RESULTS OF THE VARIOUS ATTEMPTS TO ACCLIMATISE *SALMO SALAR* IN TASMANIAN WATERS.

By R. M. Johnston, F.L.S.

Tasmania has some reason to be proud of her efforts to acclimatise the most important edible fish of Europe, well named the "King of Fishes" *(Salmo salar)*. It is now 36 years since the first attempt was made in the ship Columbus. This, with the two succeeding others, in 1860 and 1862 failed, simply because the artificially impregnated ova were not supplied with the more perfect arrangements subsequently discovered for preserving a low temperature throughout the whole period of transport by means of ice.

Nothing daunted, however, the original acclimatisers persevered in their efforts, for in the years 1862-3 James A. Youl, R. Ramsbottom, W. Ramsbottom, and Thos. Johnston carried out a series of experiments in the ice-vaults of the Wenham Lake Ice Company with such success that they actually hatched artificially impregnated ova which had previously been buried for 90 days in ice refrigerators in the Wenham Lake Company's vaults. Frank Buckland, who was asked to witness these experiments, was enthusiastic with this proof of the vitality of ova whose incubation was so long artificially retarded, and declared "these results most encouraging," and expressed the hope "that next season the actual experiment of sending the eggs to Australia in a fast sailing ship, packed in ice according to the experience now gained will be attempted." The actual attempt was made, under the supervision of Mr. (now Sir Jas.) Youl, on the 24th January, 1864, in the ship Norfolk, to Melbourne, and although the refrigerator boxes (170°) had to be transferred to the steamship Victoria in Melbourne, they finally were successfully transferred to the hatching boxes at the River Plenty on the 21st day of April, 90 days after the ova were shipped in London. The proportion of living ova was estimated to be about 45 per cent. of the whole shipped.

The subsequent mortality in the process of hatching, however, was very great, for of the original 90,000 of ova of *Salmo salar*, only 3,000 fry were distributed in our waters as healthy salmon fry, and of the original 1,500 ova of *Salmo fario* (brown trout), 300 fry were liberated in a healthy condition.

This shipment was, however, a great success, for the Tasmanian experiment demonstrated to the world that it was possible to retard incubation without destroying vitality for a period sufficiently prolonged to cover the transport of ova to the remotest parts of the globe. It also gave a fresh impulse to acclimatisation generally, for now that the main difficulty had been successfully disposed of it caused increased attention to the discovery of improved methods in the important details of packing and insulating.

One of the most important discoveries in this respect was the result of general observation, viz., that if the ova had arrived at the *eyed* stage of development prior to being insulated in refrigerating boxes and chambers they would be more able to survive the adverse conditions to which they would be subjected by artificial refrigeration and the accidents during prolonged retardation of development when transported to long distances.

Another important lesson taught by noting causes of failure was the necessity for guarding against the ice doing damage as it melted into smaller dimensions by arrangements which would confine its mass in separate though contiguous receptacles while securing a continuous supply of the melting ice to each tray of ova embedded and overlapped with clean pressed layers of soft moss. The beneficial result of these improvements in matters of detail is exemplified by the last splendid experiment carried out from start to finish by the grand veteran of acclimatisation, Sir Thomas Brady; for out of the 400,000 eyed ova packed by him in insulated boxes there were not more than 2 per cent. of mortality when transferred to the hatching boxes of the River Plenty on April 19th, 1888.

This most successful result has far surpassed the expectations of the most hopeful, and the colony owes a deep debt of gratitude to Sir Thomas Brady, "the Grand Old Man," who has in this and in former experiments enthusiastically traversed the length and breadth of "Ould Ireland," collecting ova, capturing and stripping mature fish, and fertilising and packing ova. No one but those engaged in such work can form an estimate of these loving labours; the long weary miles of travel in rain and snow; wading in rivers up to the armpits for hours together; the laborious hours preparing trays and tenderly laying out the thousands of tiny pink eggs; and the anxious care of packing and provision for transport. All these matters would be beyond the powers of ordinary men, but they have been joyously and successfully overtaken by this grand enthusiast who has shown Tasmanians, that indomitable energy and enthusiasm in a good cause breaks down all difficulties, laughs at mere inconvenience or exertion, and overthrows obstacles of every kind. If Tasmanians are thus deeply indebted to Sir Thomas Brady, the generous protector and friend of the poor struggling fishermen of Ireland, they are also under the deepest obligation to Dr. Agnew, whose unabated interest in the acclimatisation of edible fishes in Tasmania is proved by his munificence in bearing the whole expense of the last splendid enterprise.

The princely gift is not merely creditable to himself, but it adds lustre to the colony which produces men like him, who are as much distinguished for wisdom in the conception of making such thoughtful provision for the material welfare of the land of their adoption as for the generosity which carries it into effect. The "Agnew" experiment deserves to be a success.

OTHER PROBLEMS STILL AWAITING SOLUTION.

While we have to congratulate ourselves on the success so far of the Agnew experiment, there is still another problem to solve. Will the veritable progeny of *Salmo salar*, when liberated in our waters, survive and perpetuate their kind? This is now our real trouble and anxiety. It formed the subject of many interesting papers read before the members of this Society by the late Mr. Morton Allport, whose name will always be remembered in connection with the acclimatisation of the salmonidæ. That we have good reason to be anxious still of this result, and to discuss its probabilities, is manifest to every one who has taken any interest in the acclimatisation of the true salmon (*Salmo salar*). It is now twenty-two years since the first live fry of *Salmo salar* have been liberated in our waters, since which time repeated successful hatchings have added to the original stock. Notwithstanding this, no fish of the salmon family, now so common in our seas, has been captured, which can with confidence be referred to the European type of *Salmo salar*. The type of migratory salmonoid, now so common in the Derwent, in certain respects comes close to the smolt and grilse form of *Salmo salar*, but in a greater degree—although extremely variable within limits—its characters correspond more closely with the chief varieties of *Salmo trutta* (*S. eriox*, *S. brachypoma*, and *S. cambricus*). If, therefore, we assume that the varieties so common in our waters are actually the descendants of the few individuals of *S. trutta* originally liberated (496 fry liberated) in 1866, what has become of the many thousands of fry of *Salmo salar* liberated in our waters in the several experiments since the year 1864?*

* Excluding the last successful shipment it is estimated that out of the 38,000 fry hatched from British and Irish eggs, there were about 97 per cent. of *S. salar*! 2 per cent. of *S. trutta*, and scarcely 1 per cent. of *S. fario*.

To this question several rough guesses have been made by various authorities, but all of which are most unsatisfactory, as in my opinion none of them were arrived at either by a scientific method or in a scientific spirit. They were purely rough guesses, as already described.

It is not necessary to discuss the whole of the opinions advanced at different times. It will be sufficient to bring under review the three which have found more or less favour with some. These are—

1 (the Hybrid Theory).—That the ova introduced were not derived from parents that were true types of *Salmo salar*, but owing to mistake either the ova of hybrid forms were introduced, or that the ova of *S. salar* by mistake were fertilised (artificially) by the semen of *S. trutta* or *vice versa*.

2 (the Extinction Theory).—That the conditions of the new environment in Tasmania, whether of temperature, food, or enemies, were so adverse to the young of the *S. salar* that they speedily died out.

3 (the Exodus Theory).—That the temperature of our waters range so high that in consequence the fish do not return to their native rivers, but wander away from our shores to more congenial waters.

Thus we have to examine three distinct conceptions, which for convenience may respectively be classed as (1) the hybrid theory, (2) the extinction theory, and (3) the exodus theory.

THE HYBRID THEORY.

That hybrid breeds between the various species of salmon exist in large numbers in European and American waters is too well confirmed by Johnson, Gunther, Day, Brady, Francis, Buckland, and other authorities, whose observations have been extensive and accurate. That these hybrids interbreed and perpetuate their several overlapping varieties has also received the most ample confirmation.

To assume, however, as Dr. Gunther seems to have done in his "Study of Fishes" (p. 642), that only hybrid forms have been introduced to Tasmania, is quite a different matter, and is, moreover, without justification, when all the facts of the case are judicially examined.

In the first place, let it be clearly understood that the ova stated to have been obtained from *bona fide* examples of *Salmo salar* have neither been collected at one time, at one place, nor from one particular pair; neither have they been selected and fertilised by one particular person.

On the contrary, there were five distinct shipments of ova successfully transported and finally hatched and liberated in Tasmanian waters in the years 1864, 1866, 1884, 1885, and

1888. The ova of *Salmo salar* thus transported, amounted to about eight hundred and fifty thousand.

The ova were obtained under the direction of Youl, Buckland, Francis Francis, Brady and others eminently qualified to judge—aided in each district by the most skilled local experts. The pairs of parent fish, as might be expected, represent many distinct individuals taken from many widely separated salmon rivers in England, Wales, Scotland, and Ireland, including the Rivers Ribble, Hodder, and Tyne in England; the Dovey in Wales; and the rivers Shannon, Liffey, and Erne in Ireland.

Now, assuming that one or two mistakes might have been made by these various experts, this would not in any way affect the greater number of ova collected and fertilised at other times and places; and surely it would be too preposterous to assume that all the separate selections made by so many experts failed owing to a similar mistake in each separate case, in different districts, and at different periods. The idea of hybridism under all such circumstances is certainly extremely improbable.

The names already mentioned as being concerned in the selection are quite sufficient to dismiss the hybrid theory as untenable as an explanation of the apparent absence in Tasmanian waters of the pronounced types of the European *Salmo salar*.

THE EXTINCTION THEORY.

The second guess is not so easily disposed of, viz., that the conditions of the new environment in Tasmania, whether of temperature, food or enemies, were so adverse to the young of *Salmo salar* that they speedily died out. The non-appearance of unmistakable examples of *Salmo salar* after so many years certainly adds great force to this conception, and would of itself be conclusive if there were no alternative presented to us accounting for the absence of typical forms of *S. salar*.

As, however, alternative theories hereinafter discussed may also account for the absence of the normal European type it is necessary to examine the present theory most carefully. First, let me confess that the extinction theory is sufficiently reasonable to demand serious consideration.

It is conceivable that the extremes of temperature in our rivers and seas, or the numerous powerful enemies, such as the barracouta, are such as may have accomplished the destruction of the progeny of *Salmo salar*.

There are strong reasons, however, for the belief that the theory of extinction on such grounds is unsatisfactory if not untenable. In the first place the assumption that the local temperature of our waters would cause the extinction of *Salmo salar*, although apparently confirmed by the somewhat high range of surface or shallow water, is open to several objections.

1st. We have positive evidence to the contrary, gained from the close observation of many years of the progeny of *Salmo salar* in confinement in the shallow artificial ponds connected with the Hatchery at the River Plenty.

It is reasonable to infer that the water of these shallow ponds are more subject to extremes of temperature than our open rivers and seas, where the fish are at liberty to seek for the more congenial temperature in the deeper waters. When we find, however, that under the most unfavourable conditions for anadromus fishes—viz., confinement permanently in shallow fresh water ponds--the undoubted progeny of *Salmo salar* not only survive for very many years, but even breed there, we have the best of reasons for being dissatisfied with the temperature argument.

Apart from this: the idea that the temperature of our open waters of rivers and seas varies to any material degree from that of the southerly portions of Ireland and England where the salmon exists is based upon very imperfect reasoning. The vertical isotherms of our estuaries and seas have never been properly investigated, and so far I am aware we are not providing Tasmania as yet with appliances for conducting investigations of this kind.

It is true we have perfect records of fresh water shallows, as at the Plenty, and of sandy flats, as at Mr. Saville Kent's late salt water enclosures at Sandy Bay; but these are utterly deceptive as affording an index of the variations or mean temperature of neighbouring depths of the estuary, far less of the submarine depths of the various sea-basins lying beyond and hidden to ordinary observation. It must be borne in mind that the sandy flats at the old Fisheries Establishment at Sandy Bay are exposed in summer, and especially in January, to the direct rays of the sun at low water, and at high water stage the sands are only covered for a very brief period by one to two feet of water. It would be absurd, therefore, upon such evidence, to gauge the varying isotherms, even at a distance of 400 yards from the shore line. In shallows laid bare to the sun's rays for many hours at each tide, it is natural to expect that the surface layer of shallow water would indicate a very high range in January, but similar shallows in Great Britain and England might be selected showing a nearly equal high range in the height of summer. The proper way to ascertain the temperature of our waters is to follow the scientific method as carried out recently by Dr. Hugh Robert Mill* in the investigation of "The temperature of the Clyde sea area." In Dr. Mill's

* *Nature*, May, pp. 37-39 ; 56-58.

interesting account he states that he employed Messrs. Negretti and Zambra's patent standard deep-sea thermometers. The temperature was ascertained at the surface, at 5 and 10 fathoms, and at a distance of 10 fathoms down to the bottom. The Clyde sea area extends over 1,300 square miles, and includes three grand plateaux, whose mean depths were respectively 27 fathoms, 50 fathoms, and 80 fathoms. The depth off Skate Island, near Tarbert, was as much as 107 fathoms. One of the most instructive investigations was carried out at Strachur, in Upper Loch Fyne, where a depth of 50 fathoms exists.

In this region eight sets of observations were made with the following results:—

	Surface.	Bottom.
	°	°
April 20	42·6 ...	41·9
June 21	49·2 ...	44·1
August 11	54·1 ...	44·2
August 25	53·5 ...	44·2
September 27 ...	52·4 ...	44·1
November 17 ...	46·4 ...	44·2
December 29 ...	41·0 ...	44·7
February 4	43·0 ...	45·9

The remarkable lesson to be derived from this investigation is that the effects of the surface temperature in summer does not penetrate to depth of 50 fathoms until the following February, and that even then, when at the maximum of bottom temperature, it is lower than maximum surface temperature by 8·2°. It is also instructive to observe that while the surface temperature ranges from 41·0° in December to 54·1° in August, *i.e.*, total range of 13·1°; the bottom temperature only ranges between the extremes of 41·9° in April, to 45·9° in February, *i.e.*, a total range of 4°. Thus the bottom depths only feebly follows at a wide interval the variations of the surface temperature.

Besides, it is clearly shown that in the hidden depths of the sea there are hills, valleys, and protected basins, whose temperatures vary with their depths, and with the physical barriers which isolate basin from basin. When, therefore, we realise that shallows bared at low tide were not even taken into consideration, and when we have good reason for assuming similar variation in the far-reaching Derwent sea area of Tasmania, we have the strongest reasons against resting upon any argument which assumes actual knowledge of the temperature of its varying depths.

At any rate these observations are sufficient to cause us to distrust theories based upon guesses or imperfect observation

With respect to natural enemies, it is undoubted that in the barracouta (*Thyrsites atun*) and kingfish (*Thyrsites solandri*), the sea-going salmonoids have swift and rapacious foes to contend with; but surely if the existing migratory salmonoid of the Derwent is able to survive among them, there is less fear that the normal European type of *Salmo salar* would stand a smaller chance of escape.

The food of our waters, suitable for the salmon, is at least as rich and varied as in the waters of Great Britain and Ireland, and for this reason we may dismiss the last argument in favour of the extinction theory.

THE EXODUS THEORY.

The exodus theory is a very old one, indeed. It was advanced originally as an argument against the introduction of *Salmo salar* to Tasmanian waters prior to the first attempt made to transport live salmon ova to Tasmania. Owing to the absence of any sign of the normal type of the European *Salmo salar* it has been recently revived by Mr. Saville-Kent, who even went so far as to suggest the coast of Japan as the favoured shore to which possibly our wanderers directed the march of their exodus from the assumed uncongenial warmth of the temperature of Tasmanian waters. The conception of an exodus from these waters is not regarded by me as unreasonable. Far from it. Nevertheless I am not convinced that the reasons for the exodus are sufficient. Mr. Saville-Kent's suggestion that they have possibly wended their way to the coast of Japan appears to me to be altogether improbable and opposed to all our notions with respect to the instinct of animals. It is conceivable, although improbable, that some hereditary instinct of the Tasmanian salmonoids might lead them to pierce the highly-heated isotherms of the equatorial latitudes—a physical barrier as compared with the worst possible condition of Tasmania—corresponding to "jumping out of the frying-pan into the fire." But if they did attempt this strange freak of instinct, they would be guided by some notion of the natal locality of their ancestors, and that would be in the direction of the Irish coast, following the great flow of the Gulf Stream through the Atlantic, and not in the opposite direction of Japan.

If the exodus was carried out in obedience to some instinct of temperature without reference to a possible hereditary instinct of locality, we ought to expect them to travel in a southerly direction, that is, towards the latitudes of the Antarctic circle. But of this possible migration wo have not the slightest evidence. On the contrary, the evidence of New Zealand acclimatisation affords a complete parallel to that of Tasmania. Surely we might hope that in the most southerly shores of the Southern Island the progeny of the normal type of the European *Salmo salar* might find tolerably suitable conditions as regards temperature. Observation, however, discloses the important fact that the only type of migratory salmonoid found in their seas corresponds in all respects with that of the Derwent.

The only conclusions left to us, therefore, so far as I can judge, are :—either that the assumed wanderers have lost themselves in the wilderness of waters in the direction of the South Pole, or—that many of the variable types of salmonoids now inhabiting the Derwent are in reality the actual descendants of the *Salmo salar* of Europe, modified by the combined influences of retarded incubation in transit, and the varying conditions of their new environment.

MODIFICATION DUE TO ENVIRONMENT, ETC.

To assume, as a last resource, that arrested incubation, together with the changed condition of a new environment, may have modified some of the few remaining characters (such as the size of scales, relative size of maxillary and snout), which in European waters now alone serve satisfactorily to distinguish *Salmo salar* from some of the larger protean forms of *S. trutta*, is not so extravagant a notion that it may be dismissed without thoughtful enquiry.

If, on the one hand, the lack of special knowledge on the part of practical fishermen and pisciculturists frequently lead them to ignore important although variable characters (often hidden to common-sense appreciation), which distinguish closely allied forms ; yet it must be confessed that naturalists in dealing with a protean genus having a wide range of variability, may have a tendency to err at times in seizing arbitrarily upon certain extreme types, and upon these base a classification of a complicated nature, which may serve some useful purpose in grouping the few specimens preserved in Museums, but which may be of little practical value in classifying the myriads of intermediate or overlapping forms captured and sold in the fish markets. Classifiers in Museums may easily resort to the theory of hybridism for labelling the few perplexing intermediate or overlapping forms which find their way to Museum collections ; but what resources have the fishmonger and purchaser when such forms are brought in large numbers to market. Take, for example, the many examples of large-sized silvery forms of salmon caught in salt water, whose maxillary largely exceeds the length of snout, and whose transverse series of scales between root of adipose fin and lateral line exceeds 11 in number. Are these forms sold as real salmon or as salmon trout ? If we examine the fish stalls, or question the pisciculturist or fishmonger, we ascertain that in nine cases out of ten the silvery form, the colour of the flesh, and the size alone determine their opinion, and all such forms are pronounced and sold as *Salmo salar*. All doubts of the classifier regarding the nicer points are readily set aside as the trivialities of naturalists, with perhaps the contemptuous observation "that no two men of science are able to agree with each other's views in a matter of classification."

As regards the fish market it may be practically ascertained that there are only three forms of the salmon family recognised, viz.: (1) The common river or lake trout. (2) The smaller sizes of migratory species, generally recognised either as grilse or salmon trout. (3) All the large-sized migratory forms, almost invariably recognised as salmon, *i.e.*, *Salmo salar*.

In some cases the brown shade or colour, and number, colour, or disposition of spots, may cause ordinary persons to allow the possibility of hybridism; but this admission is rarely made in respect of characters which escape their observation—such as the length of the maxillary, the development of the limb of the præ-operculum, and the number and size of the transverse series of scales. Nor is this to be wondered at. As regards the genus *Salmo*, nearly all the characters selected by the classifier are of the most unsatisfactory nature. No two individuals agree in any point exactly; every selected character varies in the widest manner, and the greater number of these overlap the bounds which ideally separate the various species of the classifier.

So long as the limits of variability of individuals of the same parents in freedom are uncertain or obscure, reliance upon the minute differences of many trivial characters must certainly be a fertile source of error. Even observations made in respect of fish in artificial confinement show that within such restricted conditions individual variation is very considerable. But this is a small matter. What naturalist is prepared to declare the full extent of the limits of individual variation as regards form, colour, and ornamentation throughout the whole life development *ab ovum*, under all the possible changes of environment, including differences in food, temperature, and other important conditions characteristic of the different localities open to the migration of fishes? It does not follow because we are unable satisfactorily to view the free movements of fish throughout their life history in different localities, as in terrestrial forms of life, that the changing conditions of environment do not equally produce marked differences in many of the characters now depended upon for the distinction of species.

So long as individual variation, together with the influence of differing environments are unknown or obscure, so long must we be dissatisfied with a classification which so largely depends on the theory of hybridism to account for the vast number of intermediate forms which link together the several closely-allied types, now artificially erected into species for the mere convenience of local classification.

These remarks are not intended to reflect upon the necessary classification adopted locally for museum collections. They are only intended as a protest against the classification so artificially based when it is assumed to be in truth naturally fixed, and capable of maintaining the various characters unmodified by transference to the widely changed conditions of a new environment ; as for example, the transfer of selected types of European species to the waters of Tasmania.

When the few trival distinctions which alone serve to support the adopted nonemclature of Europe fail to appear in what in all probability are deemed to be the true acclimatised descendants of such species, we have no right to assume upon such uncertain ground that the characters of their descendants are so fixed as to remain unaffected by the new conditions under which they live. It is quite possible that it may be so ; but that is an open question. That they are not so fixed is at least equally possible; and this conception, moreover, is more probable when all the facts of the case are taken into consideration. When individuals show one or two peculiar characters in one environment which are not reproduced by what appears on good evidence to be their descendants in another widely differing environment, it is more reasonable to assume that the characters have been modified by the transfer, than that the extreme forms so largely and successfully introduced into our waters should altogether cease to exist, or vanish from our shores. It must be borne in mind that among fishes showing every gradation of change within the limits of variability, the predominant types in one locality may be due to the influence of local environment, rather than to hereditary influences. To assume, as is too frequently the case, that such prevailing types indicate greater purity of breed, is to beg the whole question at issue. It is well known that the prevailing forms of sea-trout in English, Welsh, and Scotch streams, differ so considerably with the locality that classifiers regard them as distinct species. The forms known as *S. trutta*, *S. gellivensis*, *S. Cambricus*, *S. brachypoma*, are examples of this class.

But although the minor characteristics which served imperfectly to distinguish these types are admitted, there is no proof that the prevalent type characters are not purely the effect of local environment which might be speedily obliterated or transformed by transfer to a different environment. The writer drew attention to this uncertainty in the years 1879* and 1882†. Writing of the new modification produced in the prevailing forms of migratory salmonoids acclimatised in the Derwent, he states: "Whether this local form is the result of hybridism, as suggested by Dr. Gunther, or is simply the effects of the differing conditions of a new environment, I am as yet unable to decide—perhaps a good deal may be due to both influences. It is noteworthy, however, that already in New Zealand ‡ and Tasmania the allied species *S. fario* var. *Ausonii* has developed into types which are characteristic of particular local streams. This variability in relation to environment is very suggestive, and may yet help to explain the trifling variable differences in character often overlapping between *S. cambricus*, *S. gallivensis*, *S. brachypoma*, and *S. trutta* of Scotch, English, and Irish streams. Characters which may be greatly affected by environment are not to be depended upon, and in the opinion of some authorities in other branches of natural history such differences would not be recognised as of specific or even sub-specific rank. The assumption of hybridism is to me extremely unsatisfactory, for the reason that the extreme types steadily perpetuate themselves in European waters, notwithstanding the extraordinary facilities among fishes for intercrossing by natural means which probably have existed unrestricted for ages.

The reasonableness of this opinion has received strong confirmation subsequently by Dr. Day in his works on "British and Irish Fishes," and "British and Irish Salmonidæ," where he actually reduces all the types named to varieties of one species (*S. trutta*).

It is not an easy matter to tell what characters are of specific value and what are not, even when the fullest information has been obtained as to the variability of the individuals of a group; and the greatest living authorities often come to different conclusions. It would be unreasonable, therefore, to expect, in the absence of the fullest knowledge respecting variation of size, colour, sculpture, distribution, etc., that any author could determine with accuracy those characters which alone should entitle certain forms to specific rank. Of course, I am aware of the difference of opinion which existed, and which still exists in a more modified form, with respect to what constitutes a species and what a variety; but there is now, with few exceptions, sufficient agreement among the leading philosophical naturalists to leave little room for doubt in cases

* *Mercury*, Hobart, Nov. 25, 1879: † Fishes of Tasmania, p. 130, Hobart, 1882. ‡ *On the Brown Trout introduced into Otago.* By W. Arthur, C.E. (Trans. N.Z. Inst., 1883.)

where the definition of a species is based upon the observation of a large number of specimens from different localites. I do not use the words *species* as the type of a group of allied organisms which have a rigidly determinate number of immutable characteristics in common; for the characters which, as a whole, are relatively constant in those sections which we group under a specific name are themselves variable, and are frequently to be found interlapping other groups of merely relative constant characters, but which we yet acknowledge as belonging to a distinct species.

The type of a group termed species is fixed upon mainly to define the maximum of relatively constant characteristics around which all the individual varieties may cluster, and which shall serve to distinguish the type species from a closely allied group of a similar character. Indeed, we may picture species as the nodes of an irregularly moniliform series, whose extremities are in some cases sharp and distinct, and in other cases mere constrictions, where the extreme individuals of each node or group meet, and can hardly be distinguished from each other. But even when we clearly understand, and agree with each other as regards the principles which determine classification, it is often perplexing to fix upon characters whereupon to erect the standard of a species or variety, for it is well known in practice that characters are seized upon rather from stability and association with certain other characters than from absolute differences in particular features. Gwyn Jeffreys thus defines the degrees of difference which should determine species:—"They constitute more or less extensive groups of individuals which resemble each other as well as their parents and offspring to the same extent as we observe in the case of our own kind. These groups to deserve the name of species must be distinct from others: because, if any of them are so intimately blended together by intermediate links, so as to make the line of separation too critical, the test fails, and a subordinate group, or what is called a 'variety,' is the result. For this reason it is indispensably necessary to compare as great a number of individuals as possible, and especially a series of different ages and sizes, commencing *ab ovo*, as well as specimens collected from *various localities*." And again, he states in respect of what are termed varieties, that "the characters by which they usually differ from species consist of size, comparative proportions of different parts, colour, and degree of sculpture;" and he remarks that such differences "originate in some peculiarity of climate, situation, composition of soil or water which they inhabit, the nature or supply of food, and various other conditions." These latter, he adds, may be "permanent or local." When permanent he calls them *races*, but, as he himself remarks, it would "be difficult" to discriminate between a *race* and a *species*.

When we consider all such matters, what assurance remains to us "that the remaining and only trustworthy specific character differentiating *Salmo salar* from *Salmo trutta*,"* —viz., "eleven rows of scales in an oblique row from the adipose fin to the lateral line, all forms of *S. trutta* having fourteen or more such scales,"—does not break down or become modified in the totally different environment of the antipodean waters of Tasmania to which *S. salar* has been so largely introduced?

Are English ichthyologists prepared to declare *a priori* that the scales of the variable genus *Salmo* are alone fixed, and cannot be modified by the changed conditions of a totally different environment? Surely not.

If this possible modification be admitted by them, what becomes of the classification which depends upon this last critical test for the separate specific recognition of the large, mature silvery forms of *Salmo salar* and *Salmo trutta*. The answer is simple enough: the classifier's final test breaks down entirely as a guide to the proper classification of the two supposed distinct species. The experience of acclimatisation of *S. salar*, and its results in the waters of Tasmania, formerly devoid of any form of the genus *Salmo*, affords better evidence to naturalists bearing upon variability than can possibly be obtained in regions, as in Europe, where the variability due to influence of any one locality or river is being disturbed, and inferences obscured, and made hazardous by the constant influx of stragglers originally bred in other localities where other characteristics have been developed, and which may be perpetuated for a considerable time with more or less persistency in foreign waters among the prevailing local types.

No such interfusion from foreign sources can affect the progeny of undoubted *S. salar*, largely introduced at different times, and *S. trutta* only once introduced in small number, in Tasmanian waters; and consequently in such a region there is less uncertainty as to what may or may not be the extent of the modifying effect of environment *per se* than in European waters where each region's locally-bred forms are continually being interfused with immigrants bred in distant regions.

The conclusions to be drawn from these differing conditions have not yet received that amount of attention from classifiers which they deserve, for it is too evident that *a priori* and not *a posteriori* argument still largely colours the opinions of many, and this arises, no doubt, from the treacherous tendency

* See *Nature*, January 12, 1888

to restrict observation to the local region best known to the particular observer.

Unfortunately, opinions expressed hitherto with respect to the odd examples sent to English authorities for determination, have merely added confusion to the whole question. Different specimens at different times have been doubtfully pronounced to be *S. salar*, *S. trutta*, *S. fario*, and a hybrid between *S. trutta S. fario*, without any detailed reasons having been given for arriving at these very opposite conclusions.

Authoritative opinions of this kind are worse than useless, as we do not know the points of evidence upon which the separate opinions were based. A knowledge of the local range of individual variability is absolutely necessary before a reliable opinion could be expressed by any scientific expert; and as this knowledge was not possessed by European experts I am of opinion that their decisions are not of much value in matters which relate to variation induced by local conditions in Tasmania. Besides, as urged by me in my observation on "The Fishes of Tasmania," in the year 1882, "Odd specimens cannot determine the curve of variability, nor can they determine whether the four fishes so differently named were not after all the progeny of the same parents."

I am not finding fault with the authorities referred to, as possibly they did their best in relation to the fixed classification of English types; but seeing that the new environment might be expected to produce remarkable modifications of many characters it might be expected that such considerations should have been allowed for and specially commented upon. It is true some of our types examined seemed to puzzle the best authorities, but it is significant that the nature of the variations which caused hesitation has not been publicly recorded in support of whatever opinion was expressed.

That I am not overstating the case in this respect is borne out by the high testimony of Sir Thos. Brady. In his address to the Members of the Royal Society of Tasmania on April 23rd, 1888, Sir Thos. Brady stated that three or four years ago, Mr. Seager—Secretary to the Salmon Commission of Tasmania—sent him three fish, which, after writing his opinion of, he submitted to an eminent Member of the Royal Society of Dublin, an ichthylogist, and a well known scientist, who was not aware of his opinion, and wrote one that exactly coincided with it. It was, that one fish was a true salmon, one was not, and there was a doubt about the third. He took this fish (the salmon) before one of the most celebrated scientists and ichthyologists, a man with a European reputation, but this gentleman would not give an opinion *until he knew where it came from!* After some demur the information that it came from Tasmania was given, and the authority then said *it was not a salmon!* As he went away this gentleman said—"You are going to take it to somebody else. *You may take it to the six best scientists in England, and you will get six different opinions*"! ! If such be the perplexity with respect to the progeny of well-known English species now inhabiting Tasmanian waters in such numbers, what shall we say of the sufficiency of the established classification which fails to determine satisfactorily their true relationship.

The fishes which in size, colour, and general form, approach the true salmon of England, as developed in Tasmania, although they will not fit the English classifiers' limits as regards the relative length of snout, the relative length of maxillary to snout, and the exact number of rows of scales between adipose fin and lateral line, yet conform so closely in the more apparent characteristics recognisable by fishermen and pisciculturists, that even Sir Thos. Brady—who has the widest knowledge of the common salmon of Ireland and of the fish supplied as salmon in the English markets—has no hesitation in pronouncing a fine specimen (39 inches long, and 28lbs. weight, caught in the Huon River by His Excellency Sir Robert Hamilton) to be "a true salmon," and he further added "that no practical man who would see the fish would ever think of calling it anything but a salmon." He further stated: "Whether it be the true *Salmo salar* or not, it is, at any rate a fish which would be considered and treated as a salmon in salmon countries; which would be sold and purchased as such; and if the colonists of Tasmania, seek for more than Ireland, which now exports salmon to the amount of over £600,000 worth annually, he could not help saying that . . . they are hard to please and ought to go without them."

And yet, after all, this fine fish had 14 or 15 scales in a series between adipose fin and lateral line, had a slightly brownish tinge on sides though very silvery, and the maxillary greatly exceeded the distance between the end of snout and eye, and therefore, according to the recognised classification of England, it would be pronounced *Salmo trutta*. What shall the verdict be, therefore? Has the *Salmo salar* so largely imported and liberated in Tasmanian waters failed to survive or vanished from our shores; or has the transfer to the totally different environment in antipodean waters broken down or modified the one or two trifling characteristics which now alone serve to mark the critical passage between the allied English types of *Salmo salar* and *Salmo trutta?* If I am asked to choose between these two alternatives I unhesitatingly accept the latter.

In support of this view I have to add that my opinion is not based upon the casual examination of one or two specimens. During the last twelve years I have carefully examined and noted the varying characters (over thirty in each specimen) of hundreds of examples taken in various localities. I have not made final comparison of the relative size of fins and other essential characters of different sized specimens until each absolute measurement was reduced to a common equivalent.

That is, I have been in the habit of regarding the total length of each fish as 1,000, and by computation I have reduced all other parts in relation thereto.

In no other way can the observer appreciate with the fullest accuracy the relative agreements and differences of individuals of different sizes and ages. In no other way can the various modifications of locality, age, and variety, be satisfactorily compared and appreciated.

That due attention has been paid to the many nice distinctions which characterise the individuality and species of the English and local salmonoids may be admitted upon reference to the following tabular analyses of the principal typical specimens deposited in the British Museum, for which measurements have been recorded in Dr. Gunther's Catalogue of Fishes, Vol. VI.; with which typical individuals of the three principal groups of Tasmanian salmonoids are compared according to a common standard; all the measurements have been carefully reduced by me, a work of considerable labour in itself.

			English Types.			Tasmanian Types.		
			S. salar.	S. trutta.	S. fario.	White trout.	Intermediate type.	S. fario.
*	1	Pylor-Cæca	58-77	49·61	33-46	47-62	46-72	50-56
*	2	Relative greatest depth of body	170-248	189-219	184	207-256	262-302	209-245
*	3	,, length of head	182-260	198-228	221	198-223	195-263	184-255
*	4	,, snout, length	58-123	63-93	79	53-105	66-88	67-76
*†	5	,, maxillary	67-96	74-107	89	80-82	79-106	77-103
*	6	,, greatest width of operculum	45-69	36-47	44	40-53	38-57	45-47
*	7	,, ,, depth ,, ...	57-72	71·81	63	60	66-116	62·67
**	8	,, distance occiput to origin of dorsal ...	250-304	255-346	284	256-290	220-494	290-408
*	9	,, distance end of dorsal to root of caudal	301-340	333-356	312	340 344	312-337	205-342
**	10	,, length of dorsal fin	96-115	86-104	104	110-111	115-138	122-125
**	11	,, height ,, ,, ...	91-134	81-116	114	120	88-138	105-163
*	12	,, length of pectoral fin	118-192	81-116	127	115-120	116·169	111-148
*	13	,, root of pectoral to root of ventral ...	250-272	239-272	231	253	269-300	267-282
*	14	,, length of ventral fin	96-134	86-121	114	100	92-131	104-118
**	15	,, ,, anal fin	55-72	74-84	82	80-124	77-100	86-92
**	16	,, greatest depth of anal fin	82-105	90-123	114	123-124	102-175	116-143
*	17	,, ,, length of largest caudal ray ...	130-163	108-139	114	140	111-143	111-143
*	18	,, ,, ,, of largest of middle caudal ray	67-74	63·97	76	53	70-100	74-82
*	19	Actual number of scales between adipose fin and lateral line	11-12	13-16	13-16	13-16	13-16	13-16

A study of the analytical table given reveals the fact that with the exception of one, or perhaps two, out of the 32 points, all the characters not only vary with each individual of the same species, but the range of this individual variability covers or overlaps the whole of the different species in English and Tasmanian types. The characters which alone serve to distinguish the English *S. salar* are—the transverse series of scales between lateral line and root of adipose fin, and the relative length of maxillary in adult specimens.

The specially distinguishing characteristics of Tasmanian fishes as compared with their British and Irish progenitors are common to the migratory and fresh-water forms, viz. :—

1. The prevailing greater relative depth and girth of the body.
2. The prevailing higher number of pyloric cæca* ranging as high as 56 in the brown trout form; the range of the local analogue of *S. salar* reaches as high as 72.
3. The prevailing greater relative length and depth of the dorsal and anal fins.
4. The prevailing greater relative distance of the dorsal fin from the occiput.
5. With the exception of the small silvery form of sea trout, the prevailing larger size of the adipose fin, with about six well-marked rows of rudimentary scales ascending upwards some distance from its base; the only distinguishing test between some of the large brown trout of the Great Lake and the migratory fish entering the sea is one of colour and ornamentation. No two specimens of the Great Lake fish agree in size, form, and number of the spots, nor in the general colour of the body; some having a deep brownish shade, while others are of a bright silvery colour, without a red spot or shade of brown. Between these there is every possible gradation. Every river has the effect of producing some more or less marked local characteristics.

Where the brown trout inhabit streams near to the sea they enter the salt water freely, and soon assume a bright and silvery appearance, although in most cases the tinge of the golden shade and their greater size readily distinguish these from the smaller *S. trutta*, which seems to linger in the salt water for a longer period (usually from July to November and December), and ranges farther towards the open seas.

* This great increase in the number of pyloric cæca has also been noted specially in New Zealand by Mr. Arthur.

We have, therefore, three races or varieties, if not three species, each with a wide range of variation.

1. *S. fario* var. *Ansonii*, attaining a very much larger size than the English type restricted to fresh water lakes and rivers.
2. The analogue of the English white trout, *S. trutta*.
3. The intermediate form partaking somewhat of the characters of 1 and 2 attaining a much larger size and entering salt water freely. This is the group to which the fish belongs recently caught by His Excellency, Sir Robert Hamilton, and deemed by Sir Thomas Brady to be a true salmon.

If it be the true analogue of the English *S. salar* it certainly has local characters which serve to distinguish it. And if the classifier persists in retaining the maxillary and scale tests, we must recognise it for the time being by a local name, and I propose for it the name of *S. salar* var. *Tasmanicus*, thus standing as a variety within the same species as varieties *Gaimardi* and *Ansonii* within the species *S. fario*. The characters given in table are sufficient for its determination.

By the characters already tabulated the three principal groups in Tasmania may also readily be determined.

That the introduced fishes will ultimately become an important article of food, and afford a large revenue to the colony, I have little doubt.

In conclusion, I have only to add that the peculiar nature of the problems demanding solution in the classification of our acclimatised fishes demanded of me that I should fearlessly express my convictions, as I have done in this paper. The great respect which I have for the wisdom and learning of the leading ichthyologists of England is none the less sincere because I am now obliged to state fully and clearly the nature of our difficulties, and I only hope that my observations may be of some use in establishing a more satisfactory basis for the classification of the salmonidæ of Tasmania.

IAN TYPES.

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SPECIES ACCLIMATISED IN TASMANIA.

	Anadromus.								
	S. trutta. (White Trout.)			S. trutta. Intermediate between S. trutta and S. fario.			S. fario.		
* Scales, transve to lateral li		13-16		b	13-16	*A		13-16	
** Pylor cæca ..				72	50	50	56	54	53
B				11			10·11		
D				13			13		
P				14			14		
A				10			10		
V				9			9		
L D				120			120		
L l				32			32		
3½	24	19	12½	20	c23½	39	19½	33⅝	32¼
T— 1	1	1	1	1	1	1	1	1	
* Greatest depth	·237	·263	·207	·287	·302	·262	·209	·245	·233
* Length of head	·223	·210	·207	·263	·215	·195	·255	·184	·227
Greatest girth ..	—	·592	·450	·662	·711	·665	·485	·564	·558
Least depth at ta	—	—	·080	·079	·108	·077	·077	·089	·092
Girth narrowest p	—	—	·200	·181	·252	·202	·255	·215	·227
* Distance end of	—	·105	·053	·088	·077	·066	·077	·067	·076
* Length maxilla	—	—	·080	·106	·090	·079	·102	·077	·103
Distance eye to a	—	—	·080	·072	·082	·079	—	·075	·085
* Greatest width	—	—	·053	·044	·057	·038	—	·045	·047
** Greatest dept	—	—	·060	·116	·091	·066	—	·067	·062
** Distance occip	—	—	·290	·494	·290	·323	·408	·312	·310
* Distance end of	—	—	·340	·312	·323	·337	·265	·342	·356
Length base of D	—	—	·110	·138	·125	·115	·122	·130	·124
* Greatest height	—	—	·120	·138	·129	·088	·163	·105	·101
Length of P. ..	—	—	·120	·169	·139	·116	·148	·111	·132
* Distance root o	—	—	·253	·300	·282	·269	—	·267	·267
* Length of V....	—	—	·100	·131	·118	·092	—	·104	·111
Distance root of	—	—	·170	·200	·197	·218	—	·191	·173
* Length of A.	—	—	·080	·100	·086	·077	·092	·079	·070
Greatest depth of	—	—	·123	·175	·143	·102	·122	·116	·124
Length of longest	—	—	·140	·138	·143	·111	·143	·111	·127
Length of middle	—	—	·053	·100	·82	·070	—	·074	·078

*A Th Hamilton in the Huon River, and pronounced to be "a true salmon" by Seal modifications. C. From Great Lake.

COMPARATIVE TABLE, CONTRASTING BRITISH AND TASMANIAN TYPES.

(All dimensions reduced in relation to total length, regarded as 1 or 1000 in each case).

BRITISH MUSEUM TYPE SPECIES.

	S. SALAR.					S. TRUTTA.					S. fario v. Ausonii.	S. Cambricus.		S. Cambricus x with S. fario.
* Scales, transverse series, root of adipose fin to lateral line	11-12							13-16			13-16		13-16	13-16
** Pylor cæca	generally 60-70; extremes, 55-77					43	45	44			33-46		30-47	
B	11-12							11			11-12		10 11	
D	14							13			13-14		14	
P	14							16			13		16	
A	11							11			10-11		11-12	
V	9							9			9		9	
L lat.	120							120			120		120-5	
L tr	22 26							24 26			26		27	
Total length—Inches	46	36½	22	6½	Mean.	35	20	27¾	18½	Mean.	28½	24	22½	19⅞
	1	1	1	1		1	1	1	1		1	1	1	1
* Greatest depth body	·248	·233	·170	·220	·218	·219	·206	·207	.180	·205	238	·177	·200	·184
* Length of head	·227	·200	·182	·211	·220	·228	·219	·198	·216	·215	·264	·213	·211	·221
Greatest girth	·604	·520	·454	·538	·529	—	·487	·504	479	·490	563	·410	466	468
Least depth at tail	·076	·069	·079	·086	·077	·086	·075	·090	·081	·083	·079	·078	077	·089
Girth narrowest part of tail	·216	·192	·197	·192	·199	—	—	·198	—	·198	--	·187	·200	·202
* Distance end of snout to eye	·097	·123	·068	·058	·086	·093	·099	·063	·068	·073	·106	·073	·062	079
* Length maxillary	·081	·096	·068	·067	·078	·107	·087	·074	088	·089	·121	083	·080	·089
Distance eye to angle of P.O.	·072	·082	·062	·058	·068	—	·087	·076	·081	·081	·092	·073	·084	·076
* Greatest width of O.	·040	·069	·045	·058	·054	·036	·037	·041	·047	·040	·044	047	·044	·044
** Greatest depth of O.	·065	·072	·057	·067	·065	071	·081	·072	·078	·075	·083	·067	·073	·063
** Distance occiput to origin of D	.304	·288	·295	·250	·284	·315	·309	·315	·317	·314	317	255	·295	·284
* Distance end of D. to root of C.	·324	·301	·340	·317	·320	·343	·356	·347	·351	·349	·334	·333	·344	·342
Length base of D.	·101	·099	·096	·115	·103	·086	094	·104	·101	·096	·097	·104	100	·104
* Greatest height of D.	·097	·097	·091	·134	·100	—	·094	·081	·095	·090	·116	099	·089	·114
Length of P.	·118	·123	·119	·192	·138	·121	·112	·104	·115	·113	·123	·120	122	·127
* Distance root of P. to root of V.	·270	·260	·272	·250	·263	·272	·250	·293	·257	·268	·230	·239	255	·231
* Length of V.	101	·103	·096	·134	·109	·093	·087	·086	·088	·089	·121	·099	·106	·114
Distance root of V. to origin of A.	·227	·177	·182	·096	·170	·200	·181	·207	·165	·188	·171	·187	·200	·177
* Length of A.	·072	·055	·062	·086	069	·078	·081	·081	·081	·080	·074	·078	·084	·082
Greatest depth of A.	·097	·082	·091	·105	·094	—	·094	·090	·095	·093	·123	·109	·111	·114
Length of longest C. ray	·130	130	·142	·163	·141	·114	·125	·108	·128	·119	·123	·125	·139	·114
Length of middle C. ray	—	—	·074	·067	·070	·071	·069	·063	·074	·069	·097	·073	·078	·076

SPECIES ACCLIMATISED IN TASMANIA.

	ANADROMUS. S. TRUTTA. (White Trout.)				ANADROMUS. S. TRUTTA. Intermediate between S trutta and S. fario.			S. FARIO.		
* Scales, transverse series, root of adipose fin to lateral line			13-16		h	13-16	*A		13-16	
** Pylor cæca	47				72	50	50	56	54	53
B	11				11			10·11		
D	13				13			13		
P	14				14			14		
A	10				10			10		
V	9				9			9		
L lat.	120				120			120		
L tr	28				32			32		
Total length—Inches	23½	24	19	12½	20	c23½	39	10½	33⅝	32¼
	1	1	1	1	1	1	1	1	1	
* Greatest depth body	·256	·237	·263	·207	287	·302	·262	·209	·245	·233
* Length of head	·198	·223	·210	·207	263	·215	·195	·255	·184	·227
Greatest girth	·549	—	·592	·450	·602	·711	665	·486	·504	·558
Least depth at tail	·081	—	—	·080	·079	·108	·077	·077	·089	·092
Girth narrowest part of tail	·213	—	—	·209	·181	·252	·202	·255	215	·227
* Distance end of snout to eye	—	—	105	·053	·088	·077	·066	·077	·067	·076
* Length maxillary	·082	—	—	·080	·106	·090	·079	·102	·077	·103
Distance eye to angle of P.O.	—	—	—	·080	·072	·082	·070	—	075	·085
* Greatest width of O.	.040	—	—	·053	·044	·057	·038	—	·045	·047
** Greatest depth of O.	—	—	—	·060	·116	·091	·066	—	·067	·062
** Distance occiput to origin of D	·256	—	—	·290	·494	·290	·323	·408	·312	·310
* Distance end of D. to root of C.	.314	—	—	·340	312	·323	·337	·265	·342	·356
Length base of D.	·111	—	—	·110	·138	·125	·115	·122	·130	·124
* Greatest height of D.	—	—	—	·120	·138	·129	·088	·163	·105	·101
Length of P.	·115	—	—	·120	·109	·139	·116	·148	·111	·132
* Distance root of P. to root of V.	—	—	—	·253	·300	·282	·209	—	·207	·207
* Length of V.	—	—	—	·100	·131	·118	·092	—	·104	·111
Distance root of V. to origin of A.	—	—	—	·170	·200	·197	·218	—	191	·173
* Length of A.	·124	—	—	·080	·109	·086	·077	·092	·079	·070
Greatest depth of A.	·124	—	—	123	·175	·143	·102	·122	·116	·124
Length of longest C. ray	—	—	—	·140	·138	·143	·111	·143	·111	·127
Length of middle C. ray	—	—	—	·053	·100	· 82	·070	—	·074	·078

*A This is the type of the proposed local form *S. salar* var *Tasmanicus*. The specimen was caught by His Excellency Sir Robert Hamilton in the Huon River, and pronounced to be "a true salmon" by Sir Thomas Brady. b. Type of brackish water form from the Tamar. * Principal overlapping characters. ** Principal local modifications. c. From Great Lake.