THE SONG OF FISHES.

By JOHN C. GALTON, M.A., F.L.S.

[PLATE CXIII.]

"Un vrai vagabondage musical qui saisit par sa nouveauté, et est tellement attrayant qu'on l'entend avec plus de plaisir, ou du moins avec plus d'étonnement, que ces excentricités musicales que l'Allemagne a cherché dans ces derniers temps à importer chez nous."—DUFOSSÉ, 1874.

M. DUFOSSÉ, though in the above sentence unmistakably declaring himself no disciple of the composer of *Tannhäuser* and *Lohengrin*, and showing himself a far from promising proselyte as far as "the music of the future" is concerned, and though thus sadly assimilating his musical taste to our British standard—such as it is—is, nevertheless, entitled to be heard with respect, at all events so long as fishes are under consideration, seeing that he has for a long period had several hundred of these cold-blooded musicians under constant observation.

That certain fishes produce at certain seasons sounds—nay, more, that many such sounds can be brought under the category of musical notes—is known but to few even in these our days, though the fact did not escape the notice of that most observant of all natural historians, Aristotle;* and that which he thought and wrote in Greek on this subject has, of course, as in other things, been echoed some centuries later by Pliny in Latin.†

More recently recorded observations upon the sounds produced by fishes are but few and far between. One of the best perhaps of all accounts is that given by Sir J. Emerson Tennent, late Governor of Ceylon.‡ When at Batticaloa

* "Ψόφους δέ τινας ἀφιᾶσι καὶ τριγμοὺς οὓς λέγουσι φωνεῖν, οἷον λύρα καὶ χρόμις· οὗτοι γὰρ ἀφιᾶσιν ὥσπερ γρυλλισμόν· καὶ ὁ κάπρος ὁ ἐν τῷ Ἀχελώῳ ἔτι δὲ χαλκεὺς καὶ κόκκυξ." "Hist. Anim." iv. 9, 3.

† "Nat. Hist." lib. xi. Ælian, too (Περὶ Ζωῶν Ἰδιότητος, lib. x. cap. ii.), quotes Aristotle's statement, but adds nothing new to it.

‡ "Sketches of the Natural History of Ceylon," pp. 380–85 and 401. London: 1861.

—a place half way down the east coast of this island—he made some inquiries about certain sounds "resembling the faint sweet notes of an Æolian harp," which were alleged to proceed from the bottom of a neighbouring lake. The fishermen said that both they and their fathers knew of these sounds, which were declared to be audible during the dry season, but to cease when the lake had been swollen after the rains. These, they said, proceeded not from a fish, but from two species of mollusc (a *Littorina* and a *Cerithium*), known by the Tamil name of *ǫorie cooleero cradoo*, or the "crying shell." * Sir E. Tennent took a boat and visited the lake by moonlight, and thus describes the sounds which he heard:—"They came up from the water like the gentle thrills of a musical chord, or the faint vibrations of a wine-glass when its rim is rubbed by a moistened finger. It was not one sustained note, but a multitude of tiny sounds, each clear and distinct in itself: the sweetest treble mingling with the lowest bass. On applying the ear to the woodwork of the boat the vibration was greatly increased in volume." The sounds varied considerably at different points, and could be localised, as it was possible to row away out of their influence. This fact, thought Sir E. Tennent, lends support to the view of the fishermen, that the sounds were produced by molluscs and not by fish. Similar sounds have been heard in the harbour of Bombay; described as "like the protracted booming of a distant bell, the dying cadence of an Æolian harp, the note of a pitch-pipe or pitch-fork, or any other long-drawn-out musical note." These sounds came from all directions, almost in equal strength, and arose from the surface † of the water all round the vessel. The fish which was alleged to produce these sounds closely resembled in size and shape the fresh-water perch of the north of Europe. These phenomena were carefully observed and noted by a party of five intelligent persons.

The "Magoora"—a fish found in the lake at Colombo—is stated by the fishermen to make a grunt when disturbed under water; and a certain flat-fish in Siam, according to Pallegoix, "fait entendre un bruit très sonore et même harmonieux."

At Caldera, in Chili, at the mouth of the Pascagoula, in the Mississippi State, and of the "Bayon coq del Inde" river on

* It is known, from the observations of the late Prof. Grant, that one at least of the gasteropodous molluscs (*Tritonia arborescens*) has the power of producing sounds—apparently by the mouth, which is armed by two horny plates—so that it is possible that the sounds in question were really produced by molluscs; a point on which Sir E. Tennent was not able to satisfy himself.

† It should be noted that the sounds heard by Sir E. Tennent "came evidently and sensibly from the depth of the lake."

the north shore of the Gulf of Mexico, similar submariue sounds have been remarked, but by what animal produced is at present unknown. Darwin, moreover, mentioned as occurring in the Rio Parana, in South America, a kind of *Silurus*, called "armado," which is remarkable for a harsh grating noise, which it makes when caught by hook and line, and which can be distinctly heard when the fish is beneath the water.*

The most graphic and analytic description, however, of such music is that given by M. Dufossé, who thus describes his sensations when traversing in a fishing-lugger off the coast of France a shoal of Maigres (*Sciæna aquila*), so closely packed together as to be literally "côte-à-côte"—

"Tout à coup et tandis qu'une multitude de sons mystérieux, baroques, d'un charivari inouï, frapperont l'oreille du naturaliste, il se sentira saisi d'une sorte d'enivrement passager durant les courts instants duquel il aura bien de la peine à se défendre de quelques hallucinations auditives; toutefois, redevenu observateur impassible, il ne tardera pas à constater que les parois du bâtiment qui le porte sont animées de mouvements vibratoires, et dès lors il distinguera nettement, que c'est le tremblement physique qu'il ressent qui produisait le trouble nerveux auquel il a été un moment en proie, et par suite il trouvera le secret du léger degré d'enivrement qu'il a éprouvé dans la triple nouveauté des sensations qui sont venues inopinément et simultanément envahir tout son être: nouveauté de la surexcitation nerveuse résultant des mouvements de trépidation du chasse-marée; nouveauté encore de la nature même des sons étranges qui fascinaient ses organes auditifs; nouveauté enfin du mode de transmission des vibrations sonores qu'il percevait à travers un milieu liquide." Further on the noises are thus described:—"Ces assemblages de sons extraordinaires, bourdonnant comme le feraient un grand nombre de jeux d'orgues" (shade of Charles Babbage!) "qui seraient complètement désaccordés, cacophonie d'une bizarrerie indescriptible, auxquels tous les Sciénoïdes du groupe auront pris part," &c.

M. Dufossé has further been informed by some pilots, whose testimony he considered reliable, that a sea captain who was going up the Gironde, on hearing for the first time the sounds produced by numerous maigres in the neighbourhood of the ship, was thrown into a state of great alarm, supposing that he had sprung a leak in the hold!

Though phenomena such as those just described have been from time to time observed, wondered at, and noted by more or less competent witnesses, it was not until within the last fifteen years that any attempt had been made to inquire into their nature, and to investigate by patient and closer observation, and by carefully conducted experiments, the organ or organs by which they are produced. Until quite recently, then, all had been merest conjecture. It is to two French observers,

* "Naturalist's Voyage Round the World," p. 136. Lond.: 1860.

M. Moreau, in some slight degree, but more especially to the oft-repeated and most laborious observations and experiments of M. Dufossé, carried out upon several hundreds of fishes, mostly inhabitants of the Mediterranean, that we owe all our present information—which, it must be admitted, is wonderfully full and exact—on this hitherto obscure and totally neglected subject.

It has long been known that many members of the Gurnard family possess and exercise the faculty of emitting sounds when still under water, from which circumstance they have been collectively termed "Organo" in Italy, and in France "Grondin." * M. Moreau describes the air-bladder of the "Tub-fish" or Sapphirine Gurnard (*Trigla hirundo*) as possessing thick and strong muscles, the fibres of which are of the *striped* variety, and are thus presumably voluntary. These are supplied by two large nerves which take origin from the upper part of the spinal cord, below the pneumogastric nerve, and close to the first pair of dorsal nerves. The mucous membrane lining the air-bladder is thrown into a fold or diaphragm (comp. *d*, fig. 2), which subdivides the main cavity into two secondary chambers, which communicate by an aperture (*f*, fig. 2) in this partition, having some functional analogy to the pupil of the eye; for under the microscope this structure is seen to be provided with sphincter-like muscular fibres, disposed concentrically to the opening, while other fibres, radially arranged, run at a tangent to these. Both sets of fibres are of the *smooth*, presumably involuntary, variety. In August 1863 M. Moreau "sacrificed," as he terms it, a grondin by section of its spinal cord above the dorsal region, and, after opening the abdomen of the fish, he applied a feeble galvanic current to the nerves proceeding to the air-bladder. Immediately there were produced sounds, audible to persons at some distance, having the same character as those emitted by the fish during life. A current was next applied directly to the muscle of the air-bladder, but without result. M. Moreau then cut a window in the lower portion of the bladder, so as to expose the diaphragm to view, and upon galvanisation being again repeated, this membrane was seen to be thrown into a state of vibration, but no sounds were produced. M. Moreau, who does not seem to have been satisfied with these results, then proposes to continue his experiments at some future time.† The absence of sound in the last experiment seems to me to be easily accounted for, seeing that the membranous cavity, more

* The λύρα of Aristotle probably embraced fishes of this family. Yarrell thinks that the most probable derivation of the word gurnard is from the Dutch *guurheid*, roughness, in allusion to the peculiarity of the head of this fish. ("Hist. Brit. Fishes," 3rd edition, vol. ii. p. 106.)

† Sur la voix des Poissons. "Comptes Rendus," tome lix. p. 436. 1864.

or less distended with a gas to which impulse would have been transmitted by the vibration of the diaphragm, had now been opened.

So much for M. Moreau. The rest of this article must perforce be devoted to the admirable researches of M. Dufossé, whose observations and experiments have been so numerous, so carefully conducted, and so productive of valuable results, that this *savant* is at length enabled to reduce to system and classify—an all-important step in any branch of science—the various acoustic phenomena which he has observed among fishes.* Such phenomena may be divided into two primordial groups or "categories." Under the first of these may be placed the various sounds which fishes produce when taken off the hook and line, and are pitched into a basket or some other receptacle. Such sounds are accidental, temporary, for the most part evidently involuntary; often convulsive, being produced sometimes by one part of the organism, at another time by another part. Such sounds are subservient to the exercise of a function which cannot be expressed, and cannot be brought into relation with any intention on the part of the animal. Among such noises are those produced by unusual movements of the bony elements of the jaw or gill-coverings ("opercula"), e.g. in the barbel, loach, carp, gurnard, and others. In the short-snouted variety of the sea-horse (*Hippocampus*) a peculiar sharp sound is made by a little chevron-shaped bone, loosely articulated with two of the bony (*preopercular*) elements of the gill-covering, resembling that produced by the sudden return of a displaced foot tendon into its bony groove. The tench, carp, loach, and other thick-lipped fish, make a peculiar noise if they be compelled suddenly to open the mouth. This in the tench is so often repeated as to be in a degree comparable with the croaking of a frog. To such sounds M. Dufossé gives the name of "phénomènes accoustiques irréguliers."

With regard to the sounds of the second category, which "better merit the attention of the physiologist," these are voluntary, constant, and are always produced by the same organ. They are, moreover, always reproduced under analogous circumstances, are evidently intentional, and can even serve to characterise a species. Such are the "phénomènes acoustiques réguliers." The phenomena of this category are further divided by M. Dufossé into groups or sections. The first of these comprises "expressive noises, or incommensurable expressive sounds." As the noises are not all engendered by the same

* Recherches sur les bruits et les sons expressifs que font entendre les poissons d'Europe. "Annales des Sciences Naturelles," 5ième serie, Zoologie, tome xx. 1874.

mechanism, it is necessary to subdivide them yet further into two secondary groups or "divisions." The first division includes all the expressive sounds of a harsh nature, and comprises, as far as the fishes of Europe are concerned, only one subdivision —that of stridulation, having for its cause the friction of the dental organs. Of souch sounds—"bruits de stridulation"—there are two modes of causation.

a. By friction of the pharyngeal bones.* These noises are characterised by being composed of sonorous emissions, clear, short, rough and piercing, without flexibility or softness, and by commencing and ending abruptly ("brusquement"). The best example of this has been found in a species of mackerel, namely the "Saurel" (*Scomber brachyurus*, Linn.), known in the fish-markets of Paris under the name of "Maquereau bâtard," and by that of "Séveran" on the coasts of old Provence. Both the males and females are equally sonorous, and especially so in the hottest part of summer; and, moreover, present this advantage to the physiologist, that they will live for more than ten minutes—on rainy days for even sixteen or seventeen—after removal from the water, without seeming to suffer. M. Dufossé made several experiments with the saurel, and found that puncturing the air-bladder or other viscera had no influence on the sounds emitted, while, on the other hand, they entirely ceased when various substances, such as bits of kid glove, had been stuffed between the pharyngeal teeth—those *dents-en-velours*, as Cuvier termed them, which, like a gin, jealously guard the approaches of the gullet. It must be noted that the branchial arches differ from those of most of the mackerel family in having their mucous lining not clothed with a softish cartilaginous cushion, but encrusted inside with calcareous plates, and carrying tooth-like organs of the hardness of enamel. The various muscles, too, of the hyoidean apparatus (that which mainly influences the movements of the bones carrying the lower pharyngeal teeth) are relatively largely developed. It was further found that when the fish was examined in a vessel filled with sea-water, the sounds emitted were not accompanied by the liberation of a single bubble of gas from any of the natural openings of the body, nor did the fish come to the surface to swallow the least mouthful of air.

b. By the friction of densely hard prominences from the jaws, playing the part of intermaxillary teeth, noises being thus produced which resemble the grinding of the teeth of pigs, or of certain ruminants. Only one fish is as yet known to employ such mechanism, namely the Sun-fish (*Orthragoriscus mola*), which

* These bones are described and figured in an article, "How Fishes Breathe," POPULAR SCIENCE REVIEW, Oct. 1871.

has two hard prominences, one on each jaw, fulfilling the function of intermaxillary teeth.

We now come to the second division, which comprises all kinds of blowing sounds, "bruits de souffle." Many fishes produce such sounds, among them being the carp tribe and the *Silurus glanis;* but the most remarkable effects have been noticed in the loach (*Cobitis*), the barbel, and the carp. All these fishes have an air-bladder provided with a duct, which communicates with the gullet, and which is, moreover, divided, in the carp tribe, into two chambers, which, however, communicate, by a transverse constriction. In the loach this organ lies in front of and out of the abdomen, in a box formed for it by bony plates derived from the sides of the second and third vertebræ. According to the researches of Weber, which have been confirmed by Bréchet and others, the air-bladder in the barbel and loach is brought into relation with the organs of hearing through the medium of a chain of bones, so that the slightest vibrations of the wall of the bladder can be transmitted to them. Weber, in consequence, then, regarded the air-bladder as an organ for the reinforcement of the sounds transmitted to the body of the fish by the surrounding medium. From experiments made upon the barbel and "meunier" (*Cyprinus dobula*), M. Dufossé concludes—

a. That the sounds emitted by these fish are voluntary, because the animal can open or close at pleasure little valves in the duct of the air-bladder, which control the escape of gas from this receptacle—an act essential to the production of sound.

β. That the function of the air-bladder and duct, in addition to any other which they may discharge in common with these organs in other fishes, is "to produce a certain quantity of gas, and to expel the same with the speed necessary for the formation of sounds of expression;" and that the principal agent in the propulsion of this gas is, through its anatomical relations, the posterior lobe of the air-bladder. The sounds emitted by the loach have a greater intensity, and present greater varieties.

We now come to the second and most important section of the second category. This includes sounds having the following character. Their *timbre* is more or less sweet and soft, and never excites such sensations as are produced by the grinding of teeth. It is, moreover, subject to an extraordinary degree of change, varying frequently, and even changing during the extent of a sound. Such sounds can be appreciated musically; are, in other words, "commensurable."

Let the reader place a finger in each ear, and then "set his teeth" hard. After hearing a dull low murmur, like the

rumbling of a distant chariot, he may possibly exclaim, in the language of Catullus—

"—— sonitu suopte
Tintinant aures."*

Not so. Such sound is of a totally different kind. The sound in question is due to a vibration caused by the contraction of his temporals and masseters—those "aldermanic" muscles, as we believe they have been termed—and has been investigated by many observers, among them the celebrated Wollaston, and has in consequence received many names, e.g. *Wollastonian vibration*, *Agitatio spiritum* (Grimaldi), *Bruit de rotation* (Lænnec), *Trémulation musculaire* (Dugès), &c. Wollaston essayed to count the vibrations of these sounds, and found only from 14 to 36 in a second, so that they can hardly be regarded as "commensurable," i. e. musical sounds, if Dupré's recent conclusions be correct, that a sound composed of less than 32 vibrations per second cannot be appreciated musically. Now M. Dufossé has discovered that in many fishes the sounds produced by them are essentially of an analagous nature, and that the vibrations into which these may be analysed can be measured by appropriate instruments. Further than this, he has shown that there are two methods of the causation of such sounds—1, by the contraction of muscles lying in close contiguity to the air-bladder, so that the latter fulfils the office of an instrument of reinforcement of sound, in other words, a kind of sounding-board; 2, by the contraction of muscles which are part and parcel of the air-bladder itself. So then this latter may be regarded *in toto* as an instrument of music, and not merely as playing a secondary *rôle*. The Mailed Gurnard, "Marlamat" (*Trigla cataphracta*, Linn.), offers a good instance of the first of these methods. In the abdomen of this fish, arched over by the ribs and lying within the so-called "lateral" muscles of Cuvier, may be seen on either side a muscle (*i m*, fig. 1) which runs along the whole length of this cavity. This muscle is attached posteriorly to certain fibrous internal aponeueroses, and, after increasing in size and becoming cylindrical anteriorly, splits into two slips, the shorter of which is attached by a tendon to the so-called "humeral" element of the pectoral fin (*h*, fig. 1), while the other terminates at the back of the skull. These muscles are further conspicuous by their red colour, have moreover the characters of voluntary muscles, in that their ultimate fibrils are transversely striped, and are supplied by special branches from the third pair of cervical nerves (β, γ, fig. 1)—nerves which in other gurnards pass to the "intrinsic" muscles (*i*, *m*,

* "Upon my ear a noisy nothing rings.' —Keats (*Endymion*).
βομβεῦσιν δ' ἀκοαί μοι.—Sappho.

fig. 4) of the air-bladder.* M. Dufossé has established the curious fact that, in the majority of cases, it is not the totality of the fleshy bundles of the intracostals which contract to produce sound, but only that portion of the muscular surface which is in immediate contact with the air-bladder; and that, under these circumstances, whatever organs, whether bony or otherwise, are acted upon by these muscles, come only into play as accessories to the production and propagation of sound.

Let us now briefly consider the second of the two methods of the production of "commensurable" sounds. Here the air-bladder is itself "a *generator* of sounds, as completely independent of the rest of the organism of the fish as any other apparatus of 'psophosis,'† or even of phonation with which the animal may be endowed." After placing a gurnard on its back, making a long incision in the abdominal walls, and carefully drawing aside any viscera which may obstruct the view, if the tip of a finger be held in contact with the air-bladder, vibration will be felt exactly synchronous with, and having the same intensity as the sounds produced by the fish. This can be further proved by means of a stethoscope applied to this organ. Further than this the air-bladder will be seen, during the emission of such sounds, to be affected by movements which may either throw the organ into folds or subject it to a greater tension in various parts; and this even to such a degree as somewhat to alter its general shape. Having isolated the organ as much as possible by delicate yet rapid manipulation from the rest of the body, with the exception of the vessels and nerves which pass to it, let a stethoscope, provided at its mouth with a diaphragm of gold-beater's skin, be applied to the anterior part of the organ; then let the nerves which pass to the latter be severed, first on one side and then on the other, when it will be found that the sound first decreases in intensity, and finally ceases altogether. From this and other experiments M. Dufossé concludes that the air-bladder, in the majority of the gurnard family—

α. Is a physiological organ, which, whatever may be its other functions, is a *generator* of sounds.

β. That its "intrinsic" muscles, by their vibration, aided and intensified by the rest of the organs, are the agents of such sounds.

* The anatomist Stannius mentions, among other branches of the pneumogastric nerve, certain which run "inter membranas vesicæ natatoriæ. Inde ab œsophago in ductu ad vesicam decurrentes hanc ipsam adsequuntur. *Fibræ hæ nerveæ omnes colore niveo ceteris excellunt.* (*Symbolæ ad Anatomiam piscium.* Rostochii: 1839.)

† This is a word coined by Dugès. It appears to be derived from ψόφος (Lat. *strepitus*), any articulate sound, as opposed to φωνή.

γ. That other muscles, by their contraction, can alter the shape of the organ, and thus modify the quality of the sounds emitted.

What part the internal partition, or "diaphragm" (see figs. 3, 8, *d*), takes in modification of sounds does not seem to be clearly established, except that, in the maigres, at any rate, where it is fairly developed, it does no more than play a very secondary part—"un effet bien accessoire, bien peu important dans l'emission de ces phénomènes acoustiques." Space unfortunately will not permit us to consider the interesting modifications of the air-bladder, and the concomitant variations in vocal phenomena deducible therefrom, which are met with in the maigre, umbrina, the dorées and the dactylopterus; but mention must not be entirely omitted of the fact that in one of the sea-horses (*Hippocampus brevirostris*) the mechanism of the production of sounds is reduced to its simplest expression, being merely the vibration of voluntary muscles reinforced by an air-bladder having neither duct nor diaphragm, nor "intrinsic" muscles, both sets of organs being no better developed than in fishes which do not produce any sound whatever.

As space further fails us for a proper review of the gamut of the piscine orchestra, we must content ourselves with one example. We will take the maigres, a description of whose musical performance has been already quoted at the beginning of this article. The sounds emitted by these fishes are notable principally for their length, having a mean of 25 seconds, and for their uniformity, "qui va jusqu' à la monotonie la plus fatigante." The *timbre* varies very much, the most common being that of a common reed-organ or the reed of a flageolet. Another pretty fequent *timbre* resembles that of the largest string of a violoncello, sometimes passing to that of the *bourdon* of a contre-basse. Some sounds are, however, less sweet, and may have some likeness to the tone of a hurdy-gurdy or rattle, while others are clear and pure, resembling in their *timbre* those produced by a hautboy, harmonica, or accordéon. M. Dufossé would limit the range of sounds produced by the maigres, from the most acute to the deepest, to three or four tones. They have generally a great tendency "to degenerate into a humming sound," either from an excess or from a want of intensity.

It would have been interesting, had the limits of this article permitted it, to have considered more fully the phenomena of sound just described, from a musical and physical point of view; but as the subject has in these pages been regarded rather from a biological stand-point, I would fain leave the more mechanical part of it—one fraught with great interest, and most fully and ably discussed by M. Dufossé—to the consideration

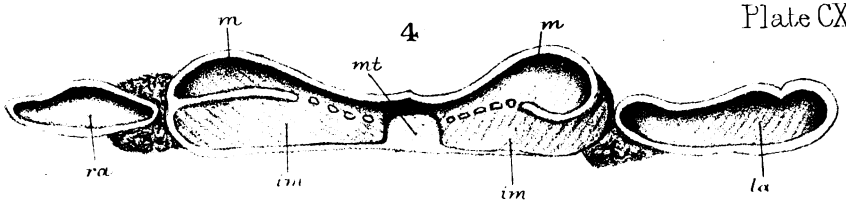
of the physicist and scientific musician, for "la vibration musculaire," as this writer well observes, "attend encore son historien; le savant qui, au moyen de recherches expérimentales assez multipliées, pour faire une étude bien approfondie, bien complète de ce fait naturel, l'élevera au rang des phénomènes les plus intéressants de la biologie."

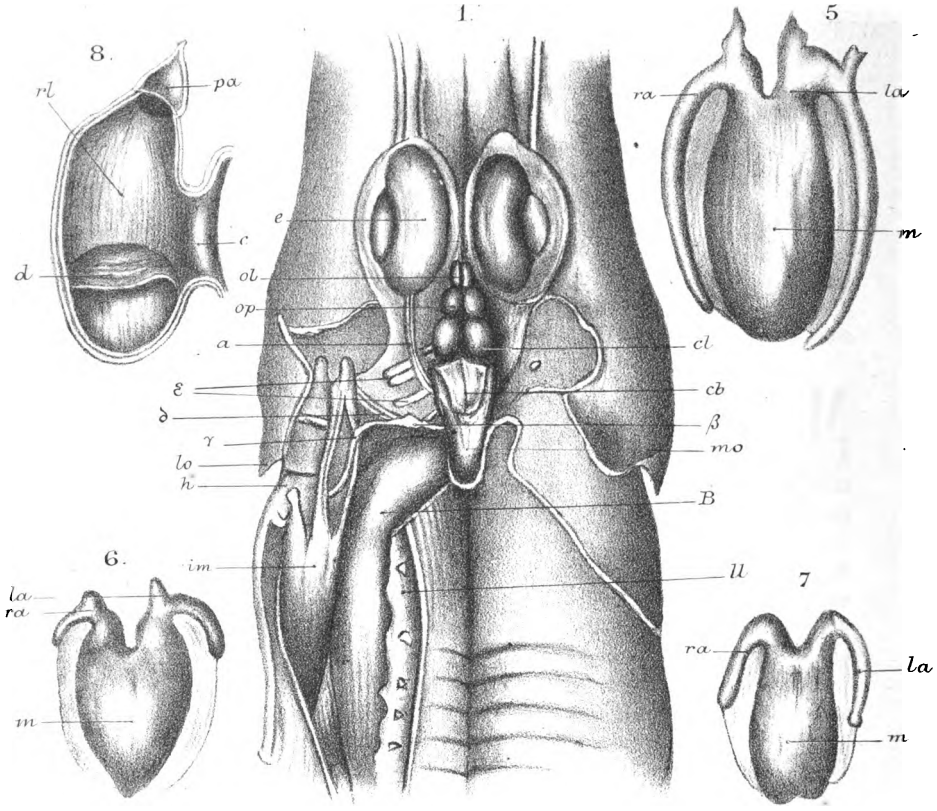
It appears that out of more than 3,000 species of fishes no more than 52 are at present known to produce sound. This contrasts most singularly with that which happens among the other four vertebrate classes, containing at least 12,000 species; for here every individual possesses a larynx—in other words, an organ of voice—and out of these those that are incapable of exercising the functions of this organ are in a very small minority.

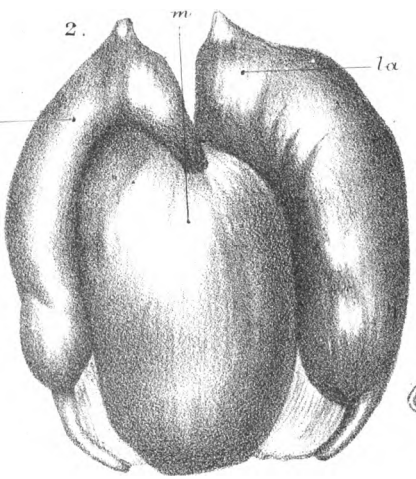
Not only is there every reason to believe that the majority of sounds produced by fishes are not casual utterances, but are truly voluntary; but there is among such as give vent to them a most remarkable development of the organs of hearing in all essential particulars—e.g. in the semicircular canals, otoliths, and nerves*—correlative with the degree of perfection of the instrument. Further than this, as the sounds generally excel in frequency and intensity at the breeding season, it will not be unreasonable to regard them—granting, as we do, that the chirp of the cricket and the croak of the frog is each in its way an alluring serenade—as nuptial hymns, or, to use language ascribed to Plutarch, as "deafening epithalamia."† More than this; seeing that the carp, and others of the same family, have given unmistakeable proofs of their aptitude to receive some rudiments of education, and in particular to perceive certain sounds, it can yet be possible that the moral admonitions of a St. Anthony of Padua—by many still regarded as a work of supererogation—may, no less than the amorous twang of the vesical zither, after all not have fallen upon totally deaf ears.

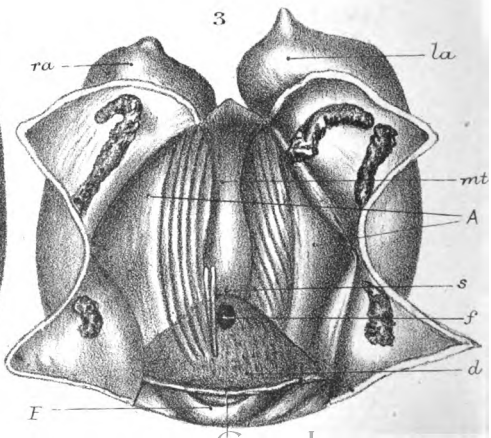
* See Retzius' "*Anatomische Untersuchungen. 1ste Lief. 1ste Abth:* Das Gehörlabyrinth der Knochenfische" (Stockholm, 1872); and the beautiful preparations, made, we believe, by Mr. Charles Stewart, the Curator, in the Museum of St. Thomas' Hospital, London.

† M. Dufossé suggests that the song of the fabled Sirens had its origin in the utterances of shoals of maigres. It is probable that the *latus*—that "marvellous morsel," as Athenæus termed it, caught in the "fretum Siculum" to garnish the tables of Roman epicures, was, as Rondelet and Cuvier suggested, none other than the maigre.









Musical Organs of Fishes.

DESCRIPTION OF PLATE CXIII

All the figures have been selected and drawn by the author from plates illustrating M. Du Fossé's article in the "Annales des Sciences Naturelles."

FIG. 1. View of the upper surface of the front part of the body of the Mailed Gurnard, or "Malarmat" (*Trigla cataphracta*). A large portion of the skull and of the front part of the spine has been removed; also all the "great lateral" muscles, both superficial and deep, at the interior end of the body, and, on the left side, all the layers of muscles, and the ribs as far as the dorsal arch of the abdomen. A portion of the membrane lining the abdomen is retained, to which are attached the "intracostal" muscle. The whole of the posterior half of this muscle has been separated from its attachments and reflected, in order to demonstrate more readily the course which the entire muscle describes. *l o.* Left gill-cover, or "operculum." *o l.* Olfactory lobe of brain. *o p.* Optic lobe. *c l.* Cerebral lobe. *c b.* Cerebellum. *m o.* Medulla oblongata, or first part of spinal cord. *α.* Two cerebral nerves belonging to the fifth pair. *β.* The three roots (of which only two are represented in the plate) of the nerve destined for the "intracostal" muscle, and the ganglion developed upon them outside the vertebral column. On dissecting this ganglion, it is found that the nerve despatched to the muscle is a continuation of the largest — the most anterior, of the three roots. *γ.* The nerve of the "intracostal" muscle after its emergence from the ganglion. *δ.* Two nerves arising from the ganglion, on their way to the "operculum" and neighbouring parts. *ε.* Three rootlets of the cerebral nerve of the eighth pair. *h.* A portion of the "humeral" bone (Cuvier)—probably one of the "clavicular" bones of more modern nomenclature, a little separated from the "operculum." *i m.* Left "intracostal" muscle, the posterior flattened portion of which has been reflected. Its extremity, which is pointed, could not be represented. *l l.* The "great lateral" muscles, superficial and deep, of the left side, seen in section, amongst which the ribs are visible, also in section. *e, e.* Eyes. B. Air-bladder.

FIG. 2. The air-bladder of a Sapphirine Gurnard, "Perlon," (*Triglahirundo*). It is seen from its lower aspect, and is distended by a greater quantity of gas than it would normally contain. *m.* Principal lobe. *ra, la.* Right and left appendicular lobes respectively.

FIG. 3. The same—also from the inferior aspect—opened by a crucial incision; the four triangular flaps resulting from which are reflected over the appendicular lobes (*ra, la*). A, P. Cavity of the principal lobe separated by the diaphragm (*d*) into two divisions—the anterior (A) and posterior (P) chambers. *d.* The "diaphragm" (Duvernoy) lying obliquely from before backwards and from above downwards, *s* indicating its anterior

superior, and *i* its posterior inferior border. It is pierced by an elliptical foramen, *f*. *m t*. Median tendon, representing a kind of "rachis" or mid-rib of the entire apparatus.

FIG. 4. Transverse section of the air-bladder of the same fish. *ra, la*. Right and left appendicular lobes. *m m*. Cavity of the principal lobe. *m t*. Median tendon. *i m*. The two "intrinsic" muscles of the air-bladder. The oblique direction of their fleshy bundles of fibres can be seen.

FIGS. 5, 6, 7. Various phases of development of the air-bladder of the same fish. The lettering as before.

FIG. 8. Right lobe of the air-bladder of the Dactylopterus (*D. volitans*), represented in section to show the incomplete diaphragm (*d*), which projects at the level of the tubular isthmus (*c*) of communication with the left lobe. *rl, pa*. Internal surface of main cavity, and "pyramidal appendix" of right lobe respectively.