

regions into the higher latitudes, and the polar air brings the less rotatory velocity of the polar regions into the lower latitudes. The latter constitute the trade-winds, which move more slowly than the earth's rotation, and consequently appear as an atmospheric current from the east; the former constitute the "counter-trades," which move more rapidly than the earth's rotation, and appear as an atmospheric current from the west.

The centrifugal force of the "counter-trades," as they circle round the poles, is the cause of the polar depression of the barometer.

The law of reaction makes it impossible for the earth's rotation to be either accelerated or retarded by the winds, and consequently the entire "torsional force" exerted by the winds on the earth must, at any given time, be equal in the easterly and westerly directions.

I have now described in outline what theory shows that the circulation of the atmosphere would be in the absence of watery vapour and in the presence of the sun's heat and the earth's rotation; and observation shows that such is the actual circulation on the large scale, and not taking account of local disturbances.

JOSEPH JOHN MURPHY

Old Forge, Dunmurry, Co. Antrim, February 23

### Halo round Shadow

It is not uncommon for an observer, when looking at his own shadow on rough ground or turbid water, to see its head surrounded by a halo, of which the brightest part is in contact with the shadow.

This phenomenon has often elicited notice, but as far as I am aware has not before now been explained, nor do those who have mentioned it seem to have observed that its appearance depended on the nature of the surface receiving the shadow.

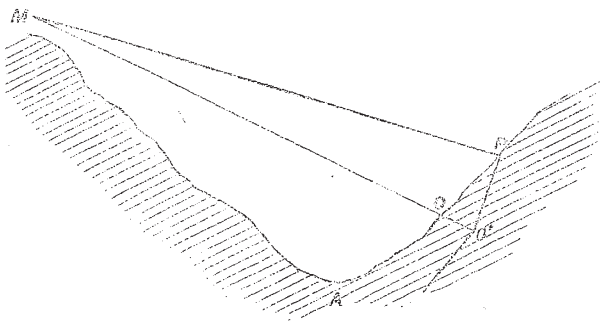
The conditions necessary for the production of these halos are—

1. That the screen, as whatever the shadow is cast on may be called, should not be a continuous surface, but a number of small surfaces with intervals between them, each of these small surfaces of course casting its own shadow on whatever happens to be behind it.

2. That the shadow should be at a considerable distance from the observer.

3. That the light should not fall very obliquely on the screen. The first of these conditions only is essential, but the fulfilment of the last two makes the phenomenon more marked.

Rough grass forms a good screen, especially if, as in the diagram, conditions 2 and 3 are fulfilled by the shadow being



cast on one side of a valley, while the observer is standing on the other.

In the case of the shadow on turbid water, it must be remembered that it is not the surface of the water which forms the screen, but the particles suspended in it.

The general explanation of these halos is this—

From the observer's point of view the screen in the immediate neighbourhood of the shadow of the head is seen in nearly the same direction as it would be from the source of light. In this direction, therefore, each of the small surfaces of which the screen is made up will hide its own shadow, but this will be true of no other direction; and the effect on the whole will be that the screen will appear brighter close to the shadow of the observer's head than elsewhere.

To examine this rather more in detail, let MAO be a section

of the ground passing through the observer at M and his shadow at O. Let

$$\begin{aligned} O'P &= r \\ O'MP &= i \\ O'PM &= \text{a right angle.} \end{aligned}$$

Let  $w$  and  $w'$  be the projections on  $O'P$  of the average breadth of the sections of the small surfaces made by the plane MAO, and the average distance between them respectively, and let  $h$  be the average distance of each of the small surfaces from its own shadow.

Then the amount of light received from any space  $r d\theta$  ( $w + w'$ ) may, *ceteris paribus*, be taken without any great error as a measure of the brightness of the cone whose mean radius is  $r$ , and whose breadth is  $w + w'$  ( $d\theta$  being a small rotation of  $r$  about  $O'M$ ), and this will be proportional to  $w + w' - h \sin. i$ . The decrease in brightness is proportional to  $h$  and  $\sin. i$ , and will reach a maximum when  $h \sin. i = w$ , if  $w < w'$ , or  $w' < w$ .

Outside the circle defined by this value of  $i$  the brightness will be sensibly constant, because the quantities of which  $w$ ,  $w'$  and  $h$  are the average values have all manner of actual values, even in a very small space.

These expressions are only approximate, but they serve, as well as the longer exact formulæ, to show the general laws of the phenomenon.

ARNULPH MALLOCH

### Meteor

THIS evening, at close upon twenty minutes past six, as I was walking in my garden towards the almost full moon (which was very bright), I observed a brilliant meteor pass from right to left over, and very near, the moon's disc. It was visible for a distance of about twice her diameter. From the amount of daylight, and the extreme brightness of the moon, I judge this meteor to be worth recording.

C. M. INGLEBY

Valentines, Ilford, February 26

### Tape-worm of Rabbits

So far as I am aware the only evidence in favour of the view that *Bothriocephali* present no hydatid stage is that which has been furnished by the researches of Knoch. To me it has always seemed that this evidence is insufficient fully to overcome the analogical probability that tape-worms of this genus resemble tape-worms of other genera in passing through a hydatid stage—and this notwithstanding the occurrence of a ciliated embryo. However, in my previous letter I ought no doubt to have alluded to the researches of Knoch, and should certainly have done so had my object in writing been other than it was, *i.e.*, merely to ascertain whether anyone had as yet taken the trouble to trace the life-history of the rabbit's tape-worm.

February 20

GEORGE J. ROMANES

### A PROBLEM IN THE NATURAL HISTORY OF THE SALMON.

MR. FRANK BUCKLAND, in giving evidence before the Parliamentary Committee, which during last session of Parliament inquired into the condition of our oyster fisheries, stated that "a salmon (*Salmo salar*) does not breed every year, but every three years!" On being asked by a member of the Committee if he had any proof of his averment, Mr. Buckland stated that, "he had a great idea of it," but was deficient in proof. Before examining this alleged fact in the life of the salmon, advanced by Mr. Buckland, it is proper that we should state briefly what induced him to make known his idea.

While illustrating the theory of oyster spatting, and telling the Commissioners that all the individual oysters on a *scalp* would not be found exuding their young at the same time, however favourable for spatting the period might be, Mr. Buckland also enunciated his opinion as to the periods at which salmon spawn. That gentleman holds that only one of every six oysters on a *scalp* will be found in a procreant state during the same season; and, by way of clenching his illustration, he said, "you never get salmon always breeding the same year, they take time to recover themselves, and so forth." This latter state-

ment is rather obscure; but the interpretation undoubtedly is, that the same salmon does not breed every season. It would be instructive if Mr. Buckland were to state his ideas on this feature of the natural history of *Salmo salar* at greater length, giving at the same time a *précis* of the data on which he has formed his opinion; because the views hitherto entertained of the spawning of salmon have been mostly contrary to those promulgated by Mr. Buckland, the prevailing idea being that salmon spawn annually. Some persons, indeed, promulgated a theory of the salmon being able to spawn twice in the same year, doubtless founded on the fact of individuals having been known to go to, and return from, the sea within a few months. There is not, however, any exact proof of these facts. There are, also, one or two gentlemen of opinion that the fish in question only spawns every two years; but the opinion hitherto has been very general that salmon deposit their ova annually.

It is remarkable how ignorant we still are of the most important phases of salmon life, notwithstanding the active investigation of the last twenty years; and it is still more remarkable that some of the best informed salmon anglers, intelligent students of the natural history of the *Salar* group of fishes, should hold diametrically opposite opinions, both on this and other important points of salmon life. One gentleman, whose works on angling have a wide reputation, and whose knowledge of fish-life is extensive, tells us he has no doubt the same salmon spawns every year, which, he further says, "is the generally accepted opinion on our border rivers by anglers and fishermen of the professional caste." The same gentleman informs us that the late Mr. Robert Buist, superintendent of the River Tay Salmon Fisheries, was induced by experience to arrive at a similar conclusion. Mr. Buist, who took great interest in the Stormontfield salmon nursery, was usually present every season at the capture of the gravid fish, from which the required supply of ova to fill the breeding boxes was obtained. On one of these occasions a fine grilse was captured, in good condition for being artificially spawned; and, after being deprived of her ova, the fish was carefully marked, and restored to the river from whence she had been taken. "On the following year, at the same spot, the *same fish*, but now grown into a salmon, was retaken, full of ova, and again stripped, in order to aid in stocking the breeding boxes at Stormontfield!" This incident Mr. Buist held to be decisive of two points in the natural history of the salmon; first, that a grilse becomes a salmon, and is not a distinct member of the *Salar* family, a point in salmon life which was at one time hotly discussed; and, second, that the same salmon spawn every year. Another gentleman, Mr. Brown, who at one time gave his personal aid in the salmon breeding experiments carried on at Stormontfield, relates, in his notice of the proceedings, that "one year we had a very fine male fish of 24 lbs., which we marked with a wire, and *two years* afterwards we spawned him from the same ford a few pounds heavier." This same fish *may* have visited the spawning ground also in the preceding year without being recaptured for spawning purposes.

Our angling authority says further, in his communication: "I have had many opportunities of examining spent and half-spent females—those in which what is vulgarly termed the *waim* was exhausted, a few particles of ova remaining, and those taken by me or others in a spawning state; and I invariably found new formations of ova, in the shape of two lobes, corresponding to what are found in the spring run or clean salmon, and often measuring two inches in length, according to the size of the female *kelt*, or half-spawned *baggit*. This formation cannot be taken otherwise than as an index of what was to happen after the migration seawards had been accomplished, and the term of the salmon's stay in the salt water had expired—a term which may extend to six or eight

months, but has been ascertained in well-ordered rivers not to exceed that period."

None of the great naturalists, or fishers, who write on the natural history of fish—Jardine, Yarrell, or Couch—have thrown any light upon this phase of the life of the salmon. We search their works in vain to obtain information on this interesting point. The late Mr. Russel, in his book, "The Salmon," speaking at one place of the mysterious clean run fish of the early springtime, thinks "they must have passed the autumn or earlier winter in the sea; then they must have passed the winter without breeding, and thus we have the discouraging fact or hypothesis that the salmon is a fish which does not breed every year."

We have the authority of a gentleman residing in the north of Scotland, who is well versed in the economy of our salmon rivers, for stating that the salmon only spawns every two years. He says: "I have marked hundreds of *kells* in the months of February, March, and April, returning downwards to the sea; I have marked them with different marks every season, so that there could be no mistake, and I have never seen one single instance of one being marked in spring return to spawn the autumn of the same year; but I have seen hundreds with the individual mark return next spring good, clean, fine full fish. I believe that all salmon spawn only once in two years till they get too old, when they become barren; but still they frequent the fresh water, I suppose from habit, although there is no sign of roe or milt, and I have seen and taken them off the *redds* along with fish which were in the act of depositing their spawn."

It would be tedious to run through the facts of the numerous controversies which have arisen as to the rate at which salmon grow. The experiment of marking large numbers of these fish has been often resorted to, and at different places. Mr. Young of Invershin, in his day a well-known authority on the natural history of the salmon, tells us that *spawned* grilse of four pounds weight were repeatedly marked; and after their journey to the sea it was found that these grilse had become beautiful salmon, varying from nine to fourteen pounds weight, "the majority" returning in about eight weeks. It is much to be regretted that Mr. Young was not more explicit in his statements, because it would have been most interesting to know when these fish returned, after an absence of only two months, if they were again ready to spawn. It is these records of quick journeys that have doubtless given rise to the theory of the Rev. Dugald Williamson, which is that salmon in the course of the year perform two migrations. At any rate, we are entitled to ask this question: What does a salmon, which is only away from its birthplace for eight weeks, do with itself during the other ten months of the year? The rate of growth indicated by Mr. Young is most astonishing, and had it not been corroborated by other observers, would have been considered doubtful. A fish marked many years ago by the Duke of Athole was found to have increased eleven pounds and a quarter in the short space of five weeks and two days! The rate of growth of the salmon is so assured, that smolts have been found to return from the sea as grilse in the same season during which they left for the salt water; but, curiously enough, none of the observers took note of what we now consider the only unsolved problem in connection with the growth of the salmon, namely, whether the *same* fish spawns annually, once in two years, or once in three years. Probably Mr. Buckland will make some additional statement on the subject. A Tay salmon fishery proprietor, whom we have consulted as to this problem in the life of the fish, will not, with all his experience, which has been very varied, and has extended over many years, venture to give an opinion, and "thinks that the question is almost beyond the reach of positive proof." It is therefore incumbent on her Majesty's Inspector of Salmon Fisheries to prove his case.