remedy is the Turlington's Balsam. It is applied as follows:—The affected parts should be dried and cleaned and the balsam applied generously with a small brush or a pledget of cotton and permitted to dry from three to five minutes. During this time the head and gills of the fish should be wrapped in a wet cloth to keep the gills moist and to prevent movement. If this is properly done no fear of endangering the life of the fish need be entertained. The Balsam coats the affected edges with an insoluble surface and protects them from the further ravages of the fungus. Also apply the parasiticides mentioned hereafter. Prompt measures have saved many valuable aquarium fishes.



FIG. 77. Head of a Goldfish affected with the so-called Black Fungus. Usually *Gyrodactylus* and *Myxidium*.

BLACK FUNGUS. This serious evil attacks the goldfish in a similar manner to the White Fungus, but is only conveyed by contagion and does not so much depend upon the water and other conditions. It is manifested on the body and fins. These first assume a mottled dark grey appearance in spots and streaks; later they become black and form a thick layer which scales off, leaving raw spots and ulcers on the body and destroy the fins and tail. The indirect causes are the same as those which induce the White

Fungus, but the direct causes are animal parasites usually *Gyrodactylidae* or *Myxidae*, Figs. 77 and 78, of the order Protozoa, the most general of the fish parasites, and others, all more fully described hereafter.

TREATMENT. If these parasites get into the gills, the best and only thing to do is to destroy the fish, to prevent further infection, thoroughly clean the aquarium or tank with antiseptics and burn the plants and the fish. If, however, only the fins and part of the body are affected, it is well, if the fish is of value, to attempt a cure. These being animal parasites and usually deeply seated in the tissues, severe treatment is required, which is often as nearly fatal as the disease itself. The parasiticides should be first tried, which sometimes effect a cure, but if not of benefit, the fins and tail should be cut off some distance beyond the affected parts, the spots on the body scraped, all the affected parts painted with a solution of Monsell's salts, and the fish



FIG. 78. Trematod parasites taken from imported Japanese and Chinese Goldfishes affected with Black Fungus. Greatly enlarged.

kept in a jar containing salt water to which 10 or 12 drops of Phenol-sodique per gallon have been added, and the affected parts also penciled with a 50 per cent. solution of peroxide of hydrogen. If the fish survives a day or two, then the affected parts should be daily painted with coal oil after cleaning with salt water, or with peroxide of hydrogen, always placing the fish into a receptacle for a few minutes before returning it to the jar. Turlington's Balsam will be greatly beneficial should the fish survive to the healing stage. Nourishing food of animal origin should be generously fed, such as the yolk of a boiled egg, ant larvæ, earthworms, etc. Everything with which the fish has come in contact should be cleaned and sterilized and its companions quarantined in water containing salt to the amount of imparting a brackish taste. Upon the microscope slide the parasites which produce the disease are killed by salt, but this remedy does not always reach and destroy them when they have burrowed into the tissues, under the scales and skin, and in the gills of the fish. The same trials of remedies as for White Fungus should also be made. Also apply the parasiticides hereafter mentioned. Cures are frequent if prompt attention is given. Severe attacks seldom occur in well-established aquaria.

TWITTERS OR ITCH. This quite common affection of the goldfish is produced by minute Infusoria, *Ichthyophthirius* and *Chromatophagus*, the leech-like *Trichodina*, and other fish parasites, which develop under unsanitary conditions or are principally troublesome in the presence of decomposing food and decaying vegetation. They are frequently introduced into established aquaria by newly received fishes, on plants or with the water.

The affected fishes become restless, endeavoring to alleviate the irritation and dislodge the parasites by rubbing against objects in the water or on the bottom. A close observation in severe cases will reveal the presence of cysts in the skin of the fish or a white scum on its surface, and sometimes a congested appearance, due to the presence of parasites.

TREATMENT. Cure is usually effected by immersion in a strong salt solution until the fish shows signs of exhaustion, or by rubbing it gently with a saturated salt solution on a pledget of cotton, followed by similar treatment with slightly diluted Phenol-sodique; or a weak solution of permanganate of potassium diluted until it is of the color of claret; but a better method is to place the fish in a weak salt solution for several days, as this is less likely to injure the mucus covering of the surface and the parasites yield as well to this mild brackish water treatment. Change of water, more scavengers, especially tadpoles, which often eat the parasites off the sides of the fishes, greater care in feeding, siphoning out the humus in the aquarium and other simple sanitary regulations will obviate this evil.

AUTOTOXINE. Fright, constant fatigue, lack of rest, too strong light and other abnormal conditions often produce in the aquarium fish a jaded and exhausted condition, loss of vitality, surface irritation and interference with the respiratory and digestive systems which render it liable to diseases to which it would be immune under normal conditions. One of these is known to the breeder as Autotoxine or self-poisoning. It affects the scales and gills and causes the formation of a scum or slime, similar in appearance to White fungus, which weakens the fish, disturbs its normal functions and causes a partial suffocation under which it soon succumbs.

This is a complaint of mature fishes, but also frequently affects younger ones during the winter months. When the latter is the case it is advisable to add rock salt to the water in which the fishes are kept at intervals of twice or thrice a week, but never to the extent of imparting a salty taste, because such excess would be injurious not only to the fishes but also to the plants, interfering with their functions as liberators of oxygen.

TREATMENT. Mature fishes so affected should be rested in a screened aquarium or placed in a jar containing a teaspoonful of epsom salt to the gallon and kept in a darkened place for several days without food. Later the food should be frequently changed to give a variety, feeding lightly and adding a tablespoonful of salt to each 5 gallons of water in the container. Usually more plant life is also required, more especially those which are the best oxygenators; the main remedy being healthful surroundings, complete rest, exclusion of excessive light, and careful feeding.

CONSTIPATION. In the aquarium or tank goldfishes often suffer from the confinement, lack of proper exercise, restlessness, the results of their

unnatural surroundings and the too concentrated forms of food, which bring about disorders of the digestive organs causing constipation. This may be detected by the appearance of the excrement, which in good health and with natural food is of a uniform brown or black color. In confinement the excrement is largely influenced by the nature of the food; but it should be of uniform color and usually pendant for quite a considerable length. When its appearance is other than usual the fish may be either overfed or constipated. The latter is usually the case when the excrement is of varying color, white, brown and black in sections or otherwise abnormal. In overfeeding the excrement is always white.

TREATMENT. A laxative is occasionally necessary, for which purpose table salt, epsom and glauber salts and earthworms are to be recommended. Many of the prepared foods contain these salts, but a little added to the water from time to time is beneficial; the fishes take it greedily, as they have the same craving for saline substances as other animals. Epsom salt is a mild laxative and will prevent constipation and the concomitant evils produced thereby. A fair-sized pinch should be dropped into the water every week or fortnight, alternating with table or rock salt, to insure a proper and healthy digestion. Aquarium water is also often deficient in mineral salts from absorption by the plant life and the salts so added are beneficial correctives. If a fish is excessively constipated, as may happen, a drop of castor oil placed well down the throat is generally effective, and at all times is harmless to the fish. A second dose may have to be given. Fresh earthworms are also an efficient laxative for aquarium fishes. What may appear to be inflammation of the swimming bladder may only be constipation, for which reason it is always well to apply these remedies in doubtful cases.

FIN CONGESTION. The fins of goldfishes, especially the tail, often become red and congested, which is manifested by inflamed and bloody streaks, lines or spots which cannot be mistaken for the arteries and capillaries. This may be produced by constant excitement, impure water, insufficient aeration, overfeeding, partial suffocation, bladder trouble, the dragging of the tail over the bottom, or from other not readily recognized causes.

TREATMENT. A successful remedy is to place the fish in water in which sufficient table salt has been dissolved to give to it a brackish taste, feeding sparingly or not at all for a few days, together with isolation in a subdued light and complete rest. Some fanciers treat the fish by frequently dipping the affected parts in a strong salt solution, though this should be done with discretion as it may have the effect of further irritating the already congested membranes. The author does not recommend these harsher methods and gives them only because they are often resorted to. Laxa-

rives, however, are always beneficial and should be given in repeated small doses, a cathartic of castor oil being preferable. Frequently dipping the body and fins into dilute peroxide of hydrogen has proven to be an effective remedy. Better aeration alone may effect a cure.

TAILROT. This affection, which seems to be a sequel of a generally congested condition, usually starts at the ends of the tail and fins. These first assume a serrated and then a shredded appearance, the disease causing

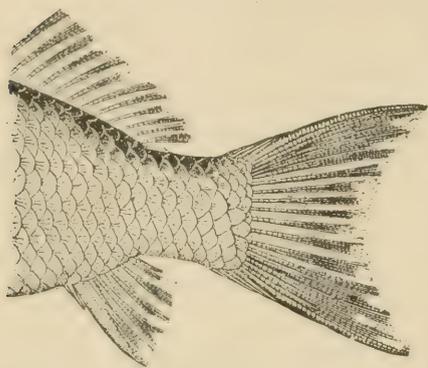


FIG. 79. Fins of a Goldfish affected with Tail-rot; early stage.

a decay and separation of the connective tissue and the rays, so that they assume a bristlelike appearance. Fig. 79. When it reaches the base of the tail and the spinal column it is usually fatal; but prompt treatment will in most cases arrest the ravages of the disease and effect a cure.

TREATMENT. The treatment for White fungus and Fin congestion should be first tried, and if found to be ineffective, the affected tail and fins should be cut off beyond the diseased parts and the fish subjected to a salt bath to prevent a further spread. A laxative of epsom salt and a drop of castor oil as a cathartic are usually called for; and treatment by dipping the affected parts into a solution of a tablespoonful of Phenol-sodique in a gill of water, or a 50 per cent. solution of peroxide of hydrogen; or into water in which bichloride of mercury has been dissolved in the proportion of one tablet to the pint, have been recommended and tried with success, but great care must be taken in using this latter remedy that it does not get on the gills. Good results have also been produced by applications of Turlington's Balsam as before suggested for Fungus, and of the Tincture of aloes and myrrh. Caustic mineral acids, especially nitric acid have been used by experts with success. To cauterize the affected parts; applications should be made with a skewer of soft wood dipped into the acid. This remedy should be resorted to only when the others have failed to effect a cure.

GILL CONGESTION. This disease, also known as Asphyxia and "Sore throat," occurs with fishes which have been subjected to sudden changes of temperature of the water or to other exposures that may cause inflammation or congestion of the gills, such as removal from the house aquarium to an out-of-door existence, undue exposure, improper water conditions or similar causes that disarrange the respiratory organs, affect the functions of the gills and debilitate the fish. Loss of appetite, emaciation and

enervation will result and then immediate remedies are necessary or the fish will succumb.

A congestion spreads over the gill membranes and into the throat, which become highly inflamed and assume a grey or whitish appearance; they no longer perform their proper functions and finally become mortified. Animal parasites also find lodgment in the diseased gills and unless treatment is at once undertaken the fish dies of exhaustion.

This condition rarely occurs with strong fishes, but is quite common with highly bred Chinese and Japanese goldfishes which have large fin and tail development and extreme delicacy of constitution. At times a condition somewhat like Consumption in the human race produces similar symptoms to the above and can only be differentiated by careful examination of the gills; but as the same treatment applies to both, the distinction is not pertinent.

TREATMENT. Rest under the most favorable conditions, stimulation by nourishing food and treatment of the gills are advisable. The fish should be placed in a receptacle having abundant plant life, shielded from strong light and an equable temperature maintained. If the disease is advanced, the gills should be treated with an injection of salt water at repeated intervals and the fish placed in shallow water in a large dish so that the action of the fins keeps it in agitation and causes the absorption of as much air as possible, or the water should have frequent aeration with a fountain syringe. The relief from the water pressure, thus afforded, is also beneficial. Placing the fish in a receptacle under constantly dripping water has preserved the life of many fine specimens that otherwise would have succumbed to diseases. Care must be taken that the water is of the same temperature as that of the aquarium, and is best at about 60° F.

When gill parasites have made considerable ravages no remedy or means for their eradication have as yet been found, and the death of the fish is certain, but the usual gill and throat congestion can be cured by immediate attention.

Young fishes are particularly liable to gill and throat parasites, the most usual of which are *Gyrodactylus* and *Echinorhynchus*. These may occur epidemically, often at intervals of several years, and have at times destroyed nearly all the fishes of an entire season's hatchings. They sometimes infest the gills in such numbers as to cause the operculæ to stand from the sides of the head, induce inflammation of the gills and ultimately cause the suffocation of the fry. For this condition there is no remedy and thorough cleaning, destruction of fry, plants, etc., by burning is necessary to prevent further infection.

CONSUMPTION. What is generally known as Consumption in the gold-

fish may be due to widely different causes. It consists of a gradual emaciation whereby the entire appearance of the fish is changed. The body becomes shrunken and lean, most noticeable at the junction of the head and the spinal column. The sides are depressed, particularly along the back, and the abdomen is shrunken. The operculæ are sometimes protruding, giving to the head an abnormally large appearance, and at other times the edges are depressed, as though folded in on the gills. The fish has a general appearance of feebleness, lethargy and listlessness, frequently accompanied by an abstinence from food.

TREATMENT. For this illness there is no certain remedy, though its progress may often be arrested by removal to a separate aquarium or to tanks out-of-doors under the most favorable conditions, together with trials of a stimulating diet of animal substances, earthworms, raw beef, ant eggs and fish-roe, the later prepared by first parboiling in salt water and then drying in a moderate heat. Great care must be exercised in feeding these animal foods that all is immediately consumed or later removed. It should be noted that extreme care may keep the fish alive and in fair condition, if it will eat, yet the slightest change or exposure will rapidly cause fatal results. When the condition is permanent, such fishes should not be used as breeders, not only because the majority of the spawn is usually unfertile but also for the reason that the hatchings produced are feeble, few of the fry reaching maturity and these generally with a similar tendency. Therefore, unless the fish is valuable it is not worth the trouble of keeping it in condition and it would better be destroyed.

EYE INFLAMMATION. The protruding eyes of the Telescope goldfishes especially those of the males during the breeding season, are frequently injured and serious inflammations may occur. When so affected the eye seems to protrude farther from the orbit and the cornea becomes opaque or of a milky color. This condition sometimes goes no farther and the eye gradually becomes normal in a month or more; but the inflammation may continue to such an extent that ulcers form and either entirely destroy the cornea or leave a blinded fish. If both eyes are affected, the fish is temporarily blinded and may suffer through inability to find food.

TREATMENT. However treated there is always danger of permanent injury, but probably the best results are obtained by washing the eye with a pledget of cotton dipped in a saturated solution of boracic acid once a day until beneficial results are produced. The fish should be isolated and food placed so that it may find it by touch, and, in extreme cases it may be fed by hand. In severe cases it takes nearly three months for complete recovery, but the above treatment is almost invariably successful in about one month, if the fish is in vigorous condition, and treatment undertaken at once.

SWIMMING BLADDER TROUBLE. The confinement incident to existence in the aquarium, together with water impurities and insufficient aeration cause affections of the swimming bladder of the goldfish; but it is more likely that such diseases are congenital and due to malformations of the bladder, as they occur most frequently in highly bred, very short-bodied fishes. The disease is not always noticeable in its incipiency but develops more and more, becoming evident in the second and third months by irregular action and later by partial or entire lack of control over the movements. For example, the fishes may not be able to rise from the bottom of the aquarium, or may swim only on the surface of the water, often in reversed position; or they may only be able to swim with the tail uppermost, or altogether on their sides.

A fish may have this affliction, be strong, eat well and grow; but it is unsatisfactory in appearance and undesirable to breed from, as many of the progeny may be similarly afflicted. This ailment is most general with the Chinese varieties, and the transparently-scaled white fishes with blue eyes are most usually so affected. Diseases of the liver and spleen produce similar symptoms. Sometimes it is due only to too cold water.

TREATMENT. No cure or method of alleviation is known, though keeping the fish in water at a temperature of 60° F. and over, has been found to be beneficial; because fishes so afflicted become worse or entirely helpless in cold water. Unless the fish is valuable it is best to destroy it, in order to put it out of its apparent misery. Castor oil and other remedies for Constipation, however, should first be tried.

DROPSY. This is not a disease in itself but is a symptom secondary to an affection of the liver or the spleen. It produces a distended appearance of the fish by the presence of serum in its tissues, together with loss of the control of its movements. In advanced cases, there is a ruffled appearance of the scales, and sometimes a protrusion of the eyes and operculæ and finally complete helplessness and death.

TREATMENT. No cure, either in fishes or other animals, is known for this affection of the liver, and its resultant dropsy. If the fish is otherwise strong, has a good appetite and assimilates its food, palliative measures by surgical operation, similar to that used with mankind, (tapping), will often prolong life for years and keep the fish in apparently good condition, although the operation may have to be frequently repeated. When the abdomen is greatly distended, a small trocar, (a hypodermatic needle is excellent for this purpose), inserted on each side from below upward and outward, just under the skin, will open canals through the connective tissue, which will enable the serum to exude, thus reducing the diameter and relieving the condition. It is, of course, imperative that no organ of the body is injured. This operation has been performed five times in

two years upon a mature "blue-ribbon" Japanese Fringetail goldfish which is in good condition at the present writing, but which will soon require another puncture. If the affected fish is immature and not otherwise strong, robust and of very fine appearance, it is not worth the labor and attention and should be destroyed. Remedies for Constipation and Bladder trouble should be tried.

INJURIES. Careless handling, rough nets, bruises, loss of scales and the injurious effects incident to transportation cause injuries to the scales and skin which should have immediate attention, as they form culture surfaces for fungi and lodging places for parasites.

TREATMENT. A thorough cleansing of the injured parts with salt water, followed by diluted phenol-sodique or peroxide of hydrogen should be first applied and then the abraded spots treated with a coating of Turlington's Balsam, to keep the water from coming into contact with the wound. This is almost always an effective remedy.

HANDLING DISEASED FISHES. Fishes may be handled out of the water by keeping the head enveloped in a wet cloth to keep the gills moist. Several minutes out of their element will not be injurious when this method is employed.

The cleanest cut in operations on fins and tail can be made by spreading them on a smooth board and making a straight pressing cut with a knife. Scissors produce uncertain results.

A microscope examination of scrapings from the diseased parts is advisable. It nearly always reveals the cause of illness and prompts in the use of proper remedies.

It is a wise precaution to employ a separate net and all other appliances in the handling of sick fishes, as there is constant danger of spreading the contagion. These should be sterilized by boiling water or with antiseptics.

The best mild disinfectants for aquaria are Monsell's salt solution and permanganate of potassium; while for radical disinfection bichloride of mercury, chlorate of potassium or formalin are most certain of result. Bichloride of mercury is to be used in the proportion of one tablet to the gallon of water and formalin in a 4 to 6 per cent. solution, both in water. Care must be taken to remove all traces of these antiseptics.

LARGER ENEMIES OF THE GOLDFISH. These are limited by the conditions and surroundings in which the fishes are kept; but all predatory animals are active enemies when they can obtain access to the young and mature fishes. These may be the common rat, cat, mink, muskrat, mole, starnosed mole, kingfisher, sandpiper, great horned owl, heron, crane, crayfish, frog, water snake, larger fishes, and all the predaceous aquatic insects. Most of these can be excluded by wire netting covers over the tanks.

CONCLUSION. There can be no question that the finely bred Goldfishes are more liable to illnesses than the ordinary breed. They are all constitutionally weak and naturally subject to disturbances of digestion, ailments of the swimming bladder, dropsical tendencies, and physical exhaustion; the latter due to atrophy of the muscles from disuse and from having gone largely into the formation of the abnormally long and duplicated fins, the very effort to wield which is exhausting and compels the fishes to swim as much by movements of the body as of the long unwieldy fins and tails. When affected by diseases these fishes are devoid of much repellent, recuperative or sustaining power, as they are coddled, weakly, unnatural monstrosities in whom life is kept by the constant attention of the fancier. It will be noticed that it is the most highly prized fishes which are most prone to illness and which soonest succumb, so that the losses to the breeder are principally these and not the "sports" or partial reverts. But on account of their value and the constant demand, the toy varieties receive the principal attention of the skilled breeders, to which must be added the fascinating uncertainty as to the result of a season's labor, as any fish that hatches may possibly develop into a fine specimen, if it survives.

Although the foregoing investigations of fish diseases were conducted by the author and his expert friends with aquarium fishes, the diseases and remedies also apply to food fishes, and the methods of treatment suggested can be used for them as well, if modified to suit existing conditions. The tenacity of life of the common goldfish is such that it is generally employed for ichthiologial research pertaining to diseases and their treatment.

PARASITES AND PARASITIC DISEASES

The diseases of fishes are both parasitic and non-parasitic. Of the former, the parasites may be either animal or vegetal; which, according to the parts infested, are classed as Ecto- or surface and Ento- or internal parasites. It is proposed to briefly describe the common forms and the more or less effectual treatment for their eradication.

ANIMAL PARASITES AND PARASITIC DISEASES. Nearly all classes of animals include among their inferior ranks members which are either parasites or messmates at some period of their existence. True parasites are those which live at the expense of their hosts, either establishing themselves in their organs and tissues or leaving them after a meal, like the leech and the larvæ of predatory insects; while others require this assistance at determinate periods, either in early youth, like the young of some mussels, or during the infirmities of old age, though many are internal or external lodgers all their lives. Messmates are those which share in the

meals of other animals, attaching themselves to, or only accompanying, their more vigorous hosts.

The science of Helminthology has determined that many of the parasites live at various stages of their existence in widely different animals. This particularly applies to those of fishes, which more than others are subject to parasitism, not only in the number which they harbor but also in the frequency with which this occurs. Each genus is subject to a number peculiar to itself as well as some common to all. These inhabit various parts of the body, the skin, connective tissues and muscles; the heart, liver, respiratory and digestive organs, either free or encysted. The most of them, however, exist in the intestines and alimentary canal or in the gills and on the surface. They are sometimes harmless but more often injurious, as their progeny may be so numerous as to tunnel in all directions until the whole organ or part of the tissue which they inhabit is little more than a sac of microscopic worms.

Fishes acquire internal parasites with their food, while those which affect them externally, are usually free-swimming at some stages of their existence. These belong to different groups of the lower animals, of which some of the common North American forms will be enumerated, for the further identification of which the reader is referred to the authorities mentioned in the Bibliography appended hereto.

TREMATODA OR FLUKES. The members of this group are small parasitic flatworms with unsegmented flattened or cylindrical unciliated bodies, usually having anterior mouth-openings, bifurcated intestine and without anal opening, which attach themselves to their host by the means of suckers or hooks, or both, and live upon their juices. The Trematoda are classed in three groups or sub-divisions, of which the *Heterocotylea* are for the most part ectoparasites and the *Aspidocotylea* and *Malacocotylea* for the most part endoparasites. The North American *Heterocotylea* consist of five families, the *Temnocephalidæ*; *Tristomidæ*, *Monocotylidæ*, *Polystomidæ* and *Gyrodactylidæ*; divided into 8 families and 52 genera, mostly parasitic on Vertebrates and principally in marine animals, but some species have freshwater fishes and amphibia as host, of which one genera, the *Gyrodactylidæ*, will be particularly mentioned.

GYRODACTYLIDÆ This family includes the genera *Gyrodactylus* and *Calcostoma*, the former having double or more numerous prehensile hooks, the latter a single horny structure at the margin of the caudal sucker.

GYRODACTYLUS. This parasite is found on the gills of freshwater fishes in numerous specific forms, almost each species supporting a different form, and sometimes two or more on the same gill. The most common species, *G. elegans*; Fig. 80; infests the gills of Cyprinidæ, especi-



FIG. 80. *Gyrodactylus elegans*.
A Trematod Parasite.
Greatly enlarged.

ally the carplike fishes, often in such numbers as to cause the death of both young and mature fishes, especially the very young. Other species which have freshwater fishes as hosts are *G. carassiusculus*, *G. cochlea* and *G. tenuis*. These parasites also attack the surface of fishes and amphibia and burrow into the skin under the scales, where they produce inflammations and raw surfaces which form seats for fungi and ultimately cause the death of the fishes. *Gyrodactylida* are among the most frequent parasites which affect the goldfish in the aquarium and breeding tank.

The North American *Aspidocotylea* and *Malacocotylea* consist of *Paramphistomida*, *Fasciolida*, *Schistosomida*, *Holostomida*, *Gasterostomida*, *Didymozöonida* and *Monostomida*; divided into 35 sub-families, 134 genera and 22 related genera, parasitic in Vertebrates, of which the following species are found in freshwater fishes and amphibia of the United States:—

SPECIES	HOST	PART INHABITED
<i>Distomum areolatum</i>	White Perch	in intestine
“ <i>rufociride</i>	Striped Bass	“ “
“ <i>seriale</i>	Salmon	“ kidneys
“ <i>tenuis</i>	Striped Bass	“ intestine
“ “ <i>tenuissime</i>	White Perch	“ peritoneum
“ <i>auriculatum</i>	Lake Sturgeon	“ intestine
“ <i>grandiporum</i>	Eel	“ stomach
“ <i>gracile</i>	Sunfish, Goldfish	“ liver and intestines
“ <i>laureatum</i>	Sucker	“ alimentary canal
“ <i>polymorphum</i>	Pike	“ bladder
<i>Diplostomum cuticola</i>	{ Red-eye Bass, Black Bass and Goldfish	{ intestines, liver and heart, <small>also gills and surface</small>
<i>Gasterostoma gracilesceus</i>	Carp and other Cyprinidæ	“ intestines
<i>Octoplectanum affine</i>	Sun Fish	“ gills
<i>Stephanochasmus tenuis</i>	Striped Bass, White Perch	“ intestine
<i>Tristoma elongatus</i>	Sturgeon	“ gills
<i>Monostomum spatulatum</i>	Carp { and other Fresh- water Fishes.	“ intestines and liver
“ <i>ampli</i>	Catfish	“ bladder
<i>Cephalogonimus vesicaudus</i>	Softshell Turtle	“ intestine
<i>Distomum chelydræ</i>	Snapping Turtle	“ “
<i>Pleorchis mollis</i>	Mud Turtle	“ lungs
<i>Telorchis angustus</i>	Painted Turtle	“ intestine
<i>Amphistoma subclavatum</i>	Frog and Tadpole	“ “
<i>Brandesia arcana</i>	“	“ phyloris
<i>Distomum quietus</i>	“	“ intestine
<i>Gorgodero cygnoides</i>	“	“ bladder
“ <i>amplicara</i>	“	“ “
“ <i>simplex</i>	“	“ mouth
<i>Halipegus ovocaudalus</i>	“	“ liver
<i>Holostomum nutidus</i>	“	“ intestine
<i>Ostioleum formosum</i>	“	“ “
<i>Cymotocarpus hospitalis</i>	“ “ “	“ “
<i>Distomum quietus</i>	Salamander	“ bladder
“ <i>ascoideum</i>	Snails	“ intestines, etc.
“ <i>coronarium</i>	“ Molluscs, Alligator	“ “ “



FIG. 81 *Distomum gracile*, a Trematod parasite. Greatly enlarged.



FIG. 82 *Diplostomum cuticola*, a Trematod parasite. Greatly enlarged.



FIG. 83. *Gasterostoma gracilescens*, a Trematod parasite. Greatly enlarged.

CESTODA OR TAPEWORMS. This group comprises the Tapeworms and other cystic Entozoa which are parasitic during the greater part of their lives; with some species the eggs only are free during certain periods to change their residence. The Cestoda are taken as one group or sub-order, the *Pseudophyllidæ*, which consists of five families, the *Bothriocephalidæ*, *Tetraphyllidæ*, *Cyclophyllidæ*, *Diphyllidæ*, and *Trypanorhychæ*; divided into 16 sub-families, 72 genera and 28 related genera, parasitic on Vertebrates, of which the following species are found in freshwater fishes and amphibia of the United States:—

SPECIES	HOST	PART INHABITED
<i>Bothriocephalis proboscideus</i>	Carp and other Cyprinidæ	in phylorus and intestines
“ <i>nodosus</i>	Stickleback	“ alimentary canal
<i>Cyathocephalus truncatus</i>	Whitefish	“ phylorus
<i>Dibothrium hastatum</i>	Sturgeon	“ intestine
“ <i>cordiceps</i>	Trout	“ “
“ <i>infundibuliforme</i>	Burbot and Whitefish	“ “
<i>Dacnitus globosa</i>	Trout	“ body cavity
<i>Ligula simplicissima</i>	Carp and Tench	“ “ “
“ <i>catostomi</i>	Sucker and Chub	“ intestine, etc.
<i>Monobothrium hexacotyle</i>	Sucker	“ “
“ <i>terebrans</i>	“ and Chub	“ “
<i>Schistocephalus dimorphus</i>	Sculpin, etc.	“ abdominal cavity
“ <i>solidus</i>	Stickleback and Cyprinidæ	“ “ “ and muscular tissues
<i>Tænia sævelini</i>	Whitefish	“ intestine
“ <i>ocellata</i>	Rock Bass	“ “
“ <i>dilatata</i>	Eel	“ “
<i>Triculpidaria nodulus</i>	Bass, Perch and Pike	“ “



FIG. 84 *Bothriocephalis proboscideus*, a Cestod parasite. Twice natural size.



FIG. 85 *Ligula simplicissima*, a Cestod parasite. Natural size of immature form, the adult is parasitic in Mammals.



FIG. 86 *Schistocephalus solidus*, a Cestod parasite. Immature form, 6 to 15 mm. long, the adult is parasitic in Aquatic Birds.

Probably the most frequent forms of Cestode parasites are *Schistocephalus solidus* and allied species, which occur in many freshwater fishes in

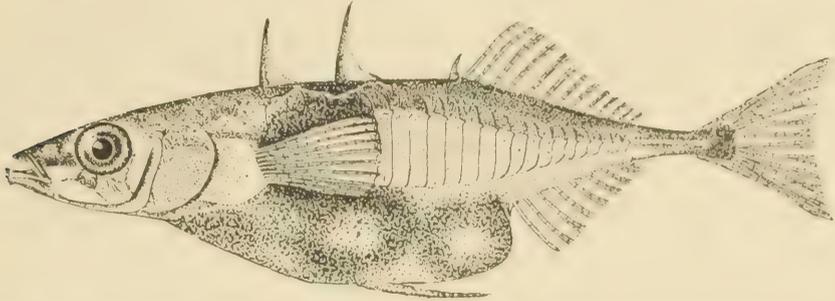


FIG. 87 Stickleback affected with *Schistocephalus solidus*; showing enlargement of side and abdomen. Slightly enlarged.

immature forms. Figs. 86, 87 and 88. As adults they have fish-feeding birds and mammals as hosts.

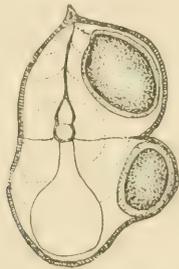


FIG. 88. Section of a Stickleback, showing cysts of *Schistocephalus solidus*. Slightly enlarged.



FIG. 89 *Ascaris acus*, a Nematod parasite. 1. Immature forms, enlarged. 2. Subsequent adult form, enlarged.

NEMATODA OR ROUNDWORMS. This group comprises the round and thread worms. They include a large number of families which occur abundantly in all genera of the Vertebrates and are more numerous and uniformly distributed than the individual members of the other parasitic orders. They have not apparently had the attention of Helminthologists that has been given to many other groups and the literature is fragmentary and widely scattered. Mention will here be made of the six principal families and the more generally distributed species.

ASCARIDÆ AND CHEIRICANTHIDÆ. These parasites inhabit higher Vertebrates, principally birds and mammals, but two Nematods, bearing close resemblance to *Ascaris teniussima*, have been found in Western trout. *Ascaris acus* in the adult form is encysted in the intestines of pike, bass and trout, Fig. 89. Its immature existence is spent in the minnow, dace and other Cyprinidæ and with them is introduced into the subsequent host.

CUCULLANIDÆ. Several species of these parasites occur in freshwater

fishes. These are *Cucullanus foveolatus* of the sunfish, and *C. elegans* of the perch and the Cyprinidæ, Fig. 90.



FIG. 90.
Cucullanus elegans,
a Nematod parasite.
Length of female 15
mm., male 8 mm.

FILARIDÆ. These parasites are more common to the marine fauna. *Filaria piscius* is found spirally coiled within the tissues of the herring, cod and whiting. A number of other species of this family occur in similar hosts and in warm-blooded animals.

GORDIIDÆ. These parasites take up a free existence in damp earth and penetrate the bodies of insects and their larvæ. Some gain access to fishes by this means, where they become encysted in the tissues.

ANGUILLULIDÆ. These minute free intestinal thread-worms usually have the higher Vertebrates as hosts, but some species are parasitic in aquatic molluscs and in insect larvæ. They are very widely distributed; the so-called Vinegar-eel, *Anguillus aceti*, belongs to this order. All the other families of this group are parasites of higher Vertebrates.

ACANTHOCEPHALA OR THORN-HEADED WORMS. This group consists of members having vermiform bodies and otherwise resemble the Nematoda, but differ in having spine-covered heads by which they attach themselves to their hosts. They are now included in the single family Echinorhynchidæ, which infests all classes of Vertebrates and are one of the more frequent parasites of fishes and amphibia. Over 100 species have been described, a considerable number in the Cyprinidæ; and of these *Echinorhynchus proteus* is the most abundant species, of which the immature form inhabits the smaller crustaceans, especially *Gammarus* and *Asellus*, to be transferred with them to freshwater fishes. Other



FIG. 91.
Echinorhynchus proteus, an Acanthocephalous parasite. Intermediate and Adult forms. Greatly enlarged.

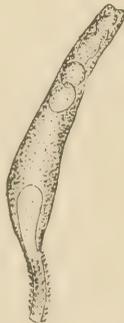


FIG. 92.
Echinorhynchus angustatus, an Acanthocephalous parasite. Length 22 to 25 mm. Enlarged.



Fig. 93.
Echinorhynchus anthuris, an Anthocephalous parasite. Greatly enlarged.

common forms are *E. angustatus*, *E. clavæceps*, *E. anthuris*, *E. globulosus*, and *E. tuberosus* in the Salmonidæ and similar fishes. Some of these and *E. clavula*, *E. fusiformis* and *E. pachysoma* frequently occur in other freshwater fishes, principally the Cyprinidæ. *E. anthuris* also occurs in the Water newt, and *E. inflexus* in the Snapping turtle. The Echinorhynchidæ cause

epidemics in fishes and in immature and adult forms have been found in such numbers in the gills of young goldfishes as to cause the death of entire hatchings. These worms grow to such size that they force the operculæ from the sides of the head and produce death from exhaustion and inability of the fishes to breathe. No preventive means or parasiticides have been devised to eradicate these destructive parasites, most of the species of which do not exceed 1 cm. in length, and many of them are much smaller.

HIRUDINIDÆ OR LEECHES. These parasites are divided into two groups, the *Rhynchobdellidæ* which pierce the tissues of their hosts by means of a fine protrusile stomodæum or proboscis, and the *Gnathobdellidæ*

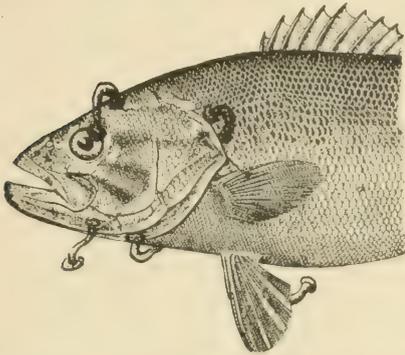


FIG. 94. *Piscicola funduli*, the Carp-leech, attached to the head of a young Small-mouthed Black Bass. Slightly enlarged.

which bite their prey by means of triangular horny jaws. They are carnivorous oblong and generally depressed contractile worms, having the mouth encircled with a lip and a flat disc at the posterior end, both adopted to adhere to other bodies and to serve as organs of locomotion. Leeches abound in both fresh and salt water and in tropical countries some forms live on the land secreted among leaves. Fishes, frogs and turtles are most frequently

attacked, but they also attach themselves to other animals which come to the water to drink. The larger blood-sucking forms are *Hirudo* and *Macrobdella*; and the true parasitic forms belong to *Ichthyobdella*, *Cystobranchus* and *Clepsine* which feed principally on fishes, and *Nephelis* and *Aulastomus* on snails and worms. The North American leeches which prey on freshwater fishes and amphibia are the species *Piscicola funduli*, known as the Carp-leech, Figs. 94 and 95, *P. punctata*, *Actinobdella inequiannulata*, *Philobdella gracile*, *Clepsine elegans*, and *C. parasitica*. Young leeches infest the gills of fishes, especially the fry, literally packing them solid, and gorge themselves with the blood, causing the death of their hosts. These epidemics sometimes occur with broods of goldfishes. The only remedy is to clean the tanks and destroy the aquatic plants. Cures of leech infested fishes have been made by the brackish water treatment and by injecting salt water into the gills.



FIG. 95. *Piscicola funduli* Enlarged 4 diameters

A very minute leech-like polyp *Trichodina pediculus*, Fig. 96, is usually parasitic on freshwater polyps but frequently changes to fishes as



FIG. 96
Trichodina pediculus
a Hirudinid parasite.
Greatly enlarged.

its host; and produces tiny red external, gill and throat ulcers into which it is pitted like a cancer. When present in numbers it is a dangerous parasite and has been found on fishes afflicted with what is popularly known as Twitters. It has a nearly circular ciliated body and on its lower side a sucktural disc.

ARACHNIA OR ARACHNID PARASITES. This group includes the Mites, Ticks, etc., of which some of the aquatic species are discussed in the appendix to the Aquatic Insects. One family, *Trachearia*, contains strictly parasitic genera, and the *Acharidæ* and *Hydrachnidæ* have parasitic and predatory members which subsist largely on the freshwater fauna. The common form is the red Water-mite, *Hydrachna geographica*, Fig. 97. With five other families of this group parasitism is but slight and on the higher Vertebrates.

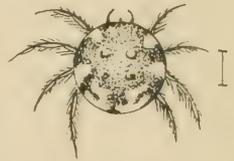


FIG. 97. *Hydrachna geographica*, an Arachnid parasite. Enlarged.

CRUSTACEA OR CRUSTACEAN PARASITES. This group includes the so-called Fish Lice, small crustaceans known as Epizoa, and belonging to the families *Lernædæ*, *Caligidæ* and *Argulidæ*.

LERNÆDÆ AND CALIGIDÆ. The members of these families rarely occur as parasites on the freshwater fauna, having those of saltwater as hosts; but some are brought into freshwater by marine fishes in their

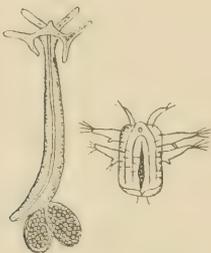


FIG. 98. *Lernæcera cyprinacea*, a Crustacean parasite. Adult and free-swimming larva. Enlarged.

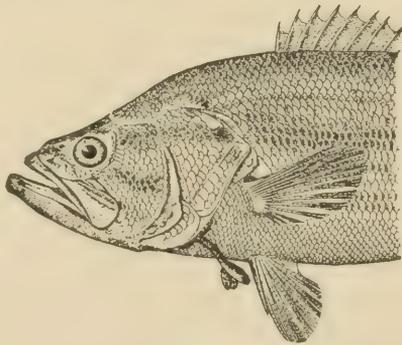


FIG. 99. *Lernæcera cyprinacea*, attached to the gill of a young Large-mouthed Black Bass. Slightly enlarged.

spawning migrations. One form, *Lernæcera cyprinacea*, Figs 98 and 99, occurs in freshwater and is a frequent parasite on fishes. It attaches itself by peculiar sucker-tentacles to the gills, fins and surface, and is a very frequent parasite on river and pond fishes, of such size as to be easily seen.

ARGULIDÆ. These Copépods are known as Carp-lice, though they have almost all the freshwater fishes and amphibia as hosts. Of the three genera *Argulus*, *Chonopeltis* and *Dolops*, 42 species have been recognized,

mostly of the first-named genus; of which some are marine and others freshwater forms. Those on migratory fishes are able to change with their hosts from salt to freshwater and the reverse. They are wholly external parasites, either in the gills or on the surface, and frequently change their host, though each species prefers a certain genus or closely related kinds, to which it is usually confined. They have a flat rounded carapace, notched on either side and bluntly projecting in the centre, nearly transparent, and elegantly marked in colors; smooth above and armed below with spines to attach themselves on the surface of their hosts, to which they also cling by anterior maxillipeds which are modified into sucking discs, and by clasping posterior legs or maxillipeds. They can swim freely and the males frequently abandon their hosts in the breeding season, as do also the larger females, at times, as unlike other copopods, the hundreds of eggs are not carried in sacs but are fastened in rows on objects on the bottom. As their food is the blood of their host, extracted through the sucking discs, they are destructive parasites which become serious

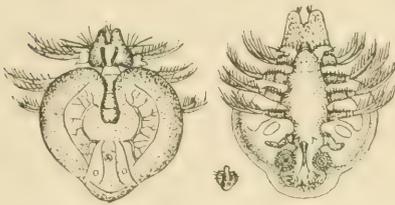


FIG. 100. *Argulus catostomi*, a Crustacean parasite. Enlarged ventral and dorsal views, and natural size.

menaces, especially in the confines of the aquarium, where they are prevented from changing to a number of fishes. They are of frequent occurrence on both pond-raised and imported goldfishes, usually easy of detection by their size and shape.

The general American freshwater form is *Argulus catostomi*, Fig. 100. Other common Crustacean parasites on the gills and surface of freshwater fishes are *Achtheres lacæ*, *A. percarum*, *Ergasilus funduli*, *Lernæopoda fontinalis*, *L. siscowet*, *L. coregoni*, *L. pomotidis*, *Lamproglena pulchella*; and *Lepeophtheirus salmonis* on Salmon in freshwater.

INSECTA OR INSECT PARASITES. This group includes the Lice, Fleas, and other insect tormentors. As they do not affect fishes and amphibia they will not be further mentioned, though many of the aquatic insects and their larvæ could be included in this group. They are elsewhere mentioned and described.

PROTOZOA OR PROTOZOAN PARASITES. This group embraces the lowest forms of the animal kingdom; organisms possessing but a single cell or colonies of unicellular beings. They are divided into 4 sections, 4 classes and 21 orders, many of the 38 genera of which are for the most part entozoal, but some are ectozoal parasites. The sections of interest to the fish-culturist are the *Bacteridæ*, *Sporozoa* and *Infusoria*.

BACTERIDÆ. This section of the Protozoa includes orders which are both saprophytic and parasitic, potent factors in the causation of

diseases of fishes. They have not received much attention from Bacteriologists and but few have been identified.

Lymphosporidium truttae produces a disease in aquaria and among domesticated fishes not yet observed in wild ones from natural waters. The bacteria, Fig. 101, are short rodlike micrococci which grow out into filaments, and infest the gills, blood, muscles, skin and surface generally. This micrococcus is usually present in cases of Autotoxine of aquarium fishes. Healthy fishes succumb to the bacteria in a few days when inoculated beneath the skin and after a longer time by mixing cultures with their food. It is to be hoped that future investigations will familiarize the fish-culturist with many other of these bacterial causes of fish diseases, and with methods for their destruction.

SPOROZOA. This section of the Protozoa includes orders which contain many parasitic genera. The orders of the *Cytosporidia* are the *Gregarinida*, *Coccidiida*, *Hæmosporidiida* and *Gymnosporidiida*. The orders of *Myxosporidia* are the *Phænocystida* and *Microsporidiida*; and in addition to these are the orders *Sarcosporidia*, *Amæbosporidia* and *Serumsporidia*.

GREGARINIDA. Of this order none of the genera have been found as parasites on freshwater fishes or amphibia.

COCCIDIIDA. The freshwater parasites of this order belong to the genera *Rhabdospora* and *Coccidium*. *R. thêlohani* have been found in the intestines of the perch, the ovarian tissues of the pike-perch, and in the liver of the stickleback; *C. metshinkovi* in the intestines of the goby; and *C. gasterostei* in the liver of the stickleback. None have been found on the Cyprinidæ.

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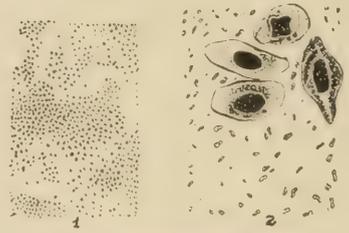


FIG. 101. *Lymphosporidium truttae*, a Bacterian parasite. 1. Enlargement. 2. Greatly enlarged Blood corpuscles and Bacteria.



FIG. 102. *Myxobolus sp. incert*, a Sporozoan parasite of the Goldfish and other Cyprinidæ. Greatly enlarged.
 1. Cyst in cuticle and tissues.
 2. Cyst containing vacuoles.
 3. Ruptured cyst and escaping vacuoles.



FIG. 102A. Head and shoulder of a Goldfish affected with *Myxobolus sp. incert*.

MYXOSPORIDIA. The freshwater fish-parasites of this order belong to the genera *Myxidium*, *Myxobolus*, *Henneguya*, *Nosema* and *Plistopora*.

MYXOSPORIDÆ. These Protozoa, Figs. 102, 102A, 103, 104 and 104A, are entirely parasitic and in the majority of cases live upon fishes. Dr. R. R. Gurly listed 102 hosts, fishes and other aquatic fauna, inhabited by them, either encysted beneath the skin, on the surface of the head and fins, or in the gills, mouth, eyes, gullet, air bladder, heart, liver, spleen, stomach, intestines and almost every other part of the body. The effect of their presence is a breaking up of the parts, which undergo a vitreous degeneration, the growth of tumors and postules and ultimately the death of the host.



FIG. 103. *Myxobolus cyprini*, a Sporozoan parasite, encysted in the Kidneys of a Carp. 1. Enlarged 2. Natural size of cysts.

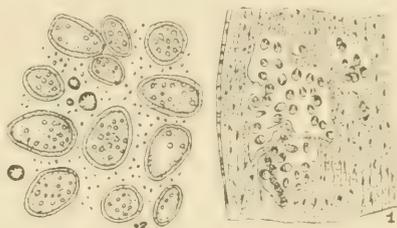


FIG. 104. *Myxobolus ellipsoides*, a Sporozoan parasite. Greatly enlarged.

1. Cyst in the tissues of the Air-bladder of a Tench.
2. Psorosporozoites liberated from the cyst, highly magnified.

They are usually amœba-like microscopic organisms, which reproduce within or without the cyst or tissue cavity with those species which inhabit the surface; and constantly within the cyst with those which inhabit the cavities of the hollow organs of their hosts. Mention will only be made of those Myxosporidæ of the orders *Phenocystida* and *Microsporidiida* common to

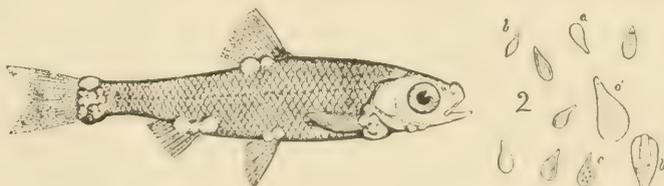


FIG. 104A. Dermal cysts of *Myxosporidium genus incert*, a Sporozoan parasite, on the skin of a Minnow. 2. Liberated psorosporozoites, highly magnified.

freshwater fishes, batracians and larger crustaceans, the table showing how many species have been identified and the parts they inhabit. It is seldom that they have more than one particular host; that of the goldfish, for instance, being *Myxobolus sp. incert*, Figs. 102 and 102A, and Table p. 156.

Myxosporidæ spare no organ or elemental cell and nearly all of them produce a cachexia, comparable with the cancerous tumors of warm-blooded animals. They are the cause of violent epidemics among fishes and have occasioned the deaths of hundreds of tons of food fishes in a very short time when outbreaks of the contagious diseases caused by them have

occurred. They are present in all bodies of water and a careful observation of catches of freshwater fishes will almost always reveal some affected with the postules or tumors produced by these protozoan parasites.

Number of species observed	Host	In Body cavity	Encysted in gills	Encysted in Subcutaneous tissue	On fins	In Vitreous humor of eye	Encysted in spleen or liver	Encysted on head	Encysted in Muscular fibre	Encysted in ovary and renal tubes	Encysted in gall bladder	Encysted in air-bladder and intestines	Surface tumors	Throughout most interior organs
1	Goldfish	x				x								
7	Carp		x	xx	x			x				x	x	
6	Tench		x	xx		x	x					x		
5	Sunfish	x	xx						x		x			
4	Stickleback			xx						xx				
4	Minnow		x	x									xx	
3	Perch	x		xx										
4	Pike-perch		xx	x				x						
2	Pike		x			x								
4	Chub-sucker	x	x						x					x
1	Mullet		x											
2	Gudgeon	x												x
1	Barbel												x	
1	Eel										x			
2	Catfish			xx										
2	Frog						x						x	
2	Toad										x			x
1	Crayfish								x					
1	Prawn								x					
1	Shrimp								x					

INFUSORIA. This section of the Protozoa includes orders which contain many parasitic genera. The countless host of Infusoria is divided into 3 classes, 13 orders and 306 genera; of which 286 recognized species occur in rivers and other freshwater, 76 species in pond water, 15 in marsh water, 4 in ditch water, 13 in bogs, 17 in standing and stagnant water, and 1 in spring water; while 80 species occur on or among aquatic plants, 35 in and on entomostraca, 16 in and on frogs, toads and salamanders, 14 in molluscs, 5 in and on polyps and sponges, 4 in earthworms and tubifex, 18 in aquatic insects, and 4 are parasitic in and on fishes. These are the following:—

ICHTHYOPHTHIRIIDÆ. These infusoria are probably the most frequent and general forms of freshwater fish parasites. Small raised white spots develop on the skin, which increase to larger blotches, spread over the sides, head and fins, until the fish assumes the appearance of being dotted with white and covered with slime. These extend to the mouth and œsophagus and enter the gills, when the fish wastes away from loss of appetite, difficulty

in breathing and the sloughing away of the skin. The following are the recognized most common freshwater species likely to be encountered by the aquarist.

ICHTHYOPHTHIRIUS MULTIFILIIS. This infusorian, Figs. 105 and 106, first forms round milky spots on the skin, fins, eyes and gills of freshwater fishes. A microscope examination will reveal that each spot is caused by

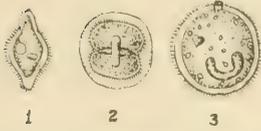


FIG. 105. *Ichthyophthirius multifiliis*, an Infusorian parasite. Greatly enlarged.
 1. Ciliated spore.
 2. Segmentation upon encystment.
 3. Adult infusorian.

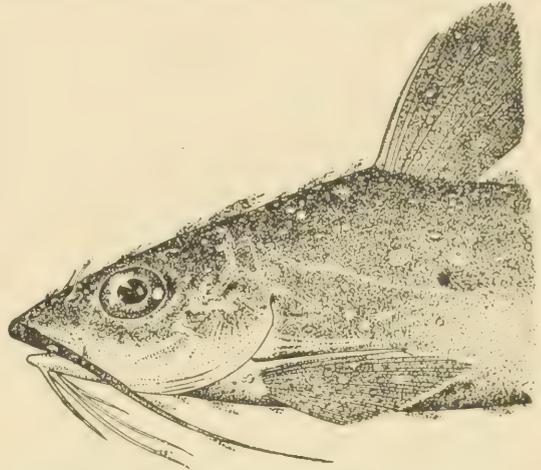


FIG. 106. Head of a Catfish affected with *Ichthyophthirius multifiliis*.

the presence of a ciliated infusorian, the epidermis of the fish forming a considerable protuberance over the parasite. Sometimes two or three infusoria inhabit the same cyst, the form of the younger differing from that of the grown individuals. The fishes soon appear completely emaciated, the skin becomes thickened where the parasite is encysted, a scum forms on the surface and deaths occur in ten days to two weeks.

PANTOTRICHUM LAGENULA (*U. lagenula*.) This infusorian, Fig. 107, is parasitic on the skin and in the gills of freshwater fishes and produces the "Spot-disease" or "Pox," by living in the pulp cavity of the scales and absorbing their contents, pigment cells, etc., producing colorless patches on the skin. These spots first appear as slimy excrescences, later assume a funguslike appearance, and finally cause the death of the fish by emaciation and destruction of the tissues.

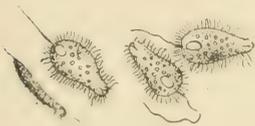


FIG. 107. *Pantotrichum lagenula*, (*Urotricha lagenula*), an Infusorian parasite. Greatly enlarged.
 Dorsal and lateral views.

The infusorian has an oval body with a sucking disc and swimming appendage, and the cuticle is covered with very fine evenly-developed cilia.

TRACHELOCERCIDÆ. Of these infusoria the most frequently occurring freshwater species, is the ciliate *Holotricha*, *H. mystacca*, Fig. 108, a more or less elongated or flask-shaped infusorian, entirely covered with cilia; with delicate flexible cuticle and the anterior part of the body at times

extended like a proboscis. It is most frequently observed on fishes kept under unsanitary conditions or which have become exhausted from fright, transshipment or other disturbing causes.

The following are nearly related forms.

CHROMATOPHAGUS PARASITICUS. On the bodies of freshwater fishes, very distinct milky-white spots develop, caused by these large infusoria lodging on, or in, the epidermis, which show a distinct rotating motion between the epidermic cells, Fig 109. These parasites are usually single, but sometimes two or three are imbedded close together.

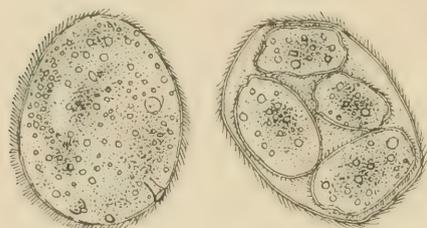


FIG. 109. *Chromatophagus parasiticus*, an Infusorian parasite. Greatly enlarged.

Their shape is variable but most often oval with the longer diameter 0.615 mm. and the shorter 0.408 mm. The body is enclosed in a thin elastic cuticle covered with fine cilia, the layer below finely granular, filled with a large number of contractile vacuoles of different size. They have a proboscis-like sucking tube. The presence of these parasites is manifested by the formation of cysts on the surface of the fishes, which enlarge until the skin and head are covered by funguslike postules in which the boring infusoria are encysted. Death results from exhaustion and the ravages produced by the parasites. A similar infusorian has been found in the blinded eye of a Telescope goldfish.

TETROMITUS NITSCHERI. This infusorian, Fig. 110, previously recognized as *Contia necarix*, is supposed to have only the Japanese Fringetail goldfish as host, but a very similar species, *Bodo necator*, is very destructive to young trout in Europe, and the described form is probably a Japanese species of the same genus. This minute organism attaches itself to the surface and under the scales in vast numbers, often hundreds in a space as large as the head of a pin. Its presence is manifested by excessive mucous coating, red spots and ulcers. In the free-swimming stage it has a flattened appearance with cilia at one side by means of which it moves through the water until it comes in contact with its future host. When not checked this parasite may become so numerous as to cause the destruction of all the fishes in an aquarium.

None of the other mentioned orders of Infusoria are parasitic on fishes but a considerable number occur with other lower forms of aquatic fauna.

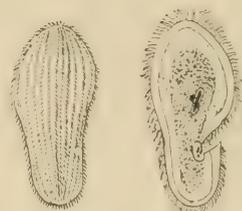


FIG. 108. *Holotrichus mystacca*, an Infusorian parasite. Greatly enlarged.

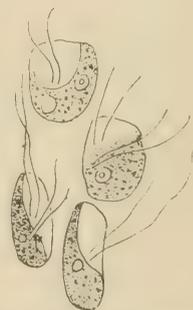


FIG. 110. *Tetromitus nitschei*, (*Contia necarix*) an Infusorian parasite. Greatly enlarged.

ROTIFERA OR PARASITIC ROTIFERS. Three genera of Rotifera, *Albertia*, *Balatro* and *Dictyophora* are parasitic on the freshwater fauna. Some of the already described forms must not be mistaken for this group, whose occurrence on the Cyprinidæ is not common. Many parasites are designated as "Rotifers" by the fish-culturists, but belong to much lower orders, or are larval forms differing in appearance from the adults.

PREVENTION OF PARASITIC DISEASES. The best preventive measures against parasites in the aquarium are care in not introducing them upon fishes and plants and guarding against their spreading by constant vigilance. A careful examination of every newly acquired fish should be made; the appearance of the surface and gills, the condition of the fins and the manner in which they are carried, the behavior of the fish and its general condition noted. Newly acquired fishes should be quarantined at least a week and aquatic plants inspected and carefully cleaned before either are put into the aquarium. A microscope examination of anything suspicious is also advisable. Infected fishes should be placed in the most salubrious surroundings, with a plentiful plant growth, abundant aeration, and nutritive food given.

An already mentioned sometimes effective remedy is to place the affected fishes, or any subjected to contagion, in water taken from neglected out-of-doors tanks which has become very green with algæ and other low forms of plant and animal life. This is worth a trial as beneficial results often follow; but if the afflicted fishes are not of value, and their disease does not yield to the remedies before and hereafter mentioned, their destruction is advised. The most rigorous sanitary regulations are required in the infected aquaria or tanks, to destroy every trace of parasites.

PARASITICIDES. An absolute means of destroying fish parasites has not yet been found, though acid and alkaline substances have proven beneficial and have effected cures. They destroy the free-swimming parasites but have not been as successful with those burrowing in the skin or in the gills. Solutions which would destroy these are oftentimes fatal to the fishes prior to exterminating the parasites. German ichthyological authorities recommend the following remedies, all of which require close attention in their application:

Two grams of salicylate of soda are to be dissolved in one litre of warm water and permitted to cool. Two vessels, holding about three gallons each, are required; one filled with well-aerated water, of the same temperature as that to which the fish has been accustomed, the other containing 1½ gallons of the same water. These should be prepared early in the morning and the fish introduced into the partly filled one, after which small even quantities of the solution are to be added at frequent

intervals until by evening all has been introduced. After about two-thirds of the solution has been added, careful attention must be given to the fish, and if its condition is weak and the indications are that it would be endangered by a stronger bath, it should be removed to the second vessel, the water of which has been aerated by frequently dipping out and pouring back. It is necessary to leave the fish in the solution as long as endurable without complete exhaustion indicated by excessive restlessness and later by partly or completely turning on its side. Should the fish not recover at once in the second vessel, it must be kept in motion by gently stirring the water.

Picric acid has also been found to be beneficial. A one-percent. solution of this poisonous acid is made in hot water. The fish is placed in well-aerated water to which small quantities of the solution are added, until $\frac{1}{1500}$ to $\frac{1}{1000}$ part of the acid is present in the water, if the fish can endure this amount, and then, after a few minutes, water of the same temperature is added at intervals until a very considerable dilution has taken place, when the fish should be removed to well-aerated water. This may be repeated after a few days, the fish to remain in the weakened bath several hours, if possible. Chlorate of potassium is used in the same manner, but the amount present in the water should not exceed 1 in 1000. All three of these remedies are certain to destroy the higher forms of surface parasites, and usually those encysted on the fish.

American breeders have successfully applied the following remedies, all of which are to be recommended:—

Permanganate of potassium solutions are powerful disinfectants and frequently used specifics, but are not always efficient. They produce an objectionable discoloration of the water and when sufficiently strong to destroy the parasites cannot be endured by the fishes. The best application is by the use of a separate vessel, and covering the mouth and gills of the fish with a wet cloth agitating the body in a strong solution for a few minutes, then placing the fish into water to wash off the potassium before returning it to the hospital jar.

Bichloride of mercury has been found to be beneficial when applied in the same manner, also a weak solution of formalin; a tablet of the former in a pint of water and a 10 percent. solution of the latter. Salt is a generally applied and safe remedy, and should be used as previously mentioned, a strong solution kept from the gills, and a weaker one by placing the fish into it for one or more days.

External applications of boracic acid in water have proven effectual for surface parasites, and should be frequently applied with a brush or a pledget of cotton. Very satisfactory results have been obtained with a 50 percent. solution of peroxide of hydrogen in water. The fish is grasped

by the head, to close the operculæ and mouth, and the rest of the body immersed for five seconds, the treatment to be repeated at intervals of one day. All newly acquired fishes should be so treated before introduction into an established aquarium. No ill results follow and salutary effects are certain.

A recent highly recommended remedy is the ANTIGYRODACTYLIN,^{*} of Paul Nitsche, for the extirpation of surface parasites on fishes, especially those of the aquarium. The fishes should be well fed about two hours before treatment and receive no food three hours thereafter. The treatment is to be applied three succeeding days. The fish is to be taken by the head and gently passed backward and forward through the Antigyrodactylin for $1\frac{1}{2}$ to $1\frac{3}{4}$ minutes, not longer. Then it should be placed in a vessel containing well-aerated water, that the parasites may drop off and sink to the bottom. After five minutes it should be transferred to a second similar vessel, and then, after expiration of another five minutes, to a third large shallow-water vessel containing just sufficient water to enable the fish to swim. This water should be changed daily and the vessel scoured. It is advisable to have the water of each vessel one or two degrees colder than the preceding, on account of its effect on the parasites, as it will aid in their leaving the fish.

If the fishes show indications of exhaustion after the bath, they should be kept in motion for some time with a light wooden rod.

A litre of Antigyrodactylin is sufficient for the treatment of twenty fishes. Taken internally it is poisonous, but is harmless externally, even on wounds and abrasions.

VEGETAL PARASITES AND PARASITIC DISEASES. All animal and vegetable substances are subject to the attack of low forms of vegetal parasites, and though they are not all necessarily malignant, many of the diseases of aquatic animals and plants are directly due to the presence of these micro-organisms, which are saprophytic upon the dead and parasitic upon the living tissue.

The vegetal parasites found on animal bodies belong to the class of Cryptogamia and the orders Algæ and Fungi; distinguished from each other by the presence of chlorophyll or other coloring substances in the former and their absence in the latter.

PARASITIC ALGÆ. The aquatic forms of this order, or those which have preserved some essential algal features, found on animals, consist of single or branching, cylindrical or flattened filaments, which have no method of fixing themselves but are firmly held by the crossing of their fibres. The reproductive system consists of round or oval spores enclosed in a case or

^{*}To be obtained of H. Lehmann & Co., Chemists, Berlin.

sporangium. They subsist on the juices of their host. Other forms are parasitic upon either growing or dead and decaying plants.

PARASITIC FUNGI. The aquatic forms of this order, the Phycomycetes, found on animals and plants, consist of densely interwoven masses of cellular filaments, which terminate in or constitute the rootlike mycelium, from which hyphæ and spore capsules are developed. With some species there is but a single hypha with reproductive bodies at the ends, this being the case with the more ordinary forms which affect the freshwater fauna. As fungi contain no chlorophyll they must take up and assimilate nutritive substances from other organisms and are therefore either saprophytic or parasitic.

The Phycomycetes are separated into five groups or sub-orders: 1, the *Clytridiaceæ*, of which a considerable number of species are parasitic upon Protozoa, Anguillulæ, Rotifera, Algæ and Saprolegnia; 2, the *Ancylistaceæ*, parasitic upon Conjugatæ, Chlorophyceæ and Anguillulæ; 3, the *Monoblepharidaceæ*, nearly all saprophytes; 4, the *Peronosporaceæ*, of which one genus, *Pythium*, has species parasitic on water plants and saprophytic on organic substances; and 5, the *Saprolegniaceæ*, the order of greatest interest to the fish-culturist, as of all the above, this group and the *Peronosporaceæ* are, to greater or lesser degree, aquatic at some or all stages of their existence. Most of the *Peronosporaceæ* are aquatic only at certain stages and afterwards become land forms, but the *Saprolegniaceæ* are aquatic at all stages.

SAPROLEGNIAEÆ. This group of water molds contain both fresh and saltwater forms, of which the genus *Saprolegnia* is widely disseminated in all bodies of freshwater. The most generally distributed genera are *Saprolegnia*, *Pythiopsis*, *Dichtyuchus*, *Achlya*, *Aphanomyces*, *Leptomitus* and *Apodachlya*, present as saprophytes on dead and decaying aquatic animals and vegetal substances, and as parasites on all aquatic fauna, including the spawn and young and mature fishes, whenever the conditions favor their active development. This occurs on skin abrasions, bruises, wounds, loss of a scale, or on a torn or congested fin. When fishes are enfeebled and the mucus coating affected, when they are kept under unsanitary conditions or in too cold water, these fungi may develop to cover the entire body, first as a film and later as white or colored blotches on the head and body, in the mouth and gills, on the fins and on and under the scales, which they often force out of place; as, when once established upon and into the living tissue, they ultimately cause its destruction. Investigators have determined that the *Saprolegniaceæ* on fishes can be communicated to dead insects and those growing on dead insects and other low forms of aquatic fauna are communicated in their turn to living and healthy fishes.

The Saprolegniaceæ have the merit of scavengers in consuming the organic compounds of dead animal matter and when this source of nutrition is exhausted it is usually followed by a disappearance of the fungi; but under favorable conditions some species of this genus become active parasites on fishes, amphibia, insects and plants, and have caused epidemics of diseases in rivers and lakes, as well as among fishes in the confines of the aquarium and breeding tank.

SAPROLEGNIA. Fig. 111. The most common species of this genus is *Saprolegnia ferax* a minute vegetative body without stem or leaf, which may exist as a saprophyte and develop its spores. These drift

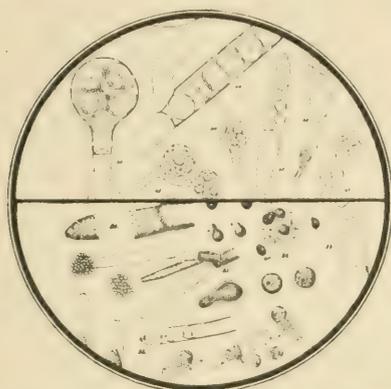


FIG. 111. Saprolegniaceæ, the most common Vegetal parasites of Freshwater. Greatly enlarged.

- 43 to 45. *Saprolegnia ferax*.
- 46 to 49. *Saprolegnia torulosa*.
- 50. *Achlya apiculata*.
- 51. *Achlya americana*.
- 1 to 4. Hyphæ with spores.
- 52. *Dictyuchus polysporus*.
- 53. *Leptomerus lacteus*.
- 54. *Aphanomyces laevis*.
- a to c. Budding spores.

about in the water, to immediately undergo a change in contact with a fitting animal surface not protected from their ravages. A rootlike nucleus or rhizoid is formed from which threadlike hyphæ grow, each bearing a Sporangium or brood-sac filled with spores, and forming a white cottony felt over a malignant sore. These ulcers, if not checked, spread over the surface and sap the vitality of the victim until death ensues. This parasitic fungus is one of the commonest and most frequent causes of epidemics among fishes. Other more or less common species of the eastern section of the United States are *S. mixta*, *S. monoica*, *S. torulosa*, *S. declina*, *S. astrophora* and *S. trileaseana*. Spores of one or more forms of these saprophytes are always

present in all freshwater and are therewith introduced into the aquarium.

PYTHIOPSIS. The most common species of this genus is *Pythiopsis cymosa*, a minute vegetative body similar to the foregoing, but with more slender hyphæ; which occurs in stagnant water and is parasitic upon low forms of vegetal life and saprophytic on organic substances.

DICTYUCHUS. This fungus produces a skin disease on cold-blooded animals and lower forms of aquatic life. In appearance it resembles Saprolegnia, but the sporangia are more fusiform. The most common species are *Dictyuchus polysporus* and *D. magnusii*; the former as frequently present as an animal parasite as *S. ferax*. Usually they are associated on the same host.

ACHYLA. This fungus is one of the most malignant of the Saprolegniaceæ. It attacks marine fishes during their freshwater spawning

migrations. The entire body becomes covered with white gnawing ulcers, the gills livid, the eyes coated and glazed, and the surface ulcerated so that the raw flesh may be seen. When the fungus reaches into the respiratory organs death results. This fungus may be recognized under the microscope by its stiff and bristly appearance. The most common species of this genus is *Achlya apiculata*, a minute vegetative body having short, stout and stiff hyphæ and abundant sporangia upon short branches. It occurs on dead leaves and similar substances in stillwater pools and ditches, in the slime of stagnant water and in rivers and other natural water courses. Other frequently occurring forms are *A. megosperma*, *A. americana*, *A. oblongata* and *A. racemosa*.

APHANOMYCES. This fungus is parasitic on the Algæ, principally on the species *Spirogyra* and *Zygnema*, also on some of the Mosses and other low forms of aquatic plant life. It consists of very slender and delicate hyphæ, forming a fine film over the plant, which it destroys. The sporangia usually have a prickly appearance. The more common species are *Aphanomyces lævis*, *A. phycophilus* and *A. scaber*.

LEPTOMETUS. This fungus grows in water containing considerable organic impurities especially in that to which the waste of factories finds its way. It may be recognized by the many-branching form of the hyphæ. The more common species of this genus is *Leptometus lacteus* a minute felted vegetative body which covers the bottom of streams for considerable distances with a thick white layer. Some of the Leptometeæ also occur abundantly in localities where the streams contain starchy refuse and much decaying vegetal matter. They also flourish on animal remains and slaughter house refuse in streams, on decaying algæ, and in the slime of stagnant water. There are no reported instances of their having become parasitic on fishes but always indicate stream pollution.

APODACHLYA. This fungus occurs most frequently upon dead animal matter in water and no certain conclusions have been reached of its becoming parasitic on living organisms. It has received some attention from investigators as it is considered to be the first instance of the occurrence of sexual organs in these low forms of plants. Three species have been established, *Apodachlya brachynema*, *A. pyriferæ* and *A. completa*. As they are harmless to fishes they need no further description here.

OTHER COMMON FORMS OF FUNGI. *Penicillium*, *Aspergillus* and *Mucor* are also saprophytes which live upon decaying organic matter and particularly flourish in water containing salts of ammonia. The common forms are *Penicillium glaucum*, *Eurotium aspergillus glaucus*, *Mucor mucedo*, *M. racemosus* and *M. circinelloides*.

The large group of Schizomycetes or Yeast fungi are not treated of here as they do not enter into the subject.

TREATMENT FOR VEGETAL PARASITES. Fishes affected with parasitic fungi may be successfully treated and cures effected. When given immediate attention, the spread of the fungi may be checked by salt baths or local application of strong brine, followed by the peroxide treatment; but when the ravages are not at once checked they produce fatal results. They sometimes produce epidemics which cause the deaths of thousands of food fishes and of entire broods of goldfishes. There is no radical fungicide which is invariably effective with the fungi. The remedies for animal parasites should be applied as usually, a microscope examination only can determine what form of parasite is present.

PREVENTION OF FUNGI IN AQUARIA. Filtration of the water is a radical prevention of the introduction of and the removal of Fungi in the aquarium; but the spores may be brought over into the filtered water by the fishes themselves or on aquatic plants, snails and tadpoles, when these are introduced in fungused condition, or together with live food taken from unsanitary localities. Cleanliness in every particular is the best preventive, together with a frequent careful inspection of both the fishes and the scavengers, and the isolation of any which may have a doubtful appearance. Prevention is always easier than a cure. Strong and healthy fishes are seldom attacked by vegetal parasites, but the disease is sometimes communicated from weakened or bruised fishes introduced into a previously sanitary and well-established aquarium.

ALGÆ MORE OR LESS PARASITIC. The common forms of Algæ which adhere to the aquarium, on the aquatic plants, or suspended in the water, belong to a number of genera. Those most frequently met with are the following:

CHLOROPHYLLACEÆ. In the clouded water of a stagnant aquarium two forms of *Chlorococcum*, one motile and the other at rest, were found by Dr. H. C. Wood; the younger forms green, the older ones darkish-brown in color. They were so numerous as to make the water opaque and stagnant.

Androgynia huntii, forms delicate bright-green fringes on the plants and glass of the aquarium.

Bulbochaeta dumosa, forms small bushy growths on larger Algæ, Confevæ and other plants in the aquarium.

Tolypothrix distorta, forms microscopic bright-green tufts or balls adhering to plants in the aquarium and to the glass.

Mastigonema elongatum, forms blackish-green nodules about the size of a pin head on Brook-moss and Characeæ.

Batrachosperms are small gelatinous masses of Algæ which attach themselves to plants and submerged wood.

Lemanea grow in masses and form a turf-like covering on stones in water often two inches long. Some of the forms of this genus are present in all freshwater.

Nostocs cæruleum, *N. depressum*, *N. spæricum* and *N. lobatus*, are Algæ which adhere to aquatic plants and form tiny dark-green, brown and blackish tufts.

Cylindrospermum minutus, forms filamentous light-green to rusty-brown intricately felted minute masses on aquatic plants.

Gloiostrichia incrustata, forms tiny clusters of light-green, straight and stiff filaments bearing round fronds the size of a mustard seed on water plants.

Rivularia cartilaginæ, appear as sub-globose, stiff, deep brown or blackish threadlike filaments, having small semi-globose fronds or cells containing spores, and attach themselves to aquatic plants.

Scytonema immersus, and *S. nægelii*, form dark green mats on aquatic plants, and *S. dubium*, dark masses binding the leaves together.

Other Algæ which cause green water and scum on ponds and stagnant water are *Oscillaria*, *Hydrodictyon*, *Zygnomacia*, *Wolffia* and *Vaucheria*.

Diatoms and *Dismids* are also often present in great numbers. These serve as food for fishes, and are in part the first food of the alevin and fry, their silicious casings aiding in the development of the bones.

CONFERVÆ. The *Cladophora* are the larger members of this genus, two of which are common in Eastern waters. These are *Cl. fracta* and *Cl. brachystelecha*. They seldom occur in aquaria, but *Scenodesmus polymorphus*, develops in quiet pools and ditches in such numbers as to make the water clouded and very green. It consists of short and slender filaments with tiny threadlike branches.

Aquarium fanciers have been led into considering all minute water plants as Confervæ. They are a small group of the large family of Algæ, and mostly of larger size than those which occur in aquaria.

SLIME FUNGI. When the sides of breeding tanks do not become coated with algæ, two or three species of the *Myxogastres* or Slime Fungi are likely to form. These are injurious to the spawn and young fishes and should be removed.

PLANT FUNGI. A number of injurious fungi on the larger aquatic and semi-aquatic plants are likely to be encountered by the aquarist. The more general of these are:—

Rhizopus necans, affecting lilies introduced from Japan. It lives as a saprophyte in the soil and becomes a wound parasite, gaining access

through broken roots or abraded surfaces and rots the bulb. A white mycelium forms upon which black sporangia stand erect on the short hyphæ. It is very destructive when once introduced.

Sclerotinia plorifera. The white pond-lily and kindred species are subject to this fungus which forms orange-brown and yellow specks on the stems, leaves and buds, which spreads and causes an unsightly appearance. It also attacks the finer species of exotic and hybrid lilies and is often communicated to other aquatic plants.

TREATMENT. The affected plants should be submerged for half an hour in a 1 or 2 percent. solution of salicylic acid and afterwards thoroughly cleansed, and the affected spots painted with a 5 to 10 percent. salicylic acid solution. Badly diseased bulbs and plants should be at once destroyed by burning and the others cleaned and repotted.

CHAPTER VIII.

Conditions of Light, Water, Aeration, etc.

CONDITIONS OF LIGHT

As elsewhere stated, the best light for the aquarium is either a northern or northeastern exposure during the summer, and a position where it may receive a good, unobstructed light during the winter, when a few hours of the morning sun would be beneficial. A fine growth of plants is the best indication of favorable conditions, for when the light is excessive at noon or during the early afternoon, it will not only cause a loss of the suspended oxygen by a marked increase in the temperature of the water, but also affect the growth of the plants by a scorching and decay of the leaves, and arrestment of their growth. Too little light is also detrimental because plants require good light to grow.

When the admission of light is principally on the surface of the water, the conditions are nearest perfect. The plants will grow vigorously and the animal inmates be the most comfortable. For this reason aquaria exposed to very strong side light should be provided with a screen for use during the heated portion of the day. This may be constructed of one or more thicknesses of violet or greenish tissue paper or cheese cloth, attached to a light rod, to be hung over the front pane of glass. Window shades partly lowered or raised from below, or the setting of the aquarium back from the window are also effective measures.

Wooden tanks only admit light on the surface and should be placed where they will get the benefit of the morning sunlight or provided with awnings or other coverings that may be used when the heat of the sun is excessive. A fine growth of plants with floating leaves is the best screen to arrest the sunlight, and for this purpose lilies and water-poppies are used.

A little experience will teach the aquarist when the conditions are the most favorable, and his ingenuity will devise methods of reaching the best results.

WATER CONDITIONS

The oxygen necessary to sustain the life of fishes is not that which forms a chemical constituent of water (H_2O) but that contained in the air dissolved or held in suspension in the water. How considerable this is may be realized by looking through a glass of water heated near the boiling point.

In streams or ponds, aeration is maintained by the action of the wind on the surface, but in aquaria this condition is absent, and if air is not

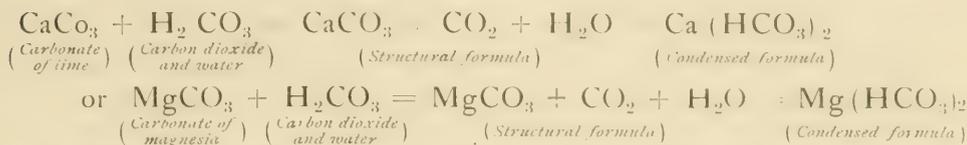
supplied as it is consumed all the living creatures suffer and the water deteriorates. Fishes transferred to water deficient in or devoid of air are speedily suffocated; but, as elsewhere stated, goldfishes are naturally of low vitality and their absorption of oxygen is small, compared with some other species whose habitat is running water. This is more or less characteristic of all stillwater fishes, notably the Carp family.

It is not chemically pure water that is required, as this does not exist in nature. Some saline, carbonaceous, sulphurous and nitrogenous combinations are always present, acquired from the atmosphere or from organic and inorganic or mineral substances by its absorbing and dissolving properties. River, brook, pond, spring, well and rain water all have different chemical composition due to these causes, and the proportion and nature of the substances present in solution vary with each locality. Rain water is usually the purest of the natural waters, containing only slight traces of ammonia, carbonic acid, and some inorganic particles taken from the air. Pond, brook and river waters usually contain mineral salts, inorganic substances, and contaminations of vegetal and animal origin. Spring and well waters usually contain mineral salts and other constituents in varying quantities and some organic contaminations.

Substances of a purely mineral nature are less injurious in character than those due to animal and vegetal decomposition, to sewage and to fungi. The presence of nitrates, nitrites, ammonia, and micro-organisms always indicate the oxidation and decomposition of organic matter. Inorganic and mineral substances are objectionable only when present in considerable quantity.

INORGANIC SUBSTANCES PRESENT IN WATER. The inorganic substances are usually the sulphates, carbonates and chlorates of calcium, magnesium, sodium and potassium; also iron, silica, traces of phosphoric acid, bromine, iodine and other mineral substances. The presence of these combinations with the hydrogen and oxygen affects the quality of the water and causes a change known as Hardness, which may be either temporary or permanent dependent upon the nature of the mineral salts present. Soft waters are those which contain the least substances in solution; temporary hardness is mainly due to the presence of the carbonates of lime and magnesium; and permanent hardness is caused by the sulphates, nitrates and chlorates of calcium, magnesium, sodium and potassium.

The carbonates of lime and magnesium which cause temporary hardness are soluble only in an excess of carbon dioxide (CO_2) and are only contained in water in which the CO_2 is present in such quantity as to hold it in solution as bicarbonate of lime and magnesium, as will be seen by the formulæ:—



The hardness produced by these causes is called temporary because it can be removed by boiling the water, the bicarbonates being thereby changed into the original simple carbonates by driving off the carbonic acid gas and precipitating the carbonates in insoluble form:—



The sulphates, nitrates and chlorates which cause permanent hardness are not affected by boiling and are retained by the water.

WATER ANALYSES. Some years past the author had occasion to make a number of analyses of Schuylkill and Croton river waters for manufacturing purposes, and collected considerable data which is of interest.

For drinking and manufacturing purposes the analytical determinations are usually ten in number, and these are, in their respective order, Total Solids, Mineral matter, Organic and Volatile matter, Organic Carbon, Ammonia both free and albuminoid, Nitrogen, in any or all the forms of nitrates and nitrites, combined nitrogen and organic nitrogen, Chlorine and Metallic salts; also the amount of Oxygen required to oxidize the water, usually by the permanganate of potassium color test, the degree of hardness, and a microscope examination. These are more than are required for the examination of aquarium water.

It is of interest to note that an analysis of the water of a balanced aquarium, which had not been changed for eight months, made for Mr. Mark Samuels by Prof. Leeds, should be of such remarkable purity. As may be naturally supposed the aquarium water contained the greatest proportion of solids, mineral matter, chlorine and the highest degree of hardness, due to easy explained causes. Rain water is the lowest in all of these constituents, while the very highest are Deep well and Spring waters. In point of purity as to ammonia, the aquarium water is as low as many of the city supply waters; and as to nitrogen, the proportion of nitrites is lower than Schuylkill water and the nitrates but two-tenths higher. The high percentage of chlorine is to be explained by the probable addition of table salt, from time to time, in the aquarium, and from the animal waste.

All natural waters are chemically impure, though they may be perfectly clear and free from suspended particles. They contain substances in solution, due to water being a natural universal solvent, which more than any other liquid dissolves and takes up solids, liquids and gaseous

Water Analyses

SOURCE OF WATER	ANALYST	TOTAL SOLIDS		MINERAL MATTER		ORGANIC CARBON		Organic and Volatile Matter		AMMONIA				NITROGEN						CHLORINE		Oxygen Required to Oxidize		DEGREES OF HARDNESS					
		Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon	Parts in 100,000	Grains per Gallon
		Free Ammonia	Parts in 100,000	Grains per Gallon	As Nitrites and Nitrites	Parts in 100,000	Grains per Gallon	Nitrites	Parts in 100,000	Grains per Gallon	Nitrates	Parts in 100,000	Grains per Gallon	Total Combined Nitrogen	Parts in 100,000	Grains per Gallon	Organic Nitrogen	Parts in 100,000	Grains per Gallon	Chlorine	Parts in 100,000	Grains per Gallon	Microscopic Examination	Oxygen Required to Oxidize	Temporary	Permanent	Total		
Balanced Aquarium Water (8 months)	Prof. A. R. Leeds, Ph.D.*	25.21	21.36		3.85		0.007	0.0286															0.452	9.04	3.29	12.3			
Rain Water	Prof. W. R. Nichols	2.95	1.65				0.029	0.0168																0.4	0.5	0.9			
Upland Surface Water	"	9.67	5.63	0.07			0.002	0.0012	0.003	0.0017														1.5	4.3	5.4			
Deep Well Water	"	43.78	25.54	0.061			0.012	0.0069	0.495	0.2888														15.8	9.2	25.0			
Spring Water	"	28.20	16.45	0.056			0.001	0.0005	0.383	0.2234														11.0	7.5	18.5			
Schuykill River Water	Prof. A. R. Leeds, Ph.D.	10.64	3.50		3.84		0.0085	0.0095															0.154						
Hudson River Water	Prof. C. F. Chandler, Ph.D.	5.78	4.12		1.59		0.0215	0.0072		0.0228													0.22	3.17	3.12	6.29			
Croton River Water	Prof. A. R. Leeds, Ph.D.	6.87	2.95		3.95		0.0019	0.0157															0.47			1.92			

* Amateur Aquarist; Mark Samuels Water Supply, Chemical and Sanitary; Prof. W. R. Nichols Report on the Philadelphia Water Supply; Prof. A. R. Leeds, Ph.D. Report on the Waters of the Hudson River; Prof. C. F. Chandler, Ph.D.

NOTE: The duplications of quantities (grains per gallon) are in some instances made by the author, to facilitate comparisons.

substances. So much is this the case that chemists distinguish substances as soluble or insoluble in water. Some which are not affected at ordinary temperatures dissolve in the superheated water of deep-lying strata, as is noticeable in geyser deposits; while other substances held in suspension are concentrated by evaporation and rendered insoluble by heat and precipitated; for instance the deposits in a teakettle or steam boiler.

When there is much vegetal or animal matter present, or when the hardness is due to salts of magnesia or to sulphate of lime, the water is not well suited for drinking purposes; and pollutions by the waste materials of factories and dwellings, by sewage or similar contaminations, are the cause of certain specific diseases which become epidemic; and injurious micro-organisms belonging to the class of fungi, algæ, bacteria and the large class of Schizomycetes, when present in drinking water, are the direct cause of typhoid and typhus fevers, diphtheria, dysentery and numerous other stomach and bowel complaints. To destroy these, thorough aeration is better than filtration, as most of the disease organisms are so small that mechanical filters will not remove them and their spores. Boiling is the best sterilization.

Any good drinking water is all that is required for the aquarium, though soft water is natural to the Carp family. Gradual changes in temperature also do not affect fishes if not too long sustained or excessive; but for those which naturally inhabit cold water streams, attention must not only be given to the character of the water but also to the required temperature, and what may be either excessively warm or cold avoided.

A constant danger in the aquarium is the fouling of the water by the decomposition of dead animals. This is indicated by a local cloudiness, a greasy surface, a foul odor, and later by the behavior of the fishes, and is followed by the death of all the inmates and the decay of the plants if the cause is not removed. This is more often due to dead scavengers than fishes.

Brook and river water abundantly contain the spores of algæ, which are beneficial in clearing the water and furnish food for the inmates, but if these are excessive or objectionable, the water should be filtered or spring water used which has been left standing to acquire oxygen and so assume the character of stillwater.

In a healthy aquarium the water must be clear and colorless though a faintly yellow or green tint is not objectionable, the one due to the decomposition of chlorophyll, the other to the presence of algæ. Comparison of condition is best made by taking a glassful and comparing it with a similar glassful of the water of a well-conditioned aquarium or with filtered water.

The odor of the water is also a means of determining its condition, as when this is strong, vitiation has advanced to a dangerous degree, and to keep the inmates alive it is not only necessary to entirely refill the aquarium but it should be cleaned, the plants reset, and after a few days the water again changed. Experienced aquarists can tell the condition of the water by its taste.

When the conditions are good there is no need of changing the water for long periods, as filling in what has evaporated is sufficient, or removing a part of the lower depth and adding a little fresh water, from time to time, especially when the weather has become warmer.

The aquarium should have a considerable change of water, more than half, when hot weather sets in, and it may be advisable to change part of the water occasionally, say once a month, if not perfectly clear. The new water also brings into the aquarium some of the mineral salts necessary for the plants and animals, which may become exhausted by long standing. Culturists of the food fishes recognize the benefit of occasionally turbid water, as the precipitation of the particles of soil act as a disinfectant, and the mineral substances are required by the fishes to digest their food. In ponds and streams, rainstorms will supply this requirement, but at the beginning of the feeding period of the alevin, breeders of the trout and other food fishes make the water of indoor hatching basins thoroughly turbid twice a day by pouring into it a mixture of water and rich sod soil, after which the young fishes take their food with particular readiness. The breeder of the goldfish supplies the required mineral constituents by placing dishes of turf in the rearing tanks, which is especially necessary to furnish soil artificially in wooden tanks and cement basins, as otherwise the health and growth of the fishes will be impaired. Muddy water is a favorable remedy for some of the illnesses of goldfishes and is frequently used. A small piece of plaster of paris is also beneficial, as it furnishes lime to the animal inmates.

Dr. W. Koch demonstrated that the addition of like quantities of nitrate of ammonia and biphosphate of potassium with a minute quantity of iron to calciferous wellwater, in which a number of water plants were placed, soon produced very green and turbid water rich in plant life consisting principally of *algæ*, *voucheria* and *wolffia*, when kept at a temperature of 50° to 54° F. This admixture produced conditions favorable to the development of the ever present spores of these low plant forms, which are beneficial to the animals in the aquarium.

When much animal life is present in proportion to the size of the aquarium and the plant growth is insufficient, frequent changes of water are necessary. In overstocked aquaria this must be done daily, but

such conditions should be avoided. Frequent aeration will then also be necessary as the vitiating carbonaceous constituents combine with oxygen and form CO_2 , the form in which the plants can best assimilate it, but which in excess is fatal to animal life. Oxygen is one of the best antiseptics and for this reason some of the water should be dipped out and slowly poured back into the aquarium that it may absorb air.

If the plants do not develop new shoots and leaves at all seasons, something is wrong with the water, if the light is sufficient but not excessive. When the roots are affected, indicated by their black appearance, the ease with which the plants are uprooted and the unsatisfactory general appearance of the leaves, the aquarium should be cleaned and refilled with clean water.

One very important consideration for success is the condition of the water when the fishes are transferred from an out-of-door to an aquarium existence. At this time many of the mishaps occur, and at no other period are the fishes more likely to contract fungus diseases. It is always better to fill the aquarium with the water in which the fishes have been kept, when this is in good condition, as they will not then be subjected to differences in temperature and composition of the water, will continue in the same conditions to which they have been accustomed, and not subjected to sudden changes, as they will be acclimated to household conditions in water which will gradually assume the temperature of the room. Experienced aquarists always employ this method of transfer.

AERATION

All animals require oxygen to maintain their existence, and have organs by which it is brought into the blood. In breathing, a part of this oxygen is taken from the air, distributed to every part of the organism and consumed in the functions of life. In exhalation and surface expulsion CO_2 or carbonic acid gas is given off, for which reason the air becomes poorer in oxygen and richer in carbon with every breath, as every 100 parts of inhaled air contains 20 parts of oxygen and approximately .04 parts of carbon, and the exhaled air 16 parts of oxygen and 4.38 parts of carbonic acid gas. This would indicate a consumption of one-fifth of the oxygen and an addition of one hundred times as much carbonic acid gas. Hence a constant breathing of normally constituted air is necessary or suffocation will result, not only from the consumption and consequent lack of oxygen but also from the poisonous effect of the exhaled carbonic acid gas.

Nature, however, has provided for the maintenance of an equilibrium by the breathing of plants which require the carbonic acid gas exhaled by

animals, taking up the carbon and liberating the purified oxygen. What occurs in the air also takes place in the water, though it contains less free or suspended oxygen, an average of only 2 to 3 percent, and considerably more suspended carbonic acid gas. The animals consume oxygen, give off carbonic acid gas, and the plants consume carbonic acid gas and liberate oxygen. Therefore, unless oxygen is added to the water, either by plants or furnished by aeration, animal life must cease. In the properly established aquarium the plant life should be in excess, and only as much animal life present as will exist comfortably under the conditions. But as plants are only active in producing this interchange when growing, and as their growth is entirely dependent upon sufficient light, when this is not abundantly obtained artificial aeration is necessary or a frequent change of water required, surface aeration alone being insufficient.

There are many methods of furnishing air to the aquarium or larger tank. The following have been given thorough trial and have proven satisfactory when arranged that the air enters in minute bubbles for ready absorption by the water. Good results may be had by either direct admission of the air, or by means of a stream of water under the pressure of a considerable elevation, through a very finely perforated nozzle fixed close to the surface of the water on the opposite side to the overflow pipe, so that the force of the water carries with it a large amount of minutely divided air. This also permits of warming or cooling the water supply by coiling the pipe in a water-tight chamber, if desired, and may be installed on a larger or smaller scale to suit the requirements.

Direct aeration, without the necessity of the overflow pipe, is arranged by the use of a pressure tank and bicycle pump, placed at any convenient location, and the compressed air admitted into the aquarium by a small block tin pipe buried under the pebbles. Several petcocks are necessary to hold the pressure and to check the amount of flow, and tiny pin holes blocked with pieces of porous wood will best serve to admit the air in the required minute bubbles. When properly installed, a pressure of 35 pounds in an air chamber 28 inches high and 12 inches in diameter, produced in three minutes by a bicycle foot-pump, will furnish a 50 gallon aquarium with air for two or three days. This system of aeration is in successful use with a number of aquarists in Philadelphia. Care must however be taken not to over-oxygenate the water.

The simplest fountain device, when the aquarium is placed at a window and is as broad as the opening, is the following. A block tin pipe may be led under the bottom of the aquarium through the base and screened by rockwork. This should have a small stopcock at the end and a rubber hose to connect with a water can outside the window or

screened by the window curtains; and arranged on a cord and pulley for raising to the desired height. If the pipe is closed to a very small opening above the water level, five gallons of water should be sufficient to cause a fine fountain play for probably an hour. The overflow may be carried out of the aquarium in the corner, and a half-inch rubber tube through the trim of the window would lead it outside, or it may be collected in a vessel under the aquarium. This device was successfully used in swamp-aquaria.

Many other ingenious aerating devices have been produced, but the simplest and most efficient are those here given.

SOIL FOR AQUATIC PLANTS

Experts in the maintenance of the freshwater aquarium favor the use of soil in shallow pots under the pebbles into which to root the aquatic plants, the result being always satisfactory. For this purpose clean turf, directly from under the roots of lawn grass, is the best, not garden earth or potting soil. Aquatic plants rooted in turf grow with vigor and there is less likelihood of its fermenting or decomposing, to cause disturbances in the aquarium, as may be the case with the rich potting soil, when used in considerable quantity. For plants required as oxygenators, the turf may be used in pots, but for those with floating leaves in out-of-door tanks a richer compost is necessary, as both the lilies and water-poppies are rank feeders and require a large quantity of rich soil, frequently renewed. The compost prepared by gardeners for this use consists of turf and some well-rotted cow manure, a little ground bone and about a quart each of pond soil and clean sand, the whole to about fill a bushel measure. This should be packed about the roots of the lilies and poppies, covered with clean turf and a thin layer of pebbles and set into pails of water for a few days, that it may "set" and expel the generating gases before introduction into the tanks. Water-poppies, water-clover and the potamogetons will thrive in the aquarium in turf, but experience has taught the aquarist that *Sagittaria natans* and *Anacharis canadensis gigantea*, the best oxygenators, will grow more vigorously when set directly into the pebbles and sand; for when the roots do not have much nutrition they serve principally to anchor the plants and consume the humus. The leaf blades will perform the functions of roots, grow more rapidly and assume a finer pale-green color. The plants are less likely to develop blossoms and seeds and will not as soon exhaust themselves or deteriorate, the propagation of *Sagittaria* then being by rhizomes or offshoots, the desired "runners" of the aquarist. It is also advisable to remove their floating floral leaves and the flower stalk, as the plants usually die after ripening the seeds.

ROCKWORK FOR THE AQUARIUM

Picturesque effects in the aquarium may be produced by the introduction of rockwork and other natural objects. Pumice adapts itself well for this purpose and is easily worked. Odd pieces fastened together to form a grotto or rockery may have the surfaces hollowed out to contain soil and sand in which plants may be grown, or form a screen behind which brackets for small flower pots may be constructed. Tuffstone is also to be recommended, as very handsome odd pieces may be obtained and natural effects produced by their tasteful arrangement. Selinite or gypsum may be introduced, as it is not only handsome in appearance but dissolving slowly in the water, it furnishes lime, necessary to the molluscs and other animal life. Small pieces of plaster of paris will also serve for this purpose. Mica schist, quartz, feldspar, agate, rock crystals and other minerals are effective, or water-worn stones to which aquatic plants are attached may be introduced, but all other objects not natural to a water garden are in questionable taste. All objects should be clean, and soaked for some time in water before they are put into the aquarium.

CHAPTER IX.

The Aquatic Plants of Freshwater

AQUATIC PLANTS

A number of generally procurable aquatic plants thrive at all seasons under the unnatural conditions of the household aquarium, and not only add to its beauty by their graceful forms and fine colors but also fulfill the imperative requirement of properly aerating or oxygenating the water, whereby supplying to the animal inmates the air necessary to their existence. These plants are sought by the aquarist, and, as they belong to different genera, they will be described not in their botanical order but in the order in which they most effectually serve these purposes. Those which grow rapidly and for the greater part of the year have their foliage submerged, taking the required carbon and nitrogen from the soil and water, also liberate the greatest amount of oxygen to remain in available form in the water. Experiment has proven that the ribbon-leaved *Sagittarias* are in every way the best aquarium plants, with *Cabomba* Giant *Anacharis* and *Vallisneria* next following, all hardy and easily propagated; while in further order of their utility, satisfactory growth and endurance are *Myriophyllum*, *Nitella* and *Anacharis*; *Ludwigia*, *Ceratophyllum*, *Hippuris*, *Fontinalis* and *Potamogeton*; *Callitriche*, *Utricularia*, *Proserpinaca*, *Heterania* and *Hottonia*; and finally the Lilies, Water-poppies and other aquatic and semi-aquatic plants either not entirely submerged or floating.

The orders to which the aquarium plants belong are:—*Sagittaria* to the *Alismaceæ*; *Cabomba* to the *Nympheaceæ*; *Vallisneria* to the *Vallisneriaceæ*; *Myriophyllum* to the *Halorrhagidaceæ*; *Ludwigia* to the *Onagraceæ*; *Nitella* and *Chara* to the *Characeæ*; *Anacharis* to the *Vallisneriaceæ*; *Ceratophyllum* to the *Ceratophyllaceæ*; *Hippuris* to the *Halorrhagidaceæ*; *Fontinalis* to the *Musci*; *Potamogeton* to the *Naiadaceæ*; *Callitriche* to the *Callitrichaceæ*; *Utricularia* to the *Lentibulaceæ*; *Proserpinaca* to the *Halorrhagidaceæ*, and *Heterania* and *Hottonia* to the *Primulaceæ*.

It may be noted that when it is the habit of an aquatic plant to carry part of its foliage above the surface of the water, better results will be obtained by rooting it in soil instead of in the sand or pebbles and covering the surface with a layer of pebbles; for, though many will thrive either rooted in the pebbles or floating unattached, as they derive nearly all of their nourishment from the water, when set in shallow dishes with soil they are more likely to root, thrive and develop satisfactorily in the aquarium.

SAGITTARIA

A small genus of very variable plants of which the number of species differs with different authorities, and, though there are quite 100 specific names, Micheli has reduced them to 13 species, 4 of which are doubtful. They are widely distributed in temperate and torrid regions, and in shallow water are effective foliage plants, most of which have the arrowshaped leaves from which the name is derived, with small buttercuplike flowers in successive whorls on an erect scape. They are perennials of easy culture, many propagating both by runners and seeds, grow on the muddy bottoms of shallow streams, ponds and lakes, raising their leaves above the water. In the beds of rapid streams, when exposed to a vigorous current, the leaf blades are almost entirely changed to the form of a spade, and not infrequently all traces of lamina are absent and the leaf is lengthened to form a limp, flat, pale-green ribbon much resembling *Vallisneria*. This is characteristic of *S. natans*, *S. pusilla* and *S. sinensis* or *S. gigantea*, which are grown in aquaria and successfully in shaded ponds in summer.

Sagittaria natans (Mul.) or Floating or Ribbon Arrowhead, Fig. 112, is a variety of *S. pusilla* and is the best of all aquarium plants, generally to be had of dealers in aquatics, who propagate it in tanks and aquaria. It originates in a tuft on the bottom of the water and spreads by runners usually in the direction of the strongest light. The clear-green linear leaves are nerved their entire length and

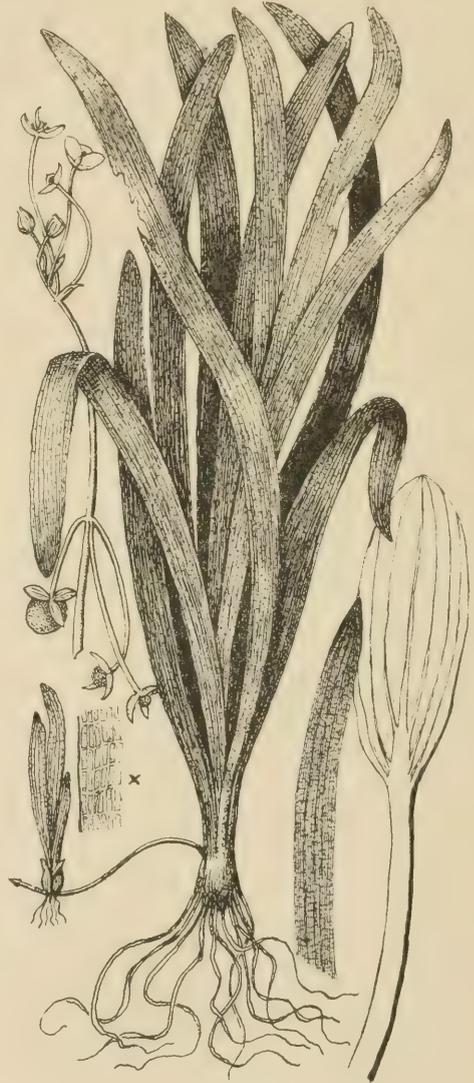


FIG. 112
Floating Arrowhead,
Sagittaria natans, with rhizoid, blossom, fruit, details of leaf
and a floral leaf. Reduced one-third.

exhibit clearly veined and distinctly outlined cellular structure, grow to and float immediately below or on the surface of the water, and in midsummer develop lanceolate emersed and floating floral leaves resembling those of other species of the Arrowheads. The small, inconspicuous white flowers have three petals with yellow centres and are developed in 2 to 4 whorls about a long floating scape. These extend above the surface until the flowers are fertilized, but the fruit ripens on or below the surface of the water. *S. natans* is an exotic which may be obtained from dealers and is in such constant demand that its extensive propagation would be a profitable industry. In replanting it is advisable to take off the partly decaying outer leaves that the younger growth may become more active.

Sagittaria pusilla (Nutt.) or Slender or Subulate Arrowhead is similar to *S. natans* but a more slender-leaved plant, sometimes but a few inches high, with narrow linear submerged and lanceolate floating leaves, and the flowers in one whorl $\frac{1}{2}$ to $\frac{3}{4}$ inches across, with broad filaments. Grows from New York to Alabama along the coast line and may be had of dealers.

Sagittaria sagittifolia (Linn.), (var. *S. floreplena*), or Long-beaked Arrowhead is a slender species with double flowers. This is a very variable form and many species have been referred to it, among them *S. sinensis* (Sims.) and *S. gigantea* (Hort.), the cultivated broad-leaved or giant aquarium sagittaria, and also the semi-aquatic Arrowhead, known to florists as *S. chinensis*. *S. sagittifolia* develops the sagittate leaves above the water in the flowering season and grows in swamps and streams in New Jersey and Pennsylvania to Alabama. *S. sinensis* is native south of the Carolinas on the Atlantic slope, and is also propagated in tanks and aquaria. *S. mulertii* is probably a hybrid of *S. natans* and *S. sinensis*. These Sagittarias are generally to be had of dealers.

Sagittaria graminea (Michx.) or Grass-leaved Arrowhead is an erect glabrous and simple-leaved plant rarely over 2 feet high, with flat broadly-linear or lance-elliptical and pointed leaves which are purplish in the Spring. The small flowers are white and in 2 or 3 whorls. Grows in shallow water from Newfoundland to Ontario and South Dakota, and south to Florida and Texas.

Sagittaria latifolia (*S. variabilis*), (Willd.) or Common American Arrowhead is variable in stature and shape of leaves, and may be only a few inches or 3 feet in height. The leaves are mostly sagittate with long basal lobes, but run to very narrow forms. The flowers are clear white with slender filaments. Common everywhere in ponds and lakes and may be had of dealers. Will thrive in the aquarium.

Sagittaria lancifolia (Linn.) or Lance-leaved Arrowhead is an erect and slender plant with the scape sometimes 4 to 5 feet high. The leaves are variable and may be lanceolate or narrow oblong, nerved with a thick midrib, and the flowers white in several whorls. Native in the United States from Delaware to the tropics.

Sagittaria montevidensis (Cham. and Schlecht) or Giant Arrowhead is a very large plant which may grow to 6 feet in height with leaf blades 1 to 2 feet long and 3 to 5 inches across. It is native to South America but has been naturalized in the southern part of the United States on both the Atlantic and Pacific coasts. It will grow in pots and thrives fairly well in the house. May be had of dealers. Quite generally used in Aqua-terraria.

For aquarium culture *Sagittaria* should be planted in bunches or clusters of three to five plants with the lower tufts deeply set directly into the sand or pebbles, so that the runners will remain covered. The younger plants will be the most likely to thrive in transplanting, as the older leaves usually die down in the fall and winter season, and sometimes after transplanting, but the tufts continually develop new foliage. Those species of *Sagittaria* which bear linear leaves and remain submerged the greater part of the year are preferable for the house aquarium; those which grow above the surface are handsome foliage plants rather than efficient oxygenators.

CABOMBA

Of the aquarium plants those most generally obtainable are the Cabombas, the botanical name taken by Linnæus from the aboriginal Guianese, but popularly known as the Watershield, Fanwort, Fish Grass, Washington Grass, etc. It is a genus of three species, native to the warmer parts of America, all of similar habit, rooting in the mud and sand of streams, ponds and lakes, and having slender branching stems which grow to a length of several feet. It is a submerged plant except in mid-summer, when the flowers are borne above the water accompanied by the floating floral leaves. The submerged fanshaped leaves are finely dissected, opposite or sometimes verticillated, and the floral leaves small and entire. The tiny flowers are white and yellow, and the fruit enclosed in a prickly pod or casing.

Cabomba caroliniana (Gray.) *C. viridifolia* (Hort.) or Carolina Watershield, Fig. 113, is the species most usually to be obtained of dealers and is largely grown for the aquarium purposes in Maryland, District of

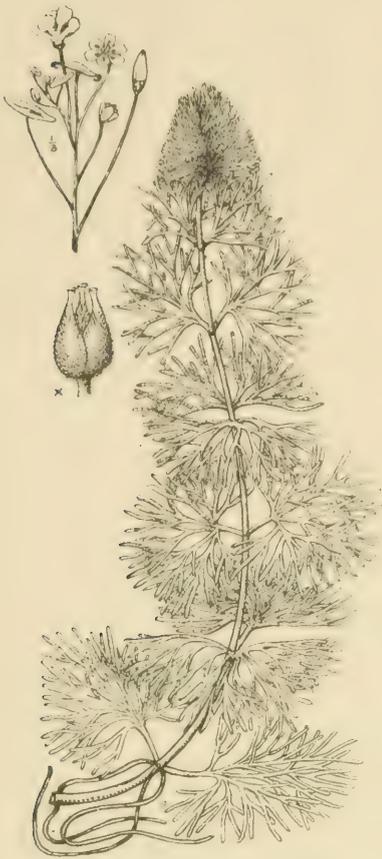


FIG. 113. Fanwort, *Cabomba caroliniana*, floral leaves, blossoms and fruit. Reduced one-third.

Columbia and North Carolina. It is a submerged creeping plant which develops rootlets on the lower part of the weak and flexible stems, having the bright-green submerged leaves opposite in pairs, finely dissected and fanlike in appearance, with small entire oblong-linear emerged leaves which appear when the plant blossoms. The small flowers are white with two yellow spots at the base of each of the 4 to 6 petals and with 4 to 6 stamens and 3 or 4 persistent sepals. The fruit is enclosed in a prickly pod with one seed in each cavity.

Cabomba rosafolia (Hort.) or Red-Stalked Watershield is a species similar to *C. caroliniana* but of a darker green color on the upper surface of the submerged leaves and the under surface a delicate pinkish-red. The stems are purplish-red and the flowers yellow with white stamens. It is a beautiful aquarium plant which retains its fine colors only in plentiful direct sunlight, and is not as hardy as the first-named species, thriving best when set into soil covered with pebbles.

Cabomba aquatica (Aubl.) or Tropical Watershield is a native tropical American species which has been introduced into the United States. It is of pale yellowish-green color, delicate and of handsome growth, as the fanshaped leaves are fuller and more spread and the joints closer to each other than in the other species. The floating floral leaves are nearly orbicular and the flowers yellow with pink stamens.

In the aquarium *Cabomba* will sometimes root but thrives as well when the stems are cleared of leaves a little distance at the ends and set into the sand or pebbles. Propagation is usually by pinching off pieces which will soon grow to considerable length, as at the joints along the stem rootlets will be projected which floating in the water sustain the plant. All the *Cabombas* are excellent oxygenators, and thrive in the household aquarium. They are offered by dealers bound in bundles with block-tin fastenings which serve as a weight to retain the plant in a natural upright position in the water, but it is advisable to separate them, planting

in smaller groups of two or three stalks, to prevent sloughing-off at the constricted binding.

VALLISNERIA

This aquatic plant, found in freshwater all over the world, is an excellent aquarium aerator, belonging to the order of Vallisneriaceæ, named for Vallisneri, the Italian naturalist, and is a genus of but one universally distributed species, the *Vallisneria spiralis*, Eel or Tape-Grass, also known as Wild Celery, due to its imparting a celerylike flavor to wild fowl.

Vallisneria spiralis (Linn.) Fig. 114, is a hardy plant with linear or strap-shaped five-nerved leaves of the same breadth their entire length and 1 to 6 feet long, dependent upon the depth of water, arranged in fascicles at the end of the creeping stems and attached to the mud or sand by root-fibres. In the axils of these leaves, buds are produced which constitute the starting points not only of new shoots growing parallel to the bottom and developing foliage buds at the extremities, but of others which grow upward. Shoots are also developed terminating in a kind of bladder composed of two concave bracts overlapping each other, within which the flowers are enclosed. Of the individual plants some develop pistillate or female flowers only and others staminate or male flowers, both small and inconspicuous. The female flowers develop on very long spiral scapes and split when the stigmas have reached the pollen-receiving stage and the flowers are thrust above the water. The male flowers are borne on short stalks near the bottom; which, when fully developed, break away from their stalks, rise to the surface, and as they float about convey the pollen to the female flowers and so fertilize them; after which the long flower stalks twist themselves into tight spirals and draw the flowers below the surface, there to ripen the fruit.

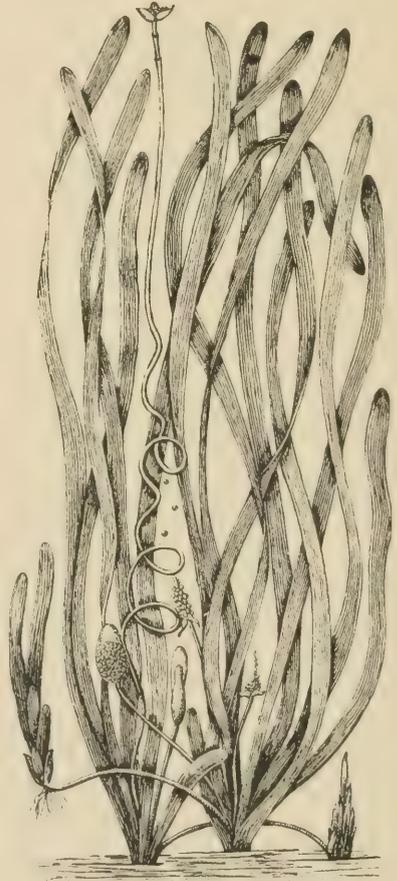


FIG. 114. Eel Grass, *Vallisneria spiralis*. Male and female plants. Reduced one-half.

In the natural state *Vallisneria* usually dies down to the tuft in the cold winter season, but in the aquarium it may thrive the entire year and is a very graceful and ornamental plant and an excellent oxygenator. It may be distinguished from the ribbon *Sagittarias* by the narrower and more uniform width of the leaves, their usually rounder and more blunt tips, their thinner, more distinctly nerved and veined appearance and the more sharply defined midribs; also the distinct close nerves at both edges of the leaf and the absence of the cellular structure, which is very marked in the leaves of *Sagittaria*. In the aquarium it should be planted deeply and the runners kept well under the pebbles or sand. The young spring growth is most likely to survive and become acclimated to household conditions.

A cultivated variety, *V. spiralis gigantea* (Hort.) recently developed, has $\frac{1}{2}$ inch broad and 1 to 3 feet long leaves. It grows better in aquarium conditions than the common native form, and may be had of florists who propagate aquatic plants.

MYRIOPHYLLUM AND PROSERPINACA

These aquatic plants are of the same family, the former very hardy and common to most ponds and still water in the United States, and two species of the latter native in eastern North America. The botanical designation of *Myriophyllum* is from the Greek and means ten-thousand-leaved, the common English names being Water-milfoil or Spikewort. It is a genus containing 15 to 20 species found from the frigid zone to the tropics, of which the three forms hereafter described may be found in water courses or procured of dealers, but any of those mentioned may be introduced into the aquarium. It is a fairly good oxygenator but does not always keep in full foliage indoors. All have pinnate submerged leaves finely divided into threadlike segments, in whorls about a weak stem, and entire or serrate floral leaves. The species indigenous to the United States and to North America are:—*M. spicatum*, Spiked Water-milfoil; *M. verticillatum*, Whorled Water-milfoil; *M. alternifolia*, Loose-flowered Water-milfoil; *M. tenellum*, Slender Water-milfoil; *M. humile*, Low Water-milfoil; *M. heterophyllum*, Various-leaved Water-milfoil; *M. pinnatum*, Pinnate Water-milfoil; and *M. farwellii*, Farwell's Water-milfoil; with the so-called *Proserpinaca* or Parrot's Feather as an additional species of the same genus.

Myriophyllum spicatum (Linn.) or Spiked Water-milfoil, Fig. 115, is the most generally distributed, and native from Newfoundland, Manitoba and the Northwestern Territory to Florida on the Atlantic slope, and Iowa, Utah and California. The submerged leaves are finely dissected into capillary divisions and grow in whorls of 4's and 5's; the small floral leaves ovate, entire or serrate, usually shorter than the flowers. The flowers

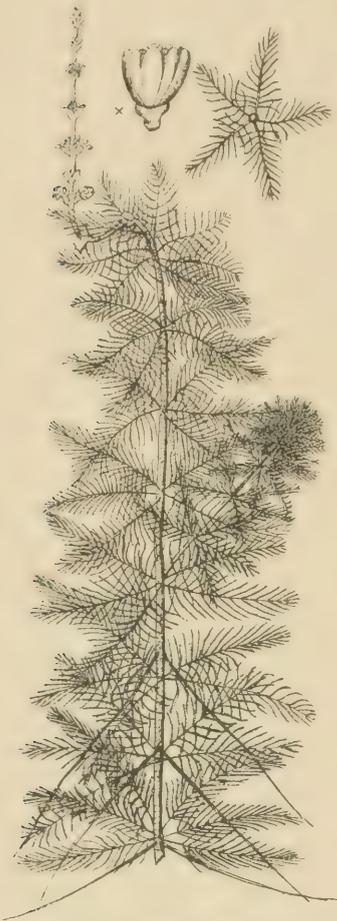


FIG. 115 Spiked Water-milfoil, *Myriophyllum spicatum*, whorled leaf, flower stalk and blossom. Reduced one-half.

are small and white, and the carpels rounded on the back with a deep and wide groove between; also thin, smooth and sometimes slightly rugose.

Myriophyllum verticillatum (Linn.) or Whorled Water-milfoil has the submerged leaves in more dense and crowded whorls of 3's and 4's, the capillary divisions very long and slender, usually finer than the above. The pectinate floral leaves are much longer than the purplish staminate flowers which have 8 stamens. May be found in both deep and shallow water from Quebec to Florida; west to Minnesota and in California.

Myriophyllum alternifolia (Gray) or Loose-flowered Water-milfoil has the submerged leaves in whorls of 3 to 5 or occasionally scattered; with finely pinnate capillary divisions and the spikes short, numerous or several on a branching stem. The floral leaves are ovate-linear, entire or minutely toothed and smaller than the 4-petaled, staminate pale rose-colored flowerets, with 8 stamens, and the carpels rounded on the back and deeply grooved. Found in Canada and the northern United States border and may be had of dealers.

Myriophyllum nitschei (Moenk) or Full-branching Water-milfoil, is a recently developed German aquarium variety having many-branched stems and beautiful long and slender leaves. It is named for the German fish-culturist, Nitsche and was developed by him from *M. verticillatum*. The slender leaf filaments are from $1\frac{1}{2}$ to 3 inches long.

As previously stated, *Myriophyllum* will thrive in the aquarium but does not grow entirely satisfactory as it loses its fine appearance. The stems often become denuded of leaves, the plant assumes a dusky appearance and the younger growth is irregular and straggling. Its principal use is in the spawning of goldfishes and is introduced into the spawning-beds in loose bunches bound at the lower ends with metallic strips. For this purpose it is the best and most easily handled aquatic plant, though goldfishes sometimes prefer the roots of the Water Hyacinth for spawning.

Proserpinaca. This species is known botanically as *Myriophyllum proserpinacoides*, meaning forward creeping, and popularly as Parrot's feather

or Chilian Water-milfoil, Fig. 116. and emersed leaves are alike and grow in whorls of 4's and 5's about a creeping stem. The minute white auxillary and pistillate flowers have 4 stamens and develop 4 carpels. Small hairlike white bracts are borne at the base of the leaves and among the flowers. The finely pinnate, brilliantly green leaves and their graceful habit in growing above the water has made this a very desirable plant, but it is an indifferent oxygenator, as the submerged leaves soon slough off and the rapidly growing plant sends its green crown of leaves 4 to 6 inches above the surface of the water.

The pectinate-pinnatifid submerged

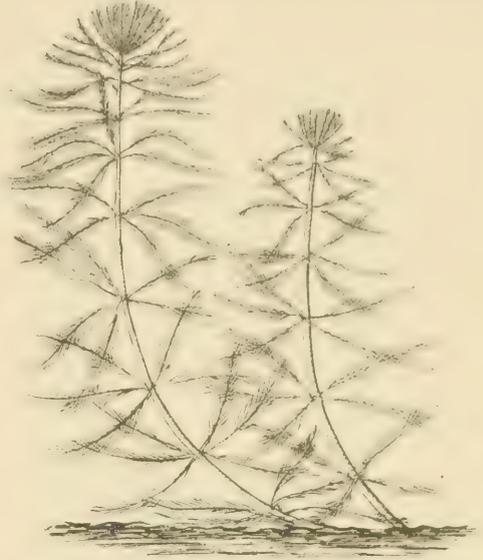


FIG. 116. Parrot's feather, *Myriophyllum proserpinacoides*. Emersed leaves. Reduced one-fourth.

The emersed leaves fold together at sundown to again open after sunrise. It is a beautiful semi-aquatic plant, and is extensively grown in watertight hanging baskets or jars where the fine single stems hang over the sides in handsome festoons.

In addition to the above described form there are two species of true *Proserpinaca* found in the United States, viz, *P. palustris* and *P. pectinata*, generally distributed in the Southern States.

Proserpinaca palustris (Linn.) or Common Mermaid-weed, Fig. 117, is not an indigenous plant but is now native to swamps from New Brunswick to Lake Huron and south to Florida, Iowa, Cuba and Central America. It is an aquatic herb with single stem and alternate dentate leaves about a weak stem. The perfect flowers are stigmatic above the middle with 3 or 4 styles, and the bony fruit has one seed in each

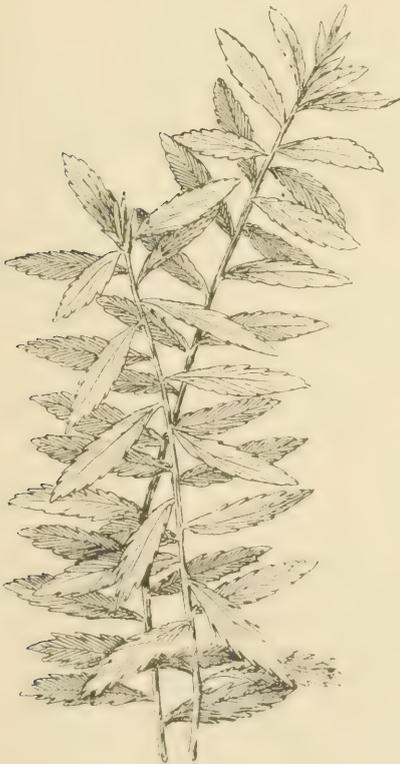


FIG. 117. Mermaid-weed, *Proserpinaca palustris*. Reduced one-third.

cavity. It is half-hardy plant introduced from Chili, of most delicate vivid green foliage composed of finely cut leaves. Flowers in July and August.

Proserpinaca pectinata (Lamm.) and *P. pectinacea* (T. and G.) or Cut-leaved Mermaid-weed may be found in sandy swamps near the coast from Massachusetts to Florida and west of Louisiana. Flowers June to September. Somewhat similar to the above. As will be seen by the illustration, these plants differ in appearance with Parrot's feather, the so-called *Proserpinaca* of the aquarium. They are tender-leaved plants and do not usually survive in household aquaria.

LUDWIGIA

Of the so-called Swamp Loosestrife, named for the German naturalist Ludwig, there are about 25 aquatic or semi-aquatic species native to warm and temperate regions and abundant in the United States and North



FIG. 118. Marsh Purslain, *Ludwigia palustris*. Reduced one-third.

America; the most generally distributed being the following, of which the popular names indicate the character; and also several introduced species extensively cultivated for the aquarium. They are beautiful foliage plants of most attractive colorings. Those most generally to be obtained are:—*Isnardia palustris* or *Ludwigia palustris*, Marsh purslain or False Loosestrife; *L. polycarpa*, Many-leaved Ludwigia; *L. sphaerocarpa*, Globe-fruited Ludwigia; *L. glandulosa*, Cylindric-fruited Ludwigia; *L. linearis*, Linear-leaved Ludwigia; *L. alternifolia*, Alternate-leaved Ludwigia; *L. hirtella*, Hairy Ludwigia; *L. alta*, Wing-stemmed Ludwigia, and several Ludwigianthas and Isnardias, kindred species of similar habit and character; all fairly good oxygenators for aquarium and aqua-terrarium culture.

Ludwigia palustris (Linn.) or Marsh Purslain, Fig. 118, is a recumbent or floating aquatic, rooting in the mud of ditches and swamps, having opposite spatulate leaves, acute at the apex and narrowed into a slender petiole or stem; with axillary flowers having bractlets at the base of the calyx, triangular lobes and reddish petals. The branching and erect stems are of purplish-red color and the submerged leaves a golden-red and pale-green, and the emersed leaves a lustrous dark-green, all having distinct

red midribs and nerves. Grows abundantly in ditches, streams and ponds in the entire eastern and western sections of the United States. Flowers June to November.

Ludwigia glandulosa (Linn.) or Cylindric-fruited Ludwigia, Fig. 119, has larger, more acutely spatulate leaves than the foregoing, and is a very abundant form in still water along the Atlantic coast line. The seed carpels are either ovate or round in form. It is known to aquarists as Wild Ludwigia, and the sometimes crisped leaves somewhat resemble the cultivated *L. mulertii*.

Ludwigia mulertii, or Mulertt's Ludwigia, Fig. 120, is said to be a South American species, introduced as an aquarium plant by Mr. Hugo Mulertt. The leaves are more lance-oblong than *L. palustris* and the

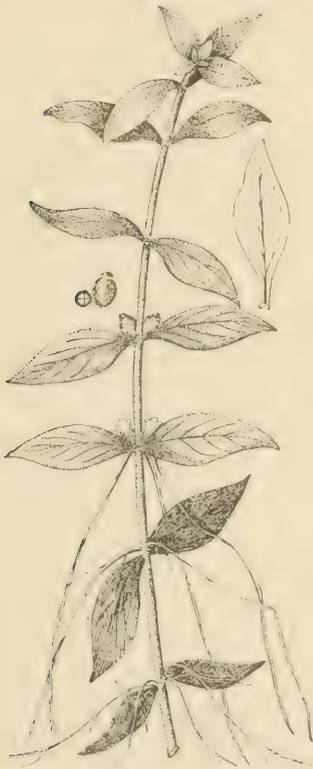


FIG. 119. Cylindric-fruited Ludwigia, *Ludwigia glandulosa*. Reduced one-third.



FIG. 120. Mulertt's Ludwigia, *Ludwigia mulertii*. Reduced one third.

brilliant coloring more permanent. The flowers are yellow. This plant has become widely distributed among growers of aquatic plants and is highly prized for its fine appearance and graceful habit in the aquarium. It is easily propagated from cuttings.

Ludwigia alternifolia (Linn.) or Alternate-leaved Ludwigia, is an erect semi-aquatic shrub and a fine foliage plant which grows to a height of 2 to

3 feet and bears yellow flowers $\frac{1}{2}$ to $\frac{3}{4}$ inch across, and alternate lanceolate entire or finely toothed leaves. Native to bogs in the Eastern and Middle States.

Ludwigia grows luxuriantly in ponds and basins and survives in the aquarium. It should be planted in shallow pots with sod soil or pond mud covered with pebbles. Its fine foliage and handsome colors make it a most desirable aquarium plant.

NITELLA AND CHARA

These dainty aquatics, belong to the order of the Characeæ and are popularly known as Stoneworts. They are good oxygenators and beautiful aquarium plants but the more delicate of them should not be grown in the rearing tanks, as the young fishes may become entangled in their dense growth of hairlike stems and leaves. The generally distributed species are:—*Nitella flexilis*, *N. gracilis*, *N. tenuissima*, *Chara coronata*, *C. gymnopus* and *C. crinita*. Fig. 121.

Nitella flexilis (Ag.) or Flexible Nitella grows to a length of 20 to 30 inches in deep water and has a very slender erect and flexible stem with heavy and long threadlike node-bearing leaflets either single or divided into two abruptly pointed segments. The spores or fruitlets are formed in the middle of the branching leaves. Common in streams and still water.

Nitella gracilis (Sm.) or Slender Nitella, Fig. 122, is more hairlike than the above with the nodes more widely separated and the leaflets somewhat shorter. The spores are formed in the axils of the branching leaves. Usually to be found in ponds and streams. Morris Pond and Schuylkill River. A desirable aquarium plant.

Nitella tenuissima (Desv.) or Clustered Nitella has very slender 2 to 6 inch long sparingly branched stems and leaves in close verticils, three or four times divided, with the first segment the longer. Native in New York, New Jersey, Rhode Island and Michigan.

Chara coronata (Ziz.) or Crowned Chara, is a large Ceratophyllum-like aquatic, growing to 18



FIG. 121. Characeæ.
Reduced one-third.
1. *Chara coronata*.
2. *Nitella flexilis*.
3. *Chara gymnopus*.
4. *Chara crinita*.
5. *Nitella tenuissima*.
6. *Nitella gracilis*.
Reduced one-third.

and 20 inches in length, having a tufted stem from a single root. The jointed capillary leaves are often $1\frac{1}{2}$ to 2 inches long and form in whorls of 8 to 11. Quite common throughout America on a sandy soil in shallow ponds and streams. This plant is sometimes mistaken for *Ceratophyllum*, but does not form the thick branching clusters of the latter plant.

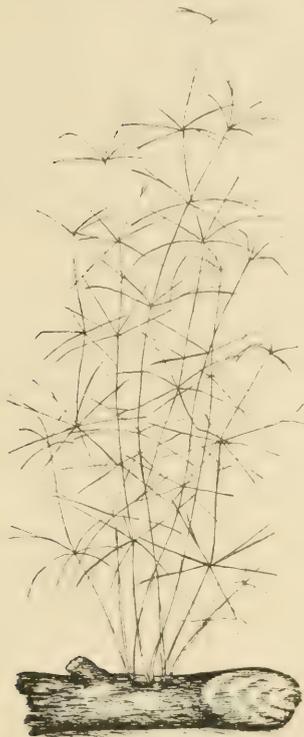


FIG. 122. Slender Nitella, *Nitella gracilis*, attached to a water soaked twig. Reduced one-third.

Chara gymnopus (A. Br.) or Elegant Chara is a slender hairy-stemmed plant growing to a length of 2 feet in deep water and having the verticils of many-celled capillary leaves surrounded by a whorl of stipules. Each leaf usually bears three spores. This beautiful species is not uncommon, new localities coming constantly into notice.

Chara crinita (Wallr.) or Crumpled Chara somewhat resembles *N. tenuissima* and has rigid and erect stems and densely clustered, fascicled hairlike leaves. The tiny spores form in the axils of the leaves. Usually grows to a height of 6 to 12 inches. It occurs more usually in brackish water in the Eastern States, notably in Massachusetts and New York.

Nitella gracilis is a fine aquarium plant but thrives so abundantly that it forms dense masses impenetrable to fishes and snails. When introduced, it should be kept down by frequently removing the excess growth. It is a good oxygenator, as are all the vigorously growing submerged aquatics. The Charas do not grow as well in the aquarium as the Nitellas.

No other aquatics so plainly show the activity of plants in liberating oxygen as this group, particularly Nitella. When the growth is dense in strong sunlight, the oxygen bubbles form on the stems and leaves like suspended clusters of tiny pearls or slender strings of transparent glass beads; and when undisturbed, the plants appear as though hung with jewels. It has been observed that the Paradise-fish seems to prefer this oxygen to breathing the air and will occupy itself for hours in taking them into the mouth for gill absorption.

Together with the Nitellas, Confervæ and other large Algæ are usually introduced into the aquarium, the principal of these being the so-called Frog-spittle, Nostocs and Zygnemæ, hereafter more fully described. These seem rather to be associated with the Characeæ than parasitic, and

will develop even after the larger plants have been cleaned before introduction into the aquarium. The dense growth probably acts as a shelter for these film-like algæ or more secure anchors for their development.

ANACHARIS

This mosslike aquatic plant is variously known to botanists as *Anacharis*, *Philotria* or *Elodea* and commonly as *Waterweed*, *Ditchmoss*, *Water Thyme*, *Water Pest* and in the British Isles as *Babington's Curse*. There are 4 or 5 very similar American species which bloom from May to August, but are also propagated by a plentiful production of offshoots which, attached or separate, rooted or floating, grow with amazing rapidity in any ditch, stream or pond throughout the United States and North America except the extreme north. It is a slender wholly submerged plant with fragile jointed and branching stem, 4 inches to 3 feet long, dependent upon the depth of water, so weak that it mats together and decays when the water is withdrawn. The male and female flowers are borne on separate plants. The pistillate flowers are raised to the surface by their long calyx tubes and the minute staminate flowers break off and rise to the surface to shed their pollen. The fruit ripens below the surface of the water. The plant also forms heavy buds in the Fall, which drop to the bottom and develop in the following Spring. It is a veritable pest, as it chokes up canals and waterways.

Anacharis canadensis (Mich.) *A. alsinastrum* (Bab.), Fig. 123, is the species most generally to be found and has a weak jointed stem with the leaves in whorls of 4's to 8's or the lower leaves opposite, linear and minutely toothed. The white pistillate flowers develop on calyx tubes from 2 to 12 inches long.

The Common *Anacharis A. canadensis*, Fig. 123, thrives fairly well in the aquarium, is a good oxygenator, but is so weak and fragile that it will easily break into sections. It should be planted in the sand or pebbles in groups of 4 to 10 stalks. Freshwater fishes and goldfishes feed upon the leaves and in the aquarium frequently entirely destroy the plant. When found in cold water streams the plants are more robust and the leaves



FIG. 123. Ditchmoss or *Anacharis*, *Anacharis canadensis*; also a modified form and leaves. Reduced one-fourth.

broader, fuller and more pointed than those of quiet or stagnant water, which probably caused it to be considered a different species. It is a very pretty aquarium plant but difficult to maintain in satisfactory condition, except with such fishes as will not molest it.

Anacharis canadensis gigantea or *Eloдея canadensis gigantea* (Hort.) Fig. 124, is a cultivated species derived from *A. canadensis*, the most generally distributed native form. It has a thick jointed stem and leaves



FIG. 124 Giant Anacharis, *Anacharis canadensis gigantea*, Hort.
Reduced one-third.

1 to 1½ inches long, in whorls of 4 to 8, with a dense cluster of the long slender leaves at the ends of the stalks. It usually grows without much branching. In general appearance it considerably resembles *Hippuris* and is an attractive aquarium plant which grows to a length of 3 to 4 feet below and on the surface of the water. Its color is a delicate greyish-green, the younger growth usually a bright green, sometimes marked with white. Less fragile than *A. canadensis*, it is a good oxygenator, of most rapid growth, which thrives with or without roots, set directly in the pebbles or sand or in small pots with soil. May be

had of dealers in aquatic plants. In small aquaria, intended for the propagation of aquarium snails, it is preferable to most of the other aquatic plants. Together with *Cabomba* it is easiest to be obtained, and is a most satisfactory plant for the novice in aquarium study.

CERATOPHYLLUM

This generally distributed aquatic weed, commonly known as Hornwort, is free-suspended in every stage of development and is shifted in position by every current, though the submerged species of this genus mostly occur in slow streams and still water. Absorption is carried on by

the epidermal cells of the foliage leaves and not by roots, though the lower leaves may assume a rootlike character. The Hornworts have weak and slender widely-branching and floating stems with verticillate leaves, which appear in thick clusters on the younger growth and branches. It is not a desirable aquarium plant as it is too fragile and requires careful attention, may decay in a brief period, contaminate the water, and cause the death of the fishes. Several species have been proposed, based on the spurs, spines or wings of the fruit but none of these distinctions are of value.

Ceratophyllum demersum (Gray), or Common Hornwort, Fig. 125, has long or short slender submerged floating stems, dependent upon the depth of the water, as it is characteristic of the plant to form thick mats immediately below the surface. The linear 2 to 3 times divided and forked leaves grow in verticils of 5's to 12's on a weak and fragile stem. The flowers are insignificant, either white or yellowish in color, of which the male and female are distinct. The former consists of about 15 sessile anthers and the latter of a small one-seeded ovary, but both surrounded by a whorl of very small bracts, while the fruit is oval with either a straight and spinelike beak, smooth or with a basal spur, or tubercular with narrow winglike spiny lower margin. Grows freely in ponds and slow streams throughout North America except in the extreme North. European authorities mention two other species, *C. submersum* and *C. platyacanthum*, not generally known in the United States. They are probably natural variants of *C. demersum* the universally distributed species.

Podostemon ceratophyllum (Linn.) is another aquatic bearing the name Ceratophyllum. It is popularly known as River Weed or Threadfoot, and is a dark green rather stiff plant, firmly attached to the stones in running streams. The densely tufted leaves are narrowly linear and sheathed at the base, but split above into filiform segments. It resembles *C. demersum* but is coarser and rougher in appearance. The white flowers are $\frac{3}{4}$ to $\frac{7}{8}$ inch broad, spreading from the spathes; and the oblong-oval capsules are borne on a

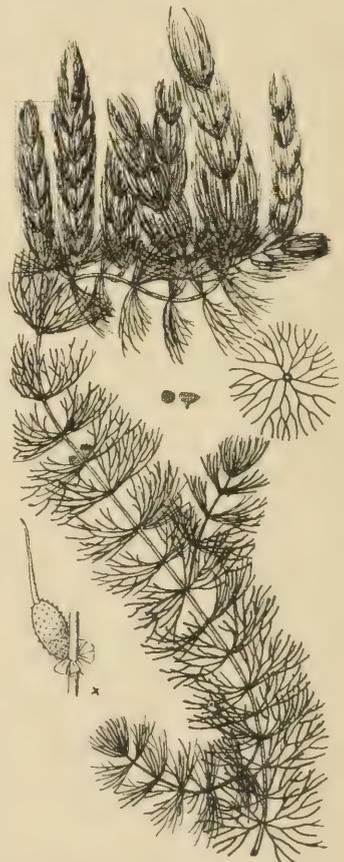


FIG. 125. Hornwort, *Ceratophyllum demersum*, whorled leaf, blossoms and enlarged seed carpel. Reduced one-third.

scape of about their own length, with recurved stigmas. Only one species is known in the United States, which occurs in shallow streams from Massachusetts to Northern New York, Ontario and Minnesota to Georgia, Alabama and Kentucky. Flowers July and August.

A few stalks of *Ceratophyllum* make a fine appearance in the aquarium, as the growth there developed is more delicate, brighter green and finer in appearance than that of the ditch, pond or stream.

HIPPURIS

This genus consists of a small group of aquatic herbs with simple erect stems and verticillate entire leaves, small axillary flowers and a one-celled, one-seeded fruit. There are three known species native to north temperate and lower arctic regions and southern South America.

Hippuris vulgaris (Linn.) or Bottle Brush, Joint-weed, Mare's tail, etc., Fig 126, has a slender stem and linear or lanceolate acute leaves in crowned whorls or verticils. The flowers have stamens with a short thick filament, comparatively large two-celled anthers and ovoid seeds hollow in the interior. The plant is native to swamps and bogs in Labrador and Greenland to Alaska; south to Maine along the shore of Lake Superior, in the Rocky Mountains to New Mexico and along the Pacific Coast.

Hippuris tetraphyllum (Linn.) *H. maritima* (Hell.) or Four-leaved Mare's tail, is a smaller species with obovate or oblanceolate entire leaves in verticils of 4's and 6's at the base of the stem. Native to Labrador and Canada to the United States border and in Alaska.



FIG. 126. Mare's Tail, *Hippuris vulgaris*, and enlarged fruit. Reduced one-half.

Hippuris has the character of *Anacharis canadensis*, but is larger, stiffer and more erect, growing 12 to 15 inches above the water. It largely takes the place of *Anacharis* in northern waters and was introduced into the Middle States by aquarium fanciers in 1898, but has recently been superseded by *A. canadensis gigantea*.

FONTINALIS

This genus of aquatic moss contains a quite considerable number of universally distributed freshwater species, two or three of which thrive in the aquarium. Ten species are recognized as native to the United States and

of these *F. antipyretica*, *F. gigantea* and *F. gracilis* are most easily obtained and best serve for aquarium purposes. The young foliage has a fine green color but changes to a dusky brown with age. A few sprigs, attached to the stone upon which they grew or in soil may be introduced if the aquarium is exposed to a good light.

Fontinalis antipyretica (Linn.) or Willowmoss, Watermoss, Fig. 127¹, has broad ovate and acuminate entire sharply plicate leaves with the borders reflexed on the side towards the base, in two or three rows, more or less imbricated and sharply keeled. The bracts are also closely imbricated and the capsules ovate-oblong with a conical lid and bright coral-red peristome or cap. The plant adheres to rocks, submerged wood and stones in rivers and cold-water streams, and flowers in summer. Its name is in allusion to the use for which it is often applied, that of filling in between chimneys and walls to exclude the air and prevent the spread of fire. It is a fairly good oxygenator.

Fontinalis gracilis (Schp.) Fig. 127² is a generally distributed species very much more slender and mosslike than the above, with divided stems considerably denuded of leaves at the base. The tiny leaves are narrow and often split to the keel, the carpels smaller and usually contracted below the mouth. Common to most ponds, rivers and often rapid streams, sometimes associated with the above.

Fontinalis gigantea (Sull.) is a very robust Willowmoss, less branched than the above with wide leaves, less acute or curved at the base, of a coppery brown color, having small capsules and less perfect peristomes. Found attached to stones and stumps by the side of the water, but less generally distributed than the two above species, and in more southern latitudes.

There are a number of other varieties of the Watermosses which are more rare and not so often met with. Their purpose in the aquarium is more for their singular and interesting appearance than special utility.

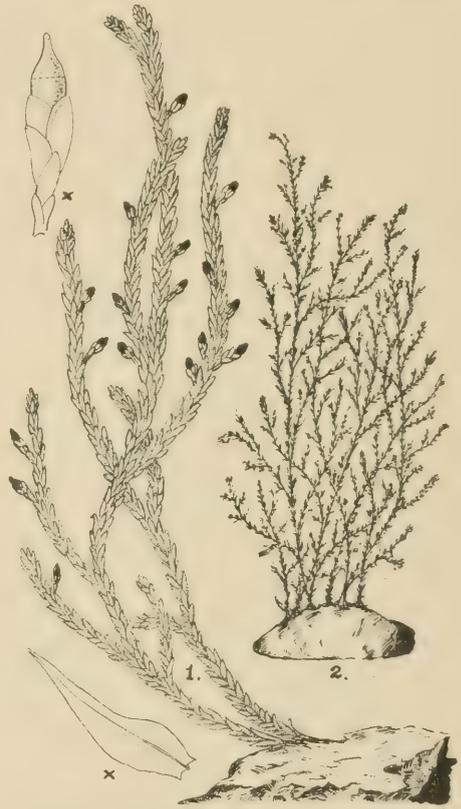


FIG. 127. Willowmoss. 1. *Fontinalis antipyretica* with enlarged leaf and fruit carpel. 2. *Fontinalis gracilis*. Reduced one-third.

POTAMOGETON

About 40 species and sub-species of *Potamogeton*, also known as Channel, Pond or Riverweed, the latter from the Greek significance of the botanical name, are native of North America. They are all weedy plants which attach themselves to the bottom of ponds, shallow lakes, streams and canals and grow so luxuriantly as to choke the waterways. They are also known as Stink-grass on account of the rank fetid odor of the plant when exposed to the sun on the banks or shore. In many of the species there are two kinds of leaves, the narrow submerged and the broader floating leaves, which surround the small green flowers consisting of 4 stamens and usually 4 one-ovuled ovaries. The fruit is a small nutlet containing a coiled or hooked embryo. Four species have come into slight notice in American water gardens.

Potamogeton crispus (Linn.) or Curled-leaved Pondweed, Fig. 128, has a dark green stem and beautiful dark olive-green, two-ranked serrulate and crisped linear leaves with a compound midrib and the outer nerves near the margins. The ovoid fruit has a small embryo with its apex pointed directly towards the base, and the peduncle or stem recurved on the fruit. It occurs generally in fresh, brackish and salt water from Massachusetts to Pennsylvania and in Virginia, and flowers in August.



FIG. 128. Curled-leaved Pondweed, *Potamogeton crispus*; and Spear-leaved Pondweed, *Potamogeton lanceolata*, with winter bud. Reduced one-third.

Potamogeton lanceolata (Linn.) or Spear-leaved Channelweed or Pondweed, Fig. 128, is generally distributed in all running and stagnant waters, forming thick almost impenetrable mats that obstruct the streams; and, as it is one of the fragile species, it often occasions the stoppage of turbines and water-wheels, especially in the late fall when it sheds its foliage. In this species the winter buds may be readily recognized. The flowers appear in July and August and consist of a cluster of tiny green pedals about a thick scape and the fruit is a hard nutlet with one or sometimes two grooves on the back; the embryo forming a spiral of one and a half turns. Native in almost all parts of the United States and North America.

Potamogeton natans (Linn.) or Common Spade-leaved Floating Channelweed or Pondweed, Fig. 129, has long and almost leafless stems with short narrow pointed submerged leaves, rounded

at the base, and larger simple sparingly branched ovate floating leaves. The peduncles of the fruit are as thick as the stems and the nutlets are hard, pitted and with two grooves on the back; the embryo forming an incomplete circlet with its apex pointed to the base. Native in canals and streams throughout North America, and flowers in July and August.

Potamogeton densus (Linn.) or Close or Broad-leaved Pondweed, Fig. 129, has single or branching stems, broad olive-green submerged and floating leaves fitted closely to the stem and overlaying each other, having sharply defined midribs. The fruit is obvoid rounded and indistinctly three-keeled and the embryo recurved or spiral. This is a European species which has become naturalized in the United States.

Other frequently occurring species are:—*P. fluitans* or Long-leaved Pondweed; *P. heterophyllum* or Varied-leaved Pondweed; *P. perfoliatum* or Perfoliate (clasping-leaved) Pondweed; *P. compressus* or Flat-stalked Pondweed; *P. pectinatus* or Fennel-leaved Pondweed; *P. lucens* or Shining-leaved Pondweed; and *P. gramineæ* or Grass-leaved Pondweed.

The Potamogetons are easily grown in basins and ponds and may thrive in the Aquarium, *P. densus* and *P. perfoliatum* being especially desirable, the handsome deep olive-green leaves of the former and the clear pea-green leaves of the latter forming a fine contrast with other aquarium plants. They should be planted in soil or pond mud in shallow pots covered with pebbles in the corners of the aquarium. They are mainly propagated by cuttings, and in nature by rhizomes and the peculiar winter buds which remain dormant in cold weather and form new plants in the spring. Botanists are at variance in naming two species of this plant; some designating *C. crispus* as *C. lanceolata* and others classing the shorter-leaved of the latter species *C. crispus* and



FIG. 129. Floating Pondweed, *Potamogeton natans* with blossom; and Broad-leaved Pondweed, *Potamogeton densus*. Reduced one-third.

assigning the long-leaved varieties of *C. lanceolata* with less crinkled leaves to *C. graminea*. This is not essential to the aquarist. The author illustrates the species as he recognizes them. It is a variable genus sometimes difficult of identification.

WATERCRESSES

The Family of *Roripa* or Watercresses contain about 25 species, most abundant in the North temperate zone, of which eleven are native to North America. Of these the species generally distributed in the Eastern and Middle States are:—

Roripa palustris (Linn.) *Nasturtium terrestre* (A. Br.) or Marsh or Yellow Watercress, an erect, branching, glabrous plant having the lower leaves petioled and the upper leaves nearly sessile, with yellow flowers and linear-oblong fruit pods. Flowers May to August. Found in swampy localities throughout entire North America, except the extreme north.

Roripa sylvestris (Linn.) *N. sylvestris* (A. Br.) or Creeping Yellow Watercress has a creeping stem rooting at the nodules, with ascending branches, pinnately divided and toothed leaves and yellow flowers. Found in low ground and wet places from Massachusetts to Virginia and Ohio.

Roripa nasturtium (Linn.) *N. officinale* (A. Br.) or Watercress, Fountaincress, the edible Watercress, has branched floating and creeping stems rooting from the nodules, with odd-pinnate, ovate leaves, and white flowers, and may be found in almost every coldwater brook of North America. Many cultivated varieties have been produced from this species.

Another species is *Roripa hispida*, or Bristly Yellow Watercress which is more seldom met with. It grows on the borders of sluggish streams and ponds.

Of these, Fountaincress and the creeping Yellow Watercress thrive fairly well submerged in the aquarium and all the species make ornate plants for the aqua-terrarium.

Closely related to the cresses is another very desirable plant which thrives in the aquarium, the generally introduced Moneywort.

Lysimachia nummularia (Linn.) or Moneywort, Creeping Loosestrife, also known as Creeping Jenny and Herb-twopence, is a border plant that overhangs the water and develops roots which take their sustenance from the water. It has a glabrous, creeping stem, rooting at the nodules, with opposite, broadly ovate leaves, obtuse at both ends and solitary yellow flowers. This plant thrives satisfactorily in the aquarium, either rooted in soil or in pebbles; and may be found in moist and wet places from Newfoundland to New Jersey, west to Indiana; and to be had of florists. It is a fairly good oxygenator and a fine foliage plant in the aquarium where

it has taken the place of Watercress. It should be introduced in loose bunches as it requires strong light to grow submerged and makes a good screen for the fishes. The dark-green, almost circular leaves with their straight stalks strive to reach the surface and give a vigorous thriving appearance to the plant, in fine contrast with the languid appearance of the usual aquatic plants in the aquarium.

CALLITRICHE

The Water Starwort family contains a number of herbaceous aquatic and semi-aquatic species, with slender stems, opposite spatulate leaves and minute axillary flowers, of which the following are native American species:—*Callitriche verna* or *C. palustris*, Vernal or Spring Water-Starwort, Water Fennel; Fig. 130, *C. bifida*, Autumnal or Northern Water-starwort; *C. heterophyllum*, Larger Water-starwort and *C. austenii*, Terrestrial Water-starwort. They are pond or basin plants but generally will not thrive in the aquarium.

Callitriche verna (Lindl.) is probably the hardiest, from the aquarist's point of view, and is the most common and generally distributed species in cold or running water throughout the United States and Canada. It grows in the mud with elongated one-nerved spatulate submerged leaves and most peculiar floating leaves; which, though a moderate distance from each other are arranged to form a rosette, as the stalks of the lower leaves are longer than those near the apex and bring the floating leaves into clusters of 4's, 6's and 8's. The small axillary flowers reach above the surface of the water and bloom from July to September. Native or wherever introduced, it spreads so rapidly as to become a nuisance, and should not be used in lily-ponds. Water Starwort is introduced into the aquarium in small bunches, but either so or floating on the surface is eagerly eaten by goldfishes.



FIG. 130. Spring Water-starwort, *Callitriche verna*.
Reduced one-third.

UTRICULARIA

The Bladderworts are divided into aquatic and marsh species, floating free or rooted in the mud. The aquatic species have finely divided leaves covered with minute bladders, the marsh species rootlets under ground and bladder-bearing leaves. There are about 150 widely distributed



FIG. 131. Greater Bladderwort, *Utricularia vulgaris*; and Lesser Bladderwort, *Utricularia minor*. Reduced one-third.

species of which 14 occur generally in the United States and 3 only in the Southern States.

Utricularia vulgaris (Linn.) or Greater Bladderwort, Hooded Water-milfoil, Pop Weed, etc. Fig 131, occurs in ponds and brooks throughout nearly the whole of North America. The delicate 2 to 3 pinnately divided and much crowded floating leaves have numerous bladders, racemose yellow flowers and long recurved fruit. Flowers June to August and also propagates by winter buds.

Utricularia minor (Linn.) or Lesser Bladderwort, Fig. 131, occurs in bogs and shallow ponds from Greenland, Labrador and British Columbia south to New Jersey, Arkansas, Utah and California. The floating leaves are short, much scattered, with fewer divisions and not as many bladders borne among the leaves. The flowers are pale yellow and the fruit has the peduncle reflexed. Flowers June to September in different altitudes.

Utricularia biflora (Lam.) or Two-flowered Bladderwort, Fig. 132, occurs on the margins of ponds in New Jersey and New York, Massachusetts and Rhode Island to Illinois, south to Louisiana and Texas. The leaves are finely divided with few divisions and are copiously provided with bladders. The flowers are yellow. Blossoms during warm weather, later in the season the farther north it occurs.

Other generally distributed species are *U. gibba*, Humped Bladderwort; *U. intermedia*, Flat-leaved Bladderwort; *U. clandestina*, Hidden-fruited Bladderwort; *U. purpurea*, Purple Bladderwort; and *U. subulata*, Tiny or Zigzag Bladderwort.

The Bladderworts are beautiful floating aquarium plants which thrive satisfactorily indoors. Any of the three described species, and occasionally some of the



FIG. 132. Two-flowered Bladderwort, *Utricularia biflora*. Reduced one-third.

others, are generally to be had and may be planted with the lower ends embedded in the sand or pebbles or loosely floating on the surface of the water. They require a strong light and grow very rapidly. Goldfishes destroy them but with Paradise fishes or for snail culture, they form handsome aquatic gardens.

A peculiar characteristic of the Bladderworts is that they are aquatic insectivorous plants. The bladders are provided with a valvelike trap on their lower sides and when filled with water also probably contain secretions which attract infusoria and small crustaceans, who upon entering are entrapped and absorbed by the plant. Of some species it is reported that they will capture the tiny fry of fishes, though in these latitudes there is no species with bladders sufficiently large to serve this purpose.

HOTTONIA

This pretty marsh herb is commonly known as Featherfoil, Water-feather, Water or Marsh-violet and Water-yarrow. Two species are native to North America.

Hottonia inflata (Ell.) or Water-feather having an entirely submerged spongy close cluster of thick and soft stems with pinnate crowded leaves in verticils and clustered at the ends and joints of the stems. An interesting pond plant but does not usually survive in the aquarium.

H. palustris (Ell.) the second species is more rarely met with, but in Europe is considerably cultivated as an aquarium plant.

FRESHWATER ALGÆ

The Algæ constitute one of the grand divisions of the Cryptogams or flowerless plants, embracing the sea weeds and lower water plants, the Fucas, Ulva and Confervæ. The most of the Fuca and Ulva are marine forms; but in counterdistinction to Algæ in general, the Confervæ are an extensive section of the order of Algæ, consisting of slender, often scum-like vegetation, the best known being the so-called "Frog-spittle." The simpler forms of Algæ, the Nostocæ, consist only of a cell wall containing a colored protoplasmic substance; but in the higher forms the cells are combined into a tissue, and the forms which they assume are more varied than in any other class of plants. Some appear as strings or linear masses, globules, laminæ, etc. In others, the Fucaceæ, a distinct stem, branches, leaflike structures and rhizoids or rootlike structures are formed, but these have none of the characteristics of true plants and consist entirely of cellular tissue.

Each season of the year, every climate, every moist spot, has its species of Algæ. Some may be found in healthy condition frozen into an icicle

or in the heated water of a boiling spring. They are the last vestige of life in the region of perpetual snow or in the heated basin of the geyser. The numerous forms are to be found in every stagnant pool and ditch, rivulets, springs and in all other bodies of water. In pools and ponds the most conspicuous forms are *Oscillatoria* and *Zygnemacia*; the former forming dense floating or attached slimy strata, having fine rays extending from the mass, of dark green, purplish or bluish-black color. The *Zygnemæ* are bright green filamentous masses, usually entangled among the water plants, twigs, etc. When in fruit they become dingy, yellowish, or dirty looking. Late in the season *Rivulæ* and *Nostocs* are often met with. These adhere to larger plants and floating matter and form fine fringes around the stems and edges of the leaves, or little green and brownish globules and small protuberances. Of the river *Algæ*, the *Desmids* are abundant in the spring and summer months, adhering to rocks and water plants; and *Chætophora*, *Scytonema* and *Palmela* are also numerous, often free but sometimes attached to objects in the water.

Diatoms are also classed in the family of *Algæ* and consist of minute silicious organisms which were formerly considered as belonging to the lowest forms of animal life. They are a higher form of *Algæ* and obtain firmness by depositions of silica. Another class, the *Acetabularia*, deposit carbonate of lime.

The mentioned *Algæ* and *Confervæ* are those with which the aquarist becomes familiar, the group being too complex in classification for further description in a work of this character. The common small aquarium species are mentioned elsewhere as they have more or less parasitic character.

Algæ have many useful purposes in the aquarium, as they form a screen on the glass to intense light, serve as a natural food for both the fishes and the scavengers, and have beneficial medicinal properties to fishes. When the growth is of a clear green color and not so thick as to be unsightly, it may be left undisturbed on the glass or removed only from the side through which the contents are viewed; but when the growth, both on the glass and in the water, assumes a brown color, it is indicative of a dead and decaying condition and it is advisable to thoroughly clean the aquarium and refill with fresh water, as the appearance of the *algæ* is a good indication of the water conditions. Excessive growth on the plants is injurious and they should be cleaned to prevent suffocation or the affected leaves removed, but usually the fishes and scavengers, when not overfed, keep them sufficiently clean. It is for this purpose that gold-fishes are kept in tanks with aquatic plants by florists, to keep down both objectional plant and injurious insect life.

Should the growth become so excessive as to destroy the lower leaves

of the plant, they should be removed, the aquarium cleaned and new plants introduced; though this may only occur in large tanks or basins. Excessive growth of some of the larger varieties, especially the Confervæ, may also form such compact masses and mats that even large fishes become entangled and may die of suffocation. These larger algæ and confervæ are best removed with tweezers, the hand, or by entangling the growth about a stick. Aquatic plants taken directly from the pond, especially *Myriophyllum* and *Nitella*, are the usual sources of introducing these objectionable algæ. The microscopic green algæ are sometimes present in aquaria in such numbers as to obscure the contents; often the decomposition of their chlorophyll makes the water brown. A small quantity of a solution of permanganate of potassium in water diluted to a claret color and then added to the aquarium water, will cause their entire disappearance without injury to the animal life.

FLOATING WATER PLANTS

Some of the native and tropical floating plants may be introduced into the aquarium with very pleasing effect. Of these the native species are Duckweed, Floating Pondmoss, and Crystalwort, and the more commonly known tropical species, *Salvinia*, *Trianea*, Frog-bit, Water Lettuce, and the Water Hyacinth.

DUCKWEED

Lemnas or Duckweeds, Fig. 133, occur on every ditch and pool; the five most generally distributed in the United States being *L. minor* or Lesser Duckweed; *L. perpusilla* or Tiny Duckweed; *L. gibba* or Thick-leaved Duckweed; *L. polyrhiza* (*Spirodela polyrhiza*) or Greater Duckweed; and *L. trisulea* or Ivy-leaved Duckweed, the last two least often found in the Eastern and Middle States. They are small flowering plants having pendant roots, and grow by the extension of offshoots from the clusters; and in winter sink to the bottom when the growth of the leaves is checked by frost.

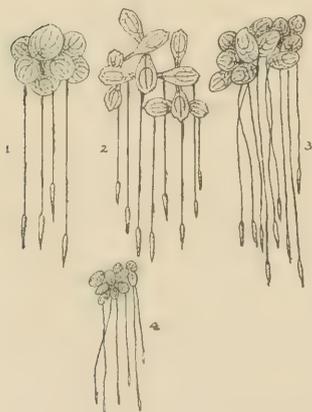


FIG. 133. Duckweed. Reduced one-third.
 1. *Lemna minor*.
 2. *Lemna trisulca*.
 3. *Spirodela polyrhiza*.
 4. *Lemna perpusilla*.

L. minor has nearly round leaves of even, small size and bright green color, with usually one rootlet attached to each leaf. It is very common and during the summer almost covers the surface of ditches and other slow flowing or stagnant water. *L. perpusilla* has a still

smaller elong-ovate leaf and grows in closely matted clusters of dull green color. *L. gibba* has a flat leaf, the larger about $\frac{3}{8}$ inch diameter, of a bright green color, to each of which is attached a single root.

L. polyrhiza has the leaves of varying outline, densely clustered and overlapping each other, of varying shades, from pea-green to light olive-green. *L. trisulca* is a pond variety with the serrated $\frac{3}{8}$ inch leaves of a light green color, which grow most oddly at right angles to each other. It is restricted to some few localities.

All the duckweeds have tiny white flowers but during warm weather increase rapidly by offshoots from the edges of the leaves. In the aquarium goldfishes feed on their roots and leaves and soon destroy them. They are to no purpose as oxygenators.

FLOATING PONDMOSS

This beautiful many-branched mosslike floating plant, known botanically as *Azolla caroliniana*, Fig. 134, consists of clusters of tiny bright red or reddish-brown leaves usually bordered with dark green, and having short roots under the centre of the founts. In warm weather it occurs on slow-flowing streams and ponds in the Eastern and Middle States, but is more generally distributed in Southern waters. It does not thrive indoors in the aquarium and is prized on account of its quaint appearance, having no merit as an oxygenator. Another very similar species is *A. filiculodes*, a northern variety.

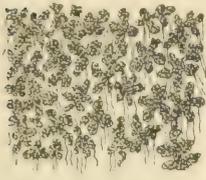


FIG. 134. Floating Pondmoss, *Azolla caroliniana*.

CRYSTALWORT

Two species of Crystalwort, *Riccia fluitans* and *R. natans*, Fig. 135, are sometimes introduced into the aquarium. They are bright-green mosslike plants growing on the surface of still water, of which the first is the most common form and may be found in many coldwater ponds and streams. It has repeatedly forked, threadlike leaves, of which the segmented branches grow about $\frac{1}{2}$ to $\frac{3}{4}$ inch in length; and the second has clusters of heart-shaped leaves with several pendant rootfibres. It is a native of Southern waters. *R. fluitans* thrives fairly well in the aquarium, but as it is brittle and the fishes break it, it soon floats on the surface in fragments or sinks to the bottom to clog the roots and stems of other plants. It has no merit as an oxygenator.

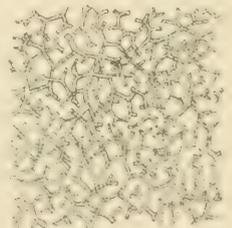


FIG. 135. Crystalwort, *Riccia fluitans*.

SALVINIA

This is the most beautiful of the smaller floating aquatic plants. Two species, *Salvinia natans*, native to the Southern and Southwestern States, and the larger tropical *S. brasiliensis*, are to be obtained of florists. Fig. 136.

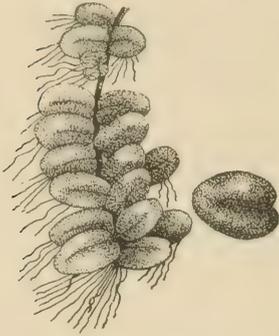


FIG. 136. *Salvinia*, *Salvinia natans*, and a leaf of *S. brasiliensis*.
Reduced one-third.

The leaves of the native species are heartshaped, and of a bright, beautiful green color, and covered with hairlike bristles, the under side of the leaf being a purplish-red. The larger, more circular leaves of the exotic species are pale golden yellow with pea-green tints and a bright-green border; and are more rounded with a depressed centre which gives the leaf a heartshaped appearance. The leaves grow in rows along a fine threadlike stem, and in the moist atmosphere of the greenhouse develop and increase with incredible rapidity, but in the household aquarium soon diminish in size

and rarely survive the winter. Goldfishes eat the roots, which also tends to check the growth. It is the handsomest of the floating aquarium plants but does not serve as an oxygenator. Two new species have recently become known, *S. auriculata* from South America, and *S. elegans* from Mexico.

TRIANEA

This sub-tropical floating water plant, *Trianea bogotensis*, Fig. 137, with its heartshaped, slightly roughened and waxlike green leaves, is an attractive floating plant, which develops with remarkable rapidity in the moist atmosphere of the greenhouse, but dwindles in size of leaf and loses vigor in the household aquarium. The pendant roots harbor infusoria and entomostraca and are eaten by the fishes. It makes a fine appearance in the aquarium, but will not serve as an oxygenator. The leaves develop in the centre of the clusters and the blossom is small and yellow with a white centre.

As a shade plant in out-of-doors tanks, it is to be recommended and grows well during the warm summer months, if not exposed to too strong sunlight. May be had of florists.

FROG-BIT

This floating plant, *Hydrocharis morsus-ranae*, (Hort.) Fig. 138, a European species, never takes



FIG. 137. *Trianea*, *Trianea bogotensis*. Reduced one-third.

root and propagates both by seed and by summer runners, upon which buds are developed which become young plants. The kidneyshaped leaves grow on long stems, and the 1 1/2 inch in diameter flowers have three petals



FIG. 138. Frog-bit, *Hydrocharia morsus-ranae*. Reduced one-third.

upon an erect scape. It is fairly hardy and easy to propagate in ponds in a mild climate, but does not thrive well in the household aquarium. Many of the water insects and most of the pond snails attack its leaves. At the approach of cold weather the leaves decay and the winter buds sink to the bottom of the pond, to

rise to the surface with the advent of warm weather. The plant is subtropical and will not survive very cold weather. Of the floating plants it is one of the largest fancied by aquarist, and the fine white blossoms are attractive and of pretty form. In the greenhouse the plant survives for years. May be had of dealers. A similar plant, the American Frog-bit, *Limnobium spongia*, having dark-green heartshaped leaves, purplish on the under side, is a desirable greenhouse plant, but also will not thrive in the household aquarium.

WATER HYACINTH

The Water hyacinth, *Eichhornia*, is steadily growing in favor with the breeder of the goldfish, as it one of the best spawning plants, in addition to its curious and handsome appearance. The thick floating leaf stalks and dark green, burnished leaves, the long trailing roots, and the beautiful flowers, give it a most ornate appearance. It propagates by seeds and buds which again develop young plants before separating from the parent plant, so that a single Water hyacinth may be developed into many hundreds in a single summer. It is native to a warm climate and difficult to keep over the winter in a cold one, even in the greenhouse. As a shade plant, in the open-air, it is to be recommended, and the easy facility for the removal of goldfish spawn to hatching dishes, which it affords, is a great advantage in its use as a spawning plant. In Florida it has become a plague, as it propagates in such numbers that it chokes the channels

and waterways. May be had of dealers and florists generally. In warmer climates great care must be exercised that it may not get into the streams. Two species are generally to be had in the Eastern and Middle states, *E. azuria*, bearing lavender-blue flowers, and *E. crassipes*, with lilac-rose flowers.

WATER LETTUCE

This curious floating plant, *Pistia stratiotes* (Linn.), consists of a cluster of large, fine, yellowish-green velvety leaves, which in general form resembles garden lettuce, and is about the size of a teacup. It is very handsome in the moist hot atmosphere of the greenhouse, but will not thrive in the household aquarium or in the open air; as it is a shade plant and can not endure direct sunlight. May be had of dealers in aquatic plants.

ORNAMENTAL AQUARIUM PLANTS

A number of beautiful plants, rooted on the bottom but having floating leaves and emersed flowers may be introduced into the aquarium, but in the household there are but few that will grow satisfactorily. The best of these are the so-called Water Poppy, *Limnocharis humboldtii*, a hardy, handsome plant with small oval floating leaves and yellow poppy-like flowers; the Water Clover, *Marsilea natans*, which develops clover-like floating leaves and a delicate white flower; and the Water Snowflake *Limnanthemum indicum*, having small lilylike leaves and a dainty fringed pure white flower, from which it derives its popular name.

Some of the dwarf lilies, *Nymphaea*, may also be grown under favorable conditions, but as they are strong feeders and require abundant rich soil, they are better adapted for large receptacles than the usual smaller freshwater aquaria.

All the above ornamental plants are indifferent generators of oxygen and should be introduced only for their ornamental appearance.

OUVIRANDRA. This unique plant is known botanically by its Madagascar name, meaning Water-yam, and popularly as the Lattice-leaf or Lace-plant. The skeletonized, dark olive-green leaves spread just below the surface of the water from a single stalk or root stock and consist of a mere tracery of many nerves and crossveins, 6 to 18 inches long and 2 to 4 inches broad.

Ouvirandra finestralsis, (Poir.) or Madagascar Lace Plant, Fig. 139, is the finest form, having broad recumbent latticed leaves and 2 white petal-like bodies borne upon spikes about 2 inches long. The Lace Plant is grown in tubs or jars of freshwater, the frequent changing of which is

differed in by authorities. Fishes are not necessary to its growth, but a few snails or tadpoles are required to carbonate the water and to keep down the algæ and scum.

Ouvirandra bernieriana, (Decne.) or Bernier's Madagascar Lace Plant, is a sub-species having leaves with smaller open spaces and four-parted pinkish spikes. The plant is usually smaller than the foregoing. Both these species are grown in the Botanical Gardens at Washington and at the University of Pennsylvania. May be had of dealers in aquatic plants.

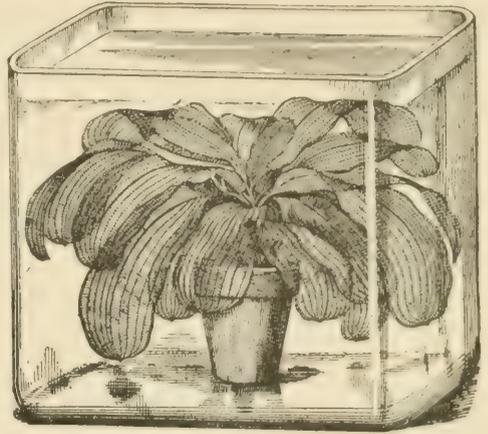


FIG. 139. Madagascar Lace Plant, *Ouvirandra finestrals*.

The water in which these plants are grown should be clean and clear and should be kept at about 65° to 75° F. in a greenhouse. Despite the delicate and lacelike appearance of the plant, the leaves are tough and will stand rough handling.

POND PLANTS

The beauty of lakes, ponds and basins largely depends upon a tasteful and picturesque arrangement of aquatic and semi-aquatic plants both in the water and along the borders. A selection of different species of the Nymphææ or Water Lilies, the Nelumbiæ or Lotus, the Limnachiæ or Water Poppies, and occasional groups of Trapaceæ or Water-nuts, Marsilea or Water Clover, Aponogetonæ or Floating Cape Pond Weeds, Limnanthemæ or Floating Heart, and of Eichhornia or Water Hyacinths will beautify the surface; and clusters of Cabomba, Myriophyllum, Proserpinaca and Ludwigia the lower depths, except in the flowering season; but care must be taken that these latter will not spread too greatly and become a nuisance. Among all these there are hardy species which will thrive perennially when introduced, especially if the ponds and lakes are fed from natural springs that will not freeze solid in the winter.

For the margins and borders a natural grouping of any of the native hardy and readily obtainable Naiads, the semi-aquatic Sagittarias or Arrowheads, the Water Lobelias, the Acorus or Sweet Flags or Calamus, the Pontederia or Pickerel weeds, the Cypera and Papyruses or Umbrella Plants, the Juncaceæ and Cyperaceæ or Rushes and Sedges, the Isoetes or Quillworts, the Orontium or Golden Club, the Peltandra or Arrow arums, and the Ranuncululi, which include the Water Crowfoots

and Marsh Buttercups; also the Cætha or Marsh Marigolds, the Typha or Cat Tails, the Trollius or Globe Flowers, and many others enumerated in the Florists' catalogues, will produce most beautiful foliage and flower effects.

If the pond is a natural basin, the plants may be set into the mud at the borders, but in cement tanks they should be planted in pots and dishes and these screened or hidden with rockwork.

TERRARIUM AND AQUA-TERRARIUM PLANTS. In addition to most of the foregoing aquarium plants, Europeans collect or cultivate a considerable number of native and exotic aquatic and semi-aquatic plants for the terrarium and aqua-terrarium; of which, for brevity, only the botanical names will be given, as the most of them have no popular names. Many of the following may be obtained of florists or collected in bogs, along canals and other natural waterways.

SUBMERGED AND PARTLY EMERSED PLANTS. *Heteranthera reniformis* and *H. zosteræfolia*, *Najas major*, *N. minor* and *N. flexilis*, *Zanichella palustris*, *Hydrilla verticillata*, *Isoëtes lacustris*, *Pilularia globulifera*, *Sulularia aquatica*, *Saururus lucidus*, *Cyperus alternifolium*, *C. gracilis*, *C. papyrus*, *C. laxus* and *C. natalensis*; *Butomus umbellatus*, *Iris pseudacorus*, *Rumex aquaticus*, *Oryza sativa*, *Zizania aquatica*, *Sparganium ramosum*, *Typha latifolia*, *T. angustifolia* and *T. minima*; *Oenanthe fistulosa*, *Richardia albo-maculata* and *R. æthiopica*; *Pontederia cordata*, *Veronica beccabunga*, *Myosotis palustris*, *Acorus calamus*, *Cætha palustris*, *Berula aquatica*, *Triglochin palustris*, *Comarus palustris*, *Isolipis prolifera* and *I. gracilis*, *Scirpus radicans*, *Carex japonica-marginatis*, *Menyanthes trifoliata*, *Menth aquatica*, *Nasturtium officinale*, and many others.

PLANTS WITH FLOATING LEAVES. Other than those already mentioned are *Alisma natans*, *Villarsia nymphaeodes* and *V. humboldtiana*; *Polygonum natans*, *Aponogeton distachyus* and others.

FLOATING PLANTS. In addition to those heretofore mentioned are *Stratiotes aloides*, *Aldrovandia vesiculosa*; and the Mexican species, *Salvinia elegans*.

Of this wide range of plants selection may be made of those best adapted to grow entirely submerged, partly submerged, floating on the water, or together with many species of ferns, on the rocks or planted in pots.

CHAPTER X.

**The Molluscs, Vermes and Hydrozoa
of Freshwater**

FRESHWATER MOLLUSCS

The molluscs of interest to the aquarist belong to two classes. They may be described as animals devoid of bony structure and joints, with soft, thick and tough tunics or mantles, fleshy bodies and calcareous shells of one or two valves; the Gasteropods or Univalves and the Lamelli-branchia or Bivalves. The first of these comprise the snails, limpets and slugs, and the second the mussels and oysters. They have simple digestive systems consisting of a mouth, a canal, digestive glands and anus; a contractile heart of several cavities with but few blood vessels, the blood being forced directly into the organs and through the spaces between them. The breathing structures are either comb-gills or simple air breathing chambers serving as lungs. The nervous system consists of special sense organs and ganglia of nerve substance located at different parts of the organism.

UNIVALVES. Most of the univalves have a single shell, but with some this is rudimentary, in others reduced to a few calcareous granules beneath the mantle, though these latter are mostly land and marine forms. The shells of freshwater snails vary in form and may be flat-coiled, spiral, oval-oblong, elongate or ear-shaped, varying also from a length of two inches and over to microscopic sizes. Some have a horny or calcareous lid or operculum attached to the foot, whereby the aperture is closed when the snail has retired into it. Fig. 140. This is usually marked with curved striations about a central nucleus, the original operculum of the young snail. A mass of muscular tissue forms the foot, constituting the organ of motion, and movement consists of its contraction and expansion from the rear to the front. A part of the foot and the digestive system are enclosed in the shell. The head is distinct and usually has two, sometimes four, tentacles serving as organs of touch and possibly of hearing. The eyes are distinct and may be developed at the ends of a second pair of tentacles or upon longer or shorter pedicels, between, to the side of, or under the tentacles.

In the aquatic species respiration is by gills in the water breathers, or by an air-chamber or rudimentary lung in the air breathers, the entrance to the breathing organs being near the mantle.

The shell is formed by an excretion of carbonate of lime and some

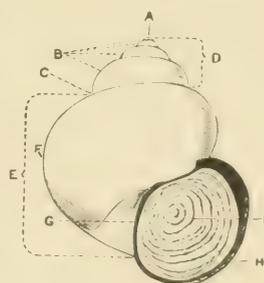


FIG. 140. Outline of a Freshwater snail.

- A. Apex.
- B. Whorls.
- C. Suture.
- D. Spire.
- E. Body whorl.
- F. Periphery.
- G. Inner lip.
- H. Outer lip.
- I. Operculum.

animal matter; the whorls turning about a central columella or pillar, with the outer or body whorl always the larger. The apex is the first growth of the shell and subsequent development is marked by lines of growth indicating a former position of the aperture. When the suture or depression between the whorl, from the apex to the aperture, forms a right hand spiral, the shell is right-handed or dextral, and when turned to the left is left-handed or sinistral. The shell grows by the addition of new layers on the lip or outer edge, but the inner portion of the mantle also forms calcareous matter to increase the thickness of the shell with age. The outer coating is the harder, but the action of the acids in the water often erodes it, whereby the shell may lose some of the whorls. When the erosion has penetrated the interior lining or nacre and the acidulated water comes into contact with the animal, death results.

Reproduction is by eggs, and some of the genera are oviparous, depositing the spawn to hatch, while others are ovoviviparous and hatch the young in the oviduct of the female. The oviparous snails deposit translucent gelatinous masses in which the yolks of the eggs are visible, which enlarge and gradually assume the form of tiny snails with transparent shells and escape from their gelatinous covers to the plant. The ovoviviparous snails bury themselves in the mud and silt and bring forth a number of perfect young, which, though very small, exactly resemble their parents. Some species carry the young with them, inside the shell, until they have grown to considerable size.

BIVALVES. Most of the Bivalves have double-hinged valves or shells, a tonguelike foot, sometimes provided with a byssus or tuft of threads with which to attach themselves. The body of the animal consists of a mantle of two lobes, leaflike gills, one or more siphons or orifices, a heart, stomach, liver, intestines, reproductive organs and muscles, Fig. 141. The valves increase in size by the addition of concentric rings to the outer edges and in thickness by deposits of nacre on the inner side; the umbone or nucleus being the original shell of the young mussel. The valves are united by a hinge which varies in structure with the different species, and are kept closed by adductor muscles connecting them at each end. The interlocking projections of the hinge are known as teeth, and according to their location are cardinal when placed under the beak, anterior and posterior lateral when placed before or behind the umbones.

A set of muscles constitute the anterior and posterior retractors and protractors which control the foot. Mussels have no distinct head, the mantle covering the entire animal and is attached to the valves by a membrane. Under it, on the posterior end, are the gill plates, partly separated by the foot and the viscera, and forming a large cavity. In front of the gills

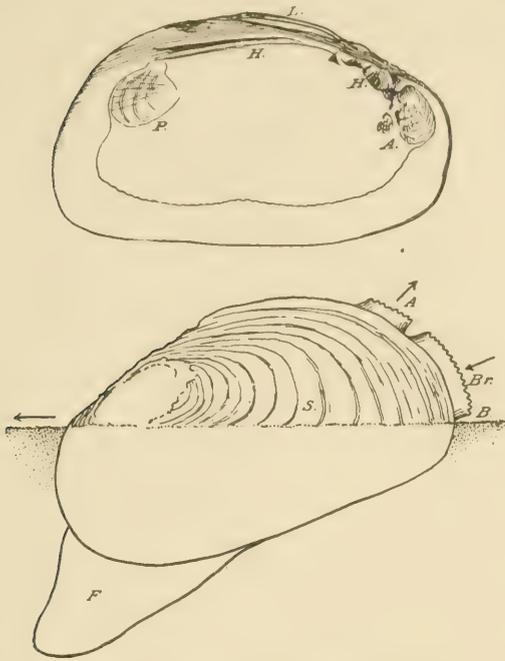


FIG. 141. Diagrams of a Freshwater Mussel.

- B. Beak.
- L. Ligament.
- H.H. Hinge.
- A. Adductor scars.
- S. Shell.
- F. Foot.
- Br. Branchial openings.
- A. Anal opening.

The Arrows indicate direction of the animal and the currents.

are the labial palps, two pairs of triangular flaps and between the gills and the hinge is the pericardium containing a three-chambered heart, and below this the organ which serves as the kidneys. The liver is a compound digestive gland over the posterior portion of the gills and under this is the stomach, connected with the mouth by the oesophagus. The digestive canal consists of an irregular coiled tube which passes through the pericardium to the posterior end of the body. The simple nervous system consists of ganglia at the mouth, foot and adductor muscles.

Respiration consist in taking the water through the inhaling siphon, passing it over and between the gills and out of the body by the exhaling siphon.

These water currents reach the other organs, aerate the blood, convey food to the stomach and carry off the waste materials of the system.

Reproduction varies with the genera, but with most of the freshwater species is the following. The eggs are developed in the ovaries, pass to the gills, where they lodge and hatch. The minute valves are connected by an elastic hinge, the foot only partly developed, as from it extends a number of slender filaments, the byssus. When ejected by the parent, they swim by opening and closing the valves until they come into contact with a fish to which they attach themselves and there undergo a metamorphosis. The byssus disappears, the foot is fully developed, the interior organs undergo material changes and the valves assume the shape of the adult. Then the mussel quits its host and falling to the bottom takes up the habits of its kind.

The hereafter described molluscs are those of fair size which will be of interest to the aquariist, the breeder of aquarium fishes, and the student of natural history in the home aquarium. The nomenclature is that now

adopted by Conchologists and differs materially from that in use prior to the past decade. The classification is in part that of Lang's Textbook of Comparative Anatomy and that of the Academy of Natural Sciences of Philadelphia. Some of the mentioned genera are undesirable in the aquarium and should only find a place in the terrarium or in special aquaria adapted to their study.

CLASSIFICATION OF THE UNIVALVES. Freshwater univalves are of two Orders, the Prosabranchia, gilled or water-breathing snails, including the families of the Neritidæ, Viviparidæ, Valvatidæ, Ampularidæ, Hydrobidæ and Melanidæ in the first Order; and in the second Order the Pulmonata or lung-breathing snails, including most of the land snails and slugs, together with the semi-aquatic family of the Succinea, the aquatic family of the Lymnæidæ, comprising the Lymnæa, Planorbis, Segmentina and Ancylus, and the family of the Physidæ, comprising the Physa and Aplexa.

The following classification will briefly describe these orders, families genera and species, and serve as a key to the subsequent descriptions, which are necessarily confined to Eastern and Middle States snails, though the most of them are also common to other sections of the United States.

ORDER PROSABRANCHEA—Shell spiral, aperture closed with an operculum, gills internal, water-breathing.

Family Neritidæ—Shell semiglobular, aperture closed with an operculum, breathing by gills.

Genus Neritina—*N. reclinata*, *N. showalteri*.

Family Viviparidæ—Shell concoidal or discoidal, aperture closed with an operculum, gills internal.

Genus Viviparus—*V. viviparus*, *V. georgianus*.

Genus Campeloma—*C. decisum*, *C. ponderosus*.

Genus Lioplax—*L. subcarinata*.

Family Valvatidæ—Shell depressed, aperture rounded, closed with an operculum, gills protrusile and plumelike.

Genus Valvata—*V. tricarinata*, *V. bicarinata*, *V. sincera*.

Family Ampullariidæ—Shell globular, depressed at apex, aperture closed with an operculum.

Genus Ampullaria—*A. depressa*, *A. miamiensis*.

Family Hydrobiidæ—Shell globose or subglobose, apex well defined, operculum wingshaped or oval.

Genus Somatogyrus—*S. altilis*, *S. subglobosus*.

Genus Amnicola—*A. limosa*, *A. granum*.

Genus Bithynia—*B. tentaculata*.

Family Melaniidæ—Shell elongated or conical or fusiform with pointed aperture usually subrhomboidal, closed with an operculum.

Genus Goniobasis—*G. virginica*, *G. multilineata*.

Genus Anculosa—*A. carinatus*.

ORDER PULMONATA.—Shell either spiral, conical, merely a calcareous plate, or altogether rudimentary; no operculum in freshwater species, breathing by a simple pulmonary sac; coming to the surface to breathe.

Family Succineadæ—Shell imperforate, thin, ovate or oblong; aperture large, no operculum, breathing by lungs.

Genus Succinea—*S. obliqua*, *S. retusa*.

Family Lymnæidæ—Shell thin, spiral or conical, no operculum, eyes sessile, breathing by lungs.

Genus Lymnæa—*L. stagnalis*, *L. palustris*, *L. columella*, *L. decidiosa*, *L. catascopium*.

Genus Planorbis—*P. bicarinatus*, *P. campanulatus*, *P. trivolvis*.

Genus Segmentina—*S. armigerus*, *S. wheatleyi*.

Genus Ancyclus—*A. rivularis*, *A. parallelus*.

Family Physidæ—Shell sinistral, oblong, thin, spire acute, aperture narrow oval, no operculum, breathing by lungs.

Genus Physa—*P. heterostropa*.

Genus Aplexa—*A. hypnorum*.

NERITINA. These snails are not generally distributed and are seldom met with. They have semi-globular shells consisting of an abrupt, flat spiral with crescent-shaped aperture and are rarely over a half inch in length.

N. reclinata, Fig. 142, the larger native species, has a thick, strong globose-oval shell of greenish-olive color undiluted with faint green lines, polished on the under side, three-quarters inch long, consisting of three

whorls, of which the body whorl takes up almost the entire shell and the spire very short and almost always eroded by the action of acids in the water.

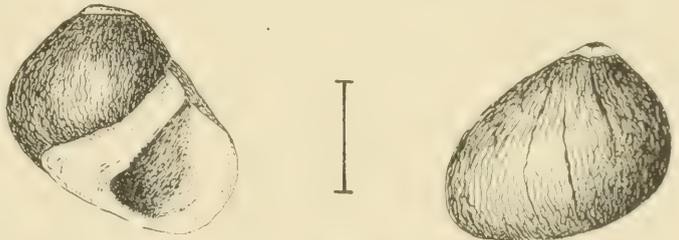


FIG. 142. *Neritina reclinata*. Enlarged.*

The aperture is about four-fifths the length of the shell. The body is pale grey clouded with black, the head dusky, the tentacles long and rodlike, the eye prominent and placed on pedicels at the outer base of the tentacles, which are marked by darker or black lines. The wingshaped operculum has the fanlike striations spread from a nucleus at the upper margin. The snail is native to Florida. Its movements are slow and it does not survive in the aquarium. It is oviparous, laying from 18 to 36 eggs on plants and stones which hatch in 14 to 16 days.

N. showalteri, Fig. 143, is a very rare smaller snail native to Alabama. Its $\frac{1}{4}$ to $\frac{3}{8}$ inch long rather thick shell is smooth, round, semi-translucent,

*The bar, in all cases, indicates the true size.

and of a greenish-yellow horn color. The three whorls are convex, the



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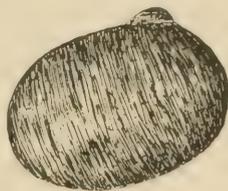


FIG. 143. *Neritina showalderi*. Enlarged.

spire very much depressed and the suture spightly impressed. The body whorl takes up almost the entire length of the shell. The incurved aperture

and the operculum are crescent-shaped, the body of a dusky grey color, the tentacles long and the eyes prominent.

The *Neritina* are widely distributed in Europe and tropical countries but only these two are native to the United States.

VIVIPARUS. These snails inhabit marshy places, still water, rivers and streams. They have the whorl of the shell very convex, an angulated aperture and a horny operculum showing concentric lines of growth. The larger species of the Eastern and Middle States attain a length of shell of $1\frac{1}{2}$ inches. The females of most of the genera have evenly developed, sharply pointed tentacles, while the males have the right thicker and more bluntly pointed. These snails live exclusively on dead animal matter, algæ and confervæ and are harmless to aquarium plants, though not as active as the *Planorbis*. They were formerly classed as the *Paludina*.

V. Viviparus, Fig. 144, the most common species, inhabits ponds and still water. It has a thick, well-rounded oblong olive-green or brownish shell of four or five inflated, sharply defined whorls; a brunt apex and deeply

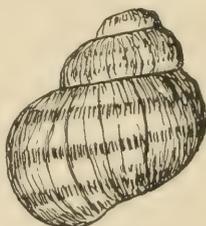
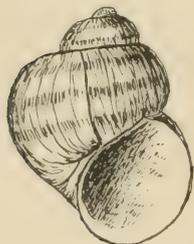


FIG. 144. Potomac Snail, *Viviparus viviparus*.

impressed suture. The body whorl is marked by three well-defined reddish-brown bands which diminish towards the smaller whorls. The thick snout and long, curved, flexible

tentacles and the body are bluish-grey with faint orange and yellow spots. The projecting eyes are placed upon short pedicels under the tentacles, and the foot is bluntly ovate and broad. The operculum is ovate and shows concentric rings. This snail is ovoviviparous, the eggs hatching at different periods in the oviduct, at which time the snail secretes itself in the mud or pebbles. It is common to America and Europe, and is popularly known as the "Potomac snail." Abundant at Washington, D. C.

V. georgianus, Fig. 145, is found in canals, lakes and slow streams, sometimes in ponds and ditches. The shell is brownish-green in color

with usually five yellow bands, more distinctly marked on the body whorl. It has four to five convex whorls, the first a mere dot and the body whorl very wide and exceeding half the shell in length. All are rounded and sharply

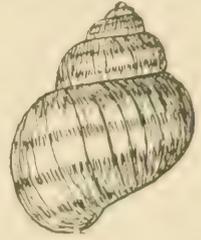


FIG. 145. Georgia Snail, *Viviparus georgianus*.

defined, with impressed suture. The operculum is bluntly pearshaped and thick, with well defined lines. The body is dark brown, spotted with yellow, the snout broad and the tentacles long and divergent. The eyes are placed on the outer bases of the tentacles. It is ovoviviparus and harmless to aquatic plants when sufficiently fed, and bears a close resemblance to the foregoing. Quite generally distributed throughout the Middle and Southern States; first found at Hopetown, Georgia. Known as the Georgian Snail. Also note the Japanese Snail, *V. malleatus* hereafter described.

CAMPELOMA. These snails inhabit still water and slow-flowing streams. The shells are thick, heavy and about as long, but narrower than the foregoing, and the whorls flatter and not as rounded. The larger Eastern and Middle States species rarely exceed $1\frac{1}{2}$ inches in length and most of the species less than $\frac{3}{4}$ inch.

C. decisum, Fig. 146, is common in ponds and nearly all freshwater in the Eastern section of North America, from Nova Scotia to the Rio Grande. The $\frac{3}{4}$ to 1 inch long shell is elongate-ovate, rather thick and heavy



FIG. 146. *Campeloma decisum*.

with a smooth surface not very considerably marked by lines of growth. Its color is greenish with irregularly disposed brown lines of growth and is usually eroded at the apex so that of the five whorls sometimes but two or three remain. The body whorl

is about two-thirds the length of the shell, the aperture oval-oblique more than half the length of the body whorl, and the operculum is elongate-ovate with a thin transparent margin. It is ovoviviparous and harmless in the aquarium, though a considerable feeder and should be furnished with food in addition to the algæ and confervæ. It is found in streams in New

Jersey, the Delaware, Schuylkill and the Susquehanna. Common throughout New England.

C. ponderosus, Fig. 147, is the largest Eastern and Middle States species but not as common as the foregoing. The $1\frac{3}{4}$ inch long polished shell is globosely-ovate, very thick and heavy, with a roughened surface showing very heavy striations of growth; of a greenish horn-color with irregularly disposed brown and black streaks. It has five or six whorls, of which the body whorl is equal to about four-fifths



FIG. 147. *Campeloma ponderosus*.

of the length of the shell, a short spire and a perfect apex, usually eroded. The aperture is oval, narrowed above, slightly oblique, and about half the length of the shell. The operculum is elongate-ovate with a thin margin. The body is a dull brown, the tentacles thick and the eyes prominent and black in color. It is ovoviviparous and is found in New York, the Lake regions, Ohio, Indiana, Illinois, Michigan, Tennessee and Alabama. No experiments with it in the aquarium have been reported.

LIOPLAX. These snails are similar to the foregoing but have parallel sides, the front truncated and the posterior extremely obtusely rounded. The shells are concoidal, elongated and thin, the apex pointed, and the operculum with concentric rings.

L. subcarinata, Fig. 148, is found in Pennsylvania, New Jersey, Ohio, Kentucky and some other of the Middle Western States. The elongated shell is $\frac{3}{4}$ inch long, of a bright brownish-green color with brown transverse lines of growth.

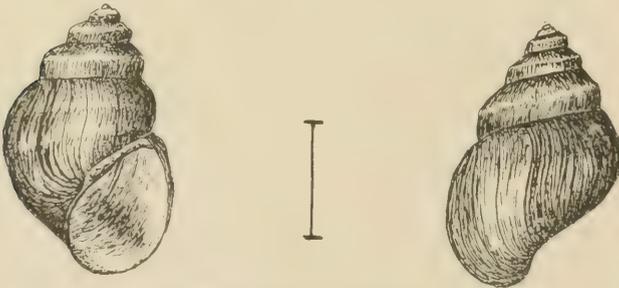


FIG. 148. *Lioplax subcarinata*.

Of the five whorls, the body whorl takes up three-fourths of the shell; the suture is distinct, the apex pointed but often eroded, and the aperture pear-shaped. The lines of the operculum are concentric, and the body a dark grey dotted with orange. It is ovoviviparous. Fine specimens have been taken from the Delaware and Schuylkill rivers and their tributaries. This is the only species of the

Eastern and Middle States and there is but one in the Southern States, *L. pilsbryi* of the Chipola River, Florida, a very rare species.

VALVATA. These small snails never exceed $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter and are principally prized on account of their odd appearance and the curious formation of their water-breathing organs or branchia. Most of the species are almost exclusively vegetable feeding and destructive to plants, and but few should be introduced into the aquarium, though they are comparatively harmless, due to their small size.

V. tricarinata. Fig. 149, has a slightly depressed turbinate, translucent yellowish-and greenish-brown shell $\frac{1}{4}$ inch in diameter, of three to four smooth whorls with faint lines of growth and flattened spire. The body is slightly translucent, the plume-like branchial filaments long, the eyes black, the posterior of the foot extending nearly to the circumference of the shell, and the thin operculum near the extremity of the foot. It is oviparous and vegetable feeding and inhabits the Eastern and

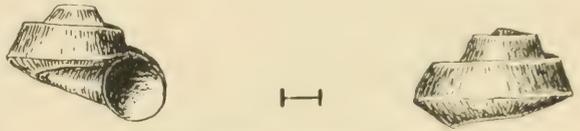


FIG. 149. *Valvata tricarinata.* Enlarged.

Middle States generally, with a kindred slightly larger variety, *V. bicarinata*, Fig. 150, native in the Schuylkill river and its tributaries. It is about $\frac{3}{8}$ inch in diameter.



FIG. 150. *Valvata bicarinata.* Enlarged.

V. sincera, Fig. 151, has a globose-discoidal faintly striated brownish-green shell, consisting of three and a half accurately rounded whorls which enlarge rapidly from the apex. The suture is deeply impressed, the spire flattened and the apex obtuse. This snail is seldom over $\frac{1}{16}$ to $\frac{1}{4}$ inch in diameter and occurs in Vermont and



FIG. 151. *Valvata sincera.* Enlarged.

the Northwestern States. There are other species of the *Valvata* but they do not occur in the Eastern or Middle States.

AMPULLARIA. This family has no members inhabiting waters of the Eastern and Middle States. All the species are large and handsome; but as their size would lead to the inference that they would be destructive to aquarium plants, experiment would be advisable before introducing them, as their food is vegetable and those kept in confinement eagerly devour lettuce. They are nocturnal in habits and seldom appear out of the shell during the day. They are interesting inmates for the Terra-aquarium.

A. depressa, Fig. 152, has a greenish-olive two inches long shell, with a series of ten to fifteen olive bands and yellow margins on the five smooth and polished whorls, which are more or less distinctly marked by lines of growth, a well defined suture and a depressed spire. The operculum is auriculate with the nucleus at the inner margin. The body is grey,



FIG. 152. *Ampullaria depressa*.

striated and dotted with black, the tentacles of the males yellowish-brown and of the females reddish or orange. It inhabits canals and ditches of soft muddy bottom and sluggish current in the middle Southern States, is oviparous and lays 30 to 70 eggs on plants above the water level, which are soft when deposited but acquire a hard shell from exposure to the atmosphere. They hatch in about 12 days and are the size of a large pea.

A. miamiensis, Fig. 153, has a globose, yellowish-brown $2\frac{1}{2}$ inches long heavy shell with moderately impressed suture, a depressed spire and large body whorl. The aperture occupies about one-half the length of



FIG. 153. *Ampullaria miamiensis*.

the shell, the operculum is calcareous and striated, with the nucleus at the upper side. This handsome snail occurs only in Southern freshwater, principally in Florida. Probably the largest native North American species is *A. pinei*, from the same locality, which reaches a length of 3 to $3\frac{1}{2}$ inches.

SOMATOGYRUS. These small snails are quite generally distributed, and on account of their size harmless and inconspicuous in the aquarium. They are slothful in their habits and hibernate in cold water. The shells are pretty and of fine form.

S. altilis, Fig. 154, has a $\frac{3}{8}$ to $\frac{7}{16}$ inch long, smooth, thick, subglobose pale light-green or horn-colored shell of four whorls, with a sharp suture, short spire, nearly rounded aperture and regularly ovate operculum. The body is brownish-grey, the tentacles long and somewhat slender, and the eyes a bright bluish-



FIG. 154. *Somatogyrus altilis*. Enlarged.

black. It is quite generally distributed in the eastern section of the United States and has been found in the Potomac at Washington, and in both the Delaware and Schuylkill rivers. Also occurs in cold water ponds in the Middle States generally.

S. subglobosus, Fig. 155, has a $\frac{1}{4}$ to $\frac{3}{8}$ inch long obliquely transverse subglobose solid polished yellowish-green shell of four whorls, an impressed suture, a short spire and an oblique white aperture. The body is yellowish-brown or grey and the tentacles brown. It is not common to the Eastern and Middle but occurs in the Southern States, principally in South Carolina, but is occasionally met with in



FIG. 155. *Somatogyrus subglobosus*. Enlarged.

Virginia and Maryland and at Washington, D. C.

AMNICOLA. These tiny snails are principally mentioned as they constitute a numerous genus, the Hydrobidæ. They have thin ovate conical shells with acute spires, small oblique, rounded ovate apertures and horny operculæ; are widely distributed and occur abundantly in many localities.

A. limosa, Fig. 156, has a conical very convex yellowish-brown slightly wrinkled $\frac{1}{4}$ inch long shell tinted with grey, of five or six whorls, with deeply impressed suture. The body whorl takes up about one-half the length of the shell. The body is brown and the tentacles of a lighter color. It



FIG. 156. *Amnicula limosa*. Enlarged.

occurs from Maine to Pennsylvania and Ohio, and is very numerous on the muddy shores of the Delaware and Schuylkill rivers.

A. granum is a very small species, not much larger than a pin's head, found in ponds near Philadelphia. It has a slender, conic-ovate yellowish-brown shell, having four or five convex whorls, deeply impressed suture and orbicular aperture. It ranges from Lake Superior to Virginia. Gould mentions another species, *A. pallida*, which has not been described as occurring in the Middle States.

BITHYNIA. These small whorled snails are usually found in ponds, ditches, canals and slow streams of not too cold water. They are oviparous and water-breathing, differing principally from some of the smaller Physa in having the whorl of the shell dextral. They thrive fairly well in the aquarium but are vegetable feeding and indifferent scavengers.

B. tentaculata, Fig. 157, has a glossy grey or horn-colored conical $\frac{3}{8}$ to $\frac{1}{2}$ inch long shell of six rounded whorls, with a distinct suture and pointed apex. The body whorl takes up more than half the length of the shell. The body is almost black, spotted with yellow and the divergent filiform tentacles are long and slender. The eyes are black and set at the



FIG. 157. *Bithynia tentaculata*. Enlarged.

base of the tentacles and the obovate operculum calcarious and brittle. It is a harmless oviparous snail, feeding principally on decaying vegetation. Found quite generally in the Eastern and Middle States.

MELANIIDÆ. It should be noted of this family that it contains many genera and hundreds of species. Almost every river drainage system of the world has either distinct or closely allied forms; those of the United States being the Strepomatidæ, of which there are many local genera, the most common of the Eastern and Middle States being the Goniobases and Anculosa of the Hudson, Susquehanna, Delaware and Potomac basins. For brevity these only are described, the others are closely related similar forms.

GONIOBASIS. This genus has most beautiful conical or fusiform shells, showing faint lines of growth and often series of longitudinal ridges on the seven to ten whorls. Occurs quite generally in flowing waters.

G. virginica, Fig. 158, is a very common species of the middle Atlantic coast States. It has a truncated turreted yellowish-brown $\frac{7}{8}$ to 1 inch long shell, usually eroded at the spire. The eight to ten whorls are marked with a dull reddish line near the base of the whorls, with a second line

near the middle of the body whorl, but one or both are sometimes absent. The slender body is pale orange above and bluish white below, banded by irregular interrupted black lines. It occurs in the above mentioned localities and is very abundant in the Delaware and Schuylkill rivers.

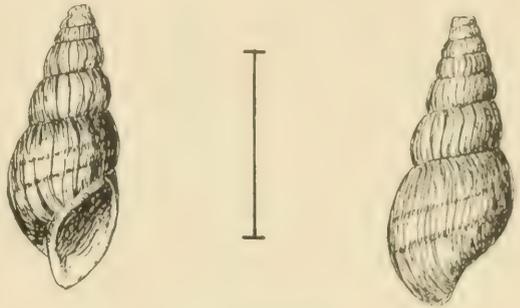


FIG. 158. *Goniobasis virginica*.

G. multilineata, Fig. 159, is also common in the tributaries of the Delaware river and in the Middle States.



FIG. 159. *Goniobasis multilineata*.

It has a gradually tapering very slightly convex $\frac{5}{8}$ to $\frac{3}{4}$ inch long conical yellowish-brown shell of seven whorls marked by a number of reddish or brown bands, a pointed oblong aperture and a usually eroded apex. It is also common to Eastern and Middle States river systems.

ANCULOSA. Many species occur in all the Middle-Western and Southern States but only one species is generally distributed in the Middle States.

A. carinata, Fig. 160, has a conical dark horn-colored or blackish $\frac{3}{4}$ inch long shell, very variable in appearance, with three or four whorls, all more or less keeled on the middle of the whorls. The suture is but slightly indented, the apex often truncated but usually eroded, and the aperture oval and one-third as long as the shell.



FIG. 160. *Anculosa carinatus*.

Varieties of this species are very generally found in streams and rivulets throughout the Middle and some of the New England States.

SUCCINEA. This genus contains the most generally distributed semi-aquatic snails which are only a part of their existence in freshwater, making their homes in marshes and the mudbanks of ditches, ponds and streams and are found in swampy places or on plants along the banks. They are to be distinguished from the aquatic snails by the presence of four cylindrical tentacles, the longer bearing the eyes. They are not desirable in the aquarium, but are frequently introduced with aquatic plants.

S. obliqua, Fig. 161, has a $\frac{7}{8}$ to $1\frac{1}{4}$ inch long, ovate, thin and fragile pale-green or amber shell, which is faintly striated and roseate in color at the apex. It has three whorls



FIG. 161. *Succinea obliqua*.

of which the body whorl is large and much expanded, and about $\frac{7}{8}$ the length of the shell. The spire is very small, the aperture oval and is two-thirds the length of the shell.

The body has a yellowish-brown color which shows through the semi-transparent shell. This snail is quite generally distributed in New York, Pennsylvania, New Jersey and Georgia. It is destructive to aquarium plants.

S. retusa, Fig. 162, has a $\frac{1}{2}$ to $\frac{7}{8}$ inch long somewhat conical ovate-oblong very thin pellucid yellowish-white minutely striated shell of three whorls, of which the body whorl constitutes nine-tenths of the entire shell and tapers gradually to the apex. The spire is short, the suture indistinct, and the aperture four-fifths the length of the shell. The body is a



FIG. 162. *Succinea retusa*. Enlarged.

little longer than the shell, of a translucent greyish color marked with black spots. This snail is found quite generally in the Eastern and Middle States.

LYMNÆA. This numerously represented genus is found in stagnant and sluggish water, ponds and streams; feeding upon waste matter and aquatic plants, as all the genus are herbivorous and a few species also carnivorous. They are active, prolific and thrive in the aquarium, but are destructive and constant feeders, preferring the healthy growing plants to algæ and decaying vegetation; though they are also effective scavengers and devour animal substances and food offal, and sometimes their own spawn. When bred in the aquarium they considerably loose their destructive habits and become feeders on algæ. All are air breathers and will leave the water to rest upon aquatic plants, but only at long intervals. The shells of this family are all dextral.

L. stagnalis, Fig. 163, is the largest representative of this group, the shell reaching a length of $1\frac{1}{2}$ to 2 inches. It is usually of a greenish-white or yellowish-grey color; of six or eight whorls; of which the body whorl is larger, fuller and rounder than the others, which are drawn to a long, graceful dextral spiral, terminating in a finely pointed apex. The suture is

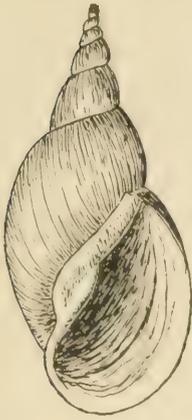


FIG. 163. Niagara Snail, *Lymnaea stagnalis*.

deep and the aperture oval. The body is yellowish-grey with a greenish tinge, spotted with brown and the tentacles flat, triangular and have a backward trend. It is oviparous and the 70 to 150 eggs, deposited at intervals

in cylindrical capsules, hatch in 15 to 20 days. This is one of the most handsome snails, of which a pair or two may be kept in the aquarium without damage to the plants. Its range is over the entire northern latitudes, and in the United States is found from Vermont through the Northern tier of States to the Pacific Ocean. It is popularly known as the "Niagara Snail."

L. palustris, Fig. 164, is a destructive though interesting common snail found in nearly all ditches, ponds and streams in the Eastern Atlantic slope and in Europe. The conical shell is $3\frac{1}{4}$ to $1\frac{1}{4}$ inches long, of a light horn-color on the body whorl and usually a dark horn-color, brown or black above. It has five or six whorls separated by white lines, with the body whorl half as long as the shell.

The ovate aperture is nearly as long as the body whorl and the suture is deeply depressed. The body is dark gray or nearly black, with a violet tint, faintly spotted with yellow and black, and the tentacles flat and conical. It ranges from New England through Pennsylvania and south. Its habit of coming above the water serves as an identification in the aquarium, into which it is sometimes introduced with aquatic plants. The 60 to 80 eggs are deposited in a cylindrical capsule and hatch in 12 to 20 days.



FIG. 164. *Lymnaea palustris*.

The ovate aperture is nearly as long as the body whorl and the suture is deeply depressed. The body is dark gray or nearly black, with a violet tint, faintly spotted with yellow and black, and the tentacles flat and conical. It ranges from New England through Pennsylvania and south. Its habit of coming above the water serves as an identification in the aquarium, into which it is sometimes introduced with aquatic plants. The 60 to 80 eggs are deposited in a cylindrical capsule and hatch in 12 to 20 days.

L. columella, Fig. 165, has an ovate thin and fragile $\frac{5}{8}$ to $3\frac{1}{4}$ inch long shell of four whorls crossed by minute lines of growth. The suture is deeply impressed and conspicuous, the spire narrow and the aperture larger than half the length of the shell. The body whorl is large and expanded, and the



FIG. 165. *Lymnaea columella*. Enlarged.

body partly translucent with the central portion light brown. The tentacles are short and mottled with black. It inhabits the Eastern coast States from Maine to South Carolina, and west to Ohio and the Northwestern States. The spawn is deposited in irregular patches of 50 to 100 and hatch in about 20 days. This species is similar to *Succinea*, but may be distinguished by the spiral line on the shell and the fold on the columella.

L. decidiosa, Fig. 166, has a somewhat inflated thin translucent light-ochre or brownish $\frac{3}{4}$ inch long shell, showing faint lines of growth. The spire is rapidly attenuated to an acute point, and the five whorls are separated by a deep suture, the aperture being one-half the length of the shell. The body is light yellowish-grey, minutely dotted with white; and the tentacles short, broad and translucent. Its range is from New England to the Mississippi and it inhabits rivulets and small lakes.



FIG. 166. *Lymnaea decidiosa*. Enlarged.

L. catascopium, Fig. 167, is very similar to *L. putris* of Europe and has a smooth and polished $\frac{3}{4}$ inch long greyish or yellowish-brown shell with lightly marked lines of growth, and is darker at the apex, with four or five convex whorls of which the body whorl is large, the suture well defined, the spire tapering to an acute point and the aperture one-half the length of the shell. The body is yellowish-brown sprinkled with light-yellow spots; the tentacles are short and the translucent foot as long as the aperture. It inhabits the rivers and streams of Massachusetts and New York near Niagara Falls, and the Delaware and Schuylkill rivers; and is one of the most frequently met with species. It is often introduced into the aquarium with plants. The 20 to 40 eggs are deposited in a transparent yellowish capsule which hatch in about 16 days.

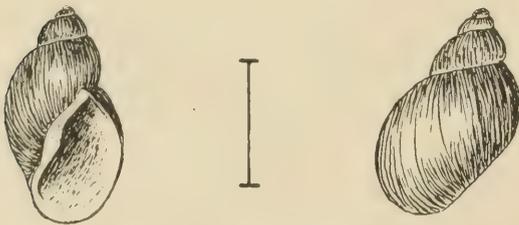


FIG. 167. *Lymnaea catascopium*.

All the native *Lymnaea* should be only sparingly introduced into the aquarium as they make havoc with the plants. Some species sever the

leaves by clean cuts across the blades, others by devouring the edges. If the aquarium is not covered they leave the water and crawling on the glass and over the edges dry out and die. One was found twenty feet from the nearest aquarium.

PLANORBIS. This numerously represented genus has the spiral shell flattened so that the view from above, below and on each side is different. The species vary in size, the largest being one and a half inch in diameter and the smallest less than $\frac{1}{32}$ inch. It is the best native easily procured snail for the aquarium, preferring algæ to any other food, and if not overstocked is harmless to aquatic plants and is a good scavenger.

P. bicarinatus, Fig. 168, has a brownish-grey shell never over $\frac{1}{2}$ inch in diameter, showing pale grey lines in the suture, with more than three complete whorls, angulated on each side with a slightly keeled periphery. The spire is on the left side and is depressed as deeply as on the other side. The body is a dusky or blackish-brown and the tentacles a yellowish-brown, generally of varying lengths. It inhabits quiet waters from New England to Georgia and westward to Tennessee, and will hibernate in cold water. The eggs are deposited from March to July in small irregular yellow masses and hatch in 15 to 25 days, dependent upon the temperature.

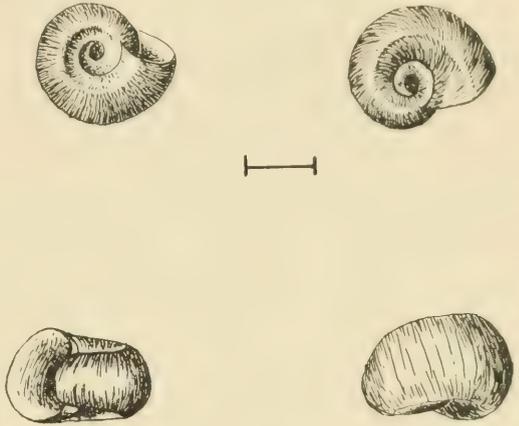


FIG. 168. *Planorbis bicarinatus*, four views. Enlarged.

P. campanulatus, Fig 169, has a yellowish $\frac{3}{4}$ inch in diameter compact shell, consisting of four slowly enlarging flattened whorls, distinctly marked

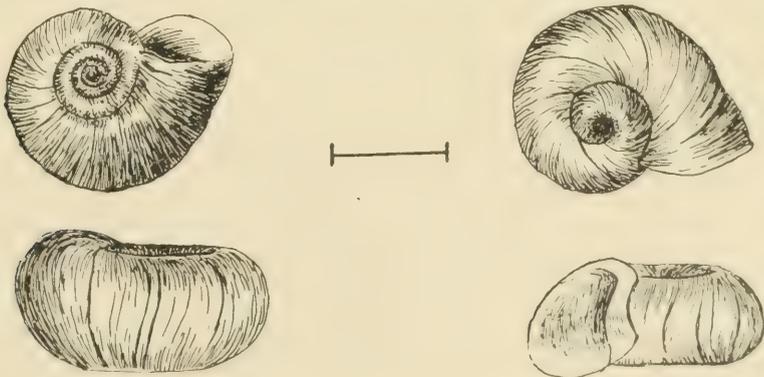


FIG. 169. *Planorbis campanulatus*, four views. Enlarged.

with lines of growth, with the body whorl slightly depressed. The suture is distinct, the apex compressed and the aperture dilated and deflected to the left; the other side showing the whorls nearly as well defined. The body is a dusky brown or russet, and the filiform tentacles are long and marked with dark brown lines. It inhabits streams of colder water in New England, New York, Northern Pennsylvania, Ohio and Illinois, and has been occasionally met with in the vicinity of Philadelphia.

P. trivolvis, Fig. 170, is a very generally distributed species having a laterally flattened $\frac{3}{4}$ to $\frac{7}{8}$ inch in diameter yellowish-green or brown shell, which consists of four and a half cylindrical whorls with finely marked lines of growth, and is slightly keeled towards the left side. The aperture is also deflected to the left. The spire is slightly impressed, nearly level on the right side, but the left side is considerably depressed and the whorls

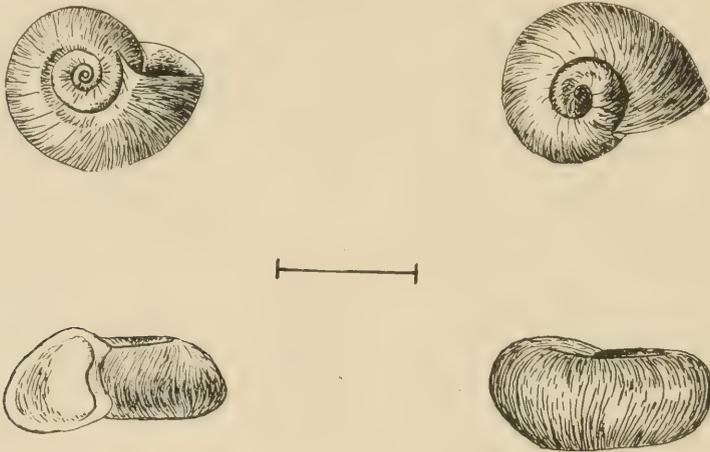


FIG. 170. *Planorbis trivolvis*, four views. Slightly enlarged.

disappear in a depression about two and a half whorls from the apex. The body is dark brown dotted with ochre and the tentacles long and slender. This snail occurs very generally in the Eastern and Middle States and is found in the Delaware and Schuylkill rivers. Its eggs are laid in a yellowish vermiform mass and hatch in 12 to 20 days.

P. magnificus, Fig. 171, is the largest recently known American species, having the flattened sinistral shell very large and heavy, about $1\frac{1}{2}$ inch in diameter and 1 inch high. The upper or spire half of the shell is pale-brown and the lower half dark-brown. The surface is glossy and marked by fine lines of growth. The spire is narrow, the suture depressed, and the summit of the nearly five complete whorls acutely angular and the umbilicus deeply funnel-shaped. The base of the whorls is so narrowly rounded as to appear almost angular. The last whorl is very large, rounded at the periphery, and the irregularly ovate aperture but slightly oblique.

Found at Lower Cape Fear river in the vicinity of Wilmington, N. C. No other locality has been reported.

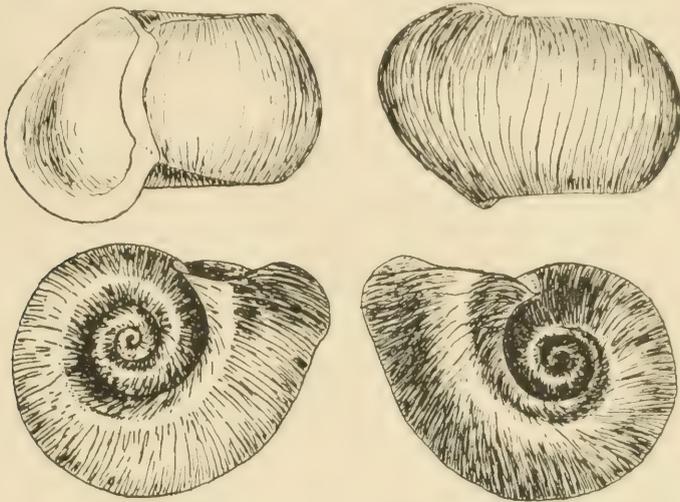


FIG. 171. Cape Fear river Snail, *Planorbis magnificus*. Four views.

There are many other smaller species of *Planorbis* but their size would preclude their use in the aquarium, though they are nearly all hardy and will survive, except the very cold water species.

SEGMENTINA. These snails differ from the *Planorbis* in having projections or teeth within the aperture of the shell, which is discoidal with but few of the whorls visible on both sides.

S. armigerus, Fig. 172, has a light-brown polished shell $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter, with the lip much darker. The four sub-cylindrical whorls are slightly keeled upon the left side and show faint lines of growth. The right side is nearly planed with a slightly depressed centre.



FIG. 172. *Segmentina armigerus*. Enlarged.

The body is a dull grey. It is a tiny insignificant snail to but little purpose in the aquarium. Quite generally met with in the Eastern and Middle States.

S. wheatleyi, Fig 173, is a still smaller species, rarely over $\frac{1}{8}$ inch in diameter, having a slightly keeled shell with the two and a half whorls distinctly outlined on the right side and lost in the depression of the left side. The aperture is at an angle pointing to the left.



FIG. 173. *Segmentina wheatleyi*. Enlarged.

Inhabits rivers and lakes of the Eastern and Middle States.

ANCYLUS. These small snails are popularly known as "Freshwater Limpets" and though belonging to the family of the Lymnæidæ greatly differ from them in appearance. They are sluggish and do not swim or float in the water but adhere to plants or move slowly over the bottom. Their food is principally algæ and aquatic fungi.

A. rivularis, Fig. 174, inhabits slow-flowing streams and may be found on aquatic plants, stones and on the bottom near the margins. The $\frac{1}{4}$ inch long dishlike shell terminates in a broad oval base which entirely covers the snail so that only the tentacles and a part of the snout protrude when the snail is active. It is of pale transparent horn-color, with the body greyish-brown marked with white, having a central yellowish longitudinal line upon the head. About 10 to 16 eggs are enclosed in a round capsule, which hatch in 20 to 36 days. It inhabits the Delaware and Susquehanna rivers and tributaries, and is met with generally in the Eastern and Middle States to Upper Missouri.

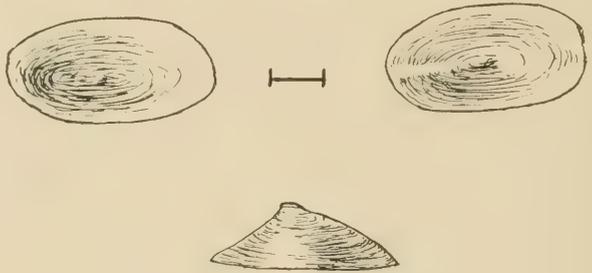


FIG. 174. *Ancyclus rivularis*. Enlarged.

A. parallelus, Fig. 175, greatly resembles *A. lacustris* of Europe, but may be distinguished in having the apex of the shell directed to the right, in opposite direction to the European species. It may be found in still

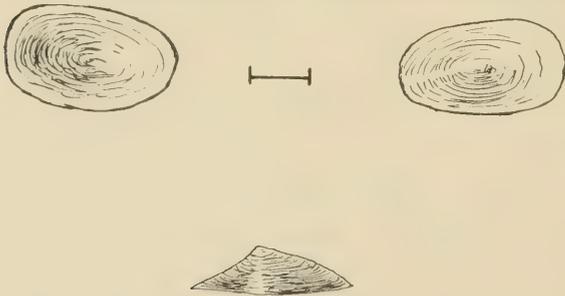


FIG. 175. *Ancyclus parallelus*. Enlarged.

water and sluggish streams on the under sides of floating plants, and has a very thin yellowish mottled shell with a sharp apex and oval aperture. It grows to a length of $\frac{5}{16}$ inch. The body is yellowish grey with the tentacles of a lighter color.

The 6 to 20 eggs are enclosed in a globular capsule and hatch in 16 to 30 days.

Neither of these species of *Ancyclus* long survive in the aquarium as they fall victims to the fishes.

PHYSA. This genus may be distinguished by the left-hand or sinistral turn of the whorls of the spindle-shaped shell. It has no operculum but an extended mantle and two long and slender tentacles. It is not a numerous genus though widely distributed. A sub-genus is *Aplexa*.

P. heterostropha, Fig. 176, reaches a length of shell $3\frac{1}{4}$ inch and is to be found on the water plants of ponds and streams quite generally in the Eastern and Middle States. The elongated translucent polished spindle-shaped shell is ovate, of yellowish-brown color terminating rather abruptly in an acute apex, and the large aperture is oval, about three-fourths the length of the shell.



FIG. 176. *Physa heterostropha*. Enlarged.

Of the four or five slightly convex whorls the body whorl is inflated and more than half the length of the shell. The suture is well marked, the apex pointed and the aperture narrow and longer than the spire. The body is yellowish-grey or darker, dotted with whitish-yellow; and the long and slender tentacles are pointed. It is an active snail but of objectionable vegetable feeding habit. It deposits 6 to 20 eggs in a capsule, which hatch in 15 to 20 days. Found generally throughout the Eastern and Middle States and in the Delaware and Schuylkill rivers. It is frequently introduced into the aquarium with aquatic plants, and is one of the most common freshwater snails.

Aplexa hypnorum, Fig. 177, has a slender translucent highly polished yellowish-brown or ochre shell, of five or six oblique revolving flattened whorls with convex apex and narrow aperture. The body is black, which tends to give the thin shell also a black color. It inhabits stagnant pools and is found in slow-flowing streams of



FIG. 177. *Aplexa hypnorum*. Enlarged.

Vermont, Massachusetts, New York, Pennsylvania and the Western States.

There are many other species of *Physa* and *Aplexa*, but not native to the Eastern and Middle States. As they are largely herbivorous and therefore objectionable in the aquarium they need not be described.

GENERAL REMARKS. Descriptions of the colors of the shells of snails can only be done approximately as they are variable and depend upon the character of the water which the snails inhabit. The presence of iron, for instance, stain them to darker colors or black, while slight acidities bleach them to paler colors. If the empty shells are laid in oxalic acid their true colors will soon appear. Those given are based on the observations of the author, either of living snails in his aquaria or of those in his cabinet collection.

BEST AQUARIUM SNAILS. Experienced aquarists avail themselves of but four species as aquarium scavengers. These are the Planorbis, usually *P. trivolvis*, the larger common species, popularly known in the author's section of the country as the "Ram's horn" or "flat Schuylkill snail;" *Viviparus viviparus* or "Potomac snail;" *Lymnæa auricularia* or "Transparent African snail;" and *Viviparus malleatus* or "Japanese snail." The first two have been already described, the latter two will now be mentioned.

L. auricularia, Fig. 178, is native to the water systems of the Mediterranean and some other parts of Europe. It is a beautiful snail having a peculiar ear-shaped shell with a broad body whorl and the others flattened and rapidly diminishing, and a depressed spire. The shell is of a nearly transparent light horn-color, through which the darker color and the brown and black spots of the body plainly show. It has broad

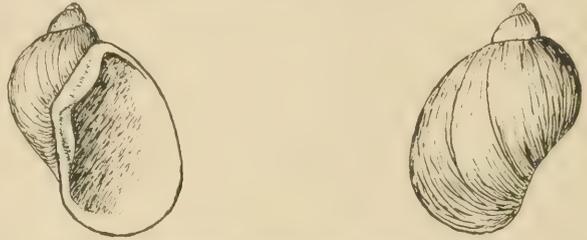


FIG. 178. Transparent African snail, *Lymnæa auricularia*.

and flat conical tentacles, small dark eyes and a broad foot, paler on the under side. It feeds entirely on algæ, decaying vegetation and offal, never attacking growing plants. It is active in habit, never comes entirely above the surface of the water, thrives in the aquarium and is one of its most interesting inmates. It is not as tenacious of life as the first two named, but is prolific and reaches a maximum length of $1\frac{1}{2}$ inches. Its eggs are deposited in long vermiform gelatinous masses on the stems and under the floating leaves of plants and on the glass of aquaria; which hatch in 12 to 20 days, the tiny snails being almost invisible in their transparent shells. This snail is exotic but is extensively bred in the Eastern and Middle States; may sometimes be had of dealers, but is usually obtained by exchange or purchase among aquarium fanciers.



FIG. 179. Japanese snail. *Viviparus malleatus*.
Nearly adult and younger shell, showing keel.

V. malleatus, the Japanese snail, Fig. 179, has now become naturalized at San José, California, in a little valley at the foot of Mount Hamilton. It is an edible snail, known to the Chinese as "Tsen law," which was either planted or accidentally introduced by the Chinese and Japanese of the neighborhood.

They are for sale in the Oriental quarters of some of the Pacific cities, and are collected in the rice fields near Yokahama and there sold for a few cents a quart. They are ovoviviparous, very hardy, most tenacious of life, and when not buried under the pebbles, the most indefatigable "workers" of any of the snails bred as aquarium scavengers. In the author's vicinity they may be had of several breeders who have given them preference to the other three desirable species. The shell is similar to *V. viviparus* but darker in color, lacking the bright color bands, and has a distinct keel in the centre of the body whorl, extending part-way on the next following. They grow to a diameter of 2 inches and over, and their almost entirely black color makes them conspicuous inhabitants of the aquarium. They are harmless to the plants, ravenous feeders on algæ and offal, never at rest and constantly moving over the glass of the aquarium, or feeding on the parasitic algæ on the water plants and on the humus under the pebbles. The young, when they leave the female, are $\frac{3}{8}$ inch in diameter, having a horn-colored, very markedly keeled shell. The Chinese species of the same genus is *V. stelmaphora*, for which the above has been mistaken; but this snail has not been introduced into the United States. The Japanese snail will cross with the Potomac snail, the mixed breed more resembling the latter, as it does not have the keeled shell of the Japanese snail.

For the aquarium intended and equipped for fishes, these four species are particularly recommended. Nearly all the others mentioned are not desirable and should be introduced only when the approved species cannot be obtained. More than one species is also advisable, as they all vary somewhat in their preference of diet.

SNAIL BREEDING. A "snail farm" in which the desirable aquarium snails may be bred is best arranged in a large jar in which there is a luxuriant growth of aquatic plants rooted in clean soil and covered with a thin layer of sand. No fishes or insects should be introduced, as they prey upon the young snails when first liberated from the gelatinous capsules of the oviparous species and the newly born young of the ovoviviparous genera. Feeding with any of the starchy fish foods should be occasionally done, as the young snails thrive better than when entirely dependent upon algæ and decaying vegetation; but this should not be done in excess that the snails may not feed too considerably upon this supply and thereafter become less effectual scavengers. Excessive feeding would also contaminate the water and cause the death of the snails.

When many snails are kept in an aquarium, it is advisable to place a few pieces of gypsum or of plaster of paris, about the size of a large pea, in the tank three or four times a year. These gradually dissolve and

furnishes lime for the shells of the snails without depriving other animal or plant life in the aquarium thereof. All water under natural conditions contain mineral salts, but those of the aquarium may become exhausted, and it is requisite that they should be replaced.

CLASSIFICATION OF THE BIVALVES. Freshwater mussels belong to the order of the Lamellibranchiata and are divided into two families, the Cycladidæ and the Unionidæ. The following classification will briefly describe the order, families, genera and species, and serve as a key to the subsequent descriptions, which are confined to Eastern and Middle States mussels, though many are common to other sections of the United States.

ORDER LAMELLIBRANCHIATA.

Family Cycladidæ—Valves small, suborbicular, hinge with cardinal and lateral teeth, animal with open simple mantle, siphon more or less united, two unequal gills each side, foot large and tongue-shaped.

Genus Sphærium—*S. simile*, *S. striatinum*.

Genus Pisidium—*P. compressum*, *P. abditum*.

Family Unionidæ—Valve large inequipartite oval or elongated, hinge with a simple or divided cardinal tooth in each valve and an elongated lateral tooth, gills free from the abdominal sac with dorsal attached to mantle, upper siphonal opening somewhat fringed.

Genus Unio—*U. complanatus*.

Genus Lampsilis—*L. radiosus*, *L. ochraceus*, *L. cariosus*.

Genus Anodonta—*A. cataracta*, *A. implicata*.

Genus Margaritana—*M. margaritifera*, *M. marginata*.

SPHÆRIUM. These small mussels are generally distributed and have thin, ovate-globose shells, and the hinge has two minute cardinal teeth in each valve, sometimes but one, and compressed marginal teeth. They are seldom over $\frac{3}{4}$ inch long.

S. simile, Fig. 180, is the larger species of the Eastern Section and has sub-oval dark chestnut-brown very convex valves, varying considerably in outline. In the adult the extremities are broader and nearly equally rounded, the posterior part somewhat longer and more pointed and the umbones nearly central; while with the young the light-yellow valves are thin, compressed and the hinge margins nearly a straight line. The surface of the adult shell is concentrically wrinkled with distinct lines of growth, and the hinge has oblique minute cardinal teeth, and those of the margin are distinct, strong and white. The valves are $\frac{3}{4}$ inch long, $\frac{1}{2}$ inch broad and $\frac{2}{3}$ inch thick. The animal is of a light salmon-pink color and

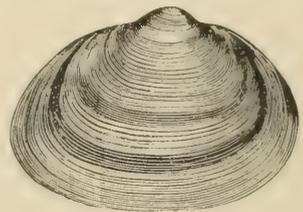


FIG. 180. *Sphærium simile*.
Enlarged.

slothful in movement. It is found in larger ponds and in rivers of the Eastern and Middle States and along the Lakes. This mussel is nearly related to *S. rivicola* of Europe, both in size and in the appearance of the valves.

S. striatinum, Fig. 181, has thin rounded-oval, pellucid, somewhat inflated valves with the umbones central and inwardly inclined. In the adult, they are of light-greenish horn-color and in the young a very light yellowish color, and are $\frac{1}{2}$ inch long, $\frac{2}{3}$ inch broad and $\frac{1}{8}$ inch thick. The animal is of light pink color and its movements are rapid. Found everywhere in the mud of freshwater ditches and streams among the roots of water plants. This mussel is nearly related to *S. cornea* of Europe resembling it in size, shape and generally in color.

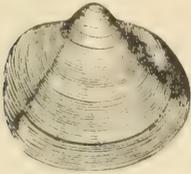


FIG. 181. *Sphaerium striatinum*.
Enlarged.

Other locally distributed *Sphaerium*s are *S. rhomboidium*, *S. tenue* and *S. truncatum*. Both the described species survive in the aquarium.

PISIDIUM. These tiny mussels differ from the foregoing in having but one siphon and are more inclined to inequilateral forms; are not generally quite so thick and are of a lighter color. They vary from $\frac{1}{8}$ to $\frac{1}{4}$ inch in length, are never active, thrive well in the aquarium and often bury themselves for a long period.

P. compressum, Fig 182, has solid, very oblique triangular inflated subequalateral yellow or grey valves with light-blue interior, a thick hinge having small cardinal and distinct lateral teeth. The umbones are prominent and placed a little posteriorly and the valves have a slight beak, the posterior being evenly rounded. The lines of growth are concentric and finely marked. The valves are about $\frac{1}{5}$ inch long, $\frac{1}{8}$ inch broad and $\frac{1}{10}$ inch thick. Found quite generally in the United States and is common to New England, New York, Pennsylvania and Ohio. This mussel considerably resembles *P. conicum* of Europe.

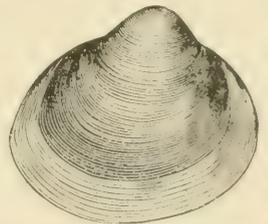


FIG. 182. *Pisidium compressum*.
Enlarged.

Other Eastern States species are *P. abditum*, Fig. 183, *P. æquilaterale*, *P. ferrugineum* and *P. ventricosum*, all still smaller than the foregoing and so tiny as to be of no considerable value to the aquarist.



FIG. 183. *Pisidium abditum*.
Enlarged.

UNIO. These most common freshwater mussels are to be found in ditches, ponds, lakes and streams. Their food is both vegetal and animal, as they subsist upon decaying vegetation, diatoms, algæ, infusoria and other water animalculæ. Their shells often contain pearls, either attached or free in the muscle and gills.

U. complanatus, Fig. 184, is the widely distributed species, found in ponds and streams. The valves vary in form but are usually oblong-ovate, rather compressed and posteriorly the broader. The umbones are mostly eroded and have an obtuse ridge to the posterior tip. The hinge has a single coarsely-striated cardinal tooth in the right and two nearly equal teeth in the left valves. The color is usually a yellowish-green in the younger and brownish-green in the older shells,

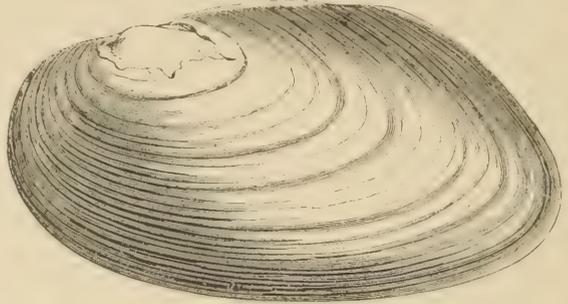


FIG. 184. *Unio complanatus*. Adult.

and is dark green posteriorly at the hinge. The lines of growth are faintly and evenly marked. The valves have an iridescent violet pearly nacre on the inner side with a delicate pink and salmon-yellow edge, and are 3 inches long, 2 inches broad and 1 inch thick at the umbones. The animal is yellowish-and greyish-white with a long foot. It occurs in almost every stream and river on the Atlantic slope and is a most active mussel, often moving several inches in a day. A good and desirable scavenger in the aquarium where it will often survive for years.

LAMPSILIS. This genus of the Unionidæ was formerly classed with the Unios and embraces most of the Eastern and Middle States species.

L. radiatum, Fig. 185, has broad oblong-ovate beautifully striated dull greenish-yellow valves showing distinct lines of growth and overlaid with green and brown rays radiating from the edges of the umbones. It is one

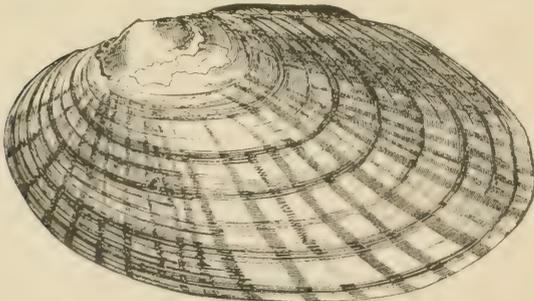


FIG. 185. *Lampsilis radiatum*. Adult.

of the handsomest fresh-water mussels. The interior of the valves shows a delicate iridescent nacre and the hinge has erect cardinal teeth strengthened by a rib behind the anterior muscular impression. It grows to a length of 3 inches, nearly 2 inches broad and

1 $\frac{1}{4}$ inch thick; and may be found in most large ponds and streams, but is not as long-lived in the aquarium as the foregoing.

L. ochraceus, Fig. 186, is variable in form but usually has thin, transversely oblong, sub-ovate, translucent, inflated and widely gaping valves, with elevated and almost touching umbones. The color is yellowish-

brown, finely radiated and zoned with dark olive, and a very dainty rose color or violet tint on the inner side. The cardinal teeth are nearly parallel with the hinge margin and the lateral teeth short and less prominent. It grows to $2\frac{3}{4}$ inches in length, 2 inches broad and $1\frac{1}{4}$ inch thick, but is usually smaller in proportion. It is a New England species rarely found in the Middle and Western States.



FIG. 186. *Lampsilis ochraceus*. Adult.

L. cariosus, Fig. 187, is also variable in form, has moderately thick inflated ovate or rounded valves, with the prominent umbones placed well towards the anterior end of the hinge, which has a straight narrow margin and a sharp obtuse ridge passing towards the posterior tip.

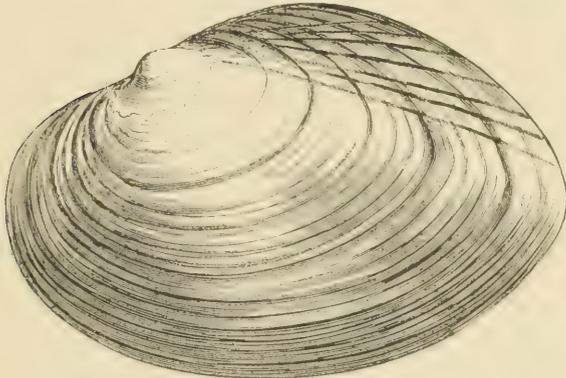


FIG. 187. *Lampsilis cariosus*. Adult.

The valves are sharply marked with lines of growth and have a smoothly polished surface. The color is greenish-yellow or light-olive, with rays of bright-green along the upper posterior margin; and the inside a bluish flesh-colored tint. The cardinal teeth are oblique and the laterals short. It grows to a length of 3 inches, the male being $1\frac{3}{4}$ and the female $2\frac{1}{4}$ inches broad and $1\frac{1}{4}$ inch thick. It is quite generally distributed but most frequently occurs in the Connecticut River and its tributaries. No information is at hand as to its longevity in the aquarium.

ANADONTA. These mussels reach a considerable size and are usually more ovate in form than any of the foregoing. They have siphonal apertures, toothless hinges and sharply defined umbones. They are difficult to keep alive in smaller aquaria, as their food consist most largely of diatoms and infusoria, but will survive in those of running water or in large properly balanced aquaria having abundant plant life. There are two generally distributed species in the Eastern Atlantic States, both of which grow to large size.

A. cataracta, Fig. 188, more generally known as *A. fluviatilis*, greatly resembles *A. cygnia* of Europe and has thin transversely sub-oval inflated valves with distinctly outlined umbones, placed well to the anterior end of

the hinge, which has the margin compressed and considerably curved. The surface is smooth, except at the posterior portion, where it is wrinkled and shows a number of radiations from the upper edge of the umbone.

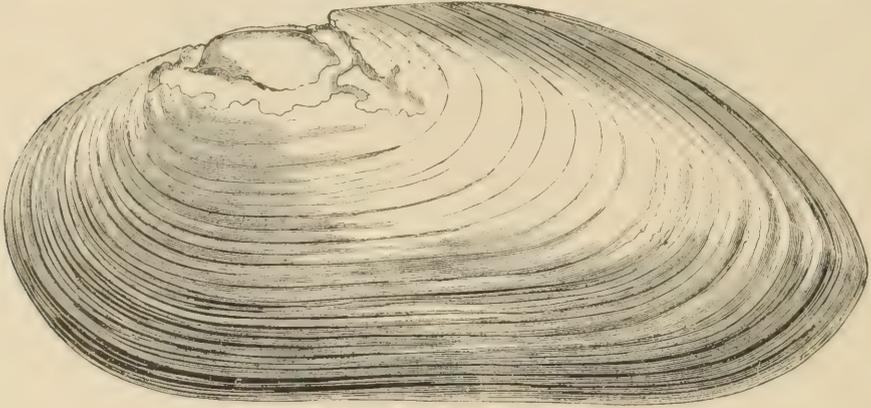


FIG. 188. *Anasonta cataracta*. Adult.

The color is a deep clear green, indistinctly radiated with a darker green and brown. On the inside the silvery nacre is tinged with blue and yellow and has a greenish margin. It reaches a large size and may be $4\frac{1}{2}$ inches long, $2\frac{3}{4}$ inches broad and $1\frac{1}{2}$ inch thick, though most of these mussels are about 3 inches long. It usually inhabits ponds and still water and occurs quite generally on the Eastern Atlantic slope.

A. implicata, Fig. 189, is a characteristic species with transversely oblong, sub-oval, thick, opaque, strong and heavy valves, almost as thick as broad; having the umbones distinct and usually eroded. It has ridges from the lower posterior edge of the umbone to the angular tip of the posterior edge. The valves are broadest behind the middle; the hinge margin is slightly curved. The outer surface is rough with coarse lines of growth, of a yellowish-olive color somewhat darker above, and the lines are marked with a dull brown.

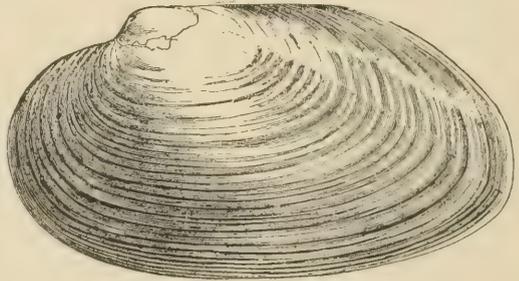


FIG. 189. *Anasonta implicata*. Young shell.

Older shells have a delicate salmon or flesh-color and the younger a silvery tint on the inside. It grows to 4 inches long, $2\frac{1}{4}$ inches broad and $1\frac{1}{3}$ inches thick, but average shells are usually about 3 inches long or under. It inhabits ponds and still water throughout the Eastern and Middle States but has a quite general distribution. This mussel is more elongate, narrower and thicker than the foregoing and may be distinguished by its obtuse ridge. The margin is also more convex.

MARGARITANA. This genus of the Unionidæ may be found in most running streams of fresh water, and has the valves transversely elongated, inequilateral, and the hinge differs from the Unios, with which some of the species have been classed by Conchologists.

M. margaritifera, Fig. 190, has the ovate or kidney-shaped thick and strong valves transversely much elongated, with the umbones but slightly raised above the line of the hinge and usually much eroded; and the hinge

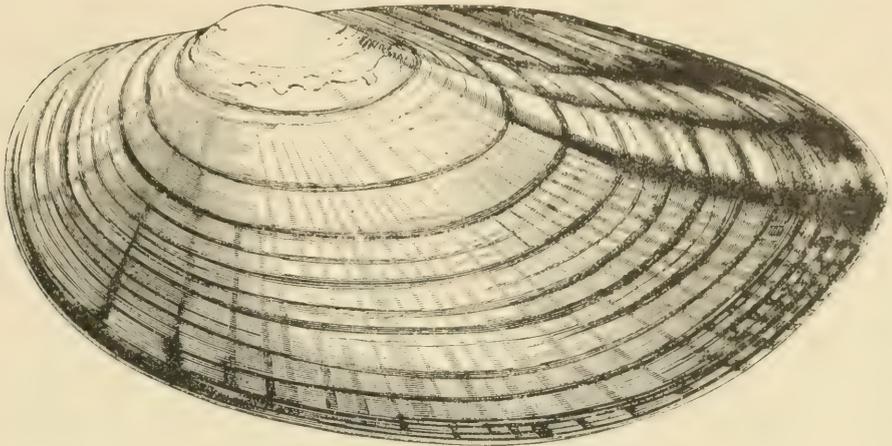


FIG. 190. *Margaritana margaritifera*. Adult.

and basal margin nearly as broad before as behind the hinge, which is usually curved and nearly parallel, with the tips slightly truncated. The surface is waved with lines of growth and loosely wrinkled posteriorly and towards the margin. The outside is pitchy-black, the inside has a greenish border at the margin while the nacre is bluish-white shading to flesh-color in the centre of the valves. There are two cardinal teeth in the left valve and one in the right. The mussel is $4\frac{1}{2}$ inches long, 2 inches broad and $1\frac{1}{4}$ inches thick, probably the largest freshwater mussel of the Atlantic slope, very generally distributed in the Eastern and Middle States.

M. marginata, Fig. 191, has thin-ovate, anteriorly wedge-shaped valves with small but elevated umbones, usually somewhat eroded. The posterior hinge margin declines abruptly to form a rounded tip and a well-

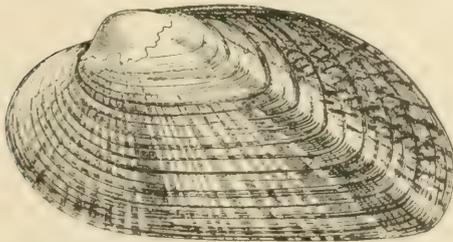


FIG. 191. *Margaritana marginata*. Nearly adult.

defined ridge extends from the umbone to the lower forward edge and the valves show rounded wrinkles and well-defined lines of growth. The color is a polished olive-green mottled with lighter and darker shades and having broken or obscure radiating darker green or brownish lines.

The interior has a chalky white margin and bluish-white nacre, overshot with delicate shades of green. The mature mussel is $2\frac{1}{2}$ inches long, $1\frac{1}{4}$ inch broad and 1 inch thick at the umbones. It is not as generally distributed as the foregoing, but may be found in almost all the river systems of the Eastern and Middle States, a Western species being *M. truncata*.

GENERAL REMARKS. What has been stated as to the colors of snail shells also applies to mussels. The presence of metallic oxides in the water affects the color and acidities erode the valves, principally on the umbones, the older portion of the valves; and when this has progressed to the extent of perforating the valves the mussel dies.

BEST AQUARIUM MUSSELS. Nearly all the mentioned species will thrive in the aquarium, instances being known of remarkable longevity. *Sphærium*, *Lampsilis* and *Margaritana* will survive for years; some in the author's household aquaria at this writing having done most effectual duty as scavengers for three and a half years and are still active and of good appearance. The introduction of one mussel into the aquarium for each 8 or 10 gallons of water is to be recommended, but watch should be kept until they become acclimated, after which an occasional tap on the valves will give assurance that they are alive. They are the best means of eradicating the objectionable *Tubicolores* worms. If they die, the decay is rapid and will cause trouble in the aquarium.

FRESHWATER VERMES AND HYDROZOA

TUBICOLA AND HYDRA. In addition to the already described low forms of animal life in the aquarium the freshwater Worms and Polyps should be mentioned. The eggs, spores or young are introduced with the water supply, in pond mud and on the aquatic plants. They may increase to such numbers as to become objectionable, as the worms bring the soil and humus to the surface of the pebbles, and by their constant activity cause turbidities in the lower water levels; and the polyps become active enemies to the spawn and young fishes.

FRESHWATER WORMS. These belong to the order Annelida. The most usual forms are *Pristina leidy* and *Stylaria lacustris* which live in the soil and mud. *Lumbriculus limosus*, about 2 inches long, and *Nais rivulosa*, about $\frac{5}{8}$ to $\frac{3}{4}$ inch long, live in the axils and under the leaves of aquatic plants. Of the Tubicolous worms, the objectionable *Trimnodrilus* is usually the only species present. As of these all but the last named are eaten by the fishes, no further mention is necessary.

Trimnodrilus claparadii, Fig. 192, and *T. montanus* are not eaten by goldfishes and may increase to such numbers that the whole bottom of the

aquarium will appear to be a living wriggling mass of threads that disappear when disturbed. These worms construct cases of the mud and of mucus secretions which they deposit, in which they live, consuming organic substances in the water and mud and bringing the residue to the surface. To dispose of them is difficult as the dipping-tube or siphon will not be effectual. A better method is to introduce one or more mussels, which cause their disappearance, or removing the other fishes introduce Sticklebacks, which, if not otherwise fed, will in a few days clear the aquarium of the pests. The *Tubifex* of Europe is sparsely represented in the United States.



FIG. 192. Common freshwater Tubicular Worms, *Timnodrilus claparadii*. Greatly enlarged.

FRESHWATER POLYPS. These belong to the order Hydrozoa, two classes of which, the Hydrida and Corynida, have frequently occurring freshwater forms, the Hydra and Cordylophora.

HYDRA. The freshwater hydra consists of a cylindrical body expanded into a single foot at one end, by which the animal attaches itself to any object, and having a mouth and a circle of from 5 to 12 tentacles at the other end. Those having short tentacles are of the species *H. viridis* and those with long filamentary tentacles *H. fusca*. The body contains a single large cavity, the rejected food being ejected from the mouth. Hydra possess the power of repairing mutilations and of multiplying artificially, and if cut into any number of pieces, each will develop into a perfect polyp. Reproduction is both sexual and by gemmation; the buds often developing and throwing out new shoots before they detach themselves from the parent. In the sexual method of reproduction, ova are developed and enclosed in sacs, which when mature are expelled through the body wall, the embryo appearing as a free-swimming tiny thread-cell, which attaches itself to foreign bodies and develops into the complete animal. Hydra occur in all waters and multiply rapidly when the temperature reaches 60° F., though cold water does not appear to injure them.

Hydra viridis. This is the most frequently met with form. Its power of changing its appearance is wonderful; those shown in Fig. 192, Nos. 1, 2, 3, 4 and 5, are all the same individual and the changes took place in less than one hour. The process of gemmation may be noticed, together with the growth of the young and its separation from the parent. The tentacles were not of the same form or length for even an instant, and seemed to ooze from and return to the body constantly.



FIG. 193. Freshwater Polyps. Greatly enlarged. 1 to 5. *Hydra viridis*. 6 and 7. *Hydra fusca*.

Hydra fusca. This polyp, Fig. 193; Nos. 6 and 7, is more stalklike than *H. viridis*, and

has greater power of extending its tentacles, often to a stretch of 2 to 5 inches. Otherwise it resembles the foregoing.

Hydra are destructive to very young fishes. The observations of Mr. A. E. Beardsly, in the investigation of the deaths of small trout, at the hatchery of Leadville, Col., will illustrate this fact. The sediment from the hatching troughs was found to contain innumerable hydra about 1 to 2 centimeters in length. Some of this sediment was removed to a number of vessels into each of which five newly hatched trout in good health were placed, and in one, as a control, the clear water of the main supply. In this experiment 25% of the trout were killed in less than 30 minutes, 60% in 45 minutes, 80% in 60 minutes and 100% in 75 minutes; while those in the control jar were all alive and in good health the following day. He states that "the hydra were seen with their mouths closely applied to the surface of the fish, particularly on the yolksac. In some cases more than a dozen hydras were attached to a single fish." This has also been the experience of a number of goldfish breeders.

CORDYLOPHORA. These polyps consist of single individuals or of a number joined by a common stalk, each developing gonosphores or germinating buds similar to those of the hydra. One species, *Cordylophora lacustra*, Fig. 194, frequently occurs in fresh-water attached to stones, shells or other firm objects. Its waving branches somewhat resemble some of the aquatic mosses but when touched the immediate change in form betrays its animal nature. It is not an active enemy to young fishes but should not be admitted to the hatching troughs.

Hydra and Cordylophora can be removed from the aquarium by the introduction of Sticklebacks, and Paradise fishes, or by its complete rearrangement. The plants should then be placed in a strong solution of Phenol-sodique, or in a bichloride of mercury solution of one tablet the pint of water, and to then carefully washed in clean water before they are returned to the aquarium; or the bichloride used directly in the aquarium after removing the animals, and the water afterwards removed and changed a number of times. The former is the preferred method, but unless the pests are very numerous, a few Paradise fishes, if not otherwise fed, will "clean them up" in a few days. Hydra are principally destructive when they are introduced into the spawning and hatching tanks.



FIG. 194. Freshwater polyp, *Cordylophora lacustra*. Enlarged.

CHAPTER XI.

The Aquatic Insects of Freshwater

AQUATIC INSECTS

Insects and their larvæ are one of the most un-
failing sources of food supply for freshwater fishes. There are many, however, which in some or all the stages of existence are injurious to the spawn and young, and these belong to many orders, families, genera and species, among them being some genera of the Heteroptera or Water-bugs; the Neuroptera or Dragon-flies and kindred insects; the Diptera or true Flies; the Coleoptera or Beetles; the Lepidoptera or Moths; the Hymenoptera or Ichneumons; the Arachnidæ or Spiders; and other families of the insect world, or forms closely related thereto.

Some are not entirely rapacious nor depend solely on the blood of animals for food, but also suck the juices from insects and plants, yet become active enemies in the confines of the rearing basins for fishes, in the absence of larger fishes which would devour them and their larvæ; thus permitting them to prey upon the smaller fishes and to so increase in numbers as to become very destructive. These will be briefly described, their habits noted, and illustrations given for their identification. Others which serve as food for young and mature fishes will also be mentioned.

Freshwater plants grow in more or less shallow water, as they are dependent for nutrition upon the decomposition of carbonic acid gas by sunlight, and as plant-feeding animals establish themselves among them, they are also frequented by predatory animals, to whom these serve as food. Insects are of both these classes but the predatory more particularly claim our attention. It should be stated that insects deriving oxygen from the air are generally lighter than water, so that, should they exhaust the air carried with them under the water or become disabled, they rise to the surface by gravity in such position that the air-breathing parts first come to the surface. The insects deriving oxygen from the air held in suspension in the water are heavier than water and no effort is necessary for them to keep below the surface. Changes in water temperature are also provided against and most of the aquatic insects pass the winter in the larval stage, to undergo the further transformations in the following spring or early summer,

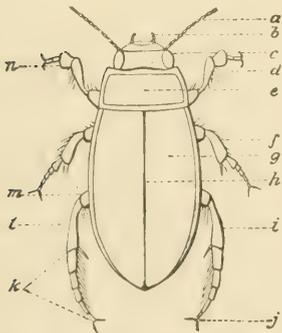


FIG. 195. Outline of a Water Beetle.

- a. Antennæ.
- b. Maxillary palpi.
- c. Eye.
- d. Fore-leg.
- e. Thorax.
- f. Middle-leg.
- g. Elytron.
- h. Suture.
- i. Hind-leg.
- j. Claw.
- k. Tarsus or foot.
- l. Tibia or shank.
- m. Femur or thigh.
- n. First three joints of foot.

though there is often more than one summer brood, and many remain more than a year in the larval state. A further provision of nature is the enormous number of eggs produced.

No insect is so completely aquatic as to pass its entire existence in the water, yet the final perfect stage and the acquisition of wings is usually a brief one; its purpose being principally the mating of the sexes and the distribution of the eggs over a wider area, where the chances of survival are improved. Fig. 195 shows the external anatomy of a beetle.

INSECT ENEMIES. The following are the principal insect enemies of the freshwater fishes.

ORDER HEMIPTERA. This order includes three sub-orders, the Heteroptera, Parasitica and Homoptera; the aquatic and semi-aquatic bugs belonging to the first named. They have four membranous wings, the first pair partly overlapping the others. The mouth parts are developed for piercing and sucking. Many families are comprised in this sub-order including the Water-boatmen or Corisidæ; the Backswimmers or Notonectidæ; the Water-scorpions or Nepidæ; the Giant Water-bugs or Belostomidæ; and the Creeping Water-bugs or Naucoridæ. Those which live near the water and are semi-aquatic are the Toad-bugs or Galgolidæ; the Broad-shouldered Water-striders or Valiidæ; the Water-striders or Hydrobatidæ; and the Marsh-treaders or Limnobatidæ: all of which will be described in this order.

WATER-BOATMEN belong to the family of Corisidæ and about forty North American species to the genus *Corisa*. They are of oval form, flattened on the back and below, of mottled grey and black color, about $\frac{3}{8}$ inch long, eyes small and inconspicuous, and the body covered with fine hairs, which, in the water, cause an almost complete envelopment in air like a glittering armor, and enables the bug to descend below the surface for considerable periods, where it attaches itself by its anterior legs. The posterior legs are more largely developed and oar-like, covered with swimming bristles. The four membranous wings lie on the back, the first pair of thicker structure, the hind wings very delicate, white and lace-like. It swims with the back upwards and in cold weather buries itself in the mud and lies dormant until spring. The eggs are attached to the stems of plants under the water and the larval stage is brief. All the genera are predatory, the food consisting of insects and other aquatic animals, and the strong and sharp beak inflicting severe bites. They are destructive to

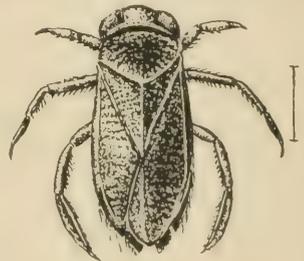


FIG. 196. Water-boatman, *Corisa interrupta*. Enlarged.*

*The line at the right of the figures indicate the natural size.

young fishes, weak flyers and clumsy of movement out of the water. In Mexico the eggs of two species, *C. mercenaria* and *C. femorata*, are collected in enormous quantities to be eaten by the Indians and are exported in a dried state as food for birds, poultry and fishes. They are distributed over the entire United States, the most general species being *C. undulata*, *C. interrupta*, Fig. 196, *C. calva*, *C. alternata* and *C. vulnerata*.

BACK-SWIMMERS belong to the family of Notonectidæ, of which about twelve species of the genera Notonecta, Anisops and Plea are known in the United States. Though greatly resembling the water-boatmen in appearance and habit they are more convex on the back, which is keeled like a boat and on which they swim with the ventral side upwards and the hind end of the body projecting to admit air beneath the wings where the breathing apparatus is located. The anterior and middle legs are shorter than

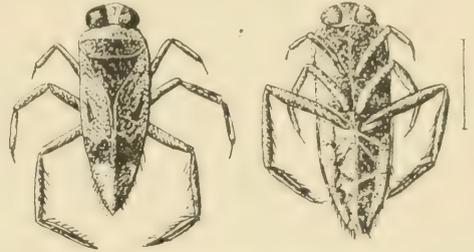


FIG. 197. Back-swimmer, *Notonecta undulata*.
Ventral and dorsal views. Enlarged.

the oarlike posterior legs, which are strongly developed for swimming. The eggs are laid in incisions, pierced by the ovipositor of the female in the stems of water plants. After hatching they rapidly pass through the larval stage and assume the appearance of the adult. They are predaceous and feed upon other water insects and small fishes, the powerful beak inflicting severe wounds to the fingers in careless handling. They attack young fishes which are entirely devoured. The most generally distributed species are *N. undulata*, Fig. 197, *N. insulata*, *N. irrorata*, *A. platycnemis* and *P. striola*.

WATER-SCORPIONS belong to the family of Nepidæ and are so named from the appearance of the anterior legs, of which the coxa are long and the femor furnished with a groove into which the tibia and tarsus fits, greatly resembling the hooklike cheliceres of the scorpion, and admirably fitted for seizing prey. The middle and posterior legs are adapted for walking. At the posterior end of the body two long half-tubes are developed, which when united form a tube for inhaling air when under water. The species of *Nepa* are flat oval in form, about one inch long, and the *Ranatra* long, slender and twiglike, with all the legs thin and very long, the body often attaining a length of 2½ to 3 inches. The eggs are deposited in the stems of water plants and have long protruding filaments with probably pul-

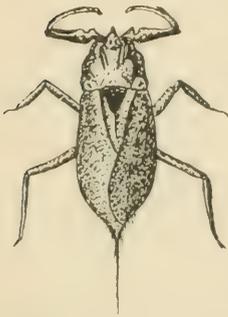


FIG. 198. Water-scorpion,
Nepa apiculata.

monary functions. The insect rests on the stalks of plants or slowly moves over the bottom and is difficult to observe on account of its form and the mud on the body. It is a weak flyer and only migrates when the pool is dry and in the mating season. Food largely consists of the eggs of fishes, frogs, snails and insects, but it will prey upon other water inhabitants and on young tadpoles and fishes. The most generally distributed species are *N. apiculata*, Fig. 198, *R. fusca*, Fig. 199, and *R. quadridentata*.

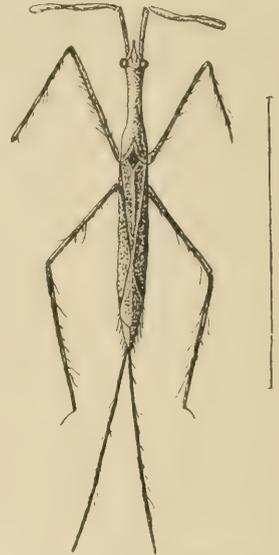


FIG. 199. Water-scorpion, *Ranatra fusca*. Enlarged.

GIANT WATER-BUGS belong to the family of Belostomatidæ, are all strictly aquatic and are most dangerous to spawn and young fishes, as they are predatory, live on the bottom and feed on aquatic animals. In the Eastern section of the United States the common forms of these bugs belong to the genera *Belostoma*, *Benucus* and *Zaitha*; of which the first named are the largest and are of elongated oval outline, very flat with almost transparent wings of greyish or brownish color. *Benucus* is almost as large and may be distinguished by the absence of the double



FIG. 200. Giant Water-bug, *Belostoma griseum*.

groove on the under side of the fore thighs, which is characteristic of the first named. But one species of *Benucus*, *B. haldermanum*, is found in the United States. The form in *Zaitha* is like the foregoing but the species are smaller. *Belostoma* are abundant in the tropical and temperate zones of America, a tropical species, *B. grande*, reaching a length of four inches and *B. griseum*, Fig. 200, the largest of the United States attains a length of three inches. Their general color is greyish, yellowish or greenish-brown but they are usually covered with mud and when wet are darker in color than in the specimen cabinet. The anterior legs are strongly developed to seize their prey and the oarshaped posterior legs for swimming. When fully developed they have strong wings capable of long sustained flight, which takes place at night, and enables them to seek other ponds and water courses when theirs dry out. They are often found in cities, their defective sight leading them to mistake large reflecting surfaces, like skylights and green-

houses for sheets of water. Lamps and electric lights also attract them in numbers. They deposit the eggs in masses under logs and stones on the borders of ponds and ditches. The young are predaceous and feed upon small snails and other living creatures and differ but little in appearance from the adults, except in the absence of wings. They reach maturity during the first year. Living prey only is acceptable to both the larva and bug and in attacking smaller fishes they seize them with the fore legs, pierce them with the proboscis, which forms a



FIG. 201. Giant Water-bug, *Zaitha fluminea*. Female with eggs on her back.

sucking tube, and extract the blood but do not eat the animal. Some of the species of *Zaitha* attack the spawn of fishes. Of this genus the most common in the Eastern section of the United States is *Z. fluminea*, which reaches a length of 1 to 1½ inches. Figs. 201 and 202. The females of all three genera deposit the eggs on their backs which are often entirely covered by nicely arranged transverse rows of from 60 to 200 elongate-ovate dark grey eggs deposited by means of a protrusile ovipositor which can be extended over the back. The Giant Water-bugs and their larvæ are among the most destructive enemies of the young of the goldfish and other freshwater fishes, which are often introduced into the hatching troughs as eggs or in the larval stage. Some adults reach the tanks in their nuptial flights.



FIG. 202. Giant Water-bug, *Zaitha fluminea*. Male.

CREeping WATER-BUGS belong to the Naucoridæ, a small family of flat-bodied oval-shaped bugs, having the anterior legs developed to seize their prey and the middle and posterior legs for creeping over the bottom of ponds and water ways. All the species are predaceous but

confine their attacks more generally to insects and their larvæ. *Pilocoris femarata* and *Ambrysus signoretti*,



FIG. 203. Creeping Water-bug, *Ambrysus signoretti*. Enlarged.

Fig. 203, are the principally distributed Atlantic Coast and Western species. They are both of small size, rarely over 3/8 inch in length and of a reddish-brown color.

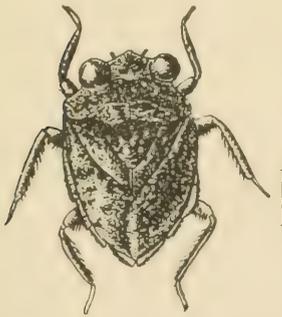


FIG. 204. Toad-bug, *Pelogonus americanus*. Enlarged.

TOAD-BUGS belong to the family of Galguliidæ, and inhabit the muddy margins of ponds,

streams and marshes. The toad-like appearance, the short and broad body, mottled color and protruding eyes led to the popular designation. They are $\frac{1}{4}$ to $\frac{3}{8}$ inch long, are all predaceous and live principally on spawn, insect larvæ and small snails. The most generally distributed species of the United States are *Galgulus oculatus*, *Pelogonus americanus*, Fig. 204, and *Mononyx stygicus*.

SHORE-BUGS belong to the family of Saldidæ, of which twelve species inhabit the United States, four on the Atlantic Coast. They may often be seen in considerable numbers on the margins of water ways and take flight when disturbed but soon alight. Their color is dark grey with white and yellow markings, and their size $\frac{5}{16}$ to $\frac{3}{8}$ inch in length. The most generally distributed Eastern United States species are *Salda signoretii*, Fig. 205, *S. pellita*, *S. splacelata* and *S. anthracina*.

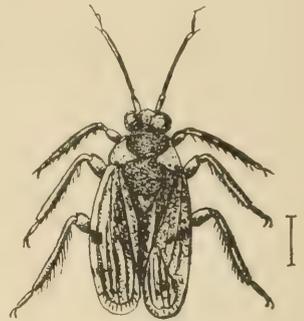


FIG. 205. Shore-bug, *Salda signoretii*. Enlarged.

BROAD-SHOULDERED WATER-STRIDERS belong to the family of Veliidæ and are distinct and different from the true Water-striders. They are smaller, much broader across the thorax and thicker of limb, all of them aquatic in habit

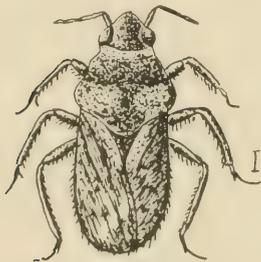


FIG. 206. Broad-shouldered Water-strider, *Hebrus americanus*. Enlarged.

and almost constantly on the water, congregating in school of hundreds. The most generally distributed species of the Atlantic Coast States are *Hebrus americanus*, Fig. 206, and *Rhagovelia collaris*, Fig. 207, both of small size. All are pre-

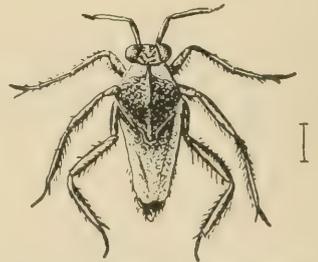


FIG. 207. Broad-shouldered Water-strider, *Rhagovelia collaris*. Enlarged.

daceous and feed on the juices of insects which fall into the water, mosquito larvæ and the tiny alevins of fishes, when they come to the surface of the water to take air.

WATER-STRIDERS belong to the family of Hydrometridæ, slender long-legged insects which dart about on the surface of ponds and pools of both fresh and salt water. Some species are winged and others wingless, varying in length from $\frac{1}{2}$ to $\frac{5}{8}$ inch. The elongated body has very closely folded wings and long hairlike legs, both covered with minute hairs, which prevent the insect from becoming wet and sustain it upon the surface of the water, the legs being almost continuously lifted to prevent their becoming wet, in which case the insect would sink into the

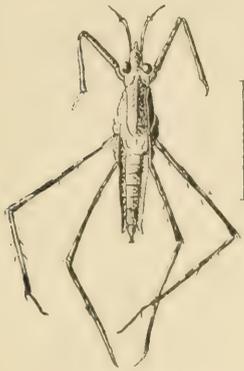


FIG. 208. Water-strider or Skater, *Hydrometra lineata*. Enlarged.

water. The eggs are remarkably large for the size of the insect. They are predaceous, feeding upon living prey from which they suck the juices. The most general species of the Eastern United States are *Hydrometra lineata*, Fig. 208, and *Hygrotrechus remigis*.

MARSH-TREADERS belong to the family of Limnobatidæ and are very slender, almost thread-like insects rarely over $\frac{1}{2}$ inch long, with long heads, elongated thorax and abdomen, hairlike legs and of inconspicuous dark color. They crawl over the mud and the water surface or adhere to water plants

partly above the surface, feeding upon the eggs and small larvæ of insects and snails. The most generally distributed species are *Limnobates lineata*, Fig. 209, and the allied *Limnopus rufoscutellatus*.

AQUATIC PLANT-LICE belong to the family of Aphididæ, commonly known as Aphides, small soft-bodied winged or wingless insects, with oval-lobed bodies, small heads, distinct eyes, filiform antennæ and six legs; which when winged have two pairs of lace-like membranous wings. At the tip of the abdomen there are usually a pair of cauda or upward protruding air breathing tubes. They are usually viviparous and feed upon juices by means of a three-jointed piercing and sucking beak inserted into the tender portion of growing plants. The most

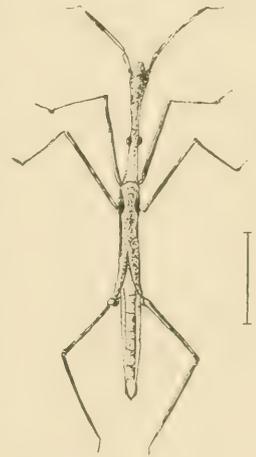


FIG. 209. Marsh-treader, *Limnobates lineata*. Enlarged.

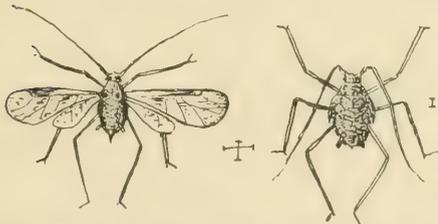


FIG. 210. Aquatic plant-louse, *Rhopalosiphus nymphææ*, winged and wingless stages. Enlarged.

general species of Aphides which the aquarist is likely to encounter is *Rhopalosiphus nymphææ*, Fig. 210, which infests the emerged and floating leaves of Sagittaria, Potamogeton, Duckweed, Cattails, Water-plantains, Water-poppies and Lilies; while the last two mentioned plants also have

Siphonophora lili, and two greenhouse species, *Aphis lilicola* and *Rhopalosiphus dianthi*. They produce a disfigurement of the leaves and cause decay by sapping the juices.

ORDER NEUROPTERA. Of this order a considerable number of families are aquatic. All have the body elongated, thin and broad, net-veined membranous wings, large head with the mouth parts well developed,

prominent eyes, filiform antennæ, long and full thorax and segmental abdomen. This order is now restricted to a few families in the United States, including the Dobsons or Sialidæ, the May- or Shad-flies or Ephemeriidæ; the Stone-flies or Plecoptera; the Dragon-flies or Odonata; and the Caddice-flies or Trichoptera.

DOBSONS belong to the family of Sialiadæ, and include the Fish-flies, Hellgramites, Alder-flies and others of diverse popular names. They have four thin, broad, net-veined wings which are folded when at rest. All are weak flyers with legs scarcely able to support the body. The mouth parts are developed for biting, the abdomen long and slender, the antennæ long, the head broad with protruding eyes, and the mandibles well developed. Of the Fish-flies or Sialis there are but two species, *S. infumata* and *S. americana*, both small insects which frequent vegetation on the banks of streams. The eggs are laid in white cottony masses on plants overhanging the water, on bridges, piers, etc., into which the larvæ drop when hatched.

The largest species of Dobson is the Horned Corydalis, *C. corinita*, which has a spread of wings of over five inches and is quite generally distributed.

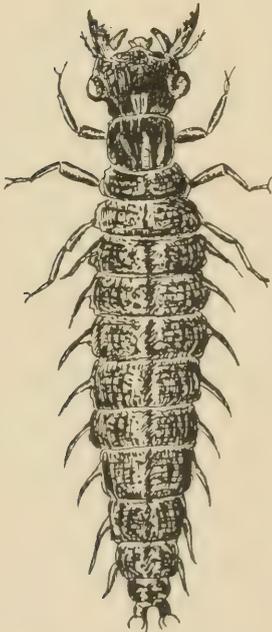


FIG. 211. Hellgramite, larva of the Dobson.

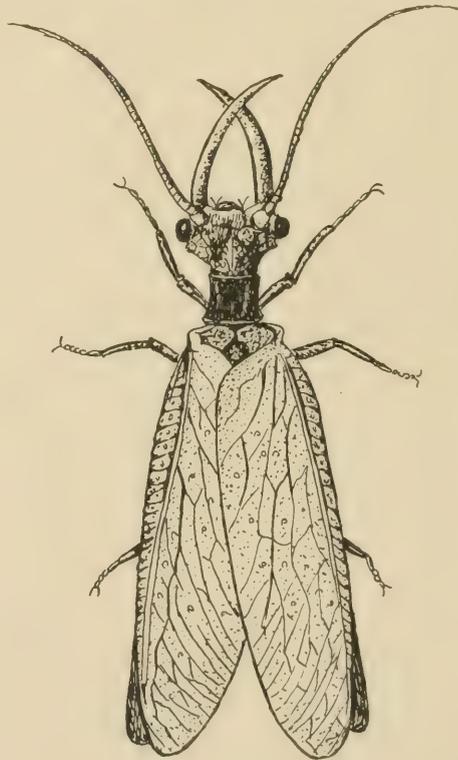


FIG. 212. Horned Dobson, *Corydalis corinita*.

The larvæ are known as Dobsons, Hellgramites, Bugies, etc., and are extensively used as bait for game fishes. They live under rocks and

stones in the streams and feed on the larvæ and nymphæ of May-flies, Stone-flies and other aquatic insects. The larval stage lasts three months and longer, but the pupal stage is quickly passed, and in less than a month after the larva leaves the water to make a cell for itself nearby, in which to undergo the metamorphosis, the adult insect or imago appears.

Some of the common species of Sialiadæ, of smaller size, the Alder-flies, or Chauliodes, are *C. pecticornis*, having greyish wings and featherlike antennæ, and *C. serricornis* of a brownish - black color with white-spotted wings. Four other species are not quite so generally distributed. All the Dobson larvæ are carnivorous and destructive to small fishes and snails.

MAY-FLIES OR SHAD-FLIES, belong to family of Ephemeriidæ, signifying lasting but a day. They have delicate membranous wings, with a fine network of veins, the fore wings larger than the second pair, which latter

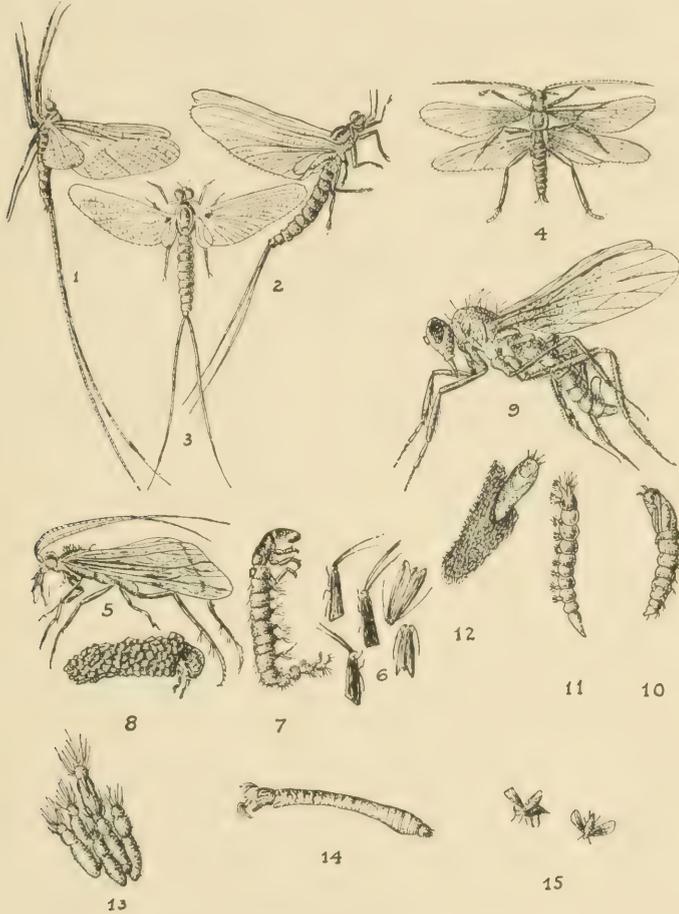


FIG. 213.

1. May-fly, *Heptagenia pulchella*, of the family Ephemeriidæ.
- 2 and 3. " *Baetis pygmaea*, lateral and dorsal views.
4. Stone-fly, *Leuctra tenella*, of the family Plecoptera.
5. Caddice-fly, *Phryganea interrupta*, of the family Hydropsychidæ. Enlarged x 6.
6. " *Phryganea interrupta*, Imagos at rest. Natural size.
7. " larva. Enlarged x 5.
8. " pupal case. Enlarged x 4.
9. Black-fly, *Roderiodes juncta*, of the family Empididæ. Enlarged x 10.
10. " larva. Enlarged x 5.
11. " pupa. " x 5.
12. " " in case. Enlarged x 5.
13. Buffalo-fly, *Simulium venustum*, of the family Simuliidæ. Enlarged x 5. Group of pupæ.
14. " larva. Enlarged x 6.
15. " Natural size.

pair are wanting in some species. All are aquatic, the larvæ active, swimming among the water plants, crawling over the bottom, or burrowing into the banks. The nymph has small wing pads and in its transformation floats on the surface of the water until the skin opens and the winged insect emerges, when a molt takes place, followed by a second before the adult stage is reached. In the final metamorphosis the mouth parts and the alimentary canal are atrophied so that the insect cannot eat, its life being very brief, often but a day; but when the atmosphere is moist, it may survive several days. Flight principally takes place in the early morning and evening hours. The eggs are deposited in the water either by dropping on the surface or by the female creeping into the water incased in a film of air. The larval life is from two to three years, during which as many as twenty molts take place. Both the larvæ and nymphæ of nearly all species feed on vegetal matter, diatoms, algæ and confervæ and are harmless to young fishes. Though enormously numerous in individuals there are comparatively few species, not more than eight or ten in the Eastern section of the United States; of which the more common are *Ephemera varia*, *Bætis pygmæa*, *Heptagenia pulchella*, Fig. 213, and *Siphonurus alternatus*, some of which are extensively grown by fish breeders as a food for young fishes, especially the trout.

STONE-FLIES belong to the order of Plecoptera, signifying plaited wing and referring to the folding of the hind wings. The body is long and flat, and of the four membranous wings the hind pair are slightly the larger and are folded on the abdomen when in repose. The antennæ are long and threadlike and the mouth parts developed for biting. All the species are aquatic and propagate in enormous numbers in almost every rapid rocky stream, the female depositing 5000 to 6000 eggs on the water. The larvæ require aerated water and will not survive in any numbers in stagnant or stillwater ponds and ditches. They are active and carnivorous, feeding upon the young May-flies, soft-bodied Dipterous larvæ and upon vegetal matter. They have large flat heads, compound eyes and a flat body, which enables them to crawl under stones in the water. Usually they have long antennæ and breathe by tracheal gills. The full-grown nymph is active and varies with different species from $\frac{1}{2}$ to $1\frac{1}{2}$ inches in length, their cast skins being common objects along the banks of streams. The most generally distributed species are *Leuctra tenella*, Fig. 213, *Pteronarays proteus*, *Acroneuria abnormis*, *Isogenus frontalis* and *Perla ephyre*. There are no records of their being injurious to young fishes, and larvæ form one of the principal natural foods of the young trout, dace and other cold-water fishes.

DRAGON-FLIES belong to the order of Odonata, signifying a tooth. More than 2000 species have been established, of which about 300 inhabit the United States. They are very slender insects having four elongated membranous wings, finely netted with veins, each with a jointed structure or nodus near the middle of the front margin. The head is large and may be rotated on the slender neck, and the large eyes are placed at the sides of the head. The antennæ are short and slender, the mouth parts developed for biting and the legs placed near the front of the thorax and fitted more for grasping their prey and adhering to leaves and twigs than for walking. They are day flyers, the prey being captured by the legs and mandibles in their darting flights. It consists of flies, mosquitoes, midges, gnats and other small insects. All the species are aquatic. The eggs are laid in the water, on the stems or in the tissue of aquatic plants. As soon as the young are hatched they begin their predatory life under water, feeding upon eggs, larvæ, small insects and entomostraca, which is continued during their entire larval and nymphal existence, attacks being directed to larger insects and animals as they increase in size. The larvæ and nymphæ, Figs. 214 and 215, have a formidable structure known as a mask, consisting of a long, hinged apparatus with sharp hook teeth which may be folded under the head or darted forward to seize insects and fishes to draw them to the mouth. Most of them breathe by rectal gills, this apparatus also affording the means of locomotion by the violent expulsion of the water. Some have both lateral and caudal abdominal gills. There is a marked difference in appearance between the larva and nymph of most species, the latter assuming a broad, flat form different from the slender larva and the adult insect. Both larva and nymph have short wing pads. When the final metamorphosis takes place the nymph crawls out of the water, the skin splits over the back, and the adult dragon-fly emerges. From nine to twelve months are required to develop

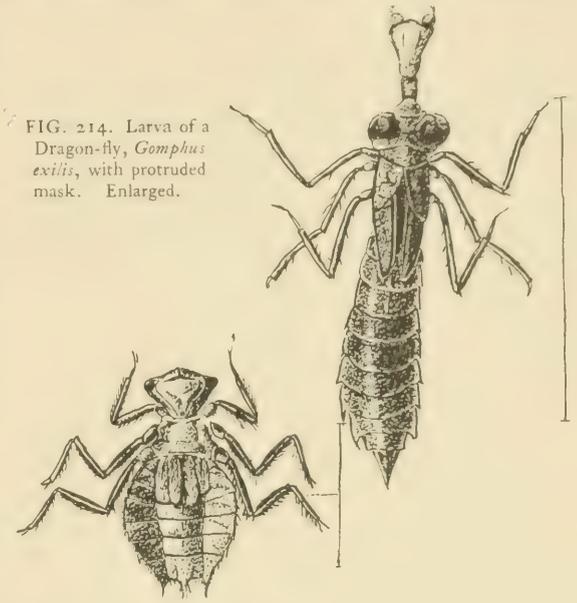


FIG. 214. Larva of a Dragon-fly, *Gomphus exilis*, with protruded mask. Enlarged.

FIG. 215. Nymph of a Dragon-fly, *Anax junius*, with mask folded, not visible from above. Enlarged.

the adult, and the winged existence lasts but a few weeks; oviposition being conducted by the same individual for a number of days. The larvæ of the same brood also develop unequally, some growing so

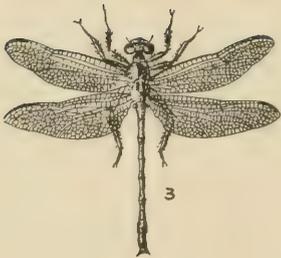
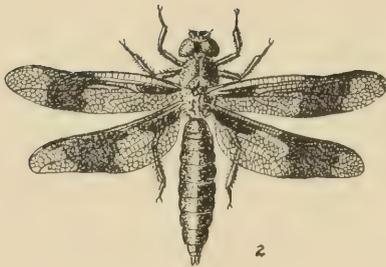


FIG. 216. Dragon-flies.

1. *Aeschna heros*.
 2. *Libellula pulchella*.
 3. *Gomphus exilis*.
 4. *Argia violacea*, a Damselfly.
- Reduced one-fourth.

rapidly that they devour their more tardy brethren. When captured, the nymphæ not only prey upon each other but upon any living thing kept with them, and the larvæ and nymphæ are the most rapacious and destructive enemies of young fishes which the aquarist encounters, a single one often destroying an entire hatching of several hundred young fishes in a few days. Nor are their attacks confined to young fishes, whatever contains life is fair game to them. The principal families of the Atlantic Coast and Gulf States are the *Æschinidæ*, *Libellulidæ*, *Cordullidæ*, *Cordulegasteridæ*, *Agriionidæ*, *Gomphidæ*; and the *Calepterygidæ* or Damselflies, Fig. 216. The "Hammer-headed dragon-flies" comprise the genera *Agrion*, *Lestes* and

Calopteryx, which frequent grassy margins of ponds, pools and swamps. The larger are the "High-flying-dragon flies," *Æschna* and *Corduligaster*, which frequent tall shrubbery and trees and are seldom seen over ponds

and waterways. These attack all winged insects, none seem too large to escape their onslaughts; but their principal prey is the evening flying Diptera and juicy, winged insects. The "Swift-flying dragon-flies" comprise the genera *Æschnina*, *Gomphus*, *Anax*, *Cordulia*, *Tramea*, *Libellula*, *Celithemis* and *Diplax*; some of them nearly as swift of wing as *Æschna* but not capable of as lofty and long-sustained flight. Dragon-flies are local in their habits, rarely flying far from their accustomed haunts, except in occasional cases of migration. *Belostoma*, *Notonecta*, *Ranatra* and other predaceous insects prey on the younger Dragon-fly larvæ, and frogs will take the perfect insect, as will also some of the birds, notably the Fly-catchers. It may be noted that Dragon-flies are most inveterate enemies of the mosquito in all the stages of its development, attempts having been made to introduce them extensively to aid in exterminating this pest. The most common species of Dragon-flies in the Eastern and Middle States are *Gomphus exilis*, *Cordulegaster maculatus*, *Æschna heros*, *A. clepsydra*, *Anax junius*, *Tramea carolina*, *Libellula pulchella*, *Celithemis elisa*, *Diplax ribicunda*, *Calopteryx maculata*, *Lestes unguiculata*, *Epicordulia princeps* and *Argia violacea*. Fig. 216. *Agrion* is not found in the Eastern section of the United States.

CADDICE-FLIES OR CADDICE-WORMS belong to the order of Trichoptera, signifying hair-winged. They are mothlike insects usually having four membranous wings with numerous longitudinal veins, few cross veins and more or less clothed with hairs, which, at rest, are folded against the abdomen, the hind wings being usually the broader. They are common near ponds, streams and lakes and frequent shady places, resting on leaves and twigs, rarely flying during the day. The eggs are laid in gelatinous masses attached to water plants. The larvæ, known as Rock-worms, are aquatic, elongate and cylindrical in form with a tough horny head and thorax and a soft thin-skinned abdomen; which construct protective cases, open at the ends, of any available materials, leaves, twigs, sand, shells and small stones, all spun together by means of silk threads, to protect the Caddice-worm from predatory insects and other natural enemies. They breathe by tracheal gills at the side of the abdomen, and live several months in the larval condition, passing the pupal stage in the cases, both ends of which are then sealed with a silk netting. The final metamorphosis takes place above the water on plants or on the banks, the fly emerging from the pupa fully developed and immediately takes to flight. The food of the larvæ is principally vegetal, but one family is carnivorous and feeds upon small insect larvæ. There are more than 150 North American species, the more generally distributed of the Eastern and Middle States being *Phryganea interrupta*, Fig. 213, *Limnephilus rhombicus*,

Sericostoma americana, *Rhyacophila torva*, *Leptocerus transversus* and *Macronema zebratus*, each also representative of a distinct genus of the order Trichoptera.

ORDER THYSANURA. This order includes the so-called Bristle-tails, Spring-tails, Fish-moths and others; wingless insects which undergo no metamorphoses and retain the larval form in the adult. The mouth parts are developed for biting and chewing soft substances and they are sometimes provided with rudimentary legs only. The sub-orders comprise the Bristle-tails or Cinura; the Spring-tails or Collembola, and the Water Spring-tails or Poduridæ, with only the last of which we are concerned.

WATER SPRING-TAILS belong to the family of Poduridæ, of which *P. aquatica*, Fig. 217, is often found on the surface of quiet ponds and still water. It is a black insect with six legs, distinctly segmental abdomen without a constriction to divide it and the thorax, plumed antennæ, reddish legs provided with hairs and sharp claws, devoid of wings, and of which the larvæ may be distinguished from the adult only by their still smaller size. *Achorutes nivicola* is another species sometimes found under the surface of the water, and *Lepidocyrtus americanus* in greenhouses, under logs and in similar situations. They are small entirely harmless insects, mentioned only because they often attract the attention of the fish culturist and Natural History collector.

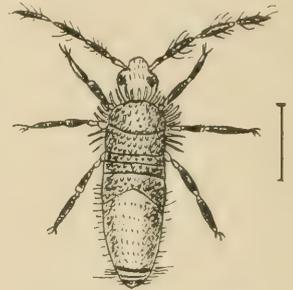


FIG. 217. Water-springtail, *Podurus aquatica*. Enlarged.

ORDER DIPTERA. This order includes insects which may be properly called Flies; those having but two wings borne by the mesothorax and include the Mosquitoes, Midges and Gnats. The wings are thin and membranous, the mouth parts formed for sucking, the thorax and abdomen slender, and the eyes distinct and placed at the sides of the head. The order includes the Mosquitoes or Culicidæ; Net-winged Midges or Blepharoceridæ and Chironomidæ; Moth-like Flies or Psychodidæ, Crane-flies and False Crane-flies, Black and Buffalo-flies, Horse-flies, Soldier-flies, the Long-legged flies, Snipe-flies and many others.

MOSQUITOES belong to the family of Culicidæ, small flies with narrow wings and long and slender abdomen, of which the males have plumelike antennæ. They frequent moist localities and pass all the stages of development to the perfect insect in the water, a new brood appearing every three or four weeks. In depositing the eggs the female rests upon some floating object with the anterior legs, the middle legs rest on the water and the posterior legs are crossed to hold the eggs as they are laid, with their longer diameter vertical, and glued together to form a raft of often 200

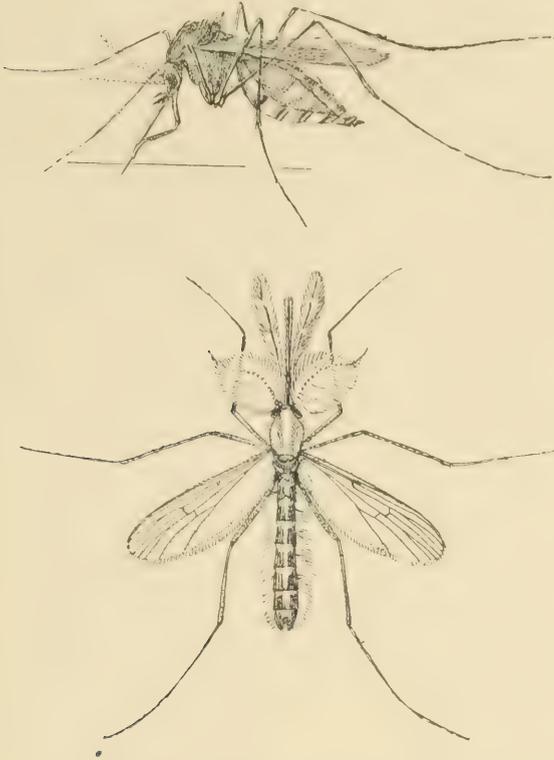


FIG. 216. Long-beaked Mosquitoes, *Culex pungens*.
Adult female and male. Greatly enlarged.

together, which float about five or six days till the embryos emerge from the under side and at once take to the water. The larvæ keep near the sides of the pools or just below the water level, as they are not deepwater feeders and must frequently come to the surface to breathe, the orifice of the air tube being thrust out of the water. After a number of molts the pupa is developed, which has the head, thorax, wings and legs folded in one mass and the abdomen free for navigation. The pupa and nymph stages are passed in a few days and when the period of emergence is reached, the nymph case opens over

the back and the perfect insect appears; which, after drying itself, takes wing and disappears. The food of the larvæ is vegetal substances and the minute water infusoria. It is only the female insect which has the proboscis developed for drawing blood, and both it and the male feed principally by sucking the juices of plants at night, the irritation of the bite being due to a venomous salivary secretion which probably serves to make the blood more liquid. The perfect insect also attacks other insects, cold-blooded vertebrates, small fishes, birds and other warm-blooded animals. The enemies of the larvæ and pupæ are all the carnivorous insects and their larvæ, tadpoles, frogs, salamanders, newts, minnows, sunfishes, perch, sticklebacks, etc.; and those of the adult Dragon-flies are frogs and toads, night-flying birds and bats. It was a theory that the female Mosquito required animal blood to perfect the eggs, but this is scarcely possible considering the enormous numbers of which only an infinitesimal proportion ever taste the blood of animals. Mosquitoes are classified as long and short beaked. The long-beaked genera of North America are *Anopheles*, *Mergarhinus*, *Psorophora*, *Toxorhynchites*, *Stegomyia*, *Conchyliaestes*, *Culex*, *Uranotænia* and *Aedes*, of which there are several hundred species.

Of these *Anopheles* bear the *Plasmodium malariae* which produces malarial fever, *Culex pipiens* those of Roman fever, *Stegomyia fasciata* those of yellow



FIG. 219. Malaria Mosquitos, *Anopheles quadrimaculatus*. Adult male and female. Greatly enlarged.

fever, and *Culex ciliaris* the parasitic *Filarias* which produce elephantiasis. Figs. 218 to 221 incl. Fishes of the carp family are very useful in ponds to destroy mosquito larvæ, but the surface-feeding Top-minnow is the best to destroy *Anopheles* the malaria mosquito larva, which develops and

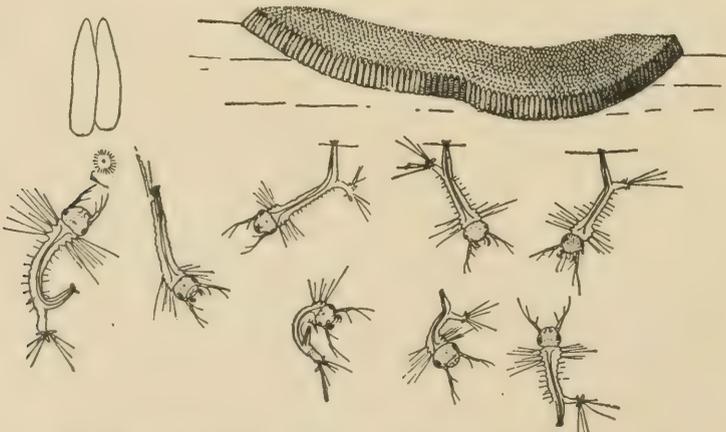


FIG. 220. Mosquito-boat or Egg-mass, with enlarged eggs and young larvæ.

hatches on the surface of the water, and stocking with these is an approved preventive measure.

The larvæ and pupæ of mosquitoes are one of the best natural foods for goldfishes, in many respects preferable to the entomostraca. They are usually more easily obtained, larger in size, more tenacious of life and are eagerly eaten by the young fishes, who acquire a most remarkably rapid growth on this diet.

It is not advisable to feed them to very small fishes, as these are not able to swallow them and may, in turn, be attacked by the larvæ, but for fishes which have reached a growth of half an inch, they should form one of the principal foods. A few barrels filled with rain water at any convenient place only are required; in which they may be bred either by the visits of female mosquitoes, or more quickly stocked by

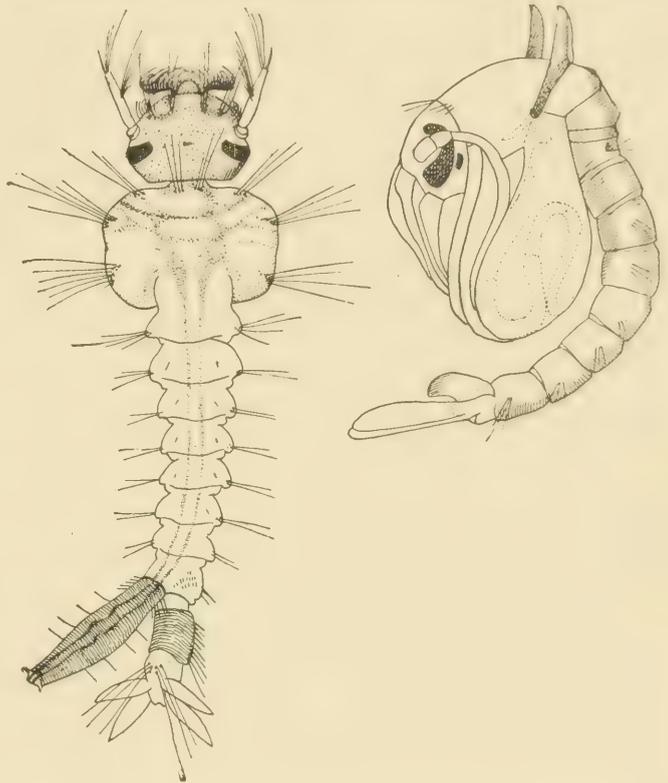


FIG. 221. Full-grown larva and pupa of *Culex pungens*. Greatly enlarged.

catches in ponds and ditches. They breed very rapidly and are a cleaner diet than the usual live pond food. The use of mosquito larvæ is almost universal among goldfish breeders and is to be in every way recommended.

NET-WINGED MIDGES belong to the families of Blepharoceridæ and Chironomidæ, of which the tiny larvæ appears more like crustaceans than insects. Some of the species, *Blepharocera capitata*, *Chironomus minutus* and *C. plumosus*, live in the water during the larval and pupal stages, are of black color and consist of segments bearing leg-like appendages, each having sucker breathing gills. They usually occur in clusters which form black patches on submerged rocks. When the final metamorphosis takes place the pupa detaches itself from its mooring, floats to the surface, and the Midge rends the case and takes to flight. They form the natural

food for many of the larger insects, young fishes, etc. Net-winged Midges are a very numerous family of hundreds of genera and species.

AQUATIC FLIES. Some of the flies frequent water courses, ponds and pools in which they deposit eggs and where they pass the larval and pupal stages. Among these are the Moth-like flies of the family *Psychodidae*; the Crane-flies of the families *Tipulidae*, *Syrphidae* and *Muscidae*; the False Crane-flies, *Rhyphidae*; the Black-flies, *Empididae*; and the Buffalo-flies, *Simulidae*; Fig. 213; the Horse-flies, *Tabanidae*; the Soldier-flies, *Stratiomyidae*; the Snipe-flies, *Leptidae*; the Long-legged Flies, *Dolichopodidae*; and many others, far too many and too complex in classification for further description in a volume of this character. The aquatic genera are all harmless to young fishes and constitute a part of their natural food.

ORDER COLEOPTERA. Of this order a number of families are aquatic. They have a pair of veinless horny wing covers or elytra, occupying the position of the fore wings, folded and meeting in a straight line down the back, under which is a single pair of membranous wings, though some species have the rudiments of fore wings under the elytra. More than 80 families of Coleoptera occur in America north of Mexico and over 11,000 species have been described. The most generally distributed genera and species of the Eastern section of the United States, which for either a part of, or their entire existence, inhabit the water, are the Predaceous Diving-beetles or Dytiscidae; the Water-scavenger beetles and Great Water-beetles or Hydrophilidae, the Whirligig-beetles or Gyrinidae; the Pond-beetles or Haliplidae; and many other smaller beetles belonging to these genera.

PREDACEOUS DIVING-BEETLES OR WATER-DIVERS belong to the family of Dytiscidae and are brownish-black shining beetles of oval form with threadlike antennæ. The anterior and middle legs are adapted for crawling, the posterior legs are longer, fringed with hairs and adapted for swimming. They abound in ponds and still water, sometimes in streams. The breathing apparatus is located at the hind end of the body, the beetle at rest floating on the water in an inclined position, head downward, and by slightly raising the wing covers admits air under them for breathing under the water. They are voracious and attack all water animals, even large fishes, frogs and snakes. The larvæ are known as Water-tigers, Fig. 222, most ferocious enemies to all living water animals, some of them growing to a length of 2½ inches. They have an elongated spindle form with a large head, and strong, curved and hollow mandibles for holding and sucking the juices of their prey. The segmental body has six legs and terminates in a pair of breathing tubes. The eggs are deposit-

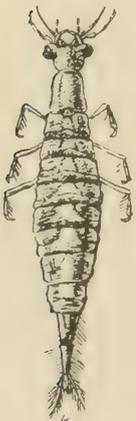


FIG. 222.
Water-tiger. Larva
of a Predaceous
Diving-beetle.

ed in the water and the larvæ leave the water, burrow into the ground to there undergo the final metamorphosis. The flight of the Diving-beetles is nocturnal and their migrations are from pond to pond, being also attracted by bright surfaces and lights. The common genus is *Acilius*



FIG. 223. Predaceous Diving-beetle, *Acilius fraternus*. Female and male. Enlarged.

which is about $\frac{3}{4}$ inch long, of a polished brownish-black color, marked with dull yellow; the elytra covered with fine punctures, the female having four furrows on each wing cover. The more common species are *A. fraternus*, Fig. 223, and *A. mediatas*. The largest belong to the *Dytiscus*, *Cybister* and allied genera; the former having the cups on the under side of the tarsal discs

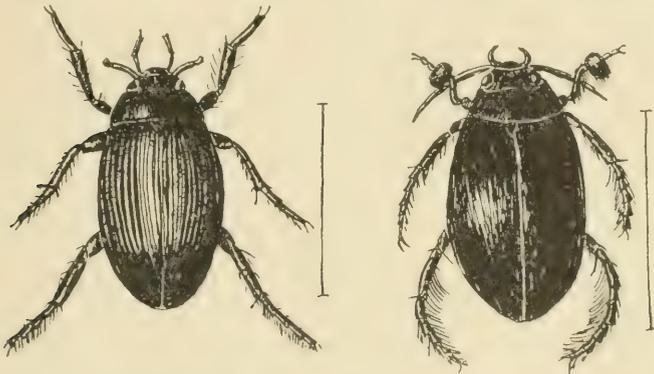


FIG. 224. Predaceous Diving-beetle, *Dytiscus fasciventris*. Female and male. Enlarged.

varying in size, and the latter similar and of uniform size. The more common of these are *D. fasciventris*, Fig. 224, *D. hybridus*, and *C. fimbriolatus*. The genus *Colymbetes* has the elytra marked with numerous fine transverse stria-

tions. The most common species is *C. sculptilis*. All are fairly good flyers and widely distributed in almost the entire United States.

WATER-SCAVENGER BEETLES (GREAT WATER-BEETLES) belong to the family of *Hydrophilidæ* and closely resemble the Predaceous Diving-beetles in general appearance, but are more convex and have short club-shaped antennæ concealed beneath the head and very long palpi, the parts next to the mandibles. They are dusky-black beetles of elong-elliptical form, strong, active and of savage disposition. Both the middle and the posterior legs are fringed with hairs and adapted for swimming; while the

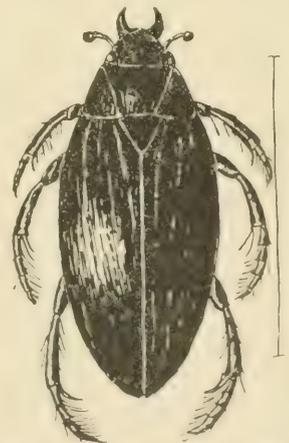


FIG. 225. Water Scavenger-beetle or Great Water-beetle, *Hydrophilus glaber*. Male.

anterior legs are prehensile and adapted to aid in holding their prey. The many hundred eggs are deposited in a cocoon spun by the female and attached to the lower side of the floating leaves of aquatic plants or drifting leaves and branches, Fig. 226, to which the female clings with her posterior legs, and guards until the larvæ are hatched. These also somewhat resemble those of the Dytiscidæ but are thicker and have shorter mandibles, those of the larger genera growing to $2\frac{1}{2}$ or 3 inches in length and $\frac{1}{2}$ inch thick. They are popularly known as Spear-mouths, and are ravenous feeders, destroying water insects, flies, small snails, tadpoles, fishes, and their younger and weaker brethren; all of

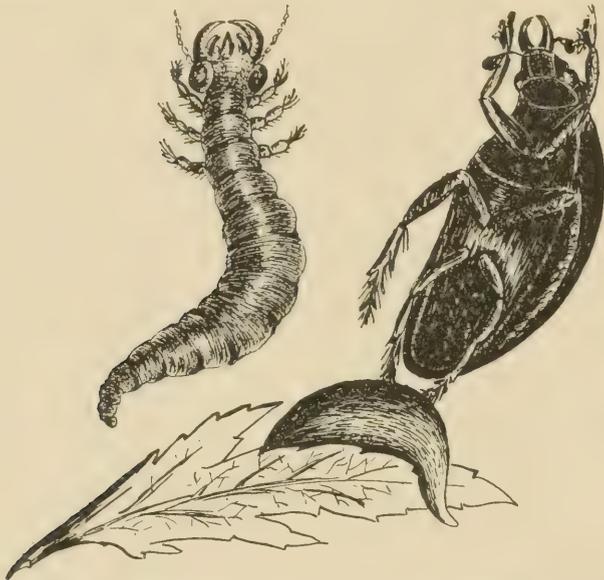


FIG. 226. Water Scavenger-beetle or Great Water-beetle, *Hydrophilus glaber*. Female attached to Egg-pouch and predaceous larva, or Spear-mouth.

which they attack and crush with their powerful mandibles to extract the juices. They are very destructive to young fishes and will destroy hundreds in a few days in the hatching and rearing tanks. The largest beetles of this family belong to the genus *Hydrophilus* of which the most common species are *H. triangularis* and *H. glaber*, Fig. 225, the next larger to *Hydrocharis*, of which *H. obtusatus* is the more common, and the smaller to *Hydrochus*, of which about twelve species inhabit the Eastern and Middle States, the more common forms being *H. scabratus* and *H. variolatus*. There are a number of other genera, and some of the smaller species are not aquatic but live in moist earth and manure, feeding upon Dipterous larvæ. The Water-scavenger beetles are nocturnal in their flights, strong of wing and are attracted by lights and bright surfaces; are frequently seen near electric lights and will penetrate into houses, instances being recorded of their having found their way into household aquaria through open windows. All of this order have short antennæ, clavate or clubbed at the tips and may easily be distinguished from the Diving-beetles.

WHIRLIGIG-BEETLES, also popularly known as Scuttle Bugs and Spinners, belong to the family of Gyridæ and occur in great numbers on almost all still and slow-flowing waters. They are brilliant bluish-black beetles

with peculiar jointed antennæ, strong mandibles and eyes divided by the margins of the head, so that they appear to have eyes for looking into the air and a second pair for seeing into the water. The body is of slightly flattened oval or elliptical form, the anterior legs very long and the middle and posterior legs short, broad and flattened. The breathing apparatus is located at the sides and back of the abdomen. Small cylindrical eggs are laid in parallel rows upon aquatic plants, and the larvæ are narrow, flat and long, somewhat resembling centipedes.

Each abdominal segment is furnished with gills and the caudal end has a pair of breathing tubes. Fig. 229. When fully developed the larva leaves the

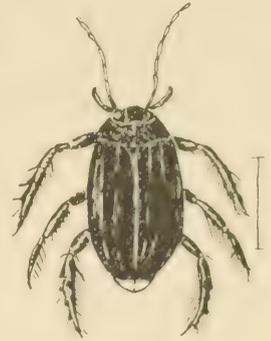


FIG. 227. Whirligig-beetle, *Gyrynus affinis*. Enlarged.



FIG. 228. Whirligig-beetle, *Dineutus vittatus*. Enlarged.

water to spin a cocoon on some near by object, in which it passes the pupal stage and emerges in about one month as the fully developed beetle. The food of the larva consists of the smaller water animals; that of the beetle of flies and other insects, small tadpoles and young fishes. The mouth parts of the beetle are developed for biting and can inflict stinging and bleeding wounds. They are very agile

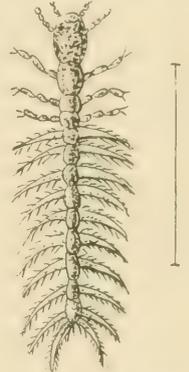


FIG. 229. False Water-milliped, larva of a Whirligig-beetle. Enlarged.

swimmers, their peculiar gyrations on the water having earned for them both their scientific and popular names.

There are three generally distributed genera, *Gyrytes*, of which the most common species is *G. simatus*; *Gyrynus*, of which *G. rockinghamensis* and *G. affinis*, Fig. 227, are most generally distributed; and *Dineutus*, of which *D. vittatus*, Fig. 228, and *D. assimelis* are the more generally distributed forms in the Eastern and Middle States.



FIG. 230. Pond-beetle or Haliplid, *Haliphilus ruficollis*. Greatly enlarged.

POND-BEETLES OR HALIPLIDS are small beetles belonging to the large family of Haliplidæ, having oval bodies more or less pointed at each end; the three most generally distributed aquatic genera being *Brychius* of the Pacific Coast States, and *Haliphilus* and *Cnemidotus*, common to almost all ponds and streams on the Atlantic slope. The larvæ are aquatic and have a slender segmental body furnished with spiny tips, the last segment bearing a long single or forked caudal appendage. The most

generally distributed species of *Haliphus* are *H. fasciatus* and *H. ruficollis*, Fig. 230, and of *Cnemidotus*, *C. punctatus*. They are harmless to young fishes but have been observed to feed upon spawn.

SMALLER WATER-BEETLES. A small water-beetle of the family Par-
nidæ, *Psephenus lecontii*, Fig. 231, has a dark five-jointed body clothed
with fine silken hair to retain a film of air when
it crawls below the water surface, adhering to
plants and stones, as the legs are not so well
developed for swimming. The larva is very flat,
broadly oval or almost circular, $\frac{5}{16}$ inch in length,
and consists of 10 to 12 closely fitted segments.
It lives principally upon vegetal substances
but attacks the spawn of snails and fishes.

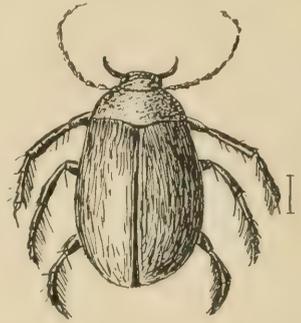


FIG. 231. A Smaller Water-beetle, *Psephenus lecontii*. Greatly enlarged.

Another small aquatic beetle belonging to
the family of *Heterocerus*, *H. pusillus*, has an
oblong or nearly oval form of dark-brown color
with bands and spots of yellow. It is almost covered with hairs for the
retention of air and burrows galleries into the mud at the margins of ponds
and streams. The mouth parts are developed for biting. The larvæ
and nymphæ of another member of this family, *H. rosæatus*, are of a
bright-red color.

There are many other small Water-beetles not so frequently met
with and mention of all of which would too greatly amplify this volume.
They are usually harmless to fishes, and are scavengers rather than
active enemies.

ORDER LEPIDOPTERA. Of this order a number of families abound
in the neighborhood of marshes and ponds and several species feed upon
the leaves of aquatic plants. Of these the larvæ have in various de-
grees adopted an aquatic existence. They are the China-Moths or *Hydro-*
campa, the China-Marks or *Cataclysta*, and several other smaller genera.

CHINA-MOTHS belong to the genus *Hydrocampa*, the species varying
in length of body from $\frac{3}{8}$ to $\frac{5}{8}$ inch and in spread of wings from $\frac{3}{4}$ to
 $1\frac{1}{4}$ inch, while the larvæ or caterpillars are $\frac{1}{2}$ to 1 inch long, of a white
color tinged with yellow, with the body thickest at the mid-
dle and narrowed at both the
ends, having 16 feet, the last
pair very short. The popular
name of the moth is due to the
markings on the wings which
are white, mottled with vary-

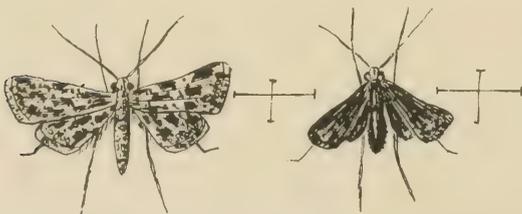


FIG. 232. Water-moths. China-moth, *Hydrocampa obliteralis*
and China-mark, *Cataclysta fulicalis*. Enlarged with extended wings.

ing patterns and shades in brown. It may be seen on the wing in early summer, deposits its eggs, encased in a gelatinous capsule, on the under side of floating leaves near the edges. The larvæ burrow into the leaf until too large to find a refuge, when they bite off oval pieces and fasten them to other parts of the leaf with a gelatinous secretion or silk; and in this secure retreat the molts take place. The more general species are *H. oblitalis*, Fig. 232, which lives on water plants in greenhouses, rarely out-of-doors, *H. albalis*, *H. allionealis*, *A. ekthlipsis*, *H. icciusalis*, *H. obscuralis*, *H. stenialis*, and six other species on the Atlantic slope of the United States.

CHINA-MARKS OR CATACLYSTA are small moths, rarely over $\frac{5}{8}$ inch spread of wings, of which those of the male are white, with black markings and of the female brownish with darker markings. The larva is brownish and is most often found among the duckweed, of which it spins together the leaves to form a casing. The more general species are *C. fulcalis*, Fig. 232, and *C. bifascialis*, with three other species not so generally distributed in the United States.

There are several other genera of Lepidoptera which are semi-aquatic but which are not generally distributed and need not be mentioned here.

ORDER ARICHNIDÆ. This order, consisting of the spiders, scorpions mites and harvest-men, possesses certain characteristics in common with the Crustaceans with which it is allied. All the families have a combined head and thorax, a globular, ovate, cylindrical or triangular abdomen connected by a slender waist; eight legs attached to the thorax, and simple eyes, varying from 2 to 12 in number, placed in two transverse rows. The mouth parts are armed with powerful forceps to seize, hold and poison their prey, below which is a pair of maxillæ, somewhat resembling a pair of legs. The spinning organs are situated at the tip of the abdomen and the breathing apparatus is at the forward portion of the abdomen. It serves the purpose of lungs, the colorless blood circulates around and through it and is aerated by the absorption of air. There is no metamorphosis, as the young, just issued from the egg, exactly resembles the adult. Molting continues after the spiders have reached the adult stage. All the aquatic genera belong to the Senoculina, or six-eyed group. One species, *Argyroneta aquatica*, Fig. 233, about $\frac{3}{8}$ inch long, spins a baglike web of silk half the size of an acorn among the water plants with the opening below the surface, and lives in it under the water, taking a bubble of air into it each time it comes to the surface; effected by erecting

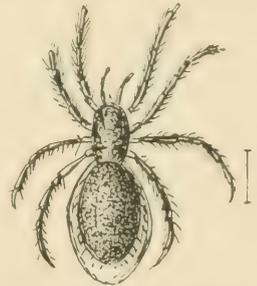


FIG. 233. Aquatic-Spider, *Argyroneta aquatica*. Abdomen surrounded with air. Enlarged.

the end of the abdomen out of the water, jerking it under and quickly crossing the hind legs over it, then descending to the nest and by opening the legs the air bubble escapes into the nest. The hairs on the body keep the surface from becoming wet, and in the nest the spider is as dry as on land. The 40 to 100 cocoons, containing the round saffron-colored eggs, are laid in the nest during June, and in July the young are large enough to spin a nest of their own. Another family of the eight-eyed group, the Lycosidæ, have semi-aquatic genera which almost exclusively live on the banks of ponds and streams and prey upon aquatic insects, chasing them on the surface of the water. Some species grow to nearly one inch in length. Other smaller species are of similar habit. These often dive below the surface when pursued by enemies from above the water or when in pursuit of their prey.

ACARINA. This family consists of the lowest order of the Arachnidæ, which live in the earth and in both fresh and salt water. They comprise the Mites and Ticks which differ from other Arachnids in their oval or rounded forms, which are not articulated. The mouth parts are developed for biting and sucking and they breathe by tracheal gills. Of this family the Water-mites are known as Hydrachnidæ, which have soft, oval unsegmented bodies, and limbs adapted for swimming, terminating with adhesive vesicles. They are parasitic on fishes and mussels, while some of the smaller species live on the Hemiptera, Coleoptera and other insects. The most generally distributed genera are Hydrachna, Atex, Limnochares and the marine Pontarachna. Atex has an oval solid body of bright red color with curved, clawlike mandibles, acute, pointed maxillaries, and short, weak legs. The species inhabit some of the mussels, *A. ypsilophorus* in Anadonta and *A. humerosa* in Unios. The eggs are laid in the spring on the stems of water plants and when hatched seek hosts in which to pass their subsequent existence. A bright red species, *Bdella maritima*, occurs under stones between tidemarks. Three species of Trombidium are represented in the United States, all of red color.

HYDRACHNA OR WATER-MITES, are common in ponds. They are tenacious of life and steadily move about by the rapid movements of their fringed legs. The larvæ have six and the adult eight legs, which increase in length, with the posterior pair the longest. The body is slightly convex, the mandibles needle-shaped, the third joint of the maxillæ the longest, and all the species have two distinct eyes. They are parasitic on both fishes and mussels, and are frequent external freshwater parasites, easily detected by their size. The largest and most widely distributed form is *H. geographica*, Fig. 234, while *H. globosa* and *H. triangularis* are also frequently occurring species.

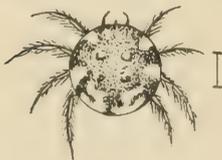


FIG. 234. Water-mite,
Hydrachna geographica.
Enlarged.

CHAPTER XII.

Aquarium Construction, Tools and Appliances

AQUARIUM CONSTRUCTION

In the construction of an aquarium the first consideration should be the comfort of the animal inmates, then the production of a pleasing form, with sufficient strength to insure against leaks or breaking of the glass by the water pressure. This latter, as previously mentioned, frequently occurs with all-glass aquaria, and has led to the more general adoption of brass and iron-framed aquarium tanks.

AQUARIUM PROPORTIONS. Surface aeration being necessary to the survival of all forms of aquatic life, the aquarium should be constructed to have large surface dimensions, greater than the depth of the water; even

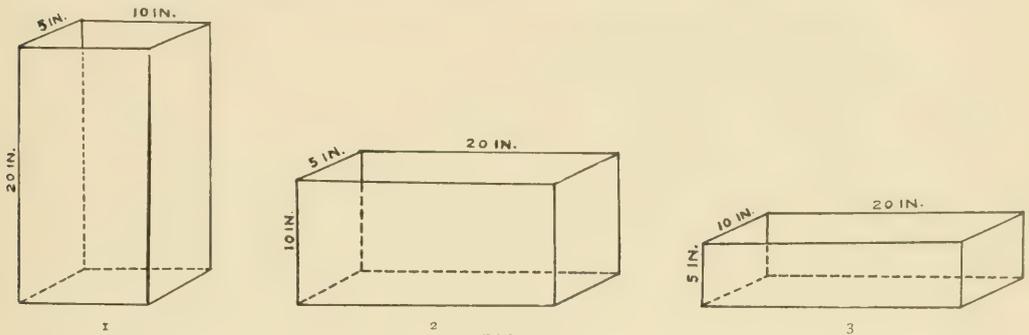


FIG. 235.

though its appearance may not be quite as pleasing as the usual high and narrow forms, designed to offer the largest field of view, to occupy the least space, and to restrict the weight of both the aquarium and its contents. To test the importance of surface aeration, a few freshwater fishes may be placed into a shallow dish of water and the same number into a high and narrow jar containing the same quantity of water, when it will be observed how soon those in the latter receptacle will come to the surface gasping for air. The diagram, Fig. 235, shows three vessels, each containing 1000 cubic inches of water, the first having a surface area of 50 square inches, the second 100 square inches, and the third 200 square inches. No. 3 will support at least twice as many fishes as No. 2 and four times as many as No. 1.

The length of an aquarium may be proportioned to the available space, but the breadth should not exceed 24 inches; when greater than this the contents will be somewhat obscured. The depth of water should not exceed 20 inches, because the pressure of the water would cause discomfort to the inmates and tend to confine their movements to the upper part of the aquarium. Large shallow tanks always give the best results. When space is available and the light is on the surface, a nearly

square aquarium may be adapted, but at a window with front light, the proportion should approximate a double cube, the length twice the breadth; but in either form the depth of the water should not be over 20 inches.

AQUARIUM BASES. A variety of materials may be utilized in the construction of a base or bottom for an aquarium. Heavy white pine, cross-battened on the under side and covered with zinc or glass; a plate of thick glass inclosed in a strong wooden or other frame, or slabs of marble or slate are all practicable; but wood will prove unsatisfactory for aquaria exposed to the weather. Slate is the best material and may be had of dealers in the desired sizes and thicknesses, with the edges either polished or marbled. Slate bases one inch thick weigh 14 pounds per square foot. The required thicknesses are:

For aquaria to	15 gallons,	not less than	$\frac{1}{2}$ inch thick.
“ “ “	40 “ “ “	“ “ “	$\frac{3}{4}$ “ “
“ “ “	80 “ “ “	“ “ “	1 “ “
“ “ “	125 “ “ “	“ “ “	$1\frac{1}{4}$ “ “

Aquaria with cast iron bases and frames may be obtained but should be thoroughly protected from rust on the surfaces in contact with the water by asphaltum varnish or other protecting covering.

AQUARIUM FRAMES. Wooden frames may serve for small aquaria, but are not satisfactory. Contact with the water will cause warping and leaks. Zinc frames are too weak for aquaria of larger size. Angle brass frames are largely used and make handsome aquaria, either polished and lacquered or nickel-plated. For very large aquaria the angles, as rolled, are weak and should be reinforced by soft-soldering two together, as otherwise the resistance to the water pressure will depend too much on the strength of the glass plates. Angle iron is the most satisfactory for all sizes and may be obtained in different widths and thicknesses. The proper sizes and weights are:

For aquaria to	15 gallons,	$\frac{1}{2}$ to $\frac{5}{8}$ inch,	weighing	.56 pounds per foot.
“ “ “	30 “	$\frac{3}{4}$ “	“ “	.62 “ “ “
“ “ “	60 “	$\frac{7}{8}$ “	“ “	.87 “ “ “
“ “ “	80 “	1 “	“ “	1.50 “ “ “
“ “ “	125 “	$1\frac{1}{4}$ “	“ “	1.75 “ “ “

AQUARIUM GLASS. Double-thick window glass may be used for aquaria under 20 gallons, or for the narrower sides of those under 30 gallons capacity; but its composition is such that its power of expansion and contraction is slight and it is liable to fracture from slight strains. Double-thick Crown or German-flint glass is preferable, and better resists pressure and danger from accidents. Plate glass is best for all aquaria, and may be had in two or more thicknesses, $\frac{1}{4}$ inch for aquaria under 60

gallons, and $\frac{3}{8}$ inch for larger ones. Crystal plate is a beautifully polished, white flint glass used for the finest aquaria. It is softer in composition than the usual American plate glass.

AQUARIUM CEMENTS. The desired properties of an aquarium cement are insolubility, resistance to the action of water, strong adhesion, and absence of deleterious substances in its composition. It should "set," or become fairly hard, but not too quickly, nor become so hard that it will not permit of some expansion and contraction of the glass and frame. It should be sufficiently soft to be readily applied and to adhere closely to the surfaces. When its consistency is like that of stiff glazier's putty it is sufficiently thinned for use.

White and red leads form durable chemical combinations with linseed oil, but the acid substances which accumulate in the aquarium produce combinations with them which are injurious, so that when they are used they should be covered with a coating of paste composed of whiting and of shellac dissolved in naphtha. Together with litharge, they may be used where the glass is set into grooves; but for all purposes, zinc white is more satisfactory and should be given the preference.

CEMENTS FOR WOODEN-FRAMED AQUARIA. For securing the glass into wooden-framed aquaria, either of two cements may be used. One is composed of 4 parts by weight of pitch and 1 part of gutta percha, boiled together and applied warm to the heated frame and glass. The other consists of 2 parts by weight of zinc white, 1 part of litharge, 3 parts of Portland cement, 3 parts of fine sand and 1 part of powdered resin, kept dry in an air-tight receptacle, and when used made into a thick paste with boiled linseed oil. It "sets" quickly and becomes very hard.

CEMENT FOR ZINC-FRAMED AQUARIA. The glass and frame are painted with "gold size" and permitted to dry. The cement is composed of equal parts of zinc white and red lead, rubbed into boiled linseed oil, to which sufficient litharge is added to make a thick putty.

CEMENT FOR BRASS AND IRON-FRAMED AQUARIA. A good cement for aquaria of thin glass, but not so well adapted for double-thick or plate glass, consists of 3 parts by weight of zinc white, 2 parts of litharge and 2 parts of Portland cement, mixed into a thick paste with boiled linseed oil, and an equal bulk of glazier's putty added. This "sets" hard and makes a very durable cement. For plate glass the following are extensively used: First, the frame, base and glass are painted with gold size. The cement is made of 1 part by weight of zinc white, 1 part of red lead, 1 part of litharge, 16 parts of glazier's putty and a very little ivory black, well kneaded together with a little boiled linseed oil and a small quantity of Japan drier. This "sets" slowly and never becomes perfectly hard, so as

to allow of the slight expansion and contraction. Second, a harder drying cement may be made of 2 parts by weight of red lead, 1 part of litharge and 16 parts of glazier's putty, mixed and applied similarly to the foregoing. Third, equal parts, by measure, of litharge, red lead, plaster of paris, powdered resin, boiled linseed oil and Japan drier; mixed and used at once. Fourth, one gill each of litharge, powdered resin, fine white sand and plaster of paris; mixed and cooked to a paste with boiled linseed oil and a little Japan varnish.

Should any of these cements not set sufficiently hard, as may happen in warm weather, Portland cement will remedy the difficulty. The bright-red color of these cements may be modified to any desired shade by the addition of ivory black.

CEMENTS FOR MARINE AQUARIA. A cement composed of 2 parts of litharge, 3 parts of Portland cement, 3 parts of fine sand, 1 part of powdered resin, mixed to a thick putty with boiled linseed oil, is most generally used. Another cement is composed of litharge made into a stiff putty with glycerine and sets very hard. It may be also used to stop leaks.

CEMENT FOR FRAMELESS AQUARIA. Powdered sulphur is added to melted beeswax to form a very thick fluid, and poured into the corner posts after the aquarium is assembled. Another cement for aquaria, having the base grooved to dispense with a lower frame, consists of zinc white, and spar varnish, to which any coloring substance may be added, and made into a thick paste or putty.

CEMENT FOR ROCKWORK AND TUFTSTONE. Equal parts of Portland cement and sharp white sand are the best for these uses. Mineral and animal oils should never be used in aquarium construction.

AQUARIUM PAINTS. Asphaltum varnish is the best coating for all frames, over which oil paints of an desired color may be used; but not where it will come into contact with the aquarium water. Bronze, silver or aluminum powders in gold size make a handsome finish. Surfaces in contact with the water, or in moist places, are best protected with asphaltum varnish. Decalcomania decorations on the frames, covered with varnish, make handsome embellishments.

CONSTRUCTING AQUARIUM FRAMES. To facilitate comprehension of the construction of angle-framed aquaria, the parts will be described as the lower and upper frames and the corner posts. The greatest accuracy must be observed to have all the parts of exactly the same size, true, plumb and at right angles. The angle iron, which constitutes the upper and lower frames, must be marked of exactly the right lengths and the mitre-pieces sawed or filed out at the corners so that the frames when bent will be true in all directions, prior to which the bolt holes in the lower frame should

be drilled and countersunk to take in the flat heads of the bolts. A rivet hole is drilled through the frames on each side of the corners, to exactly correspond with those in the corner posts, which are countersunk for the rivets, that they may be hammered flush on the inside of the frame.

The base is usually 3 inches greater in length and breadth, so as to extend $1\frac{1}{2}$ inches beyond the frame on all sides. The frame is set upon the base and the bolt holes marked; which are then drilled through the slate and opened on the under side to accommodate the nuts. Stove-bolts of the exact required length are the best for this purpose.

ASSEMBLING THE AQUARIUM. When assured that all the parts are true and in perfect alignment, and the bolt holes in the lower frame and in the base exactly plumb, the lower frame and the base under it should be coated with zinc white, and after this dries, aquarium cement spread over this part of the base and the frame evenly and securely drawn tight by the bolts, the number of which depends upon the size of the aquarium; but one should be placed very near each side of the four corners, with one, two or three between, at even intervals, on both the long and the short sides, to make the frame rigid and to prevent subsequent leaks. The bolt holes and the space about the nuts should be filled with aquarium cement. A method of construction is to use separate corner pieces to unite the lower and upper frames with the corner posts, usually adopted for large aquaria, which has the advantage of making all the inner sides flush; but riveting them together and filling the space between the frame and the glass with cement is quite as neat and strong in construction.

SETTING THE GLASS. The glass should be carefully cleaned with whiting to remove grease. The frame having been filled with a smooth coating of cement, the glass should be carefully pressed against it, the longer sides being first inserted and kept in place by wooden strips at the top and bottom, and then those of the shorter sides inserted; all done by very gentle pressure and supported in place by the wooden strips, acting as braces. After a day, the lower and upper edges of the glass at the frames and the corners, where front and side meet, may be covered with aquarium cement, and this left to harden or covered with slender strips of glass. Filling the aquarium with water will tend to exert an even pressure on all sides and cause the glass to press evenly on the cement. The cement however will take longer to become hard. When taking an angle-framed aquarium apart, there will be less likelihood of breaking the glass if the cement is softened by running a knife-blade between it and the glass and pouring in coal oil.

SOME AQUARIA DATA

231 cubic inches of water are a gallon, which weighs $8\frac{1}{3}$ pounds; a cubic foot of water contains $7\frac{1}{2}$ gallons, and 268 gallons weigh a long ton of 2240 pounds.

The weight in pounds of the water in an aquarium may be obtained by multiplying the number of gallons by $8\frac{1}{3}$.

The pressure on the bottom of an aquarium is obtained by multiplying the height, in inches, by 0.43, the result being pounds per square inch of bottom; the pressure on the sides by multiplying the length by the breadth, in inches, and this by one-half the pounds pressure per inch on the bottom, obtained as above. The result is the total pressure in pounds.

The number of gallons in a rectangular aquarium is obtained by multiplying the length, breadth and depth, in inches, and dividing by 231. The result is in gallons. Should the sides be sloping, the mean of the upper and lower diameters, (the diameter in the middle,) is taken.

The capacity of a sphere is obtained by multiplying the cube of the diameter, in inches, by 0.5236 and dividing by 231. The result is in gallons.

The capacity of a cylinder is obtained by multiplying the square of the radius (one-half the diameter,) in inches, by 3.1415; multiplying this result by the depth, in inches, and dividing by 231. The result is in gallons.

For ready reference, data is given of the usual sizes of household aquaria. The weights are in pounds, the pressure in pounds per square inch.

Length.	Breadth.	Depth.	Gallons.	Weight of water.	Pressure per square inch on bottom.	Total pressure on sides.	Total weight of aquarium and contents.
20	12	12	12	100	5.16	625	150
24	12	12	15	125	"	740	185
30	12	12	18	150	"	925	225
30	14	14	25	210	6.02	1250	290
30	16	16	33	275	6.88	1825	375
36	18	18	50	415	7.75	2450	550
40	18	18	56	465	"	2675	610
48	18	18	67	550	"	3275	715
48	20	20	80	665	8.60	4125	880
54	20	20	90	750	"	4640	985
60	20	20	100	835	"	5100	1110

A number of methods have been devised to construct aquaria without frames, some of which have been successful and of handsome appearance; but a neat frame appears more structural, and for sizes over 24 inches is essential to both strength and safety.

AQUARIUM TOOLS AND APPLIANCES.

The experienced aquarist avails himself of a number of simple tools and appliances to facilitate the manipulation of the aquarium. Of these a brief description follows:

NETS. The knotted-mesh twine nets sold by dealers are usually of poor form and too rough for handling goldfishes. It is preferable to employ very shallow ones of Brussels netting. The simplest construction of frame is one piece of wire, first turned into the circle and the end twisted upon the shank. A neater one may be made of a wire ring soldered into the head of a brass wood-screw, and fastened to a light wooden rod. The most practical size for the aquarium is about $4\frac{1}{2}$ to 5 inches in diameter, rounded in form at the back and straight in front; and for the tank a solid brass wire-framed rectangular net about 8 by 12 inches.

FORCEPS. One of the handiest aquarium tools is the forceps. The simplest construction is of one piece of brass wire bent into equal legs, crossed and slightly flattened at the rivet holes and the ends serrated. Pressure applied anywhere above the rivet closes the jaws and even the smallest particles can be removed or plants forced into the pebbles by grasping the roots. Another form may be made of two straight pieces of wood screwed to a light block and long enough to be operated without putting the hand into the water. A spring clothespin to which two slender pieces of wood are fastened is another approved form of forceps.

HANDY STICKS. What have been appropriately called "handy sticks" consist of two light wooden rods, having one end notched like an inverted V and the other cut to a chisel edge. They may be applied to many uses; making holes in the pebbles for planting, forcing down plants, cutting off runners, and straightening the leaves.

PLANT SCISSORS. The leaves and blades of aquatic plants should not be torn off, even cutting them with the finger nails so bruises them that further decay results. A scissors only should be used and to avoid putting the hand into the water, they should have long shanks. These may be made of a pair of round-end scissors from which the finger holes have been removed and replaced by long brass rods with finger holes bent at the ends. In using them two hands will be necessary. The clean cut affects the plant the least and insures a neat and tidy appearance.

DIPPING OR LIFTING TUBE. With this handy tool objectionable substances may be removed from the aquarium. The best form is a chemist's pipette or $\frac{1}{2}$ inch glass tubing at least 6 inches longer than the depth of the water, having the lower end protected by a rubber gasket to prevent fracture or scratching of the aquarium glass. In use the upper end is closed with the fingers and the tube directed over the object, when the removal of the fingers causes an inrush of the water by atmospheric pressure, carrying with it the substances to be removed. Then the upper end is again closed with the fingers and the tube raised to the surface of the water, the lower end is closed by the fingers and the tube and its contents removed.

SIPHON. A very useful accessory is a siphoning tube of $\frac{3}{8}$ inch rubber hose, that of red rubber being usually of the best quality, more durable and not so likely to kink or lose its cylindrical form. A piece of glass tubing of smaller diameter than the hose, inserted at the end, will prevent the sucking in of pebbles that may clog the tube; but the best device is a glass calcium tube larger in diameter than the hose and having a bulb to arrest any particles and check their entrance into the hose. To remove these particles the hose is pinched to stop the flow of water and the pebbles, snails, or whatever else may have been sucked in, will fall out of the bulb. Another device at the other end will serve to avoid getting water into the mouth in creating the necessary suction. This consists of a glass tube with a branching side to which a piece of small hose is attached, which when taken into the mouth and the lower end of the tube closed with the finger, in drawing up the water the finger will feel it before it ascends the small tube to the mouth. Unpleasant involuntary swallows are thereby avoided.

THERMOMETER. A thermometer is indispensable for the culture and maintenance of the goldfish. For the aquarium, floating thermometers are to be recommended, dairy thermometers answering the purpose, are the cheapest and most readily to be had. The bulb should reach to the centre of the water to indicate the mean temperature, as that of the surface is usually warmer. A little tin foil above the bulb will cause it to float upright.

ASPIRATORS. A fountain syringe with which to aerate the water is not absolutely necessary, but if at hand will be frequently used, as it may obviate the frequent change of water in aquaria that are not properly conditioned or balanced, and may greatly relieve the fishes in hot weather. An ordinary rubber air bulb and a short piece of hose will suffice, but a garden sprinkler at the end will cause a finer division of the air particles

and a larger absorption by the water. A generally used device is the rubber florist's aspirator.

CONSTANT LEVEL SIPHON. Aquaria having a constant water supply or tanks in the open air sometimes require means of keeping the water at a fixed level. For this purpose the constant level siphon is best adapted, which consists of a metal or glass tube bent into the form of an irregular S with the inlet leg the longer; then bent at right angle and downward to carry it over the side, and the upper part bent upwards so that the outlet is at the desired water level. Once filled with water it will be in constant operation by capillary attraction. A funnel and tube may be arranged to carry off the overflow water, when necessary.

THE STRAINER. The ordinary household strainer will be found convenient to gather floating particles from the surface of the water. A tea sieve is of convenient size for the aquarium.

THE POLISHER. The best form of polisher to remove algæ from the glass sides of aquaria may be made of a felt jeweler's buff attached to a rod, the centre holding pin sunk into the felt to prevent scratching the glass. Brushes, wood blocks covered with several thicknesses of canton flannel or other materials have been tried but are not as good. Polishers are not intended for use when the algæ are thick, as then only the hand, a piece of soft cloth and a little table salt will properly clean the glass.

THE SCOOP OR DREDGE. A metal scoop on a rod is handy in many ways. With it the pebbles may be moved and shifted or put into the aquarium at the exactly desired locality. Any form having a straight front edge will serve this purpose.

THE MAGNIFYING GLASS. A good reading glass is a useful adjunct, as by its use objects in the aquarium will be enlarged and a clear observation of the contents obtained.

AQUARIUM STANDS. Stands may be constructed of a variety of materials. Tables of wood with shelves for smaller aquaria and brackets for flowering plants are quite general, and may be inexpensively constructed. An iron stand of $\frac{3}{4}$ inch gas pipe with iron fittings, either painted the color of the aquarium frame or with any desired color of bronze powder, makes a clean, neat and inexpensive support. Window brackets, secured at different heights to the trim of the window, have been shown in illustrations and are intended for one-piece glass or other small aquaria. If taste is displayed in their arrangement and of the contained plants, a very pretty effect may be produced. Shelving across the upper sash for placing a row of battery-jar aquaria would also be a pleasing arrangement.

A picturesque aquarium stand for the porch or garden may be made of a portion of the gnarled trunk of a tree, the main stem furnished with

a flat board the size of the aquarium and the branches sawed off at different levels to accommodate smaller aquaria and pots of growing plants. Other pots or trays could be arranged about the bottom and planted with creepers, which may be trained around the trunk and branches. The whole arrangement can be constructed on rollers, for use on the porch in summer and in the conservatory during the cold weather.

CHAPTER XIII.

The Marine Aquarium, Inmates, and Maintenance

MARINE AQUARIA

Freshwater aquaria are familiar household objects, but the Marine aquarium is known to the general public only through the exhibitions at World's fairs or those in some of the larger cities, as in Castle Garden, Battery Park, New York; the Vivarium of the University of Pennsylvania, at Philadelphia; and the Grotto of the Fish Commission Building, at Washington, D. C.

It is a general opinion that the marine aquarium is difficult to establish in the household, though it is really easier to maintain, when properly installed, than those of freshwater, as ventilation, good light and sunshine are not as important; they are even to some extent objectionable, as strong light is likely to produce an excessive growth of algæ, and oscillatoria, which may cause turbidity in the water, and the marine fauna is more comfortable without much light, as in the ocean they obtain comparatively little.

AERATION. The necessary aeration is not produced by the growth of plants, as is the case in the freshwater aquarium. The marine flora cannot be kept in fine growing condition under any circumstances, and may be largely dispensed with, its purpose being more to enhance the beauty and add to the natural appearance of the aquarium than to serve as oxygenators. The all-important necessity is an efficient artificial aeration, and some little experimentation is necessary that the introduced air is evenly distributed at all times, and in sufficient quantity to satisfy the requirements of the animals without excess and overstimulation. The correct amount under varying conditions is soon learned. The air should be admitted along the rear of the aquarium as a heavy fog, not in small bubbles to burst on the surface. More air must be introduced when the water is warm than when it is cold, as at higher temperatures less is absorbed by the water, while the animal requirements are greater, they being then the most active.

The simplest and most efficient aerating device is the cylinder and pump described on page 178; and which should be kept in constant operation, though care should be taken not to over-aerate the water.

Another simpler aerating device consists of a flowerpot or jardinaire, having the bottom hole plugged with a piece of sponge and suspended over or supported on the frame of the aquarium. Into this some of the water is filled and in perculating through the sponge is both cleared and aerated. It fully answers the purpose for shallow smaller tanks.

FORMS OF MARINE AQUARIA. Any large glass receptacle may be used, but the best forms have glass fronts and sides, slate backs and bottoms, and are constructed so that no metal or cement comes into contact with the salt water. The cement should be covered with strips of glass and the frames arranged outside the glass so that the glass cover-plate rests on the upper edges of the glass and slate, and protects the frame from the action of the salt water, to prevent its rusting and to exclude iron rust from the water. The purpose of the cover is to check a too rapid evaporation and to avoid the trifling splashing caused by the escape of the air through the water.

ARRANGING THE AQUARIUM. In the arrangement of the aquarium the bottom should be covered with sand and small pebbles, upon which either a central or two side mounds of stones, preferably granite, may be erected, interspersed with sea shells, corals and other marine objects, to form grottos and caves, but kept away from the glass, as they may topple and break it. Then the bottom should be covered with a thick layer of fine beach sand, the purpose being to produce a realistic effect, simulating a small section of the quiet bottom of the sea. The slate back may also be covered with pieces of rock, pumice and corals, to form a background, having shelves and projections at different elevations to which the sea anemones and other polyps may attach themselves, or on and behind which deep pockets may be formed and filled with sand, into which the other animals may burrow and hide. Very picturesque marine effects in the decorations and embellishments are possible, different in character from those employed for the freshwater aquarium or the terrarium. The animals will also burrow into the sand on the bottom as it offers the best medium for the continuance of their natural habits.

SEAWATER. Admirers of the marine aquarium in seaboard towns have ready access to seawater and others may have it shipped to them. It should not be taken near the outlet of a freshwater stream, or where contaminated by sewage, but at some distance from the shore; and should be permitted to stand several days before use, that it may purify itself. Care is also necessary that the vessel in which it is transported is clean, odorless and tasteless.

The simplest and best method, however, is to produce seawater artificially, as when the constituents are in proper proportions, it is preferable to the natural water, and is cleaner, clearer, and less likely to contain algæ in excess; those present being introduced with the plants and animals and are required by some of the inmates. Marine plants and animals have been found to thrive as well and better in the artificial than in the natural seawater.

Analyses have shown that seawater contains mineral salts of the following proportion, in 1000 parts:

Sodium chloride	26.9 parts.
Magnesium chloride	3.2 “
Magnesium sulphate	2.2 “
Calcium sulphate	1.4 “
Potassium chloride6 “
Sodium bromide06 “
Potassium sulphate04 “
Water	965.6 “
	1000.

ARTIFICIAL SEAWATER. Experienced marine aquarists prepare artificial seawater with the following salts, the proportions given being for a volume of ten gallons, and the weights in Apothecaries' weight, as this is the most convenient source from which they may be obtained.

Sodium chloride (Tablesalt)	2 lb. 8 $\bar{5}$. 2 $\bar{5}$.	18 gr.
Magnesium chloride	3 $\bar{5}$. 5 $\bar{5}$.	13 gr.
Magnesium sulphate	2 $\bar{3}$. 3 $\bar{5}$. 1 $\bar{0}$	8 gr.
Potassium sulphate	5 $\bar{5}$. 2 $\bar{0}$	10 gr.

and sufficient wellwater to bring the whole to ten gallons.

These proportions of salts, expressed in the Metric system, would be:

Sodium chloride	663 grams.
Magnesium chloride	75 “
Magnesium sulphate	50 “
Potassium sulphate	15 “

Added to 25 litres of wellwater.

The salts should be fresh and be kept in glass-stoppered bottles. The magnesium chloride deteriorates when exposed to the atmosphere, and the tablesalt should not be very moist.

Each of the salts must be dissolved in a glass or porcelain vessel by stirring in a little water and then separately added to the wellwater, until the whole quantity is exactly ten gallons, or any desired part or multiple thereof, in the same proportions. The prepared seawater should be kept in a clean glass or stoneware vessel in a cool place and lightly covered for two or three weeks, and occasionally stirred to insure a complete solution and uniform mixture; after which it is ready for use.

A solution of Turk's Island salt of the proper gravity has been successfully used by the Fish Commission, at Washington, for small aquaria, but it is best to prepare the saltwater as above given.

When the aquarium has been filled, it should be left undisturbed for a day or two, after which the water will be found to be clear and limpid.

More water than is required to fill the aquarium should be prepared so that a part may be kept in reserve, which, in a cool place, will not deteriorate but improve in quality and in fitness for use in case of necessity, which may happen to the novice.

HYDROMETER. A hydrometer or specific gravity bulb is not absolutely necessary but is useful. Seawater has a specific gravity of 1.023 to 1.031, which means that a volume equal to one cubic centimeter is approximately .027 grams heavier than the same volume of freshwater of the same temperature, customarily taken at 10°C. or 50°F. Should the hydrometer sink below this point, then the water is not sufficiently saline, or should it rise above, it is too concentrated. Having established the degree of salinity of the water when the aquarium has been filled, its maintenance is simple; evaporation to produce concentration is only the wellwater, which may be filled in, or should changes occur to affect the degree of salinity, a part of the water may be siphoned and some of the reserve water added, to again establish the correct balance. This very rarely or never occurs.

Before the living inmates are introduced, the aeration should be operated for some time, that the water will be charged with air, to revive the animals after their exhausting journey or from other disturbances which may affect their survival.

TEMPERATURE. With proper aeration the temperature of the water does not seriously affect the inmates. Those of the household, of 70°F. to 80°F. in the summer, are not injurious, if the air supply is sufficient; for which reason the aeration should be more considerable in warm than in cool weather. The activity of the animals also increases with the temperature, whereby they liberate more carbonic acid gas and require a corresponding increase of oxygen for their comfort.

MARINE AQUARIUM PLANTS. The growth of plants in the marine aquarium for other than ornamental purposes has never been satisfactorily accomplished. No dependence can be placed on them to serve as oxygenators; for, though they are of most exquisite and delicate forms and beautiful colors, they are all of the lower order of cryptogamous plants which rank as very indifferent generators of oxygen.

MARINE FLORA. These marine cryptogams or algals are all non-flowering, cellular plants, which may be classed by their colors, as this very nearly corresponds with the botanist's classification based on their methods of reproduction. The lowest and simplest forms, Chlorospermeæ, are bright or grass-green in color, the next higher, Melanospermeæ, olive-colored, and the highest forms, Rhodospermeæ, are red in color. All have a wide range of distribution in America and Europe, and consist of arctic,

temperate and tropical genera. Those of the Atlantic and Pacific oceans are similar, but for the purpose of this volume the Middle Atlantic coast species only will be described.

Cape Cod is accepted as the dividing line, as north and south of it a markedly different marine flora exists, because the great arctic and equatorial currents maintain different temperatures of the water; and though the more common seaweeds may be found in both sections, those to the north are essentially arctic and those to the south temperate zone species. About a third of the species of each section do not extend very far into the other. The common forms here mentioned occur from New England to the Carolinas and some still further south.

GREEN MARINE ALGÆ. Chlorospermæ have the widest range, and those tide-mark forms which flourish in full light and where freshwater reaches them at some stages of the tide, or which survive when laid bare by the receding tides, are the hardiest and will thrive best in the marine aquarium. Of these Green Algæ the most generally distributed species are:

Ulva lactuca, (Linn.) or Sea Lettuce, Oyster Green, has pale yellowish-green 6 to 8 inches long and 4 inches wide, thin, membranous fronds with crisped edges, which consist of a single layer of cellules. Quite generally distributed on the Atlantic coast between tide-marks and in deeper water, usually attached to all kinds of objects in the water.

Ulva latissima (Linn.) or Green Laver, Heavy Sea Lettuce, has dark bluish-green very much broader variable fronds, which may attain a length of 24 to 36 inches and a width of 12 to 20 inches. The fronds are thin, soft and glossy, of irregular outline with waved and ragged edges. It grows attached below low-tide marks and is common everywhere.

Purpyra vulgaris (Ag.) or Purple Laver, Purple Weed, is variable in color and may have blackish-green, purple or brown, with thin, satiny, ribbon-like fronds, elegantly waved, crisped and puckered on the edges. The fronds are also variable in form, sometimes two inches broad in the centre and tapering to both ends, or a broad membrane ten inches across. Common in shallower water everywhere, but grows to largest size in California.

Enteromorpha intestinalis (Link.) or Gut Weed, has simple unbranched fronds 6 to 10 inches high and $\frac{1}{2}$ inch wide, slender at the bottom but of the same width above. It is often inflated with air bubbles and then assumes the intestinal appearance indicated by the name. The color is light green, often yellow or white at the top. Grows in tide-pools and shallow water along the Middle Atlantic coast.

Enteromorpha compressa (Grev.) or Band Weed, has two layers of cellules in the compressed or flattened fronds, slender at the base but gradually expanding above, with a blunt, straight-cut top. This alga grows to 8 and 10 inches in length and is of a dark-green color. It may be found along the entire Atlantic coast and is one of the few which may survive in the aquarium.

Cladophora rupestris (Linn.) or Rock Branchweed, has dark, dull-green, stiff and rigid fronds with secondary acutely divided branches and closely clustered branchlets. The plant forms a tuft 3 to 6 inches high. May be found near low-water marks in tide pools or attached to the sides of rocks and wreckage. Most plentiful along the New England shore, but extends south to Florida.

Cladophora arcta (Dillw.) or Arched Branchweed, has very thickly clustered branches and straight branchlets, giving the tuft a graceful arched appearance. The color is a glossy yellowish-green. It is frequently met with below tide-marks from Cape Cod south to Virginia and near Santa Cruz in California.

Bryopsis pulmosa (Lam.) or Sea Feather, has beautiful bright-green tufted 2 to 6 inches long branches, with spreading slender filamentous pinnate fronds, which are shorter at the ends of the branches and placed to give the plant a feathery appearance. May be found in tide-pools growing on the rocks and on wreckage, and is very widely distributed on the Atlantic and Pacific coasts.

Chaetomorpha melagonium (Web.) or Flowing Hair, has stiff wirey 4 to 12 inches long, articulated, bristly fronds tapering at the base, with blunt tips, rising from a disclike holdfast. It is of clear dark-green color and common on northern rocky shores; very rarely in sandy localities.

Chaetomorpha tortuosa (Dillw.) or Sea Wool, forms green mats composed of very thin filaments on rocks and shells, a densely felted and interwoven mass of wooley, confervalike growth. Common from Delaware northward.

Vaucheria marina (Dillw.) or Marine Vaucheria is a small brilliantly green tufted plant growing quite generally on the mud banks and rocks between tide-marks. Another form, *V. submarina*, occurs in deeper water.

OLIVE-COLORED MARINE ALGÆ. Melanospermeæ are mostly of strong growth and leathery consistency, and will not thrive in the aquarium. They are a very numerous family of which but a few species of the more widely distributed genera are here given.

Alaria esculenta (Grev.) or Edible Bladderlock, belongs to the group of Algæ popularly known as "Kelps," and has a quillike midrib which constitutes the stem, winged at each side with ribless leaflets, often divided

to somewhat resemble a frond of the "Boston fern." It usually grows to 5 to 6 feet with instances of over 20 feet in length, and is of olive-green color. The young plants soon grow to 6 to 8 inches and are of delicate green and yellowish color. Rarely occurs south of Cape Cod, in both shallow and deep water, but sometimes found in the Gulf Stream drift.

Fucus vesiculosus (Linn.) or Rock Weed, is common on submerged woodwork and rocks and is variable both in the size of the plant and of the fronds; but occurs to two feet in length. It is of leathery texture with flat fronds having numerous small air bladders on each frond and is fastened by disclike holdfasts. The color is olive-green in the younger plants and greenish-brown in the older growth. Occurs generally as far south as the Carolinas.

Fucus nodosus (Linn.) or Knotted Sea Whistle, derives its name from the "knots" in the fronds produced by the larger air bladders. It is a stringy plant of rich olive-green color. The fronds are generally small and pinnate. Usually found associated with the foregoing. Other common Fuca are *F. furcatus*, Forked Rock Weed; and the California Rock Weed, *F. fastigatus*.

Sargassum vulgare (Ag.) or Gulf Weed, Sea Lentel, occurs principally in the drift of the sea on the coast. It has a disclike holdfast with a central stem and branching fronds, with the midrib distinct and crisped and toothed edges. The globular air vessels are set between the leaves on short stems. The plant grows below low-tide marks and is common along the Atlantic coast.

Laminaria saccharina (Lam.) or Oar Weed, Sugar Sea Belt, has an eight inch long stem and a flat base consisting of rootlike prongs. The stem expands into a wide, dark olive-green, leathery, thick and smooth frond, ruffled at the edges, 4 to 8 feet long and 6 to 12 inches wide. There are also a number of smaller varieties. Found in deep pools and below tide-marks south to Virginia.

Laminaria flexicaulis (Le Jolis) or Sea Tangle, is somewhat similar to the above, but the frond is broader and divided into long segments; which together with *L. longicuris*, are popularly known as Finger Tangles. They usually grow in deeper water than the first named and may reach a length of ten feet. Sometimes found in the Gulf Stream drift.

Stilophora rhizodes (Ag.) or Needle Weed, is a bristlelike filiform seaweed with widely spreading irregularly forked branches and cylindrical fronds, with wartlike clusters of spores which resemble chaplets of beads. It is of olive-green color and occurs below tide-marks from Cape Cod southward.

Punctaria latifolia (Grey) or Broad-leaved Dotted Weed, is a variable plant which has a cylindrical stem enlarged into a flat tender frond 3 inches wide and 12 inches long, of pale olive-green color, crisped on the edges and dotted with minute spore masses. Very common between tide-marks along the whole Middle Atlantic coast.

Chorda filum (Stack.) or Mermaid's Fish-line, consists of thread-like tough and elastic cords rising from a disclike holdfast, which reach a length of 10 to 30 feet, dependent upon the depth of water. It affords an anchorage to many of the smaller Algæ, which attach themselves to it. Quite common along the Middle Atlantic coast.

Chordaria divaricata (Ag.) or String Weed, is a bushy tough and elastic dark olive-green plant with threadlike sticky cylindrical branches fastened by a small disc to shells, stones and other algæ. It is a deep-water plant usually not over 15 inches high, distributed along the entire Middle Atlantic coast. *C. flagelliformis* (Ag.) or Whiplash, is a very dark-brown, threadlike plant greatly resembling the foregoing.

There are quite a number of other Olive-colored Algæ, but as none of them should find a place in the marine aquarium, they need not be mentioned.

RED MARINE ALGÆ. Rhodospermeæ are mostly of fragile texture and grow in sheltered rock pools, protected from light and the chafing of the waves, or in deep water. Exposed to strong light they lose much of their red color and become greenish, yellowish and white, and soon decay. This group also comprehends some of orange, brown and purple colors, but most of them are a deep red. It is the largest order, and only a few of the most generally distributed forms will be described.

Corallina officinalis (Linn.) or Coral Weed, is a variable alga both in size and general appearance, which may vary in color from reddish-purple to greenish-red. It is usually from 1 to 4 inches in height, the frond composed of slightly flattened filaments with the stem and principal branches diverging from the edges; the plant being composed of small wedge-shaped joints. It grows in great abundance upon rocks, wreckage, and in tidewater pools along the Middle Atlantic coast and in California.

Delesseria sinuosa (Lam.) or Oak Leaf Weed, is a delicate, often parasitical, 3 to 8 inch high alga, of which the stem is flattened to form the midrib and veins of the fronds, greatly resembling an oakleaf. It is met with in the drift on the beach, and is a deepwater species of fine pink to deep lake-red color. Another form is *D. alata* (Lam.), having the margins of the lobes entire and the fronds narrower. Both found north of Cape Cod and on the California coast.

Polyisiphonia violacea (Grev.) or Many-tubed Violet Weed, is a very common form in tide-pools and below tidewater; very variable in appearance. The stem is thick and twiglike, the primary branches widely spread, the secondary branches short and much divided, with feathery tufts at their ends. The color is violet and brownish-red and the plant grows to a height of 12 to 16 inches. May be found from Cape Cod south to Florida.

Polysephonia urceolata (Grev.) or Pitcher Weed, has very fine silky filaments which grow in a 4 to 10 inch tuft of fine carmine-red color. The thin stems are many-branched and the fronds assume a bushy appearance composed of many slender filaments. Its name is derived from the form of the seed vessels. Common on both the Atlantic and Pacific coasts.

Polysephonia fastigiata (Grev.) or Black Tassel Weed, consists of a dense tuft of many times divided filaments all of about the same length so as to form a cockadelike tuft. It is parasitic on some of the Fuca. The color is dark-brown or black. Common along the entire Middle Atlantic coast.

Polysephonia elongata (Grev.) or Lobster-horn Weed, consists of a cluster of straight stalks about the thickness of heavy twine, joined at the upper ends, with the branches irregularly forked. The winter form is almost denuded of branches and from it the name is derived. The color is light-brown, pink and red. Common on the Middle Atlantic coast and grows in deeper water.

Chondrus crispus (Lyn.) or Irish Moss, has 3 to 6 inch high tough, leathery, curled and fan-shaped fronds on a flattened stem. From it a tasteless gelatine is made. Grows on a rocky bottom on the entire Atlantic coast, and is a deep brown or purple color in deep water and yellowish-green in shallow water.

Phyllophora membranifolia (Ag.) or Red Leafweed, consists of a bunch of 12 to 20 irregular branched stems bearing wedge-shaped, fanlike $\frac{1}{2}$ to 1 inch long fronds, having forked and divided edges. The plant reaches a height of 3 to 6 inches and grows on rocks and solid bottom in deep water in the warmer section of the Atlantic coast. It is clear red in color, sometimes violet in the older growths.

Calithamnion americanum (Harv.) or Sea Shrub, is a dainty and beautiful crimson or rose-red shrublike alga, of which the fronds are almost as fine as a cobweb and the plant composed of innumerable delicate branches from a central stalk attached by a disclike holdfast. Generally distributed on the Atlantic coast south of Cape Cod. One of the handsomest common forms. Another frequent form of these fine algæ is *C. versicolor* (Ag.) the Many-colored Sea Shrub, distinguishable from the ten other

forms by the diversity of its colors; which shade in different parts of the same plant from rosy-red and bright-green to violet, brown, dark-green, olive and yellow. It grows to about 3 to 5 inches in height. All of the genus are beautiful plants, common to the Middle Atlantic coast.

Grinnellia americana (Harv.) or Flame Weed, is a very beautiful alga, having a delicate red membranous frond 12 to 24 inches long and about 3 inches across the centre; with crisped and sinuous margins, and tapering to a fine point at both ends. It usually grows in 5 to 8 fathoms of water and is so beautiful that it is to be regretted that it will not usually survive in the aquarium.

There are many other common genera of Red Algæ, but space will not permit of a further mention.

ALGÆ FOR MARINE AQUARIA. The following are the best Algæ for the marine aquarium:—Green Algæ. *Ulva lactuca* and *U. latissima*; *Cladophora rupestris*, *Bryopsis plumosa* and *Vaucheria marina*. Red Algæ. *Corallina officinalis*, *Delesseria sinuosa*, *Polysiphonia violacea*, *P. urceolata* and *P. fastigiata*; *Phyllophora membranifolia*, *Callithamnion americanum* and *C. versicolor*.

The Olive-colored Algæ should not be introduced or only small plants under careful supervision. Some of the above may survive for a longer or shorter period, but very rarely become fully acclimated. For the aquarium to which considerable light has access, the Green Algæ will best serve, as they are the most likely to adopt themselves to these conditions; while those which are in subdued light or protected by green tissue paper on the front next to the light will serve for some of the Red Algæ and still allow sufficient light to pass for the Green. The arrangement should be by planting the green nearest the window or source of light, and the red farthest away or screened by rockwork.

For the aquarium in which marine fauna are kept a few tufts of *Ulva* and *Enteromorpha*, and one or more each of *Polysiphonia* and *Phyllophora* will be all that it is advisable to introduce.

It is best to speedily transfer the plants from their native sites to the aquarium, and to clean them with saltwater before placing them into it. Any clean vessel will serve for their conveyance, and they should be transmitted unhurt by friction or exposure to the atmosphere. Packed between thick layers of moist seaweed they may be carried considerable distances, this being better than in seawater which may rise considerably in temperature and so injure the plants. Trials should be made, and experience will be the best guide for their care and treatment.

MARINE ANIMALS. Even a list of the marine fauna of the Middle Atlantic coast would be so long, diverse and complicated that it could not

find a place in this book. Only the most common *littoral* forms, those living on or near the shore, are mentioned and those of greatest interest to the collector are described. The Marine fauna may be roughly classed as:—

I. Porifera.	Sponges.
II. Cœlenterata.	{ Polyps, etc., Seaweedlike Zoöphytes and small Jellyfishes, some of the Corallines, and Hydrozoa generally. Larger Jellyfishes and Scyphozoa generally. Sea-anemones, Actinoid corals and Actinozoa generally. Comb-jellies and Ctenophora generally.
III. Vermes.	Worms and Leeches.
IV. Molluscoïda.	Sea-mats or Polyzoa, and Corallines or Brachiopods.
V. Echinodermata.	{ Starfishes, Brittle-stars, Sea-urchins, Sea-cucumbers, Feather-stars, Sea-lilies and Radiates generally.
VI. Arthropoda.	{ Crustaceans, Entomostraca, Barnacles, Lobsters, Shrimps, etc., King Crabs, Sea Spiders, Squilla, and the Amphipods and Isopods in general.
VII. Mollusca.	{ Limpets, Tops, Whelks, Periwinkles and other Gasteropods; Mussels, Clams, Scallops and Pelecypods generally. Cuttles and other Cephalopods.
VIII. Chordata.	Sea Squirts and allied forms.
IX. Pisces.	Fishes.

PORIFERA OR SPONGES. These constitute one of the lowest forms of animal life, propagating by gemmation or budding. The sponge of commerce is the skeleton or framework, the organic portion being a soft and jellylike substance of which the external layer is composed of flat cells with numerous pores and larger openings for inhaling and straining the water; the middle layer of cells having various functions, as the formation of the framework, digestion and reproduction; and the internal layer of cylindrical cells leading to sacs, each having a flagellate hair to create a current. These take in the food, digest it and eject the excrement. Almost every seaweed, rock, mollusc and crab has some member of this family attached to it, which vary in size from tiny specks to large and substantial masses of varying forms and colors. Sponges are roughly divided into two classes, Calcarea and Non-Calcarea.

The genera most usually met with are the following, of which a brief description will suffice, as they do not survive in the marine aquarium.

DUSEIDEIA, having an imperfectly cellular body composed of a gelatinous membrane covered with amorphous particles of sand.

GRANTIA, having a firm, elastic body with calcareous spicula compacted in a gelatinous base.

HALISARCA, having a gelatinous or fleshy substance forming an irregular crust on the object to which it adheres.

HALICHONDRIA, having an elastic body permeated by canals opening to the surface and siliceous spicula in the fibre distributed throughout its homologous body.

SPONGIA, having a very porous body composed of net-fibres traversed by canals opening to the surface, the fibres without spicula. Very irregular and variable in form, and parasitical or incrustated on and under stones and other objects.

Sponges should not be introduced into smaller aquaria and should be carefully scraped from stones and other objects, as they soon decay and may pollute the water.

CÆLEENTERATA OR POLYPS. These are somewhat higher forms of animals. The Hydrozoa are zoöphytes resembling seaweeds, which live in colonies, small compound jellyfishes composed of many individuals; and the Mil-lepores live in colonies and secrete a stony instead of horny skeleton. Of these no further mention need be made. The Scyphozoa are larger jellyfishes of various forms of development, but also do not require mention. The Actinozoa include anemones, actinia and actinoid corals, of which the first are of particular interest, but other forms of Corals, Cor-allines, Sea-pens, Sea-whips and Sea-fans, and the Ctenophora, including the Comb-jellies, require but brief mention, as none of them will survive in the Marine aquarium.

SEA ANEMONES and ACTINIA. These polyps belong to the order Actinaria. They mostly inhabit crevices, dark holes and under stones, but some hardy species may be taken in exposed positions, or piles, submerged woodwork and other firm objects. There are both deep and shallow-water forms. They generally consist of an undivided column or stalk with a pedal disc or holdfast at the under side, and an oral disc with central mouth surrounded by circles of tentacles at the upper. They are capricious in the forms which they assume and when fully expanded are often of considerable size, but are sensitive and when disturbed collapse and shrink into inconspicuous dusky buttons, as they are soft and very contractile. The most of the Actinaria are developed from eggs which form on the edges of the inner walls of the column. These, when mature, are ejected from the mouth, small ciliated spheres which swim about until they find a suitable location to which to attach themselves. Some forms reproduce by budding, either on the disc or from the sides of the column. As a means of defense they emit long slender threads or acontia, having minute stinging cells. Nearly all are carnivorous and feed on small animal organisms, crustaceans and molluscs.

The most common and generally distributed Middle Atlantic coast forms are :

Metridium marginatum, (Les.), having a smooth, cylindrical, light-brownish column with deeply folded and fringed margin, and numerous short, fringelike tentacles, of which the central are the longest. The color is variable, the disc usually a light flesh-color and the tentacles greyish with brighter colored tips. When expanded it is sometimes ten inches across the disc, and when contracted appears as a broad flat cone. This is the most conspicuous and abundant form, found from low-water marks to 90 fathoms, on piles, bridges, submerged woodwork, etc., and in rock crevices and under stones, from Cape Hatteras northward.

Eloactis producta, (Stimp.), has rows of suckers the entire length of the column. It can expand to a length of 12 inches, but is usually shorter and thicker. There are twenty tentacles about the margin of the thick disc. The colors are variable but usually in dusky tones with brighter shades and mottlings. Found from Cape Cod to the Carolinas, on sandy beaches and under rocks at low-water marks; or buried under the sand with the mouth and tentacles only above the surface. One other form, *Ilyanthus lævis*, (Stimp.), is found south of the Carolinas to Florida. These are nearly related to the numerous genus *Halocampa* of Europe, of which there are two American species, both north of Cape Cod.

Aulactinia capitata, (Ver.), has a 6-inch long dark-grey or bluish column, $1\frac{3}{8}$ inches in greatest diameter when extended, and 96 tentacles in four rows about a rose-colored disc. Found at low-water marks from Cape Cod to Florida. There are other deep-water species of this genus.

Cerianthus americanus, (Ver.), a very long and slender form, has an 18 to 20 inches long column tapering from the disc to the base, which can be contracted to 8 inches. The 124 marginal tentacles are $1\frac{1}{2}$ inches in diameter across the disc, when expanded. Found in shallow water from Cape Cod to Cape Hatteras.

Tælia crassicornis, (Gosse), has a short and thick $1\frac{1}{2}$ to 2 inches high column when extended, and short, thick tentacles. The colors of the disc are brilliant in varying shades of bluish-green mottled with crimson, often bright cherry-red. The tentacles are somewhat lighter in color, usually grey and flesh-colored. It is voracious and will entrap small fishes, crabs, etc., that come into contact with the disc and tentacles. Found in shallow water from Massachusetts northward on ledges and in tide-pools.

Edwardsia sipunculoides, (Stimp.), has a slender, brownish, truncated 1 to $1\frac{1}{4}$ inch long column, and 24 to 30 short tentacles about a narrow disc, usually of a dull grey or pinkish color. Another form, *E. lineata*,

(Ver.), is similar to the above. This genus has one other Middle Atlantic coast parasitic form and four species north of Cape Cod.

Ammophilactis rapiformis, (Ver.), has a 3-inches long column surmounted with a $1\frac{1}{4}$ inches diameter disc, with 144 tentacles in a crowded circle. The colors are variable, but incline to pinkish and bluish tones. Found in tide-pools from Cape Cod to Cape Hatteras.

Cylista leucolena, (Ver.), has the $2\frac{1}{2}$ to 3 inches long cylindrical, translucent column usually rose-colored and covered with scattered wartlets. The disc is simple and thin and the 96 slender, crowded tentacles are placed in five rows on the margin of the $\frac{1}{2}$ inch diameter disc. The tentacles are pinkish- and whitish-grey, darkest in color at the disc; and in size are twice as long as the diameter of the extended column. Common from Cape Cod to North Carolina on submerged woodwork and under stones.

Sagartia lucia, (Ver.), is a small $\frac{1}{4}$ to $\frac{3}{8}$ inch high and $\frac{1}{4}$ inch diameter polyp, having 84 tentacles in four rows, of which the central are the longest. The colors are bright but variable. Found from Cape Hatteras north. Another form, *S. pustulata*, (McMur.), has the $\frac{3}{8}$ inch column broken by longitudinal and transverse furrows. The $\frac{1}{4}$ inch diameter disc has 64 long tentacles arranged in four rows. Found in the same localities, often associated with the above. Other shallow- and low-water forms are *S. gracillima*, having a 1-inch column and 48 tentacles, and *S. modesta*, very similar in form to *C. leucolena*, but smaller and having a few hairy excrescences on the column.

PARASITIC ANEMONES. This interesting group contains a number of species which attach themselves to the shells of hermit crabs, whelks and other animals, probably on account of the change of location they afford, and they in their turn aid as a disguise to the animals with which they are associated. There are a number of American forms which have this habit, among them some of those already described, which are the more generally distributed forms.

GORGONACEA, the family of the Sea-fans, Sea-whips and Sea-feathers; and Pennatulacea, the Sea-pens, are colonies of polyps closely united about a horny axis, which resemble miniature trees and branches covered with a coating of animal matter. None of these survive in the aquarium.

MADROPORES, the family of the Branch and Reef Corals, also cannot be kept alive in smaller aquaria and further mention of them is omitted. For purposes of ornament some of the calcareous structures of American Corals are desirable, especially those of the Florida reefs. These are *Gorgonia flabellum*, the Sea Fan; *G. cervicornis*, the Stag-horn Coral; *Meandrina labyrinthiformis*, the Brain Coral; *Orbicella annularis*, the Star

Coral; *Agaricia agaricites*, the Fungus Coral; and *Millepora alcicornis*, the Finger Coral or Sea Ginger. These corals cleared of the polyps may be obtained adhering to the rocks upon which they grew, or may be fastened with hydraulic cement in desired localities in the aquarium.

VERMES OR WORMS AND LEECHES. The marine forms occur in mud and sand, under stones and in rock crevices, crawling over the weeds and the bottom; or, either free or attached, in tubular cases, or sometimes attached to other animals. The Platyhelminths are principally flat worms, the Nemertinea thread-worms, the Nematelminths round-worms, and the Polychæta many-bristled-worms; the Annulata ringed worms, and the Sedentaria tubicolous or pipe-worms. With but few of these we are concerned. Elsewhere the Trematoda, internal and external parasitic, and the Cestoda, strictly internal parasitic worms are mentioned.

NEMERTINA. These long and slender marine worms are generally distributed between tide-marks and are from $\frac{1}{2}$ inch to many feet in length and exceedingly contractile. Some will survive in confinement. The most generally species are:

Nemertes socialis, color black or brown, slender slightly flattened, 5 to 6 inches long when extended, with four eyes on each side of the head; and *N. viridis*, color olive-green or brown, rather thick, slightly flattened, 6 to 8 inches long when extended; eyes black in two rows. Both common under stones, etc., in shallow water.

Tetrastemma arenicola, color dark-pink or purple, slender, cylindrical, 4 to 5 inches long when extended, head changeable in form, neck slightly constricted. Common in sand and mud at low water marks.

Cosmocephala ochracea, color grey or yellowish-white and mottled, 2 to 3 inches long when extended, rather stout and cylindrical. Common on low-water-marks, usually in empty shells.

Polina glutinosa, color orange or light-yellow, eyes numerous in oblique lines on head, 2 to 3 inches long when extended, usually on algæ and woodwork.

This group of worms will not long survive in aquaria together with other animals.

SEDENTARIA. These tubicolous marine worms make interesting aquarium studies as they construct tubes of grains of sand, seaweeds and particles of shell by mucus secretions; other secrete calcareous matter which forms hard cases. All have the anterior portion more developed than the posterior end of the body. The most general and interesting are:

Amphitrite ornata, color red or brown, 8 to 12 inches long, with three pairs of plumelike gills and many flesh colored tentacles at the head, which are constantly in motion. The tubes are $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter,

composed of sand and mud. Found in sand and gravel and under or attached to fixed objects; from Cape Cod to Maryland.

Cistenides gouldii, color light red, body short and slightly curved, head obliquely flat, with two broad groups of golden bristles on each side of head, $\frac{1}{2}$ to 2 inches long. Constructs conical horn-shaped tubes of a single layer of sand. Found on sandy beaches from New Jersey northward.

Clymenella torquata, color pale red with bright bands, 4 inches long; body segmented and bristled, head funnel-shaped. Constructs nearly straight tubes of sand. Ranges from New Jersey northward close to low-water marks.

Serpular dianthus, color variable, dull olive and reddish, with plume-like gills which form a wreath about the head. The white calcareous tube is 3 inches long and $\frac{1}{8}$ inch in diameter, and has the end coiled and contorted. The free end has a circular opening with an operculum. Found in tide-pools attached to shells and rocks, from Cape Cod to Florida.

These are a few of the most characteristic forms.

MOLLUSCOIDA. Of the Polyzoa there are hundreds of named species, mostly consisting of colonies of small polyplike organisms, depositing calcareous matter and attached to plants, stones and other fixed objects. The Branchiopods are somewhat similar to the lamellibranch molluscs, but the two valves of the shell are always dissimilar. They are usually fastened to some marine object by a fleshy peduncle extending between or through the valve; and the body cavity is lined with cilia. In the order Inarticulata the hinge of the shell is wanting and the thin plates may be moved in every direction. In the order Articulata the valves are articulated by a hinge formed by teeth on the lower and sockets on the upper valve. They are much lower forms than the Mollusca and need not be here further described.

ECHINODERMATA. These Radiates of the higher type have an exterior skeleton and most of them have the spines from which the name is derived. They include the Asteroidea or Starfishes, Ophiuroidea or Brittle-stars, Desmosticha or Sea-urchins, Holothuroidea or Sea-cucumbers, and the Crinoidea or Feather-stars and Stone-lilies. Brief mention of these will be made, description being confined to the most common species of the Middle Atlantic coast.

STAR FISHES OR RAYS. These animals derive their name from their asteroid or starshaped forms, the different species having from 5 to 22 rays. The external skeleton is complex, and consists of calcareous plates and spines either firmly united to form a solid shield or separate and imbedded in the integument. The mouth is in the centre of the ventral

side, a furrow extending along each arm in which are the ambulacra or tube-suckers by which the animal moves and seizes its prey. The folded stomach is connected to the mouth and occupies the greater part of the central space. The four species of the Middle Atlantic coast are:

Asterias forbesii, (Stimp.), the most common Atlantic coast ray, has a comparatively small body with five rather broad arms swollen at the base and tapering to a blunt point. The upper surface is rough and covered with short spines which are larger at the edges of the rays. The colors are variable, but usually red or reddish-brown, with bright-orange plates in the younger and yellowish-red, brown and purple in the older individuals. It grows from 10 to 16 inches in diameter and is common from Massachusetts to Florida. Another form, *A. vulgaris*, has a very similar body, but the five rays are not as swollen, a little more slender, and taper to sharper points. It may also usually be distinguished by the difference in color, as it is darker and the yellowish-red tones are absent. Common and often associated with the above from Cape Cod to New Jersey. Both are very destructive to oysters.

Luidia clathrata, (Stimp.), is a slender five-rayed 4 to 5 inches in diameter light colored ray, with the long arms tapering to a point and fringed on the edges with distinct spines, but rather smooth on the surface. The body is small and there are two rows of ambulacra. It has the habit of breaking into pieces when taken from the water and can rarely be transported entire to the aquarium. Common from New York to the Carolinas. There are two other Florida forms of the genus.

Echinaster sentus, (Ver.), is heavier than the above with five broader arms and a relatively larger body, and has the surface rough with spines. It is purplish-red in color, 4 to 4½ inches in diameter, and has two rows of ambulacra. Found near the shore from New Jersey to Florida.

Only the five-rayed forms are common on our coast, those of ten and more rays are deep-sea forms. Starfishes are voracious and only very small ones should be introduced into the aquarium with other weaker animals or with molluscs. If kept by themselves any of the described forms often survive for a long time, especially in large aquaria.

BRITTLE-STARS. The Ophiurans or Brittle-stars have the long distinct and serpentine cylindrical arms attaches like appendages to a small, round body. They have no tube-suckers, locomotion being by movements of the arms. Three species are common on the Middle Atlantic coast, but most of them are found in warmer southern and western waters.

Ophiopholis aculeata, (Ver.), has the upper surface of the body covered with variously arranged plates surmounted by small, short spines. The five arms are long, slender and tapering, having transverse oval plates

with flat granules, and fringed with thick obtuse spines. The under side is covered with regular rows of quadrangular plates. The color is variable, usually variegated and spotted with purple. It is a large species, about 18 inches in diameter, and may be found in shallow water along the entire Northern Atlantic coast.

Ophiothrix angulata, (Ver.), is a small Florida species, sometimes found farther north. The body is covered with short rough spines, and the five arms are narrow, tapering and beset with long spines serrated on the edges and ends. The color may be pinkish-yellow or light-brown, according to the bottom upon which it lives.

Amphiura squamata, (Ver.), is a small 2 to 4 inch diameter animal. The body is less than $\frac{1}{2}$ diameter, and the five arms threadlike and almost smooth on their surface. This is a delicate species found from New Jersey northward below low-water marks.

SEA URCHINS. These animals are closely related to the Starfishes, the shell-like covering showing the lines of union of the rays. They are mostly deep-water forms, the two shallow-water species on the Middle Atlantic States coast are:

Arbacia punctulata, (Ver.), having a one inch in diameter shell with $\frac{1}{2}$ to $\frac{3}{4}$ inch long spines. The color varies from straw-yellow and whiteish-grey to brown, with the spines tipped with brown. A small species found in shallow water from Massachusetts to Florida.

Strongylocentrotus drobachiensis, (Grey,) the Common Sea-egg, has a 2 inch in diameter shell, greatly resembling a large chestnut-burr, usually of greenish-purple color. The body is circular and sometimes depressed, and the tube-feet slender. It moves slowly and feeds on small algæ, oscillatoria, and decaying animal matter. Common in shallow water along both the Atlantic and Pacific coasts, most abundant on the coast of Maine.

Both these forms are harmless and useful aquarium inmates.

SAND DOLLARS OR SHIELD URCHINS. This urchin, of which the circular disc forming the skeleton, is a common object on some beaches, belongs to the genus *Echinarachnius*, of which one species occurs in Middle Atlantic coast waters.

Echinarachnius parma, (Stimp.) has a skeleton consisting of a flat disc composed of calcareous matter and sand, often 4 to 5 inches in diameter, which in life is covered by short silky spines. The animal is somewhat like a jellyfish in general form, occurs in deeper water, and is very rarely taken near the shore.

SEA CUCUMBERS. These higher forms of Echinoderms are native to warm waters, and but one species occurs on the Middle Atlantic coast.

Pentacta frondosa, (Jaeg.), or Brown-Sea-cucumber is the largest common Atlantic species which measures from a few inches to a foot in length when extended. *Holothuria princeps* and *H. floridana*, the Florida Sea-cucumbers, are large species which have been collected and dried for export to China.

FEATHER STARS AND STONE LILIES. This class of Crinoidea inhabit deep water where they form branching featherlike and flowerlike beds. Some are permanently attached, others become detached and float about by movements of the raylike arms. They are rarely found on the shore and fail to survive in aquaria.

CRUSTACEANS. The larger Marine crustaceans are divided into a number of groups, the Branchyura or true Crabs, the Anomoura or Hermit Crabs, etc., the Macroura or Lobsters and Shrimps, the Xiphosura or King Crabs, the Squillidæ or Mantis Shrimp, the Cirripedia or Barnacles and Tops; and the smaller Marine Entomostraca or Water Fleas.

These will be mentioned in this order.

Callinectes hastatus, (Ord.), or Common Edible Crab, Blue Crab, Sea Crab, has the shell or carapace about twice as broad as long, and armed with a distinct projecting spine and eight short acute teeth on each side, gradually increasing in size towards the eyes. There are four unequal-sided teeth between the eyes and a median spine beneath. The front limbs, bearing the claws, are similar to each other in form, and the three succeeding pairs of legs are slender, terminating in sharp points, and the posterior pair end in expanded oval joints for swimming. The carapace grows to a length of 3 inches and a breadth of $5\frac{1}{2}$ to 6 inches, and is covered with minute granulations and margined with fine hairs. The upper surface is of dark-green or bluish color, the lower dusky-white, the feet and claws blue, tipped with yellowish-red. The period of spawning and shedding extends over several months. It is very active, crawling and swimming rapidly, and may be taken on muddy and sandy bottoms in both salt and blackish water, from Cade Cod to Florida. It is predaceous and feeds upon all living and dead animals. This species may be distinguished by the sharp spine on each side of the carapace. There are four other species of this genus in more southern waters.

Carcinus maenas, (Say), or Green Crab, has a bright green color varied with spots and blotches of dull yellow and brown, and has the carapace and limbs more or less granulated. It has heavy claws and legs shorter than the foregoing and shorter spines at the sides of the narrower carapace, with four unevenly ciliated teeth at each side and three between the eyes. The last pair of legs also nearly resemble the other three pairs and lack the broad swimming blades of the foregoing species. Abundant between tide-

marks and in tidal pools, but also resorts to the peaty banks on the shore and in ditches and streams of salt and brackish waters. In some parts of New England it is known as the "Joe Rocker." Abounds from Cape Cod to New Jersey and further south.

Cancer irroratus, (Say), or Common Rock Crab, may be distinguished by the nine blunt teeth on each side of the front margin of the nearly smooth carapace, which is evenly sub-oval in outline, two-thirds as long as broad. The claws are short and stout and the four posterior legs long and rather slender, with pointed tips. The carapace and upper surface of the legs are yellowish in color with purplish-brown dots and mottlings at the sides and rear. Between tides it burrows in the sand and gravel or is concealed among rocks and weeds. Its range is from Labrador to South Carolina but occurs most generally above Virginia.

Cancer borealis, (Stimp.), or Jonah Crab, is closely related to the foregoing, and may be distinguished by the rougher carapace and claws, the shorter and thicker legs and the bright-red color above and yellowish color beneath the carapace, claws and legs. The carapace reaches $3\frac{1}{2}$ inches in length and $5\frac{3}{4}$ inches in breadth. Its habitat is similar to the above, but does not occur below the New England States. It lives a more exposed existence and is rarely concealed among the rocks.

Panopeus herbstii, (Edw.), the most common and largest of the Mud Crabs, is dark-olive above and yellowish-white below the carapace, and has the large claws black, tipped with lighter color. The largest measure 2 inches across the carapace and range from Massachusetts to Brazil. Other smaller Mud Crabs are *P. depressus*, *P. sayi* and *P. harrisii*, all ranging along the Middle Atlantic coast as far south as Florida.

Platyonichus ocellatus, (Lat.), or Lady Crab, Sand Crab, has a $2\frac{1}{2}$ to 3 inches carapace, nearly as long as broad, the form roughly suggesting a six-sided figure. The lateral margins bear five spines or teeth and the front limbs and claws are long and somewhat slender. The color is dingy-white and the back is covered with red and purple spots. It frequents the sand of low-water marks and exposed beaches buried to the eyes, and feeds on smaller living and dead animals. It is a common feature of the sea beach. Found from northern New England to Florida, from low-water marks to ten fathoms.

Ocypoda arenaria, (Rath.), or Sand Crab, Ghost Crab, is a small shore crab about 1 inch long, $1\frac{1}{2}$ inch broad and 1 inch thick. The carapace folds down between the eyes, which are prominent on the long peduncles. It burrows in the sand in holes often three feet deep and is very quick in its movements when disturbed. It has the habit of raising itself on its feet and moving the eyes in its desire to see approaching enemies and prey. The

colors are almost exactly those of the sand and the coarsely granulated carapace appears like a little mound of wet sand. Common from Long Island to Brazil, and subsists largely on Beach fleas, upon which it springs by a sudden movement of the legs.

Menippe mercenaria, (Say), the Stone Crab, is a frequently occurring Southern form not present on more northern shores.

Libinia emarginata, (Leach), or Common Spider Crab, or Sea Spider, has the whole surface of the body covered with hairs, matted with mud and algæ. The carapace is nearly round and the limbs have a thick granulated covering. The legs are long and slender and the claws short and weak. The males are larger than the females and often have a spread of 12 inches. It hides in the mud and decaying weeds and is sluggish in movement. Common from Maine to Florida. A second species, *L. dubia*, closely resembles the above, but its range is more to the north.

Lambrus Pourtalesii, (Say), or Long-armed Spider Crab, has a thick roughly spined, almost pear-shaped $1\frac{1}{2}$ inches broad carapace, very long, heavy, roughly granular and spined 3 inches long forelimbs with very short claws. Lives among rocks, which it closely resembles, and ranges from Cape Cod to Florida.

Hyas coarctatus, (Say), or Toad Crab, inhabits both shallow and deep water, its name being derived from the repulsive appearance of the carapace and the size of the body, which resembles a toad. The legs are slender and the claws short and weak. Common along the Atlantic coast.

Eupagurus pollicaris, (Stimp.), or Hermit Crab, Soldier Crab, lives in shallow water and protects its soft hinder portion in empty Gasteropod shells, which it carries with it by holding fast with the hooklike end of the body. Found from Massachusetts to Florida. Three other Middle Atlantic coast species are *E. pubescens*, *E. bernhardus* and *E. longicarpus*, all of similar form and habits. These crabs make interesting aquarium inmates and thrive best when they can come on rocks above the surface.

Gelasimus minax, (*Uca minax*), (Le Côte), or Common Fiddler Crab, abounds in almost every salt water and brackish marsh and estuary. The males are provided with unequal claws, the larger of which is likened to a fiddle and the smaller to the bow. The claws of the female are of equal size. They congregate in numbers and excavate holes in mud banks above the reach of the tides, to which they scamper when disturbed. Two other very similar species, *G. pugnax* and *G. pugilator*, also occur from New England to Florida. Of these the one described is the larger. Associated with the Fiddler another crab, *Sesarma reticulata*, the Brown Shore Crab, will often be found. It is reddish-brown in color and has

stout claws of nearly equal size. In form it very nearly resembles the Fiddler.

Pinnotheres ostreum, (Say), or Oyster Crab, of which the female lives parasitically in the gill cavity of the oyster and the smaller male leads a free existence on or near oyster beds, are very unlike in appearance; the male having a firm carapace, dark-brown above with a central dorsal stripe and two white spots, and white below, with white legs and yellowish claws; and the thin-shelled female has a transparent whitish color tinged with pink; the carapace of the adult female being about $\frac{1}{2}$ inch broad and a little less in length. Occurs from Massachusetts to South Carolina.

Pinnotheres maculatum, (Say), or Scallop Crab, occurs in the shells of some Sea Mussels and Scallops and attains somewhat larger size than the foregoing. The female only is parasitic, the smaller male usually lives among seaweeds and on the mud bottoms. Occurs most generally along the New England coast.

Hippa talpoida, (Say), or Sand Bug, has an oval body about half as long as broad, the sides forming a nearly regular curve, giving to the animal a buglike appearance. The tail is carried under the body and the eyes are placed on long peduncles. The color is translucent yellowish-white, overlaid with a purplish tinge on the back, sometimes mottled. Ranges from Cape Cod to Florida, and is known to fishermen as the Bait-bug.

Limulus polyphemus, (Lat.), or King Crab, Horseshoe Crab, though not a true crab and belonging to the order Xiphosura, should be here described, as some naturalists regard it as a low type of Crustacean, while others place it among the Arachnida. It has a very large carapace terminating in a spine at the posterior angle on both sides, a small abdomen with a long, tapering spine at its end. The basal portion of the legs serve as masticating organs. It is slothful in its habits and is usually buried in the mud and sand in the shallow water of estuaries and along the shore, feeding upon various smaller animals. Its range is from Maine to Florida, and is abundant along the shores of the Delaware Bay. Very small specimens have survived for long periods in aquaria.

CRABS AS SCAVENGERS. Crabs are voracious feeders and will attack their own species and most of the other living inmates of the aquarium. Only small specimens should be introduced, which serve as excellent scavengers.

Homarus americanus, (M-E.), the American Lobster, is one of the most important food invertebrates, and has the body made up of two sections. The anterior portion, consisting of the head and thorax, is covered with a carapace, and the posterior portion or abdomen is covered with six

segments and a terminal flap or telson. Below the carapace there are five segments corresponding to the pairs of legs, of which the anterior pair bear the claws. Each segment of the abdomen has a pair of appendages on the lower side, the swimmerets, and the telson has two larger ones terminating in two broad plates. The eyes are on two short movable peduncles and there are two long and two short antennæ or feelers. The American Lobster is variable in color, usually darker green and bluish on the carapace with the under side and the limbs of a lighter color; that of the adult is usually a greenish black, but the color depends upon the character of the bottom which it inhabits. Its range is from Labrador to Delaware and Virginia, but it occurs most numerously from Massachusetts northward, as it prefers a rocky and gravelly bottom covered with a growth of the larger seaweeds. Of the Atlantic species there are but two varieties, known to fishermen as the School Lobster and the Rock Lobster. One other species, *Panulirus interruptus*, (Rand.), also classified as *Senex interruptus*, the California Spring Lobster, is a smaller form, ranging southward from California, and is similar to the European *P. vulgaris*.

SHRIMPS and PRAWNS. These animals have compressed bodies and soft carapaces with the abdomen large in comparison with the combined head and thorax. The difference between the Shrimps and Prawns is not well defined, as they are nearly related forms. In France they are known as Crevettes and in Germany as Garnellen.

Crangon vulgaris, (Fabr.), or Common Sand Shrimp, reaches a length of two inches, and varies in color with the character of its habitat, from pale translucent grey, to resemble the surface upon which it lives, to darker colors and mottlings on a muddy bottom. It secretes itself so that only the eyes and antennæ are visible, and buries itself when disturbed. Abounds from Labrador to North Carolina between tide-marks, principally on weedy bottoms. *B. franciscorum* is the California species.

Penæus setiferus, (M-E.), the largest Southern Shrimp of the markets, ranges from Charleston, S. C., south. *P. brasiliensis* is another form from the same locality.

Squilla empusa, (Say.), or Mantis Shrimp, is a larger deepwater species belonging to the Squillidæ, and is similar to the Squilla of Europe. It somewhat resembles the lobster and is 6 to 10 inches in length. Its range is from Cape Cod to Florida, and is rarely found near the shore.

Palaemonetes vulgaris, (Stimp.), or Common American Prawn, is usually one inch long, but reaches a length of 1½ inches, and occurs abundantly along the Middle Atlantic coast. The body is almost colorless and transparent, marked by irregular spots and blotches of grey and brown. It is the "bait" shrimp of the angler, and inhabits both salt and

brackish water, preferably on a muddy bottom; and is abundant in calm weather in pools and ditches among vegetation, and about piles and other submerged woodwork. It is a very good aquarium scavenger; also serving as food for the fishes and other inmates.

Pandalus borealis, (Kroyer), or Deep Water Prawn, is a 6 to 7 inch long species which never approaches the shore. Two other forms, *P. montagni* and *P. prepinquus*, also inhabit deep water having abundant vegetation.

CIRRIPEDIA. These Crustaceans include the Barnacles and similar forms everywhere plentiful in salt and brackish water. A few of the larger forms attached to a plant or stone may be introduced into the aquarium, but should be under careful observation, as they do not usually survive. The most common are *Balanus eburneus*, or Black Barnacle, Sea-acorn; *B. balanoides*, or Ivory Barnacle, common on the Atlantic coast on most submerged woodwork, either fixed or floating, and *B. crenatus*, a parasitic form attached to crabshells, stones, etc. The larger *B. tintinabulum*, and *Lepas fascicularis*, or Goose Barnacle, are found attached to the bottoms of vessels that have come from warmer latitudes.

MARINE ENTOMOSTRACA. The order Crustacea also includes those of minute size, Water-fleas which are both free-swimming and parasitic. They form a considerable part of the food of fishes and other marine animals and need no further mention here.

AMPHIPODA. These forms are numerous on all beaches; the most generally distributed are:

Orchestia agilis, (Smith), or Beach Flea, Sand Hopper, which occurs in countless numbers on every beach. When disturbed it hops by means of the three pairs of abdominal legs and buries itself in the sand. In color it resembles the sandy shore, and is $\frac{5}{8}$ inch and less in length. Another form *Talorchestia lingiconis*, is similar to the above.

Gammarus locusta, (Lat.), also resembles the above but is larger and lives in the water under stones and among the weeds. The colors are uncertain and variable.

Caprella geometrica, (Lat.), or Skeleton Shrimp, is a small and curious amphipod, so slender as to appear like a skeleton adhering to the seaweeds. It is about $\frac{5}{8}$ inch long and moves like a measuring-worm. Will survive in the aquarium.

There are a number of Boring Amphipods which do not require mention here.

ISOPODA. This numerous class is widely distributed and is frequently found on marine plants. The most general form is:

Cirolena concharum, (Lat.), having a rounded segmental body and seven pairs of short legs. It is found swimming in shallow water among plants from Cape Cod to South Carolina, and is rarely over $\frac{1}{2}$ inch long. Four other smaller and larger Isopods need no further mention. All are of similar form and habits.

MOLLUSCA. Of the Marine Mollusca it is proposed to mention only a few of the shallow-water Middle Atlantic coast species most likely to be found by the collector, as there are so many hundreds of genera and thousands of species that space will permit of their being only superficially treated.

UNIVALVES. The most common Limpets, Periwinkles and Whelks, are:

Acnæa testudinalis, (Müll.), or Smooth Limpet, which has a thin, elevated, oblong-oval, saucer-shaped shell, with the apex turned forward. The surface is checked with minute radiating lines and the color is generally a greenish-white, with darker brown stripes. It is about $\frac{4}{5}$ inch long, $\frac{1}{2}$ inch broad, and $\frac{1}{4}$ inch high. The most common limpet, found along almost the entire Northeastern Atlantic coast.

Crepidula fornicata, (Lam.), or Slipper Limpet, Quarter Deck, has a basin-shaped obliquely-oval shell, one side more oblique than the other, with a thin, shelf-like projection at the apical end, and the apex turned to one side. The surface is wrinkled with lines of growth, the aperture obliquely sub-oval, the edge entire and sharply defined with dark spots and blotches. Length $1\frac{1}{2}$ inches, breadth $1\frac{1}{5}$ inches, color light-brown. Found adhering to each other and to shells on the Atlantic coast generally.

Littorina irrorata, (Say), or Common Periwinkle, has a thick variegated greenish shell of six whorls, a shallow suture, pointed apex and sub-oval aperture. Found in estuaries of the Middle and Southern States coast.

Natica duplicata, (Say), or Coned Natica, has a large, dark and solid $1\frac{1}{2}$ to 2 inches shell, the upper whorls compressed to give a pyramidal form. The surface is marked with faint revolving lines, and the color is chestnut-brown or black. Found on sandy and muddy shores and beaches along the Northern Atlantic coast to Massachusetts.

Columbella lunata, (Sowb.), or Dove Shell, has a small, ovate-conic, six-whorled, reddish-brown shell with flat whorls, a shallow suture and smooth surface. Crescent-shaped yellowish-white spots mark the surface, and the interior is a soft dove-color. Length $\frac{8}{8}$ inch. Abundant from Cape Cod to Florida.

Nassa obsoleta, (Say), or Small Whelk, has an ovular dark reddish-brown or olivate, six-whorled, polished 1 inch long shell with some-

what rounded whorls, a moderately elevated spire and blunt apex. Found on muddy shores not exposed to the surf, from Maine to Florida.

Nassa trivittata, (Say), a smaller form, has an ovate-conic $\frac{7}{8}$ inch greenish-white, seven-whorled shell, with the surface marked with lines and granulations. The whorls are rounded, suture depressed and apex acute. Found at low-water marks along the Atlantic coast generally.

Buccinum undatum, (Linn.), or Common Whelk, has a heavy ovate-conic six-whorled greyish 3 inches shell, marked with coarse revolving lines and waved transverse wrinkles. Found from Canada to the Carolinas and further south.

Urosalpinx cinereum, (Say), or Oyster Drill, has a long-oval coarse and solid five- or six-whorled, ash-colored or reddish-brown, one inch long shell with a number of rib-like undulations and revolving lines on the convex whorls. The suture is depressed and the beak slightly curved. Common along the Middle Atlantic coast and larger in southern waters.

Fulgur canaliculata, (Say), or Turret Conch, has a 6 to 9 inches long pear-shaped, rather thin, pale faun-colored shell, with about six turreted whorls and a deeply impressed channeled suture. It is one of the common Conchs of the Atlantic coast, found from Cape Cod to Georgia.

Fulgur carica, (Linn.), or Spined Conch, has a solid ash-colored six-whorled shell, with a series of compressed spines or nodules about the larger three whorls. The upper whorls are somewhat depressed and the suture shallow and not channeled as in the foregoing. It is less abundant but is distributed in the same localities.

BIVALVES. The most common Bivalves of the Middle Atlantic States coast are:

Ensis directus, (Conr.), or Common Razor Clam, has yellowish-green scabbard-shaped valves about 5 to 6 inches long and 1 inch broad, with rounded, nearly parallel ends. It lives on sandy beaches near low-water marks along almost the entire Atlantic coast.

Mya truncata, (Linn.), or Common Soft-shell Clam, or Gaper, has oblong-ovate inequilateral strong, deeply concave 3 inches long valves with distinctly marked umbones. The valves are rounded anteriorly and truncated posteriorly, dingy white in color with yellowish and brown wrinkled epidermis. Generally distributed along the Atlantic coast south to South Carolina, and most abundant along the New England coast.

Macra solidissima, (Dillw.), or Trough Clam, another soft-shelled form, has very large, massive, transversely ovate, sometimes triangular $4\frac{1}{4}$ inches long valves, with the epidermis usually worn or eroded. The umbones are usually distinct and the surface slightly folded at the lines of growth. This clam is also known as the Beach- or Dipper-clam, and is

found on the sandy beaches on the Atlantic coast from Labrador to Cape Hatteras.

Petricola pholadiformis, (Lam.), or Boring Clam, has elongated, acutely rounded, chalky, $1\frac{1}{2}$ inches long valves, the anterior part short and the posterior long and neatly rounded. The animal has two long siphon tubes united at the base, with the inhaling tube the longer. Found in varying localities along the Atlantic coast at low-water marks.

Acra transversa, (Say), or Common Cockle, has rhomboidal, oblong $1\frac{1}{2}$ inches long valves, with 32 to 35 ridges or ribs placed in radiating lines from the umbones to the margins. This is the common radiate-shelled clam of the Atlantic coast.

Venus mercinaria, (Linn.), or Common Hard-shell Clam, Quahog, has thick and solid, obliquely ovate or heart-shaped grey and chalky valves with the anterior ends very short, the posterior ends terminating in a blunt truncated point, and the curved and elevated umbones placed far forward to project nearly to the front of the shell. This clam is brought into the market under different names, the younger as the Cherry Stone and Little-neck, the older as the Hardshell, and the very large ones, which reach a length of $3\frac{1}{2}$ to 4 inches, as the Chowder Clam. Those having shells 6 inches long or larger are known as Horse or Sea Clams. Common along the entire Eastern and Middle States Coast.

Mytilus edulis (Linn.), or Edible Mussel, has thin, polished, triangular-ovate, dark-bluish, $2\frac{1}{2}$ inches long valves, with a pointed beak and plainly defined lines of growth. The umbones are immediately at the beak. Very common between tide-marks on the Atlantic coast, from the Arctics to North Carolina.

Modiolus plicatulus, (Lam.), or Horse Mussel, has oblong-ovate much elongated greenish-brown and horn-colored 2 to 3 inches long valves; with the posterior end traversed by numerous radiating ribs. The umbones are placed above the beak. Common on muddy banks of estuaries and shores, crowded in vast numbers, exposed at low tide; from Nova Scotia to Georgia.

Pecten gibbus, var. *irradians*, (Lam.), or Common Scallop, has nearly round, rather strong, dusky or blackish $2\frac{1}{2}$ inches long valves, having about 20 elevated, rounded ribs, wrinkled concentrically by fine lines of growth, and an ear-like hinge about two-thirds as broad as the shell. Common along almost the entire Atlantic coast from Nova Scotia to Tampa, Fla.

Ostrea virginica, (Gmel.), or Chesapeake Bay Oyster, has now become a widely distributed native species, found along the entire Atlantic coast. Owing to its sedentary life, it has become very irregular in both

form and size, and specimens from different localities would scarcely be recognized as of one and the same species.

Anomia simplex (Orb.), or Jingle Shell, or Jingle, has rounded, scaly, variously wrinkled and undulated, $\frac{3}{4}$ inch in diameter valves. The shells are a common feature on the seashore, their fine pearly lustre and flattened form distinguishing them from other oysters and clams. It is a hardy species found abundantly on oyster beds and adhering to fixed objects along the Atlantic coast.

MARINE MOLLUSCS AS SCAVENGERS. Marine Univalves feed upon plants and animals, more particularly the lower forms, algæ, oscillaria, protozoans and hydroids. In the aquarium they perform useful purposes, keeping the glass clean and devouring food particles which might contaminate the water. They are not quite as good scavengers as some of the freshwater species. Bivalves also render good service in keeping the water clear, but only a few should be introduced, as they require considerable water for respiration and to obtain sufficient of the minute vegetable and animal life upon which they feed.

SQUIDS. Two of the Squids may be mentioned, as they are common along almost the entire Atlantic coast. These are *Ommastrephes sagittatus* (Lam.), and *Loligo pealii*, (Les.), both from 6 to 12 inches long. All the family are ferocious creatures, the tyrants of the lower orders; solid fleshy animals having powerful arms furnished with rows of cup-like suckers, strong jaws and membranous tongues, armed with recurved prickles. They discharge an inky fluid through a siphon. The beak or pen is the cuttle-fish bone of commerce and forms the skeleton of the animal.

CHORDATA. These animals are common on marine plants, submerged woodwork and other fixed objects. Their characteristic of ejecting jets of water secured for them their popular name of Sea-squirts. They are usually of dull colors except in southern waters, and are either individual or compound animals. The common species are:

Molgula manhattensis, (Say), a very general form, has an olive-green globular body with slightly rough surface, about $\frac{3}{4}$ inch diameter. Two siphon tubes extend above the upper end. Found on seaweed, etc., either singly or in clusters.

Cynthia partita, (Say), another common form, has an oblong body, one inch in diameter, of rusty brown color, marked with red and purple. Usually found on piles or flattened under stones.

Botyllus gouldii, (Stimp.), is a generally distributed compound form which appear as thick incrustations and bands on plants and piles. There are many other common forms. Individual Sea-squirts will survive in smaller aquaria, but it is not advisable to introduce the compound forms.

PISCES. Of the Marine fishes only those forms will be mentioned which are readily obtainable, the native Eastern and Middle States coast species, and strays of the Gulf Stream, which may survive in the marine aquarium. These are:

Herrings or Clupeidæ. These fishes are distributed throughout the whole of the North Atlantic, and the young make interesting aquaria inmates. They may be obtained in abundance along the shore in summer. Of these the Common Herring, *Clupea harengus*, the Sardine, *Sardinella*, and the Menhaden, *Brevoortia tyrannus*, are the most numerous forms.

Toothed Minnows or Pæciliidæ occur in brackish water near the mouths of rivers and along the coast. They are all small fishes varying in the adult from 2 to 6 inches. The most common forms are Pursy Minnow, *Cyprinodon variegatus*; the Killifish, *Fundulus heteroclitus*; the May Fish, *F. majalis*; and the Rainwater Fish, *Lucania parva*. All are very hardy and will survive in the aquarium.

Sea-horses or Hippocampidæ. The strange shape and interesting habits of these fishes make them very desirable aquarium inmates which survive for long periods. The abundant form on the Atlantic coast is *Hippocampus hudsonius*, very similar in appearance to *H. hippocampus* of Europe.

Pipe-Fishes or Syngnathidæ. These fishes are closely related to the Sea-horses and are found everywhere on the Atlantic coast. The head is small and the body elongated, somewhat resembling the eel. The common form is *Siphostoma fuscum*, a most interesting aquarium fish.

Sticklebacks or Gasterosteidæ. These interesting nest-builders have three salt and brackish water species which thrive in the aquarium. These are the four-spined Stickleback, *Apeltes quadracus*; the ten-spined Stickleback, *Pygosteus pungitius*, which also inhabits fresh water, and the Two-spined Stickleback, *Gasterosteus bispinosus*. Schools of them may sometimes be encountered in midsummer in bays and brackish water estuaries. Their habits are described on page 72.

Silver-Sides or Atherinidæ. These small carnivorous fishes are found in numbers near the shore in brackish water and at the mouths of rivers. They resemble the smelt. Two species occur on the Middle Atlantic coast, *Menidia cerea* and *M. notata*, known as the Sand Smelt and the White Bait.

Mulletts or Mugilidæ. The young of this genus will survive in the aquarium. The adults reach a size of 2 feet and over. The most numerous marine forms are the Grey Mulletts, *Mugil cephalus* and *M. curema*, both numerous in salt and brackish water during the summer.

Crevallés or Carangidæ. The young of three species of these fish are abundant during the summer months along almost the entire Middle

Atlantic coast. These are the Goggler, *Trachurops crumenophthalmus*; the Thread-fish, *Alectis crinitus*; the Common Moon-fish, *Vomer setapinis*; and the Silver Moon-fish, *Selene vomer*.

Sea-Basses or Serranidæ. More than 20 species of these fishes occur on the Atlantic coast and the young of other tropical forms are carried up in the Gulf Stream. They are popularly known at the seaside as Blackfish and Rock Blackfish. The most common species is *Centropristes striatus*, small specimens of which are very interesting aquarium inmates.

Snappers or Lutianidæ. The young of these fine food fishes will survive in the aquarium. They are widely distributed, those frequenting the Gulf Stream and straying to the Middle Atlantic coast being the Grey Snapper, *Neomænis griseus*; the Dog Snapper, *N. jocu*; the Schoolmaster, *N. apodus*; the Mutton-fish, *N. analis* and others.

Grunts or Hæmulidæ. The young of these beautiful sub-tropical fishes also stray to more northern waters. Among these are the Common Grunt, *Hæmulon plumieri*; the Grey Grunt, *H. macrostomum*, and the Yellow Grunt, *H. sciurus*.

Croakers or Sciaenidæ. This family contains about 30 genera and 150 species, including the Weakfish, *Cynoscion*; Kingfish, *Menticirrhus*; Croaker, *Micropogon*; Drum, *Pogonias*; Cape May Goodie, *Leiostomus*; Mademoiselle, *Bairdiella*, and others, the young of which will thrive fairly well in the aquarium. Most of these make peculiar noises from which they derive their common name. Some of them reach a large size and occur in shallow water on sandy shores along the Atlantic coast.

Wrasses or Labridæ. Of these fishes there are 8 or 10 species on the Atlantic coast, the most common being the Tautog or Blackfish, *Tautoga onitis*, and the Cunner, *Ctenolobrus adspersus*. These are large fishes of which the young may be kept in the aquarium.

Harvest Fishes or Stromateidæ. Three species of these fishes occur on the Middle Atlantic coast. These are the Harvest-fish, *Peprilus paru*; the Butter-fish, *Poronotus triacanthus*, also known as the Pumpkin-seed; and the Black Rudder-fish, *Palinurichthys perciformis*.

Butterfly Fishes or Chaetodontidæ. The young of these fishes frequent the Gulf Stream and are sometimes taken in northern latitudes. They are most beautiful marked and of singular appearance. There are 8 to 10 genera and nearly 200 species; carnivorous fishes of tropical seas, very hardy, which will survive in the aquarium. They are also known as Angel Fishes.

File-Fishes or Monacanthidæ. These small shore fishes of warmer waters are closely related to the Balistidæ of the tropical seas, and may be taken in shallow water in summer. They are beautiful in form and

colors. The common form is *Stephanolepis hispidus* of the Eastern and Middle States coast.

Swell Fishes or Tetradontidae. These curious fishes, also known as Puffers, Globe-and Porcupine-fishes, are summer visitors from warmer seas. Two species are taken on the Middle Atlantic coast, the common Swell-fish, *Spheroides maculatus*, very abundant, and the Rabbit-fish, *Lagocephalus levigatus*, an occasional straggler.

Sculpins or Cottidae. These fishes are most abundant in the waters of the northern seas, several forms straying below Cape Cod. The common Miller's Thumb or Blob, *Uranidea gracilis*, may also be found in clear, cold freshwater streams; and the common Marine Sculpin, or Grubby, *Acanthocottus aeneus*, near the coast, from Maine to Cape Hatteras.

Toad Fishes or Batrachidae. These fishes resemble the Sculpins, and are the most repulsive looking fishes of the coast. They frequent oyster beds, and the common form, *Opsanus tau*, is abundant along the coast, the young, when cleaned of the adhering mud, making hardy and odd aquarium inmates.

Blennies or Blenniidae. Two species of these small fishes inhabit the shallower waters on the Atlantic coast, living principally in the Kelp and other weeds. The common form is *Pholis gunnellus*, the well-known Butter-fish.

Gobies or Gobiidae. Several species of small size, the Scaleless Goby, *Gobiosoma boscii*; and the Chubby Goby, *Gobius soporator*, are sometimes seen in aquaria. The former ranges from Cape Cod to Texas, the latter along the Gulf States and farther north. They are hardy and will survive in the aquarium for long periods.

Gurnards or Triglidae. Several species of Sea Robbins are represented on the Atlantic coast. The young of the Web-fingered Sea-robbin, *Prinotus Palmipes*, and the Wing-fish, *P. evolans*, make interesting aquarium inmates, as they have the habit of crawling over the bottom on their pectoral appendages.

Flying Gurnards or Cephalacanthidae. These fishes, known as Sea-bats, occur on the Atlantic coast and the young are frequently taken for the aquarium. The one common species is *Cephalacanthus volitans*.

Star Gazers or Uranoscopidae. Of these fishes there is but one species along the Middle Atlantic coast, *Astroscopus anoplus*, which reaches a length of 12 inches. The young are sometimes seen in aquaria in which they may survive for long periods.

Cusk Eels or Ophidiidae. But one species occur on the New Jersey coast, *Rissola marginata*, about 7 inches in length, found in the surf and

shallow water. It differs from the Eel in being scaleless and having the ventral fins on the throat as long and forked barbels.

Cods or Gadiidæ. The Tom-cods are small fishes of which the Frost-fish, *Microgadus tom-cod*, is found from Cape Sable north. The young make interesting aquarium fishes.

Flat Fishes, Soleidæ and Pleuronectidæ. A number of species of Flat-fishes occur on the Atlantic coast of which the young are frequent seen in aquaria. They have the habit of secreting themselves to the eyes in the sand, and their peculiar movements in swimming and odd appearance are interesting. There is but one common species of Sole on the Middle Atlantic coast, the Hog Choker *Achirus fascitus*, which will live in freshwater. Of the Flounders there are a number of common forms, the common Flat-fish or Winter Flounder, *Pseudopleuronectes americanus*; the Summer Flounder, *Paralichthys dentatus*; the Southern Flounder, *P. lethostigmus*; the Four-spotted Flounder *P. oblongus*; the Window-pane, *Lophopsetta maculata*; and the Rusty Dab, *Limanda ferruginea*.

Skates or Rajidæ. The common skate, *Raja erinecea*, is frequently taken on the coast from Virginia northward. It reaches a length of 18 inches. Sometimes the larger *R. radiata* strays south of Cape Cod but it is a northern form. Another very large species is the Barndoor skate, *R. lewis*, which reaches a length of four feet. The first named is very hardy and easily kept, and is a common feature of all larger Marine aquaria.

Sting-rays or Dasyatidæ. Of this family the young of one species the Common Sting-ray or Stingaree, *Dasyatis centrurus*, is frequently taken near the shore and in salt bays and inlets. It is common from Cape Cod south. The adults reach a length of 12 feet. The long spine on the slender tail can inflict dangerous wounds.

Frog Fishes or Antennariidæ. In the floating seaweed from the Gulf Stream a bright colored little fish, the Mousefish or Sargassum-fish, *Pterophryne histrio*, is often found, which will survive in the aquarium. It is of bright orange color mottled with various shades of red and brown.

Fishing Frogs or Lophiidæ. The common form is known as the Angler or Goose-fish, *Lophius piscatorius*, which occurs in the shoals and flats, and is singular on account of its repulsive ugliness and voracity. It grows to a large size but the young are interesting aquarium inmates.

Salt-water Eels or Leptocephalidæ. The common form is the Conger-eel, *Leptocephalus conger*; but occasionally some rare straggling tropical eel is found by the collector, borne to northern waters in the Gulf Stream.

CARE OF THE MARINE AQUARIUM. The maintenance of the marine aquarium, when properly understood, is as simple as that of freshwater.

Less humus will form, the glass need but seldom be cleaned, the evaporation is inconsiderable, and the conditions of the water and its temperature, when the aquarium is properly established and aerated, require but little attention. The inmates, however, should have close supervision until they have become accustomed to their changed environments. Occasionally, even with the most careful attention, water contamination may occur or a cloudiness of the water manifest itself. This may be due to an excessive growth of algæ in the water, the death of an inmate, the decay of a plant, or mistakes on the part of the attendant. A more rapid aeration may often relieve this condition, when some such happening has been the cause and corrections have been made; but should this prove ineffectual, or after several days not improve the appearance and remove the turbidity, then some of the water should be siphoned and replaced by the reserve water. The turbid water, if the contamination was not a dangerous one, may be filtered and when clear and in normal condition, may be again used or reserved. Mishaps of this kind should not occur more frequently than in the freshwater aquarium.

FILTERS. A charcoal filter or any other mechanical, not chemical, household filter will answer the requirements; but one easily constructed can be made of two glass funnels or of two flower pots, one a trifle smaller than the other. When constructed of the pots, pieces of pipe are cemented into the bottom holes and cotton gauze laid over these openings. The smaller pot is filled halfway with coarse sand, then to the top with fine sand and covered with a piece of gauze, brought over the edge and secured about the outside of the pot. The larger pot is filled about one-fourth with fine sand. Upon this is placed a layer of powdered charcoal to nearly fill it, and the opening of the smaller pot then tightly inserted into the opening of the larger pot and firmly secured. A siphoning tube is placed into the aquarium, suction applied with the lips, the tube then put over the inlet tube in the smaller pot, the filter secured that the water of the aquarium will flow through it, and by a hose placed over the outlet of the larger pot led into a receptacle. From this it may then be returned to the aquarium. By siphoning from the bottom, sometimes drawing but a part of the water through the filter will correct the difficulties; more often, however, the aquarium must be almost or entirely drained. Experience will teach when this is necessary, and should not be needlessly done, as the disturbance caused thereby is always detrimental to the animal life.

FEEDING MARINE ANIMALS. Some of the inmates cannot be fed and must take their nutriment from the water in the form of algæ, oscillatoria, diatoms and infusoria. Fanciers often arrange a number of smaller all-glass battery jars on a shelf below the larger aquarium, sometimes con-

nected with the aerating device, for the breeding of these low forms, and containing a marine plant or two; from which they are dipped with water, but this is not imperatively necessary. Other and larger animals should be furnished with more substantial food, the preferable dietary being finely scraped lean beef and mutton, minced angle worms, and small particles of oysters, fish and crab-meat. Tweezers or feeding rods are required to place the food in, on or near the molluscs, anemones and other polyps, which should be fed once a week; but the small crabs, starfishes, other higher forms, and the fishes, should have the same food, given them at intervals of two or three days. Great care must be exercised that all the food is consumed, as its rapid decomposition will cause water contaminations. If any remains uneaten, it should be at once removed with the dipping-tube. The partly digested or rejected food fragments, given off by the lower animals and the skins of the polyps, should also be removed. Careful sanitation is as necessary with the marine as with the freshwater aquarium; even more so, as the scavengers of the sea are not as efficient as those of freshwater.

Anemones should be sufficiently fed or they will become dissatisfied with their positions and move about to find a more desirable situation. The food should be placed on the end of the feeding stick and the tentacles lightly touched with it, several very small pieces being offered to the same individual. If they are rejected the anemone is not hungry, as it has the power of making its tentacles adhesive, or not, at will. Some forms kill their prey by acontia, small threads and spicules with stinging cells, which they give off at will. These should have the food brought directly into the centre of the disc, for if the tentacles are touched they will immediately collapse. When hungry, they will at once engorge the food, if not, it will be rejected and should be removed. The water in the vicinity of anemones should also be stirred occasionally.

It should be noted that the food requirements of marine animals in the aquarium are less than in natural surroundings, which should be considered in feeding, and that they take more food when the water is warm than when it is cold.

STOCKING THE AQUARIUM. Overcrowding is as objectionable in the marine as in the freshwater aquarium. Not more than one inmate of any kind to the quart of water should be introduced, or less according to the existing conditions and the kind and size of the animals. Overstocking is one of the most frequent causes of discouragement and failure to the novice. It should be remembered that marine aquaria are to be admired as much for the artistic arrangement of the inanimate objects they contain as for the wonderful and varied forms of marine life; and a few healthy and

comfortable animals and plants are preferable to a larger number in sickly or dying condition.

In handling the animals, to place them into the aquarium, the anemones and similar fauna should be introduced together with the shells and stones to which they may adhere. All the other low forms should be handled in a spoon; while fishes, crabs, etc., should be transferred with a shallow net. None should be forcibly removed from any object to which they are attached, as it is always injurious, very often fatal to them. After they have been put into the aquarium, they should not be touched, and if it is necessary to assure oneself that they are alive, a very small glass tube will serve as a blowpipe and a breath of air will cause sufficient movement to determine the question.

A very little experience and observation will enable the fancier to distinguish between a sick or dead inmate and a healthy and living one. If the shape and position of the anemones have not changed, a clouded appearance forms about the sponges, the bristles of the pipe worms remain unchanged and motionless, the snails on one spot and enclosed in their shells, the mussels, clams and oxygen in the same position with constantly gaping valves and no appearance of water currents over them, the crabs without movement of the eyes or antennæ, and the fishes torpid and motionless; these are all suspicious signs requiring investigation.

MARINE SCAVENGERS. The scavengers of the marine aquarium are gasteropods, shrimps and crabs, which are effectual when the amount of food is properly regulated.

ACCLIMITIZATION IN THE MARINE AQUARIUM. Deaths are most likely to occur when the animals are first introduced, as the changed conditions during their transportation affect them even more than existence in a properly arranged, well aerated aquarium; but after they have become acclimated to their new surroundings, the deaths are not more numerous than with the fauna of the freshwater aquarium. Trials with the marine aquarium are earnestly advocated; they have a novelty and beauty all their own, may be set up anywhere and maintained at no greater expense than the keeping of the finely bred goldfishes.

COLLECTING FOR THE MARINE AQUARIUM. In making collections the periods of lowest water twice a month, at the new and full moon, give the most satisfactory results, but especially at full moon in the months of September and October and in March and April. A sandy beach may not yield many specimens, but back-bays and thoroughfares, their borders and outlets, are favorable localities. Cliffs, rocks and boulder-strewn beaches, or where tide-pools and depressions have formed, overflow at high tide and above low-water when the tide recedes, are the best; and

often many forms of plants and animals may be found in a limited space. It is necessary to have some experience in collecting, as localities passed over by the novice as devoid of specimens may yield an abundance to the experienced collector. A thorough examination of the whole area should be made, the seaweeds lifted, submerged woodwork examined, stones overturned, and every rock, depression and cavity explored with both the net and the fingers.

A light basket with shoulder-straps, containing a number of large-mouthed bottles and jars, a shrimp net, a pole with a strong iron point at one end and a detachable garden rake for the other, a coldchisel and

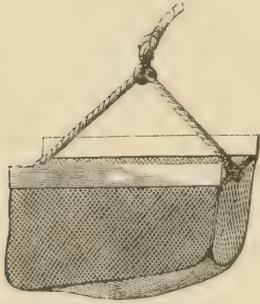


FIG. 236. Dredge net.

hammer, hip boots and felt gloves to protect from the sharp edges of mussels and the slippery footing and concealed crevices, will be desirable; and for use in a boat, a dragnet, constructed of an iron frame 24 by 8 inches, with hoop-iron scrapers on the longer sides will be useful. This dredge, Fig. 236, will collect sponges, worms, anemones, corals, molluscs, shrimps, crabs, fishes and often the rarer deepwater plants. Anemones and coral-

lines should be taken with the smaller objects to which they adhere or a piece of it removed with the chissel, but when this cannot be done they should be carefully removed with a paper knife or with the finger nails, so as not to injure their bases.

Fishes may be taken in a net, the simplest being an iron hoop and netting attached by a rope to a long pole and baited with a broken clam, or the wire netting lobster trap. The flat fishes lie under the sand and are usually taken in the dragnet.

A constant observation of the tide should be kept, as its unobserved advance is often dangerous to the collector.

TRANSPORTING MARINE CATCHES. The best forms of jars are wide-mouthed and of glass or stoneware, with tightly fitted corks through which a glass tube has been passed to extend two inches above and below, to prevent spilling. These receptacles should be not over three-fourths full of water, so that the motion in transportation will change the air. Many of the animals may be shipped in moist, not wet, seaweed. A thick layer should be placed in the bottom of a can or box, and upon this the plants intended for the aquarium, then a second layer of weeds, and upon this the animals. These should

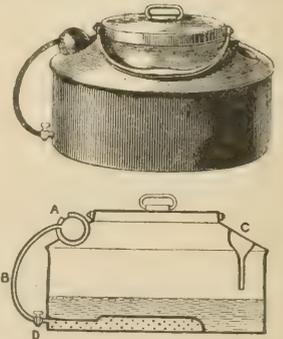


FIG. 237. Buckland Collecting can.

then be covered with a considerable quantity of moist weeds. Some of the fishes and other forms will survive for hours, if carefully packed as suggested. The illustration, Fig. 237, is the Buckland collecting can, which has a perforated false bottom connected by a pipe, pet-cock and hose, D. and B., with the air bulb, A. The funnel C. aids in aerating and siphoning the water. This may be set under the car seat and the bulb operated with the foot. Modifications of this device are easily made, and are in general use.

RECEIVING CONSIGNMENTS. Upon arrival, a number of shallow receptacles filled with seawater should be at hand, to separate the animals and to quarantine them until assured that they are in healthy condition. The marine plants also should be cleaned with saltwater and quarantined a day or two before introduction into the established aquarium. The anemones may not at once adhere in the desired positions, may attach themselves to the glass or roll on the bottom; or they may, by expanding their discs on the surface, float about for days in reversed position. Pouring water into the hollow depression of the disc will cause them to sink, as they then lose their buoyancy. It will be found that most of them will expand more freely on bright days, though some forms, which prefer darkness, will seek these localities, when offered. When considerably fed they will not open for some days, but if it is desired to have them do this, a very small particle of food given an hour before will excite the appetite and cause them to open very widely in expectation of a further meal.

AQUARIUM TOOLS. These should consist of straight and bent dipping tubes, a siphoning tube and hose, a shallow net with a straight front, a sponge or piece of felt on a stick to clean the glass, a glass syringe for aeration and feeding the mussels and other low forms; a filter, as already described, long scissors, tweezers and feeding sticks. Pieces of charcoal behind and under the rockwork will serve as antiseptics and aid in keeping the water clear. With larger aquaria some efficient method of aeration is imperatively necessary.

CHAPTER XIV.

**The Terrarium, Aqua-terrarium, Inmates
and Maintenance**

TERRARIA AND AQUA-TERRARIA

Various forms of terraria have been devised to fulfill special purposes. These may be classed as Dry terraria for reptiles and for plants which best thrive in a dry atmosphere; Moist terraria for amphibia and for plants which require a moist atmosphere; Heated dry terraria for tropical reptiles and for plants requiring a warm, dry atmosphere; Heated moist terraria for tropical amphibia and for plants which thrive best in a warm and moist atmosphere; and the Aqua-terraria which combine many of the features of both the terrarium and aquarium. These will be treated of separately, as their respective purposes must be kept in mind in their construction, arrangement and maintenance.

DRY TERRARIA. The simplest form consists of a box with a glass front, the right hand side either a hinged frame or one fitted into grooves, and covered with cotton gauze, Brussell's netting or fine wire screening. The left hand side is also a frame covered with netting and having a central sliding door. The back is of wood covered with cork slabs; and the top a wooden frame fitted with glass, for the observation of the contents and with netting, and arranged for ready removal. The bottom is furnished with a neatly fitting zinc tray having a 3 or 4 inch raised edge to contain soil. The most approved form has a zinc or iron frame with the sides hinged to facilitate planting and cleaning. The uprights are tee irons with angle iron upper and lower frames. The sides may have either wooden or angle iron frames to fasten into the uprights by turn-buckles or other simple device. The top may be made with slanting sides either as a mansard or gable roof. A shallow water basin for the inmates must also be provided either of metal or made in cement of irregular outline with a mirror to form the bottom of the pool.

MOIST TERRARIA. The construction of the moist terraria may be similar to the above, but control of the ventilation must be kept in mind so as to maintain a moist atmosphere necessary to the animals and plants. The approved form consists of either a wooden or metal-framed box, two or three of the sides of which are of glass in grooved or hinged frames, and one of glass with a netting ventilator below, provided with a sliding door. The top may be of netting, over which a glass plate is arranged to be raised or lowered as required for ventilation. The zinc tray should have a small outlet pipe through the sides of the terrarium to permit of drainage of the excess of water. As the animals in this form of terrarium are usually amphibious a larger water basin is required.

HEATED DRY TERRARIA. The same arrangement as the above may be used, but heating appliances must be provided. For this purpose a second or false bottom should be constructed about 3 inches above the bottom of the terrarium on which the planting tray may rest. Wood is best for this false bottom as it is a better insulator and will allow of a more even distribution of the heat than metal surfaces. The space between the two bottoms may be arranged as a drawer lined with sheet iron for heated sand, or fitted with a flat zinc flask for hot water, the latter being preferable. The flask may also be permanently inserted, in which case an outer tube should be soldered into the planting tray through which the tube communicating with the flask may be brought above the surface of the soil in the tray, that the cooled water may be removed with a siphon and hot water introduced with a hose; or a tube let through the side closed with a pet-cock. This need be done but once or twice a day. The water basin for the inhabitants is usually arranged in one corner.

HEATED MOIST TERRARIA. These are similar to the heated dry terraria in construction, but contain a larger and deeper basin for the amphibious animals; and should be arranged to permit of control of the ventilation to maintain a heated moist atmosphere. The water basin is usually constructed to occupy one side or a corner and has one of its sides at an angle to permit of a shallow approach to the water.

With all forms of terraria the main consideration must be the reproduction, as nearly as possible, of the natural conditions and surroundings of the animals and of the plants, and the establishment of good and ample ventilation.

PLANTING THE TERRARIA. The plantings should be directly into the trays and in flower pots. A lower drainage layer of large pebbles and a thin leveling layer of fine grit should be first put into the trays. For the Dry terraria these should be covered with rich garden soil, of which the lower layer has been mixed with fertilizer; and for the Moist terraria with clean lawn turf to which a little fertilizer has been added. Upon the pebble foundation a background or central mound of rocks may be constructed, to form caves and hollows in which the animals may secrete themselves, and pockets in which to set plants; or the rocks may be arranged to screen the receptacles of potted plants. In arrangement and planting the natural home of reptiles should be simulated and the Dry terraria arranged to resemble sunny, arid and rocky localities, and in the Moist terraria miniature woodland landscapes natural to amphibious animals. The former should also not have too considerable vegetation, with spots devoid of soil and covered with fine gravel and a few scattered stones, while the

latter should have an ample growth of small vegetation, sod, moss, lichens and ferns, and an abundance of larger foliage and flowering plants.

In the Dry terrarium the water basin may be treated as incidental, but in the Moist terrarium it should be one of the principal features. The best form has three vertical sides covered with a thin coating of hydraulic cement into which small pieces of stone, pumice, tuftstone, etc., have been pressed to resemble rough stone walls, and one partly sloping side to permit of a gradual approach to the water level, in the foreground, arranged to resemble a pebbly beach. The water may be siphoned out or a drainage pipe led through the side. In large terraria the water tank is often utilized for semi-aquatic plants in concealed pots.

In terraria miniature bridges, castles, fountains, cascades and other landscape features are introduced with pleasing effect. Backgrounds are made of rocks cemented at different levels to the back of the terraria and in the pockets so formed ferns and other plants are grown. Pumice is well adapted to this use, its pores absorbing large quantities of water. The general appearance will be improved if the raised sides of the soil tray are concealed by painting the glass to that level.

Reptiles require heat and strong sunlight, as they delight to sun themselves for hours; but amphibious animals generally should be sheltered from strong light, as it is objectionable to them, and a temperature of about 75° to 80° F. by daylight and not below 55° F. at night is best suited for the indigenous forms; but for tropical species temperatures from 15 to 20 degrees higher are required.

PLANTS FOR TERRARIA. For the Dry terrarium cacti, aloes and agaves are best suited for direct planting in the soil, and houseleeks for the pots; also hardy ferns and a number of other plants which will thrive in pots in a dry atmosphere. For the Moist terrarium a much larger number of plants are available and almost all that thrive in the greenhouse may be successfully introduced. The plants should be frequently sprayed with water. For this purpose either a small sprinkling can or a florist's aspirator is best.

ANIMALS FOR TERRARIA. Almost any of the lower forms of small land animals may be introduced. For the Dry terrarium, butterflies, beetles and other insects, land snails, slugs, hop toads, tree toads, horned toads, lizards, snakes and small tortoises; and for the Moist terrarium aquatic insects, snails, tadpoles, frogs, newts, salamanders, water snakes and turtles. Most interesting collections can be made of animals which live in harmony with each other and such added which will serve them as food.

AQUA-TERRARIA. These receptacles combine the aquarium and the terrarium, their purpose being the growing of aquatic and semi-aquatic plants and the maintenance of aquatic and amphibious animals in surroundings nearest to those of their natural habitats, that the adults as well as the larvæ and young may be kept for observation and study. The



FIG. 238. Swamp Aquarium.

effect produced is far more handsome than that of the aquarium alone, and when the aqua-terrarium is of large size, it permits of most beautiful and interesting arrangement, as may be seen by the illustration at the end of this volume. The upper part is arranged to set upon the lower aquarium, and of this latter the two sides and a part of the back are built

of or screened with slate to conceal the back of the rockwork and earth in which the plants are grown.

Another form consists of a shallow open tank or aquarium having a layer of soil covered with pebbles arranged to slope from a depth of 2 inches to within a half inch of the surface, screened by paint on the glass to just above the soil level so that only the clean surface of pebbles is exposed. In these varying depths of water a great variety of aquatic and semi-aquatic plants may be grown, sagittaria, ludwigia, fontinalis, anacharis and cabomba to grow submerged; parrot's feather, water-hyacinth, salvinia, triana and frog-bit on the surface, and semi-aquatic plants to grow one to four feet above the surface.

Fig. 238 gives a good idea of the beauty and the arrangement of a receptacle of this kind, the plants shown being Maidenhair, *Scirpus gracilis*, in the pot, Water-hyacinth and Parrot's feather on the surface and Chinese and Montevidean Arrowheads and Umbrella plants growing above the surface. This receptacle offers opportunities for tasteful and artistic arrangement of plants and for keeping the lower forms of animal life, and is usually installed in conservatories and greenhouses.

Under proper conditions any of the following animals can be kept in Terraria and Aqua-terraria.

BATRACHIA. Frogs and Toads belong to the order Salientia or tail-less Leapers, the Ranidæ or frogs, the Bufonidæ or toads and the Hylidæ or tree toads. All are closely related, differing only in structural features and habit. They have bony skeletons with projections on each side of the vertebræ but no ribs, respiration being made by the throat and consists of a continuous gulping to force air to the lungs. Almost the entire cranium is taken up by the orbits, the brain cavity being very small. The hind-legs are long and have webbed toes, the fore-legs are short and the toes are without webs. In repose they sit nearly upright, a position admitting of instant movement which consists of long leaps, short jumps and a crawling movement. They are oviparous and deposit spawn in the spring and early summer months, which is fertilized by the male as it is extruded by the female, the size of the ova being 1.75 to 2.6 millimeters, varying with the different species. The frog spawn receives a coating of albuminous substance as it passes down the oviduct, which rapidly swells when the eggs enter the water and forms clusters of gelatinous globules enclosing the eggs, also keeping them well apart and serving as a protection. The spawn of the toad is enclosed in long strings or ropes of the gelatinous substance, usually attached to aquatic plants. The eggs develop as soon as fertilized, appearing as partly white and black spheres, but as the embryo develops the entire egg enlarges, become black and

assumes either an ovoid or a lozenge form. Dependent upon the temperature of the water and the different species, the period of incubation may be from 6 to 30 days. When the tadpole wriggles out of the gelatinous cover, which serves as its first food consumed by absorption, the mouth and anus soon become functionary, the alimentary canal elongates, and the tadpole begins to feed on macerated vegetal and animal matter. At first respiration takes place by external gills, but these are soon replaced by internal structures covered by operculæ. The rapidity of development depends upon natural conditions and in the different species may be in 3 months to 2 years. The first indication of the metamorphosis is in the development of the hind legs, then the fore-legs develop under the gill membranes, and finally the tail is absorbed, at which period the gills are replaced by lungs and the young frog or toad becomes amphibious. The food is no longer organic matter but living organisms, and its usefulness as an aquarium scavenger ceases.

Tadpoles of the toad may be distinguished from those of the frog by their blacker color, the latter being preferable in the aquarium, as they are better scavengers and remain longer in the tadpole stage.

FROGS. These have long and tapering tongues fastened to the front of the mouth, free behind, and the tip pointing down the throat. Their prey is taken by its quick protrusion, and the adhesion to its viscid covering. Maturity is reached by the toad in one season, but with some of the frogs it is delayed for 2 or 3 years; while tadpoles in aquaria sometimes never undergo the final metamorphosis, probably due to the enforced aquatic conditions. In the United States there are 13 recognized species and 6 sub-species of frogs; those most generally distributed being the Spring or Leopard Frog, the Green Frog, the Common Bullfrog, the Western Frog and the Western Bullfrog.

Rana virescens, (Shaw), the Spring or Leopard Frog, is found from the Atlantic Coast to the Sierra Nevada Mountains and from Lake Athabasca to Central America, but is most abundant in the Eastern States. It grows to a length of $3\frac{1}{2}$ inches, exclusive of the legs; has a rather pointed snout, and the tympanum of the male is nearly as large as the eye. The color is bright green marked with olive, with dark-brown and black blotches in two irregular rows on the back, and one or more indefinite rows on the sides. The yellow glandular fold, which is a distinguishing characteristic in the different species, reaches from the orbit to the posterior end of the body. This frog passes through the tadpole stages in one season and its cry may be defined by the syllables *cluck cluck*; *cluck cluck* in guttural tones.

Rana clamatans, (Shaw), the Green Frog, is distributed throughout the Eastern and Central States and a part of Canada. The head is rounder than the above, the body and limbs shorter and more massive, the tympanum of the male larger than the eye and smaller in the female. The glandular fold runs from the eye to the hip with a shorter one to the shoulders. The color is dark-olive on the back, brilliant green on the head and shoulders, and usually white or greenish-white below with citron-yellow throat. At some seasons it may be greenish-brown on the back and the sides marked with brown spots. It is aquatic in its habit and emits a shrill cry when disturbed, the usual note being a nasal *chung*, and its call is *chock, chock chock*.

Rana catesbeana, (Shaw), the Common Bullfrog, is distributed over the entire country east of the Rocky Mountains and is the largest of the North American frogs, often reaching a body length of 8 inches. It has a broad head, bulky body and thick legs. A fold of the skin extends from the eye to the tympanum around the forearm socket to the breast. The tympanum of the male is larger than the eye. The complete webbing of the fourth toe and the absence of the dorsal or back fold are other distinguishing characteristics of this species. Its cry is the deep guttural oft-repeated croak, *wuūm, wuūm, wuūm, wuūm*.

Rana pretiosa (Cope), the Western Frog, and the Western Bullfrog, *Rana aurora*, are not found in the Eastern States, the distribution of the former being from Montana west to Puget Sound and south to Lower California. Its head is obtuse, rounded and broader than long, the body stout, the eyes smaller than the Eastern Frogs, and the indistinctly outlined tympanum often smaller than the eye. A depressed ridge extends from the eye to the flank; and the color is yellowish-brown above, darker on the side, circular brown blotches on the back, and transverse markings on the legs. The Western Bullfrog is distributed on the Western Coast regions of the United States. Its head is broad, acute and rounded anteriorly, the body depressed and elongated, the eye moderately large, and the tympanum smaller than the eye. The glandular fold reaches from the eye to the hind leg. The color is greenish-yellow with golden reflections spotted with black, and the sides and abdomen reddish-brown. The under side is dull, spotted greenish-yellow.

The sexes of the frogs may be determined by the size of the tympanum, that of the female being the smaller.

TOADS. There are several varieties of the common or hop-toad which will not be mentioned here. Toads are terrestrial in habit, of dull, inconspicuous color and usually considered of uncouth repulsive form.

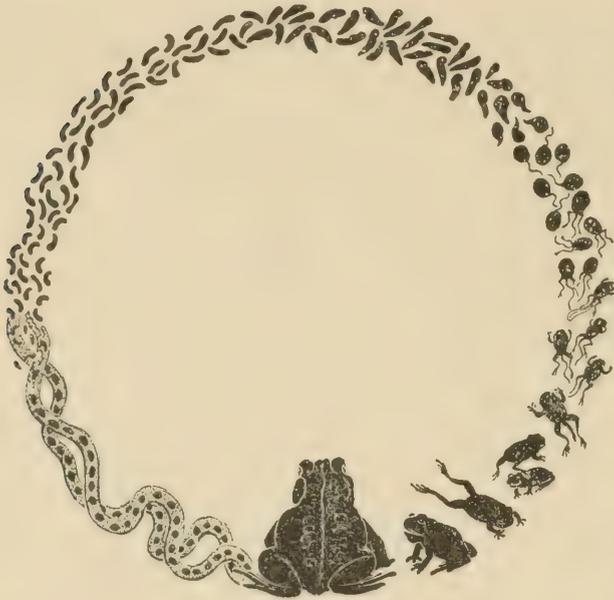


FIG. 239

10,000 insects and worms in a single summer. The illustration of the metamorphosis of the common American Hoptoad, *Bufo lentiginosis*, (Shaw), Fig. 239, is taken from the Nature Study leaflets of the Cornell University College of Agriculture and shows the life history of the toad and the devastation wrought by its enemies, as of probably 1000 eggs and tadpoles but one or two toads survive to the adult stage.

The toad is common to almost all parts of the United States. It rapidly passes through all the stages of development from tadpole to maturity, and its usefulness to the agriculturist should afford it better protection. A rarer form, the Burrowing Toad or Spade Foot, *Sacphiopus holbrookii* (Har.) is a smaller extremely noisy toad, which burrows in the ground.

In the aquarium toad tadpoles are less beneficial than those of the frog as their change to the adult form is briefer.

TREE TOADS. The most generally distributed tree toads and tree frogs are the Common Tree Toad or Tree Squeak, *Hyla versicolor* (Le Conte), inhabiting the Eastern part of the United States, and having a body length of 2 inches; the smaller Pickering's Tree Frog, *Hyla pickeringii* (Hol.) about 1 inch in length; the Common or Swamp Tree Frog, *Chorophilis nigritus* (Le Conte); the Savannah Cricket Frog, *Acris gryllus* (Hol.), the Green Tree Frog, *Hyla arborea* (Hol.); and the Changeable or Chameleon Tree Frog, *Hyla chameleonis*, (Hol.), which possesses the capacity of changing its tints to such extent that its color cannot be definitely described.

Tree toads are most interesting pets. They are so sensitive to atmospheric changes that they serve as barometers, and are kept in aquaria furnished with a small ladder which they either ascend or return to the water according to the atmospheric conditions.

URODELA. Salamanders and Newts belong to the order of Urodela, cold-blooded animals having a naked body, teeth in both jaws, four limbs, a tail persistent through life, and no external gills in the adult. In the larval form all are aquatic and some retain an aquatic or semi-aquatic existence through life. The common Eastern and Middle States species are:

Amblystoma punctatum (Linn.), or Spotted Salamander, a common form, has a moderate-sized head with rounded, blunt snout; broad, depressed and full body, and thick, rather long tail. The skin is punctured with small pores, and clusters of larger ones are on the head. The back is marked with a strong dorsal groove, and the legs have short digits and nails. The color is black above with a series of round yellow spots on each side of the back, head and tail, and the under side is greyish-black. Length 6 inches. Common from Nova Scotia to Nebraska and south. Frequents shady localities near water.

Plethodon cinereus (Green,) or Ashy Salamander, a small form, has a short head and rather pointed snout, very slender body and cylindrical acuminate tail. The fore-legs are short with four digits, and the hind-legs longer with five digits. The colors are reddish-brown on the head, the body plumbeous, lead- or ash-colored, with usually a broad brownish-red dorsal stripe, the limbs yellowish-grey above, and the entire lower surface dusky-white. Length $3\frac{1}{2}$ inches. It is active and may be found under logs, etc., ranging over the entire Eastern United States. It is nocturnal in habit.

Spelerpes bilineatus (Green), or Striped Salamander, another small form, has a small head, with somewhat rounded snout, cylindrical body, and long cylindrical tail, thick at the base and tapering to a point. The upper surface is brownish-yellow with a dark line on each side of the back, and the lower surface bright yellow with a faint brown dotted marking. Length 3 inches. Found from Maine to Florida. It is a land form inhabiting damp places in concealment under rocks, decayed wood, moss, lichens, etc.

Spelerpes ruber (Daud.), or Red Salamander, has a rather large wide head, rounded snout, short limbs, small digits, and a rather short tail, thick at its base and bluntly pointed. The colors of the entire upper surface are vermilion-red with numerous crowded faint dark spots; and the lower side salmon-pink. Length 5 inches. A land form, common from Maine to Nebraska and South.

Desmognathus fusca (Raf.,) or Common Triton, Water Salamander, has a rather large head, obtuse and rounded snout, rather long cylindrical body, moderately long compressed and keeled tail. The limbs are rather short with small digits. The colors are brown above, sometimes black, with faint grey or purplish spots or shades, which become darker with age. The lower side is marbled in dull greys and blackish tints. Length 4 inches. A very common and active form in springs and cold water streams. Other species, are *D. nigra*, (Green,) having a stouter body and is uniformly black in color, length 6 inches, found in mountain streams and springs from Pennsylvania to Illinois and south, and *D. ochrophæa* (Cope,) brownish-yellow, 3 inches long and may sometimes be found under the moss on the banks of mountain streams and other cold water.

Diemictylus veridescens (Raf.,) or Common Newt, Evet, Eft, has a short and broad head, rather slender body, slender delicate limbs, and a long, compressed tail. Three large pores are located behind the eye. The colors of the upper surface of the adult are olive-green, sometimes reddish of varying shades, with a number of scarlet spots on the sides, and the lower side yellow with small blackish spots. Length 3½ inches. Abundant over the entire eastern section of the United States in ponds and streams.

Diemictylus viridescens, (*var. miniatus*) (Raf.,) or Red Eft, is similar to the above, but of bright vermilion red, with a rougher skin. The larvæ of both species are similar in appearance and markings, and the difference in color of the adult may be largely due to its life out of the water. Found in the same localities but away from water under moss and stones.

The two forms of salamander-like animals found in the eastern section of the United States are:

Necturus maculosus (Raf.), or Mud Puppy, another of the Batrachia, has a large flattened head with abrupt truncated snout, large bushy bright-red gills forming three tufts on each side of the head; very short, weak limbs, and a depressed and keeled tail. The colors are brownish or ashy-grey with scattered darker spots, and the lower surface dusky-white. Found over the eastern range of States, most numerous north and west of the Alleghanies and the Great Lakes. It is sluggish in movement and usually inhabits the greater depths, or is concealed in the mud and silt.

Cryptobranchs alleganiensis (Daud.), or Hellbender, has a large broad and flat head, with a short rounded snout, short neck, and a thick sub-cylindrical body with thick folds of skin on the sides. The limbs are short and weak, having short digits without nails. The tail is keeled and very much compressed. The colors above are blackish, with darker indistinct markings, and paler below. Reaches a length of 18 inches.

Found in warmer streams and lakes on the western border of the Middle States, the Ohio Valley, and South. A repulsive-looking but harmless large salamander, which during life retains many of the larval characteristics.

SQUAMATA. Lizards and Snakes belong to the order Squamata, cold-blooded animals with the body covered with imbricated scales, the vent a cross slit. There are many other individual anatomical differences which mark them as distinct from the Urodela and Reptilia.

LACERTILIA. The Lizards have no carapace, the body is covered with overlapping scales. There are four limbs, the feet generally have five digits, and the tail is usually long and brittle. The Eastern and Middle States have but few species, which will be described; but some of the common Southern and Western forms are to be had of dealers, and will also be briefly mentioned.

Eumeces fasciatus (Linn.), or Blue-tailed Lizard, has a short, broad head with pointed snout, an elongated cylindrical body covered with scales. The cylindrical tail is very long, covered above with small scales and below with a central row of larger plates. The fore-legs are short and the hind legs longer, both covered with scales and having long delicate digits with very long curved nails. The colors of the head and body above are bluish-black with five longitudinal yellow lines on the back, and yellow veinings on the head. The lower surface is white, except the tail, which is rich ultra-marine blue above and a little paler below. Length 8 to 11 inches. Found throughout the eastern section of the United States, from the Rocky Mountains to the coast; in shady places and under the bark of decaying trees. Its food is principally insectivorous.

Sceloporus undulatus (Daud.), or Pine Tree Lizard, Swift, Fence Lizard, has a short, sub-triangular, rounded head with obtusely pointed snout, a short body, fuller than the foregoing, and the long tail cylindrical and tapering to a fine point. The legs are moderately long, and the digits delicate, furnished with long curved nails. The colors of the head and neck above are dark dusky-brown with black, the back mottled brownish-grey, with 5 or 6 transverse black bands having white borders, and similar markings are on the limbs and tail. The throat and lower surface of the limbs and tail are silvery-grey, marked with small and large black bands. On each side of the abdomen is a bright green stripe surrounded with black, but in the females and the young the green is usually absent. Length 7 inches. Very common in forests, and along fences in the Eastern and Middle States.

Eumeces anthracinus (Baird), or Black-lined Lizard, is a rarer eastern species found from Pennsylvania to Texas. The colors are bronze with

four yellow stripes, and between and below these are the coal-black lines for which the name anthracite has been applied. Length 6 to 8 inches.

Other Lizards sometimes offered by Eastern dealers are *Anolis principalis* (Linn.), the Green Lizard or Chamaeleon, and *Leiopisma laterale* (Say), the Ground Lizard, both southern forms, 5 inches long; *Phrynosoma cornutus* (Gir.), the Common Horned Toad of the southwest, 5 inches long; and *Ophisaurus ventralis* (Linn.), the so-called Glass Snake, or Joint Snake which reaches a length of 25 inches, also a southern form.

OPHIDIA. The Serpents have elongated bodies, obsolete limbs, imbricated scales, bones of both jaws movable, no eyelids, forked tongues, and other anatomical characteristics, which separate them from other Vertebrates, except the snakelike lizard *Ophisaurus*, above mentioned. The common species of the Eastern and Middle States are:

Carphophiops amoenus (Say), or Ground Snake, has a small flat head, broad snout, robust body for the size of the animal, rounded above, flattened below, and covered with small, sub-hexagonal scales above and larger plates below. The colors of the upper surface are light, glossy chestnut-brown, lower surface salmon-red. Length 12 inches. Common from Massachusetts to Illinois south, mostly found under rocks and the bark of old trees, feeding on insects.

Storeria occipitomaculata (Stor.), or Red-bellied Snake, has a rather large narrow head and pointed snout; rather stout elongated body covered above with carinated hexagonal scales and broad plates below. The colors of the upper surface are greyish- or chestnut-brown with paler ventral bands, bordered with black dots, also obscure dots on the sides and back of the head, with three pale blotches. The lower surface is bright salmon-red. Length 12 inches. Found from Massachusetts to Minnesota, south to Georgia, and very abundant in the Middle States.

Storeria dekayi (Hol.), or De Kay's Snake, is another form very similar to the foregoing. The colors are greyish-brown with a clay colored dorsal band, bordered with dotted lines, and a dark patch on each side of the occiput. The lower surface is greyish-white. Found in the same localities as the above, abundant in the Eastern section to the Rocky Mountains and south.

Thamnophis sauritus (Linn.), or Riband snake, Swift Garter, has a long ovoid head with a prolonged snout rounded at the apex; long and slender body covered with rather long carinate scales, notched behind, and moderately large plates below. The tail is very long, thin, and terminates on a point. The colors above are light olive-brown or chocolate, with three yellow stripes, and light brown or milky-white below with a

greenish tinge. Length 36 inches. Found about streams in the entire Eastern section, most abundant east of the Alleghanies.

Thamnophis sirtalis (Linn.), or Common Garter Snake, Striped Snake, is very similar to the foregoing. The colors are olivaceous with a narrow yellow dorsal stripe, three series of small dark spots on each side, and a paler stripe on the lower side. The under surface is pale straw-color with a greenish tinge. The most generally distributed snake, common to almost entire North America, in high grass and shady places.

Natrix sipedon (Linn.), or Common Water Snake, False-Moccasin, has a large sub-oval flattened head with rounded snout; long robust body covered above with small sub-hexagonal strongly carinate scales, and broad plates on the lower side. The tail is large and triangular in form. The colors are dusky-brown with bands of dull-yellow, bordered with dark brown or black; and dirty-white or pale reddish-brown on the lower surface; somewhat variable in color. Length 30 to 50 inches. Found abundantly about streams, feeding on frogs and fishes. Ranging from New England to Kansas and south. It is ill tempered but harmless. This snake should not be confused with the Water Moccasin or Black Moccasin, a southern and western form, *Agkistrodon piscivorous* (Hol.) which is also aquatic, often resting on bushes overhanging streams and is the most dangerous and treacherous of the United States snakes.

Ophedryx æstivus (Linn.), or Green Snake, has an elongated narrow conical head, a long and slender body, with carinate scales above, rather narrow plates below, and a very long and slender tail. The color above is a bright clear golden-green and clear yellowish-white on the under surface. Length 30 inches. This beautiful, harmless and gentle snake feeds upon insects, inhabits trees, and is often found on bushes over the water. Common from southern New Jersey to Indiana and south.

Liopeltis vernalis (De Kay) or Grass Snake, is similar to the foregoing but smaller. Its color is a uniformly darker grass-green above, and less yellow, nearer to the white, below. Length 20 inches. It is harmless and is found in high grass and meadows, living on grasshoppers and crickets, and occurs in the Eastern and Middle States north of the Carolinas.

Bascanion constrictor (Linn.), or Black Snake, Blue Racer, has an elongated oval head with rather pointed prolonged snout; a long and slender body covered with smooth, large hexagonal scales above and broad plates below. The whole upper surface is lustrous pitch-or blue-black, with the throat white, the abdomen and the lower surface of the tail greenish-or bluish slate-color. The young are olivate in color with rhomboid black blotches. Length 50 to 60 inches. It is an active snake, running and climbing with facility, hence the popular name of

“Racer”. Found in shady places or near streams and ponds, sometimes basking in the sun. Common in the Eastern and Middle States, and south. It is a harmless constrictor, living on small animals and fishes.

Pituophis melanoleucus (Daud.), or Pine Snake, Bull Snake, has a small oval head with projecting elongated snout, long and somewhat robust body covered with large hexagonal strongly carinate scales above, and very large and broad plates below. The abrupt slender tail terminates in a horny point. The color of the head is dusky-white with black mottlings, that of the back and tail milky-white, more or less clouded and covered with brown blotches margined with black, and the lower surface cream-white. There are three series of lateral blotches on the side. Length 60 inches. It feeds on small animals and is common in pine woods from New Jersey to Michigan and south.

Diadophis punctatus (Linn.), or Ring-necked Snake, has a rather small, flattened head and rounded snout, a slender body covered with evenly imbricated carinated scales above, and rather broad plates on the under surface. The tail is rather short, slender and pointed. The color of the head is greyish-black with a conspicuous yellow ring about the neck. The back and tail above are blue-black, each plate usually having a black spot on each side and sometimes a fainter median one. The lower surface is reddish-yellow, sometimes mottled with a darker color on the sides. Length 15 inches. A timid, harmless, beautiful snake, living concealed under the bark of trees, logs and stones, feeding upon insects, and found along almost the entire eastern tier of States, west to Kansas.

Lampropeltis getulus (Linn.), or Chain Snake, Thunder Snake, has a small short head rounded at the snout, a robust elongated body covered above with smooth large hexagonal scales, and large plates below. The tail is short and tapering, and ends in a horny point. This finely marked snake has a shining raven-black color with yellow lines forking on the flanks, and is marked with about twenty transverse bars, which form white blotches below, where the black color assumes a somewhat violet tone. Found in the Eastern and Middle States, from the Alleghany to the Rocky Mountains, in moist and shady places, feeding on small animals.

Lampropeltis doliiatus (Linn.), or Red Snake, Corn Snake, has a rather short head and rounded snout, an elongated moderately robust body covered with small smooth hexagonal scales above and broad plates below. The tail is rather short and tapering with a horny point. The upper surface is red, with about twenty pairs of black rings about smaller yellowish-white ones, and the head is red with a white band about the neck. The lower surface is dull white, marked with broad black lines and blotches. A most beautiful red, black and white snake.

Length 30 to 50 inches. Common in the Middle States and from Maryland to Kansas, and south, harmless and easily domesticated.

Lampropeltis doliatius triangulus (Boie), or Milk Snake, House Snake, is very similar to the foregoing, but the colors are bluish-grey or milk-white, with three series of rounded brownish blotches, bordered with black, and an arrow-shaped occipital spot; and a silvery-white lower surface, marked with evenly-placed broad black lines and patches. Length 36 inches. Very common in New England and Middle States, south to Virginia and west to Iowa.

Heterodon platirhinus (Latr.), or Spreading Adder, has a large flat triangular head with elongated and pointed snout, an elongated, thick rounded body slightly flattened on the abdomen, covered above with strongly carinated scales, and moderately large plates below. The tail is long, narrow and pointed. The colors above are brownish, reddish or iron-grey with dark blotches and half-rings on the tail. The lower surface is yellowish-grey. This snake has a somewhat mottled appearance, as the scales are often outlined with lighter colors, and the general color is variable. Length 30 inches. It is harmless but when angry will depress and expand the head like an adder, coiling, hissing and assuming a very threatening aspect, but is cowardly, and if hard pressed will feign to be dead. It feeds on small animals, principally toads, small reptiles and insects. Found abundantly in moist places from New Hampshire to Florida, and west to the Rockies.

Agkistrodon contortrix (Linn.), or Copperhead, Cotton-mouth, has a large, triangular, posteriorly broad head with strong upper jaw and poison fangs; a short neck, an elongated heavy thick body, covered with carinated rhomboidal scales above and moderately broad plates below, which extend nearly to the end of the thick, conical tail, ending in a horny point. The color of the head and the ground color of the entire upper side is a coppery red, lighter at the sides, where the scales are flecked with small dark spots. Behind the occiput, to the end of the tail, are a series of transverse bars, or X-shaped blotches, of dark-brown, lighter on the back and darker to the sides, and also bordered with darker brown. The under surface is dull flesh-pink, flecked with brown. Length 40 inches. Frequents dark and shady places, sometimes in high grass, from western New England to Florida, westward to Wisconsin, and south. Feeds on small animals, principally birds and mice. A dangerous, poisonous snake; now only occurring in wild and uncultivated places.

Crotalis horridus (Linn.), or Common Rattlesnake, has a very large, triangular head with broad truncate snout, a short neck, and a thick elongated body covered with rough carinated rhomboidal scales above and

broad plates below. The tail is short, slightly conical and bears a number of rattles. The color of the head above is ashy-brown or yellowish, and the body and tail yellowish-brown, overlaid with three rows of confluent irregular brown spots and cross-blotches, darker at the tail. Length 60 inches. Inhabits rocky places from New England to the Rocky Mountains and south. This is the most common once abundant species, but now nearly exterminated except in wild and uninhabited localities. Another more western form is *C. adamanteus* (Beau.), the Diamond Rattlesnake, and *Sistrurus catenatus* (Raf.), the Prairie Rattlesnake.

LORICATA. Alligators and Crocodiles belong to this order. They are cold-blooded animals, body elongated and rounded, covered with plates, scales or granulations, limbs four and tail elongated, mouth large, armed with teeth. Of this order only the Alligator is found in the United States. *Alligator mississippiensis* (Daud.), the one species of American giant reptile, is a native of southern waters, living in stagnant ponds and deep morasses. Its range at one time extended along the Atlantic border from the Neus river in North Carolina south, and west as far as New Orleans, and up the Mississippi as far as the Red river. The persecutions of the last half century have restricted it to localities difficult of access, although the very young are sometimes to be had of northern dealers.

TESTUDINATA. Turtles belong to the order Testudinata, cold-blooded animals, body enclosed between two bony shells, the *carapace* and *plastron*; neck and tail only flexible parts of the spinal column, these and the legs usually retractile within the shields; no teeth, but jaws armed with horny sheaths with cutting edges; respiration by swallowing air. There are a considerable number of Eastern and Middle States species which will be briefly described :

Terrapene carolina (Linn.), or Box Turtle, has a nearly hemispherical carapace and somewhat smaller plastron, a narrow elongated head, the upper jaw emarginate with a broad hook, and the lower jaw with a smaller one. The fore-legs short with five digits and short thick nails, the hind-legs short and flattened at the tarsus, with five digits and four nails. The tail is short and thick with blunt point. Usually the carapace is yellowish-brown with spots and stripes of bright yellow, sometimes radiating or disposed without order, to appear like tortoise-shell. Length of carapace $6\frac{1}{2}$ in., breadth $4\frac{1}{2}$ in., elevation $2\frac{3}{4}$ in., length of plastron $5\frac{1}{2}$ in. It is entirely a land animal, found generally in the New England and Middle States and south.

Gopherus polyphemus (Daud.), or Gopher Turtle, has a depressed, flattened carapace and thick plastron prolonged beyond the shell in front; a short, thick and obtuse head, serrated jaws with horny plates, short neck

and granular skin. The fore-legs are large and thick, with five digits and thick strong nails; the hind-legs are short, thick and clavate, with four digits and strong nails. The tail varies somewhat in length. The general color of the carapace is brownish-yellow clouded with dark brown, and the plastron a dirty yellow. Length of shell $14\frac{3}{4}$ in. and plastron $12\frac{1}{2}$ in. Found in the pine woods as far north as the Carolinas and lives in burrows like the Woodchuck or Ground Hog; feeding on plants, vegetable matter, worms and grubs.

Clemmys insculptus (Le Conte), or Wood Tortoise, has an oval emarginate carapace and an oblong smaller plastron. The head is large and elongated; the upper jaw emarginate in front and notched to form two cutting teeth; the lower jaw having a strong hook. The fore-legs are the larger and have five digits with short, strong and slightly curved nails, the hind-legs broad with five digits and four nails. The tail is long, thick at the base and slender at the end. The color of the carapace is brown, marked with radiating black lines and concentric striæ of yellowish color. The head and limbs are dull cinnibar-red and the plastron yellow with large black blotches at the margins. Length of carapace 8 in., breadth 5 in., elevation $2\frac{3}{4}$ in. Found throughout entire States east of Ohio, in woods and fields, sometimes in or near water. It is very restless and constantly in motion.

Clemmys muhlenbergi (Schw.), or Muhlenberg's Tortoise, has an oblong arched and slightly carinate carapace and oblong plastron. The head is short and broad with pointed snout, the jaws strong, the upper notched with a short hook and the lower with a nearly straight cutting edge. The limbs are like those of the Box Turtle, and the tail large, nearly conical, thick at the base and pointed at the end. The color of the smooth carapace is dark brown, with the plates relieved with dull yellow and pale brown, and the plastron is almost black at the margins and yellow in the middle. Its principal character is the large orange spot at each side of the head, encircling the eyes. Found in small brooks and running water of Pennsylvania and New Jersey and adjoining States.

Clemmys gutattus (Schn.), or Speckled Tortoise, has an ovoid, more or less flattened, smooth carapace and large oval plastron. The head is short, smooth and rather pointed; the upper jaw emarginate in front, and the lower jaw notched to form a rounded hook. The forelegs are short and the five digits slightly webbed with long slender nails; the hind-legs short with five digits and four nails. The tail is long and slightly compressed, tapering to a point. The color of the carapace, head and limbs is black, dotted with orange spots, and the upper surface of the tail reddish, spotted with brown. This Tortoise may be found in ponds, brooks

and rivers, where it lives on smaller animals, tadpoles, young frogs, fishes, etc., and sometimes on land, when it lives on earthworms, snails, grasshoppers, crickets, etc. It is abundant in the eastern section of the United States, and west to Indiana.

Chrysemys picta (Herm.), or Painted Turtle, Checkered Turtle, has a sub-oval, smooth, flattened carapace and broad, oblong plastron, nearly equal in length with the shell. The head is small and rounded in front with an obtuse snout. The upper jaw is entire at the sides, notched in front, and the lower jaw is slightly hooked and turned upward in front. The fore-legs are long and the five digits have short nails; the hind-legs are flattened at the tarsus with five digits and four nails. The tail is moderately long and narrow. The fine markings of the carapace are greenish-black with the plates outlined in yellow, the marginal plates lighter and marked with bright red. The plastron is bright yellow, and the head and neck above are almost black, with yellow lines, and veined below in black and yellow. Length of carapace $6\frac{1}{2}$ in., breadth $4\frac{1}{2}$ in., elevation $2\frac{1}{2}$ in. Found in ditches, ponds and rivers of almost the entire United States; one of the most common turtles, usually to be had of dealers.

Kinosternon pennsylvanicum (Bosc.), or Mud Turtle, has a slightly flattened, oval and smooth carapace, with an oval, rounded shorter plastron. The head is large, rather pointed at the snout, and the jaws very strong, both furnished with a hook on the front of the cutting edges. The neck is long and slender and the fore-legs short, rounded and covered with a warty skin, and having five digits with short nails; the hind-legs short, flattened at the tarsus, and having five digits with four nails. The tail is short, thick at the base, pointed, and horny at the end. The color of the carapace is dusky-brown and that of the plastron variable, usually of a yellowish color. The head is dark, flecked with yellowish spots. Length of carapace 4 in., breadth $2\frac{3}{4}$ in., elevation $1\frac{3}{4}$ in. Found from New York to Florida.

Aromochelys odoratus (Latr.), or Stink-pot, Musk Turtle, is very similar to the foregoing, but may be distinguished by the carapace having more distinct plates with sharper edges and traces of a keel. It has a repulsive, strong and musky odor. Length of carapace 6 in., breadth $4\frac{3}{4}$ in., elevation $1\frac{3}{4}$ to 2 in. Found abundantly in the waters of the Eastern States and west to Illinois.

Aspionectes spinifer (Le S.), or Common Soft-shelled Turtle, has a very much flattened, leathery, smooth sub-oval carapace and flat plastron. The head is large, broad and rounded behind and so much pointed in front as to form a prolonged cylindrical snout. The carapace is marked front and back with a number of raised tubercles and the plastron is larger

than the carapace. The jaws have strong cutting margins, the lower fitting within the upper. The fore-legs are somewhat long, with five digits and long nails, and the hind-legs broad with five digits and four nails. The tail is short and blunt. The color of the carapace is umber-brown with dark spots and patches, and the translucent plastron white marked with waving blood-vessels. The head and neck are striped, and the legs and digits mottled. Length of carapace 12 in., breadth $10\frac{1}{2}$ in., elevation $2\frac{3}{4}$ in., and occasionally larger. Found in the Great Lakes and Mississippi Valley and has been introduced into the Delaware River. It is voracious and feeds upon fishes and other animals.

Chelydra serpentina (Linn.), or Common Snapping Turtle, has a sub-quadrilateral, deeply emarginate and serrated carapace, and an anteriorly rounded posteriorly pointed plastron. The head is very large, broad behind, flattened above with a short pointed snout, and strong jaws with sharp cutting edges and both upper and lower hooks. The neck is long, and the legs large, with five digits and strong nails. The tail is very long, thick at the base and tapering to a pointed tip. The color of the carapace is dusky brown, the plastron yellowish-grey, and the head and limbs dark brown with black spots. Length 25 inches. Found abundantly in streams and ponds everywhere from Maine to Florida.

Malaclemmys centrata (Latr.), or Diamond-back Terrapin, Salt-marsh Turtle, has a smooth oval, almost entire carapace, sub-oval plastron, and a very large head posteriorly broad with a pointed snout. The jaws are strong, with the upper slightly emarginate and the lower curved in front with a slight hook. The neck is short and thick; the fore-legs moderately long and the hind-legs short, both having short and strong nails. The tail is short, thick at the base, pointed at the tip and has a sharp ridge. The colors of the carapace are variable, generally a dusky brown, sometimes greenish or dark olive, rarely black. The plates are usually yellowish-brown, each with concentric dark stripes and lines to form a pattern, the name being derived from these markings. Length of carapace 9 inches, plastron $8\frac{1}{4}$ inches, elevation 3 inches. Found in saltwater and salt and brackish marshes from New York to Texas; once plentifully, now almost exterminated. It is valued as food and is considered a delicacy.

Pseudemys rubriventris (Lec.), or Red-bellied Terrapin, has an elongated oval, smooth carapace, an oblong plastron, and a moderate sized head, enlarged posteriorly with a slightly pointed snout. The jaws are strong, with the upper cutting edge so deeply emarginated as to appear to have two teeth, the lower serrated at the sides with three emarginated processes like teeth in front, the central a hook. The fore-legs are rather long, the hind-legs shorter, both having strong digits with short, slightly

curved nails. The tail is short, thick at the base and suddenly pointed. The color of the carapace is dusky brown with irregular red markings on and around the plates, the plastron red, clouded with a dusky shade. The head and neck are dark brown above with obscured red lines, and the legs and tail dusky brown and black, also marked with red. Length of carapace 11 in., breadth 7 in., elevation $4\frac{3}{4}$ in. Found in brackish and fresh-water from New Jersey to Virginia. Under the name of "Slider," it is largely used as a substitute for the Diamond-back Terrapin. Another form of the same genus, *P. troosti* (Hol.), or Yellow-bellied Terrapin, of the Mississippi Valley, does not occur in the Eastern or Middle States, but may be sometimes found in the markets, as it is also used as food.

Sea Turtles. These Turtles are all of very large size and are occasionally taken in the more northern latitudes, coming in the Gulf Stream from the South. They are *Dermochelys coriacea* (Vand.) or Leather-Turtle, one of the largest Sea Turtles, reaching a length of 6 to 8 feet and a weight of 1200 pounds; *Thalassochelys caretta* (Linn.), or Logger-head Turtle, 3 to 6 feet in length and weighing 350 to 450 pounds; *Eretmochelys imbricata* (Linn.), or Hawks-bill Turtle, the carapace of which is the valued turtle-shell of commerce; and *Chelonia mydas* (Linn.), or Green Turtle, valued as food, with a carapace of 3 to 4 feet and a weight of 850 pounds. These may occasionally be seen in the larger public aquaria.

FEEDING IN THE TERRARIUM. A variety of food is necessary for the requirements of reptiles and amphibia. Frogs, Toads and Tree Toads require insects, worms, grubs, particles of meat and fish; Salamanders and Newts, snails, minced mussels or oysters, meat, fish and fish eggs; Lizards and Snakes, insects, worms, grubs and small live animals; Alligators and Snapping Turtles, tadpoles, crayfish, minnows, other small animals, and worms and grubs, and when these cannot be obtained, minced fish, oysters, meat, etc.; and Land Turtles should also receive snails, mussels, insects and garden vegetables, lettuce, celery, tomato, berries and mushrooms.

Feeding should be carefully done and anything not eaten should be removed before it decays.

CHAPTER XV.

**Don'ts for Beginners, Aquarium Societies,
Bibliography, Glossary, etc.**

DON'TS FOR BEGINNERS

- Don't, as a novice, begin with a large aquarium; one of 10 to 12 gallons is sufficiently large.
- Don't, except as a hospital or temporary receptacle, use the ordinary fish globe.
- Don't use all-glass receptacles as permanent aquaria, they are too liable to fracture.
- Don't use an aquarium greater in depth of water than in width.
- Don't handle an aquarium until the cement has "set" or become hardened.
- Don't arrange an aquarium until it is thoroughly cleaned on the inside.
- Don't clean the glass with anything but table salt when filled, or with whiting when empty.
- Don't move a filled aquarium; first decant most or all of the water.
- Don't move an all-glass aquarium at any time; lift it clear and set it down gently in its new place.
- Don't change the water when moving an aquarium; keep it in another vessel and afterwards return it, filling in with fresh water.
- Don't needlessly disturb the aquarium and its contents.
- Don't place the aquarium in a strong sunlight if a good steady light may be had elsewhere.
- Don't forget that a northeast exposure is the best, and light on the surface better than strong side-light.
- Don't exclude the free access of air to the surface by tightly covering the aquarium.
- Don't keep the glass too free of healthy algæ, except on the front.
- Don't use unclean vessels or appliances of any kind.
- Don't fail to exercise the most scrupulous cleanliness with everything pertaining to the aquarium.
- Don't permit the accumulation of refuse, of any kind, on the bottom.
- Don't put the hand into the filled aquarium, when this can be avoided.
- Don't have more than one person in charge of the aquarium.
- Don't fail to give it a little attention every day; this soon becomes a habit and will insure success.
- Don't use deep, narrow or funnel-shaped nets nor those of coarse knotted twine; use shallow ones of soft Brussels netting.
- Don't use the same net, or any other appliance, for sick and healthy fishes; this is sure to spread the contagion. Scald the net frequently.
- Don't fail to place a screen between the aquarium and the light on warm summer days, especially strong sunlight. Tissue paper or cheese cloth will answer the purpose.

- Don't expect success except when the aquarium is well conditioned or balanced, with ample growing plants and a good light.
- Don't fail to remember that the plant life should exceed the animal life and scavengers be present. There can scarcely be too many health-growing plants in the aquarium.
- Don't place fishes into an aquarium until the plants are well established, but introduce scavengers at once.
- Don't change the water needlessly, its appearance and taste is the best guide.
- Don't occasion sudden changes in the temperature of the water.
- Don't forget that colder water will sustain more fishes than when it becomes warmer.
- Don't, as a novice, begin with fine fishes; the ordinary goldfishes are more hardy than the finely bred toy varieties.
- Don't, when no longer a novice, be contented with the common goldfishes; the inexpensive "sports" of the finer breeds are more interesting.
- Don't needlessly frighten the fishes; kind treatment will make them very tame.
- Don't jar the aquarium or rap on the glass; fishes have finely organized nervous systems. Guard against even the most unintentional cruelties.
- Don't handle fishes roughly; bruises and the loss of the mucus covering of the scales become seats for fungus diseases.
- Don't place large fishes in small aquaria, nor keep large and small fishes in the same receptacle, if avoidable.
- Don't keep fishes together which molest each other.
- Don't keep diseased fishes with healthy ones; remove them to a hospital jar for treatment.
- Don't buy fishes and plants promiscuously; be sure that they are clean and free from infection.
- Don't immediately introduce newly acquired fishes or plants into an established aquarium; keep them for some time in a separate receptacle, until fully assured that they are in perfect condition. This is a frequent cause of infection.
- Don't starve the fishes, but be even more careful not to overfeed them. Feed more sparingly in winter than in summer.
- Don't fail to remember that mistaken kindnesses kill as many fishes as neglect or inexperience.
- Don't feed more than the fishes will eat at once; they may only masticate the food and later eject it to contaminate the water.

Don't overfeed; very many of the ills of aquarium fishes are due to this mistaken kindness.

Don't leave uneaten food or offal in the aquarium. Use the dipping tube.

Don't feed worms without first cleaning them; they are carriers of both parasites and fungus diseases. Scalding them is a good method.

Don't overstock the aquarium at any time; until it is fully established the one safe rule is not more than one fish for every two or three gallons of water; even fewer large fishes.

Don't fail to get a large aquarium as soon as you become expert; the larger the tank, the surer the results.

Don't, as a novice, keep other fishes with the goldfish; they may not be altogether harmless.

Don't keep water bugs and beetles in the aquarium with fishes; they are all harmful and predatory.

Don't introduce plant-eating snails as scavengers. The Planorbis and Vivipara are the best common snails.

Don't feel discouraged by occasional reverses; they happen to every one, even to the most experienced aquarists.

Don't fail to remember that success with the aquarium depends upon the following prime conditions; inattention to any of these, or mistakes or neglect, will certainly lead to failure:—

1. Cleanliness of the vessel and all appliances.
2. A good and strong light.
3. A vigorous growth of plants.
4. Careful feeding of the proper food.
5. The immediate removal of sick or doubtful fishes.
6. Ample scavengers.
7. Avoidance of overstocking.
8. Persistence, determination to succeed, and a considerable good fortune.

Don't fail to join an Aquarium Society; if none exists, organize one.

Don't disregard any of the precepts of this volume; they are based on tried experience.

Don't fail to frequently review these *Don'ts*, and confer with authorities if in serious difficulties; the Aquarium Society of Philadelphia will be pleased to answer all inquiries.

These Don'ts apply more particularly to the Freshwater aquarium, but it may be beneficial to keep most of them in mind for the Marine aquarium, Terrarium and Aqua-terrarium as well.

AQUARIUM SOCIETIES

Europeans apparently interest themselves more in the study of Natural History than Americans. The middle and more educated classes devote much of their leisure to pursuits which take them far afield for healthful exercise, agreeable diversion from the cares of business and every day existence, and pleasant mental occupation. This particularly applies to the Germans, their elementary schools devoting considerable attention to subjects which foster in the minds of the children a desire for information and research. The beginning of the pursuit may be some chance animal or plant noticed during a ramble and taken to the home, there to awaken a desire for further information of its habits. This interest then grows and often culminates in the establishment of a household collection of animals and plants, sometimes far in advance of what would satisfy the more practical-minded citizen of the United States.

The outcome of this desire for a glimpse of nature in the household is a very large number of popular societies devoted to various branches of nature study, among them many Aquarium Societies. Every larger city of Germany has one or more of these of which the best-known are:

Verband der Aquarien und Terrarien Freunde, Berlin.

Verein für Aquarienfreunde, Berlin.

Triton, Berlin.

Elodea, Berlin-Moabit.

Nymphæ alba, Berlin.

Lotus, Vienna.

Humboldt, Hamburg.

Salvinia, Hamburg.

Nymphæa, Leipzig.

Wasserrose, Dresden.

Isis, Munich.

Sagittaria, Kœln.

Hottonia, Darmstadt.

Ulva, Kiel.

Heros, Nürnberg.

Tausendblatt, Plauen i. V.

Vallisneria, Magdeburg.

Nerthus, Braunschweig.

Brehm, Gelsenkirchen.

Aquaria, Zwickau.

Verein für Volkstümliche Naturkunde, Stettin.

Verein für Aquarien und Terrarienkunde, Dortmund, and others.

Four or more periodicals are published under the auspices of these Societies, a weekly, two fortnightly and a monthly; devoted to popular zoölogical, ichthyological and botanical study and the elucidation of subjects of interest to their members.

A Society of this kind has been established in Philadelphia since 1898, and has accomplished much to popularize the aquarium, its inhabitants and its maintenance. To encourage this both interesting study and beautifier of the home, some descriptions of this Society and its proceedings will be of interest.

The Aquarium Society of Philadelphia, on January 1, 1908, had 128 active members, a number of which reside in neighboring cities. Its purpose is more particularly the propagation of the finer breeds of the goldfish and the keeping of freshwater aquaria. The sessions occur monthly, except June, July and August. Set topics of interest are discussed, exhibitions take place, prizes are awarded and inquiries from any source are invited and answered.

POINTS FOR THE JUDGMENT OF GOLDFISHES. Authorities differ somewhat in the standards for judging goldfishes in prize competitions and as to their respective merits as fine specimens. Dr. E. Bade, one of the best-known German ichthyologists, advocates the following scales in awards:

Japanese Fringetail Goldfish	Body	Caudal fin	Dorsal fin	Pectoral and Ventral fins	Double anal fins	Color. Scaled or Transparently Scaled	Points
	30	20	20	20	5	5	100

A long body would, for instance, take from the merit of the fish as many as 30 points and would in no case permit of over 70 points in its favor, or should the anal fin be single, its merit would not be over 95 points. If the body is not sufficiently rotund, but short and otherwise acceptable, then its merit as to body would be expressed by not over 20 to 25 points, and so with the other details of the fish.

For the Chinese Telescope goldfish he advocates the standard of:

Body	Eyes	Caudal fin	Dorsal fin	Pectoral and Ventral fins	Double anal fins	Color. Scaled or Transparently Scaled	Points
30	30	10	10	10	5	5	100

Merit as to eyes is dependent upon their size and shape, as well as uniformity of size and equal projection from the head. The larger the eyes the higher the points in favor of the fish. Fig. 17 will explain the different forms of eyes, and this authority claims that the ovoid and conical are valued the highest and should be awarded the maximum number of points.

The Aquarium Society of Philadelphia has set a slightly different standard, the judging being for general conformation, eye and fin development rather than for color.

	Color	Eyes	Body	Caudal fins	Other fins	Points
Comets			25	50	25	100
Nymphs			40	35	25	100
Single-tailed Telescopes, as a separate class			40	35	25	100
Fringetails			35	40	25	100
Fantails			35	40	25	100
Mottled Telescopes	35	25	15	15	10	100
Moor Telescopes	30	30	20	10	10	100
Variagated Telescopes, (other than the two above)		35	25	20	20	100
Celestial Telescopes.		30	30	20	20	100

Scaled and Transparently-scaled fishes are also judged in separate classes, and highly colored fishes preferred to white or uncolored ones.

As absolute perfection in every particular has not yet been reached in any goldfish, modifications of the above standards are necessary in judging goldfish breeds, and though none may reach the standard of 100 points, the relative value of fishes in competitions may be arrived at by either of the above tables.

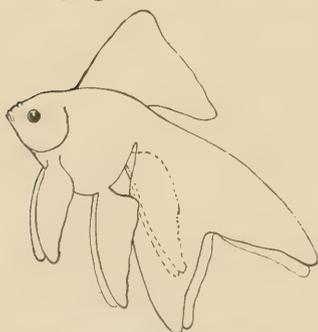


FIG. 240. Outline of a fine Fringetail Goldfish, half life size.

It is left to the reader to decide how many points a fish of the conformation of the outline half-life-sized drawing, Fig. 240, should receive in a competition. It is needless to say that few have seen so highly meritorious a Fringetail goldfish.



ENCLOSED AQUA-TERRARIUM
First prize awarded by the Triton Society, Berlin.

GLOSSARY

Glossary of Scientific Terms used in this work

- Abdomen Belly
 Abdominal Pertaining to the belly
 Abortive Remaining or becoming imperfect
 Acuminate Tapering gradually to a point
 Acute Sharp-pointed
 Adipose Fleshy
 Air-bladder A sac filled with air, lying near the backbone of fishes ; the swimming-bladder
 Alevin The newly hatched of fishes still attached to the umbilical sac
 Alternate Opposite
 Anal Pertaining to the anus or vent
 Anal fin The fin behind the vent, in fishes
 Anus The exterior opening of the intestines ; the vent
 Arterial bulb The muscular swelling at the base of the great artery, in fishes
 Articulate Jointed
 Atrophy Non-development
 Attenuate Drawn out; long and slender
 Axillary In the hollow where a branch unites with the plant
 Auricle One of the chambers of the heart
 Barbel An elongated projection at the head, in fishes
 Basal At or near the base
 Bifurcated Forked; divided into two branches
 Bracts Small leaves or scales
 Branchiæ Gills; respiratory organs of fishes
 Branchial Pertaining to the gills
 Branchiostegals Bony rays below the opercular bones under the heads of fishes
 Byssus Tuft of threads, in molluscs
 Cæcum An appendage connected with the alimentary canal
 Calcareous Containing or composed of carbonate of lime
 Calyx Cup or outer covering of a flower
 Capillaries Hairlike vessels in animals and plants
 Capsule A seed pod
 Carapace A shell; the upper shell of a turtle, the covering of crustaceans
 Cardinal Teeth near the beak, in molluscs
 Carinate Keeled; having a ridge along the middle line
 Caudal Pertaining to the tail
 Caudal fin The fin constituting the tail of fishes
 Cilia Hairlike projections
 Ciliated Fringed; having hairlike projections
 Cinereous Having the color of wood ashes
 Clavate Club-shaped
 Concentric Having a common centre
 Conchology Science of shells
 Cuneate Wedge-shaped
 Cycloid Smooth-edged and circular

GLOSSARY

- Cyprinidæ Fishes included in the families of Minnows, Carps, Chubs, Dace, Breams, Tench, Ides, Goldfishes, Gudgeons, Shiners, Barbels, Stone-Rollers, etc., and many among the multitudes of freshwater forms collectively known as Minnys and not distinguishable except by the naturalist from the young of other fishes which they are supposed to be by the laity
- Depressed Flattened vertically
- Depth Vertical diameter, of body of fishes and molluscs
- Dermal Pertaining to the skin
- Dextral Right-handed
- Diaphanous Translucent; semi-transparent
- Diaphragm Muscular septum between the thorax and abdomen
- Dorsal Pertaining to the back
- Dorsal fin The fin on the back of fishes
- Elong-ovate A long egg shape
- Emarginate Slightly forked; notched at the tip
- Epidermis The skin
- Erectile Susceptible of being raised or erected
- Fascicle A close cluster
- Fauna The animals inhabiting any region, taken collectively
- Filament Any slender or threadlike structure
- Filiform Thread-form
- Finely dissected Split into fine threads
- Flora The plants of any region, taken collectively
- Fry The young fish after the absorption of the umbilical sac
- Furcate Forked
- Fusiform Shaped to taper at each end
- Gemmation Budding
- Gills Organs for breathing the air contained in water
- Gill arches The bony arches to which the gills are attached
- Glabrous Smooth
- Gonospores Germinating buds
- Gullet Passage to stomach
- Haustellated Provided with a sucker
- Height Vertical diameter
- Helminth A wormlike animal
- Hexagonal Six-sided
- Hypa Rod-like Structures; spore capsules; brood sacs
- Hyoid Pertaining to the tongue
- Ichthyology Science of fishes
- Imbricate Overlapping like shingles
- Inarticulate Not jointed
- Infraoral Below the mouth
- Infraorbital Below the orbits or eyes
- Inperforate Not pierced through
- Intermaxillaries Bones forming the middle of the front part of the upper jaw, in fishes
- Interorbital Space between the eyes
- Interopercle Membrane bone between the preopercle and the branchiostegals
- Interspinal Bones in which fin-rays are attached, in fishes
- Iris Part of eye surrounding the pupil

GLOSSARY

- Irides Plural of iris
Keel'd Having a ridge along the middle
Labial Pertaining to the lips
Laminae A thin plate or scale
Lance-elliptical A long ellipse
Lanceolate Oblong, gradually tapers to the outer extremity
Larva An immature form
Lateral To or towards the side
Lateral line The muciferous tubes along the sides of a fish
Laterally Sideways
Linear Like a line, of the same breadth throughout
Littoral Near the shore
Longitudinal Running lengthwise
Lunate Form of the new moon
Mammæ Milk glands, breasts
Mammary glands Glands secreting milk
Mandible Under jaw
Maxilla Upper jaw
Maxillaries Outermost bones of the upper jaw, in fishes
Maxillipeds Foot-jaws of Crustaceans
Metamorphosis A decided change in form
Midrib The central or main rib of leaves in plants
Mycelium A filamentous body from which a mushroom is developed
Naked Without scales
Nerves The fine veins in leaves of plants
Nodule A rounded mass of irregular shape
Nucleus The umbone or beginning of a shell of molluscs
Oblique Slanting inclined
Obscure Scarcely visible
Obsolete Faintly marked; scarcely evident
Obtuse Blunt
Occiput Back of head
Olivaceous Color of the olive
Operculum Gill cover in fishes; calcareous lid closing the aperture, in molluscs
Orbicular Nearly circular
Orbit Eye socket
Osseous Bony
Ova Eggs Ovum Egg
Ovate Shaped like an egg
Oviparous Producing eggs which are developed after extrusion from the body
Ovoviviparous Producing eggs which are developed before extrusion from the body
Ovoid Shaped like an egg
Palmate Web-footed
Papillose With pimple-like elevations or tubercles
Pectinate Having teeth like a comb
Pectoral Pertaining to the breast
Pectoral fin The foremost paired fins, in fishes
Pediculated The stalk which supports only one flower

- Peduncle The supporting stem of a flower or seed
- Pelagic On or near the high seas
- Pellucid Clear, admitting light
- Perforate Pierced through
- Peristome A cap, or cover of a cup, in plants
- Persistent Continuing through life
- Pigment Coloring matter
- Pinnate Shaped like a feather
- Pinnatifid Divided in a feathery manner
- Pistillate Having a pistil and no stamens
- Plastron Lower shell of turtle
- Plicate Folded; forming folds or wrinkles
- Plumbeous Lead-colored; dull bluish-grey
- Poissons French for fishes
- Prehensile Clasping
- Protuberance A small excrescence like a pimple
- Pubis Lower part of the pelvis
- Pulmonary Pertaining to the lungs
- Punctate Dotted with points
- Pupa An immature form ; transformation after the larval stage
- Pyloric cæca Glandular appendage or sac opening into the alimentary canal, in fishes
- Pylorus The orifice through which food passes out of the stomach
- Quadrangular Having four angles
- Quadrilateral Having four sides
- Ray Cartilaginous rods in the fins, of fishes; arm of a star fish; the star fish
- Rhizomes A creeping branch or stem
- Rudimentary Undeveloped
- Rugose Rough with wrinkles
- Sagittate Lance or sword-shaped
- Sepal A leaf or division of the calyx
- Serrate Notched, like a saw
- Sessile Without a stem or peduncle
- Setiform Bristle-like
- Sinistral Left-handed
- Soft rays Branched fin-rays
- Specific gravity A weight which belongs to an equal bulk of each body
- Spiked A fin in which the main rays extend considerably beyond the tissue or web. A single-rayed fin
- Spikes Alternated growths on a common stem, in plants
- Spinous Stiff or composed of spines
- Stamen Male organ of flowers
- Staminate Furnished with stamens
- Sternum The breast bone
- Striate Striped or streaked
- Sub Less than; not quite; under
- Subulate Awl-shaped
- Suture A groove or line in snail shells
- Synonym A different word having the same meaning

GLOSSARY

- Tentacles Feelers
Terete Cylindrical and tapering
Terminal At the end
Tessellated Marked with checks or squares
Thoracic Pertaining to the throat
Translucent Nearly transparent
Transverse Crosswise
Trenchant Compressed to a sharp edge
Trifurcated Forked; divided into three branches
Truncate Abrupt; cut off square
Tubercle A small excrescence like a pimple, a papilla
Typical Of a structure the most usual of a group
Umbilicus The navel
Umbone Nucleus of a shell
Vent The external opening of the alimentary canal; anus
Ventral Pertaining to the abdomen
Ventral fins The paired fins behind the pectoral fins, in fishes
Ventricular One of the walls of the heart
Vermes Worms
Vertebra One of the bones of the spinal column
Vertical Up and down
Verticil A small whorl
Viscid Sticky
Viscous Slimy
Viviparous Bringing forth living young
Web Membrane connecting the toes; also the fin-rays in fishes
Whorl Arrangement around a stem in plants; volution or turn of the spire of a snail

BIBLIOGRAPHY

Literature cited. The books, papers and miscellaneous publications of which a list is hereto appended, have all been consulted in the original, except those marked with an asterisk. These are based upon abstracts or citations by other authors.

- A Handbook of Systematic Botany. D. E. Warming, 1895
 An Account of the Fish Epidemic in Lake Mendota. S. A. Forbes, 1890
 *Aquaria and Construction. C. E. Driver
 *Aquaria; Their Construction, &c. W. Saville Kent
 A Manual for the Study of Insects. J. H. Comstock, 1895
 A Manual of Fish Culture. U. S. Com. of Fish and Fisheries, 1900
 American Fishes. G. Brown Good, 1888
 American Fish Culture. Thaddeus Norris, 1868
 Aquatic Insects in the Adirondacks. Jas. G. Needham, 1901
 Atlas der Meeresalgen. J. Reinke, 1889
 A Report of Work on the Protozoa of Lake Erie. H. S. Jennings, 1900
 A Text Book of Entomology. A. S. Packard, M. D., 1898
 A Treatise on Zoölogy. W. B. Benham, 1901
 Bilder aus dem Aquarium. Dr. W. Hess, 1883
 Book on the Black Bass. Dr. J. A. Henshall, 1881
 Catalogue of the Odonata of North America. P. P. Calvert, 1893
 Compendium der Helminthologie. Dr. von Linstow, 1868
 Cyclopedia of American Horticulture. L. H. Bailey, 1900
 Das Süßwasseraquarium. Dr. W. Hess, 1887
 Das Süßwasser-Aquarium. E. A. Roszmäszsler, 1892
 Das Süßwasseraquarium und Terrarium. A. & G. Ortleb, 1890
 Das Thierreich. German Society of Zoölogists, 1903
 *Der Flusskrebs; Seine Beschreibung und Zucht. O. F. Rank, 1898
 Der Goldfisch; Seine Pflege und Zucht. Guido Findeis, 1887
 Der Goldfisch. Die Gartenlaube, 1903
 Der Schleierschwanz und Telescopschleierschwanz, &c. Dr. E. Bade, 1900
 Die Ernährung des Karpfen und seine Teichgenossen. W. Susta, 1888
 Die Künstliche Fischzucht nach dem neuesten Stande. E. Bade, 1897
 Die mikroskopische Thierwelt des Süßwassers. F. Blochmann, 1886
 Die Mitteleuropäischen Süßwasserfische. E. Bade, 1900
 *Die Teichwirthschaft. Carl Nicklas, 1897
 Die Süßwasserfische Deutschlands. M. Nitsche, 1898
 Die Thier und Pflanzenwelt des Süßwassers. Dr. Otto Zacharias, 1886
 Die Räderthiere und ihre beobachteten Arten. S. Bartsch, 1870
 Die Verunreinigung der Gewässer. A. Koenig, 1887
 Domesticated Trout. Livingston Stone, 1891
 Ein Beitrag zur Parasitenlehre. C. Kerbert, 1884
 Entozoa. T. Spencer Cobbold, 1864
 Entomological News
 Feeding and Rearing Fishes, particularly Trout, &c. Wm. F. Page, 1895
 Fish Culture on the Farm. J. J. Stranahan in Trans. Am. Fisheries Society, 1902
 Fish Hatching and Fish Catching. Seth Green and R. B. Roosevelt, 1870

BIBLIOGRAPHY

- Fish Parasites, collected at Wood's Hole in 1898. Edwin Linton, Ph. D.
- Flora of the Northern United States. Britton and Brown, 1898
- Fresh-water Algæ of the United States. Rev. Francis Wolle, 1887
- Fresh-water Algæ. M. C. Cooke, 1890
- Fresh-water Aquaria. Rev. G. C. Bateman, 1902
- Fremdländische Zierfische. B. Düringer, 1902
- Fungi Affecting Fishes. Samuel Lockwood, 1890
- Fungi, Mycetoza and Bacteria. A. De Bary, 1887
- Gas Bubble Disease of Fishes and Its Cause. F. P. Gorham, A. M., 1900
- *Handbook of the Marine Aquarium. P. H. Gosse, 1855
- Histoire Naturelle des Dorades de la Chine. M. de Sauvigni, 1780
- Histoire Naturelle des Poissons. M. Lacépède, 1803
- Histoire Naturelle des Poissons. M. le B. Cuvier and M. A. Valenciennes, 1842
- Histoire Naturelle des Vegetaux Parasites. Charles Robin, 1853
- History of the Fresh-water Algæ. Horatio C. Wood, M. D., 1873
- Ichthiologie. Elieser Bloch, 1784
- Inherited Modifications in the Japanese Domesticated Golden Carp, &c. John A. Rider, 1893
- Intusionsthier als Hautparasiten bei Süßwasserfische. Drs. Helgendorf and Paulicki, 1869
- *Intensive Teichwirthschaft. S. Jaffé, 1894
- Insects; Their Structure and Life. G. H. Carpenter, 1899
- Invertebrates of Massachusetts. August A. Gould, 1845
- Katechismus für Aquarienliebhaber. W. Geyer, 1902
- Krankheiten der Pflanzen. B. Frank, 1881
- Land and Freshwater Shells of North America. W. G. Binney, 1886
- Leitfaden für Aquarien und Terrarienfreunde. Dr. E. Zernecke, 1897
- Les Poissons d'eau douce du Canada. A. N. Montpetit, 1897
- Manual of the Infusoria. W. Saville Kent, 1881-1882
- Marine Algæ. W. J. Farlow, M. D., 1881
- Marine Aquaria. R. A. R. Bennett, 1889
- Modern Fish Culture in Fresh and Salt Water. Fred'k Mather, 1900
- *Monographie des Saprolegniées. M. Cornu, 1877
- Nouveau Memoirs de la Societe des Naturalists de Moscow. M. Basiewsky, 1855
- Notes on American Rotifera. E. L. Herrick, 1898
- Notes on Distoma Endemicum. Isoa Ijima, 1885
- Notes on Entozoa of Marine Fishes of New England. Edwin Linton, Ph. D., 1895
- Notes on Fish Culture in Germany. S. Jaffé, 1895
- Notes on the Mosquitoes of the United States. L. O. Howard, 1900
- *Notes sur une espece d'Infusores Parasites des Poissons d'eau douce. D. Fouquet, 1876
- Notes on Trematode Parasites on Fishes. Edwin Linton, 1898
- Notice of the Occurrence of Protozoan Parasites on Fishes in Ohio. Edwin Linton, 1897
- Observation on a Fungus infesting the Fish. G. P. Clinton, 1894
- Observations on the Aquaria of the United States Fish Commission. William P. Seal, 1890
- *On Entomostraca. Emil Weeger, 1890
- On the Caudal and Anal Fins of Goldfishes. Dr. S. Watasa, 1887
- On Some Lake Superior Entomostraca. S. A. Forbes, 1890
- Parasites. T. Spencer Cobbold, 1879
- Photography of Live Fishes. R. H. Shufeldt, 1899
- *Popular History of the Aquarium. G. B. Sowerby

BIBLIOGRAPHY

- Practical Carp Culture. L. B. Logan, 1888
- Practical Trout Culture. J. H. Slack, 1872
- Praxis der Aquarienkunde. Dr. E. Bade, 1899
- Proceedings of the Fish-Culture Society, 1880
- Report on a Parasitic Protozoan observed on the Fish. C. W. Stiles, 1894
- Rotatoria of the United States. H. S. Jennings, 1900
- Saprolegniaceæ of the United States. Jas. E. Humphreys, 1892
- Sea Mosses. A. B. Harvey, 1882
- Seaside Studies in Natural History. E. C. & A. Agassiz, 1865
- Some Chemical Changes in the Development of the Fish Egg. P. A. Levene, 1900
- Some Observations concerning Fish Parasites. Edwin Linton, 1894
- Sporozoa. Alphonse Labbé, 1899
- Seewasser-aquarien im Zimmer. R. E. Hoffmann, 1900
- The Care of Goldfishes. C. H. Townsend in Bulletins of the New York Zoological Society, 1907
- The Cultivation of Fishes in Natural and Artificial Ponds. C. H. Townsend, 1907
- Studies on Ectoparasitic Trematoda of Japan. Seitaro Goto, 1885
- *The American Angler. J. A. Henshall, Vol. III
- The Aquarium; a Brief Exposition of its Principles and Management. Wm. P. Seal, 1887
- The Aquarium. Mark Samuels, 1898
- *The Aquarium. J. E. Taylor, 1876
- *The Aquarium. P. H. Gosse, 1854
- The Aquarium as an aid to Biological Research. Wm. P. Seal, 1883
- The Aquarium of the U. S. Fish Commission at the World's Columbian Exposition. S. A. Forbes and others, 1894
- The Black Bass. Jas. H. Henshall, 1899
- *The Book of the Aquarium. Shirley Hibberd
- The Brook Book. Mary R. Miller, 1902
- The Crustacea of the Fresh Waters of the U. S. Sidney Smith, 1872
- The Destruction of Trout Fry by Hydra. E. A. Beardsley, 1903
- The Family Aquarium or Aqua-vivarium. Henry D. Butler, 1858
- The Fishes of Pennsylvania. Tarleton H. Bean, 1893
- The Fishes of Pennsylvania. E. D. Cope, 1881
- The Fishes of North and Middle America. Jordan and Everman, 1896
- The Fish of the Fresh and Brackish Waters in the Vicinity of New York. Eugene Smith, 1897
- The Fisheries and Fishery Industries of the United States. Geo. Brown Goode, 1884
- *The Fresh and Saltwater Aquarium. Rev. J. G. Wood
- The Goldfish and Its Culture. Hugo Mulertt, 1883
- The Home Aquarium and How to care for it. Eugene Smith, 1902
- *The Home Naturalist. Harland Coultas
- The Insect Book. Leland O. Howard, 1901
- The Myxosporidia of Fishes, &c. Dr. R. R. Gurley, 1888
- The Natural History of Plants. A. K. von Marilaun, 1895
- The Pearly Freshwater Mussels of the U. S. Chas. T. Simpson, 1899
- The Sea-Beach at Ebb-Tide. Augusta F. Arnold, 1901
- Transactions of the American Entomological Society
- The Trematodes. H. S. Pratt. American Naturalist, 1900 and 1902
- *Trout Culture. Seth Green, 1870

- *The Vivarium. Rev. G. C. Bateman, 1893
Über Aquarien. F. Rossbach, 1875
*Über die Feinde der Fische. V. La V. St. George, 1879
Untersuchungen über Peronosporeen und Saprolegnieen. A. De Bary, 1881
Vertebrate Animals of the Northern United States. David S. Jordan, 1899
Zur Kenntniss Kleiner Lebensformen. M. Perty, 1852

AQUARIUM AND FISH-CULTURE PERIODICALS

- Allgemeine Fischerei-Zeitung, München
Blätter für Aquarien und Terrarien-Kunde, Magdeburg
Correspondenzblatt für Fischzüchter, Crangen in Pommern
Deutsche Fischerei-Zeitung, Stettin
Fischerei Correspondenz, Dresden
Forschungsberichte aus der Biologischen Station zu Plön
Isis, Magdeburg
*L' Acclimatation, Paris
L' Aquarium, Paris
Natur und Haus, Dresden-Strehlen
Nerthus, Kiel
Reports and Bulletins of the New York Zoological Society

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