New Zealand Fish Oils

4. OBSERVATIONS ON THE OIL CONTENT OF FRESH WATER EELS

By F. B. SHORLAND AND J. RUSSELL, *Fats Research Laboratory, Department of Scientific and Industrial Research and the Fisheries Laboratory, Marine Department, Wellington, New Zealand*

(Received 25 August 1947)

Two species of fresh water eel *Anguilla australis schmidti* Phillips and *A. dieffenbachii* Gray are known to occur in New Zealand, where they are conveniently termed respectively, short-finned and long-finned eels. Although the former species has been comparatively neglected apart from the determination of the vitamin A and vitamin D content of the body oil (Denz & Shorland, 1934; Cunningham, 1935; Weeber, 1945), the latter species has received the attention of several investigators in respect of the fatty-acid composition of the body oil (Shorland & McIntosh, 1936) and distribution of vitamin A and oil in the tissues (Edisbury, Lovern & Morton, 1937). The contributions made by the latter investigators as well as by Lovern (1938) on the European eel, *A. anguilla* L., suggest that the oil content increases with the length of the fish. McCance (1944), however, denied that the oil content could be foretold from the length, and his data showed that the oil content of the migrant eel, irrespective of length, was relatively constant. In regard to the immature eels it is our belief that no generalization was justified as he used only two samples and, although our results agree with those of McCance in respect of migrant eels, the results for immature eels support Lovern's (1938) contention that the oil content increases with the length of the eel.

EXPERIMENTAL

The material used in this work was collected from Lake Ellesmere migrant populations in 1942 and from immature eels from that lake in 1943 and 1944 as well as from Foxton

Lakes, 1943, Manawatu River, 1943, and Hutt River, 1943. To eliminate the possibility of seasonal effects the samples were taken during the months of March and April. The eels were divided into length groups, each group from each locality containing usually 5–10 eels commencing with the length group 22 in. and under, and proceeding by 3 and 4 in. intervals respectively for short-finned and long-finned eels, up to the largest sizes obtained. This yielded four groups of short-finned eels and four to six groups of immature long-finned eels. The migrant long-finned eels were in general longer than the immature specimens, and were divided into four groups, covering a range of 39–55 in. General consideration of the length-weight relationships will be published elsewhere, but it may be stated here that the same species of eel showed similar relationships in the various localities studied.

The eels from each group were subdivided into head, trunk, tail, liver, viscera (excluding liver) and ovary, when the latter was present. The head was severed at the first vertebra, while the trunk and tail portions were separated by a transverse cut at the vent.

RESULTS

The proportions of the various tissues in the eels examined are shown in Table 1.

In both short-finned and long-finned species, the immature eels from Foxton Lakes are shown to have heads which are significantly larger than those from other localities studied. Other locality differences of a lesser degree may also be noted in the proportions of other tissues of the immature eels. Comparing migrant with immature eels it will be seen that the changes in tissue proportions are confined in the case

Table 1. *Proportions of the dissected tissues of eels expressed as a percentage of the total weight*

Source	Head	Trunk	Tail	Ovary	Viscera	Liver
Short-finned eels						
†Lake Ellesmere, 1943	4.79 ± 0.61*	43.19 ± 1.52	45.93 ± 0.32	—	5.16 ± 0.78	0.93 ± 0.05
†Lake Ellesmere, 1944	5.04 ± 0.50	43.49 ± 0.62	45.67 ± 0.77	—	5.08 ± 0.80	0.72 ± 0.04
†Foxton Lakes, 1943	9.84 ± 1.38	41.91 ± 1.19	43.59 ± 1.36	—	4.11 ± 0.50	0.55 ± 0.02
†Hutt River, 1943	4.07 ± 0.27	41.91 ± 0.76	49.38 ± 1.28	—	3.55 ± 0.37	1.09 ± 0.06
‡Lake Ellesmere, 1942	4.8 ± 0.43	43.30 ± 1.17	45.60 ± 0.90	3.5	c. 1.83	0.97 ± 0.07
Long-finned eels						
†Lake Ellesmere, 1943	9.08 ± 1.01	46.05 ± 0.61	37.02 ± 1.18	0.64	6.17 ± 0.34	1.04 ± 0.01
†Lake Ellesmere, 1944	7.42 ± 1.16	44.79 ± 0.89	41.79 ± 2.11	—	5.24 ± 0.46	0.76 ± 0.06
†Foxton Lakes, 1943	12.96 ± 0.24	42.16 ± 1.37	39.12 ± 1.38	—	4.78 ± 0.39	0.98 ± 0.18
†Hutt River, 1943	7.42 ± 0.87	42.72 ± 0.88	43.17 ± 1.60	—	5.51 ± 0.43	1.18 ± 0.06
†Manawatu River system, 1943	10.18 ± 0.38	39.12 ± 1.72	44.42 ± 2.23	—	5.26 ± 0.46	1.02 ± 0.05
‡Lake Ellesmere, 1942	5.5 ± 0.4	43.2 ± 1.28	36.9 ± 1.26	10.7 ± 0.8	2.0 ± 0.31	1.7 ± 0.05

* Standard error.

† Immature eels.

‡ Migrant eels.

Fig. 1. Oil content of tissues of *A. australis*.

Fig. 2. Oil content of tissues of *A. dieffenbachii*.

of the short-finned eels to the development of 3.5 % of ovary with a corresponding reduction in the amount of viscera. In the long-finned species the transition from the immature eel to the migrant is accompanied by a relatively greater production of ovary (10.7 %) and a significant increase in the proportion of liver, with a decrease in the amount of head.

The oil content of the various tissues of the eels is given in Figs. 1 and 2. As no significant differences were observed between the oil content of similar groups of short-finned eels from different localities the separate results for the percentage total oil and percentage oil in the dissected tissues have been respectively combined. For similar reasons results

Certain differences may be noted in respect of the oil content of the two species. The short-finned migrant is shown to contain (cf. Fig. 1) a higher percentage of total oil than the immature eel of the same length, while in the case of the long-finned species (cf. Fig. 2) the reverse is true. In the short-finned species the migrant, as compared with the immature eel of the same length, tended to have a lower percentage of oil in the tail but a higher percentage in the head and trunk. In this connexion the long-finned species resembled the short-finned as regards the tail oil, but differed in respect of the trunk and head oil percentages which showed relatively small variation between migrant and immature specimens of the same length (Table 2).

Table 2. $\frac{\text{Percentage of oil in tail } (T)}{\text{Percentage of oil in head } (H)}$ and $\frac{\text{Percentage of oil in tail } (T)}{\text{Percentage of oil in trunk } (F)}$ in immature and migrant eels

	Immature eels		Migrants	
	T/F	T/H	T/F	T/H
Short-finned	$3.42 \pm 1.06^*$	2.80 ± 0.84	1.69 ± 0.13	1.51 ± 0.19
Long-finned	3.29 ± 1.13	2.54 ± 0.85	1.47 ± 0.20	1.47 ± 0.06

* Standard deviation.

for long-finned eels from Foxton Lakes and Lake Ellesmere have also been combined, while the average total oil content of the Manawatu and Hutt River specimens, which were significantly oilier, are shown separately. Since, however, the results for the oil content of the tissues of the long-finned eels from the Manawatu and Hutt Rivers showed similar variations to those exhibited by the Foxton Lakes and Lake Ellesmere specimens, they have been omitted from Fig. 2.

It will be observed from Figs. 1 and 2 that the oil content of immature eels tended to increase with the length of the fish in agreement with Lovern's (1938) observations on *A. anguilla* L. This tendency, however, appeared to be confined to the immature eel, the migrant showing little, if any, increase in oil content with length.

The general picture of the relationship between the oil content and length of both species is shown to be somewhat similar, but the long-finned eels may be distinguished from the short-finned by their greater variability in the oil content of the tail as well as by their less uniform relationship between total oil content and length. Attention is drawn to the interesting relationship between the oil content of the head and trunk which was found to be similar in both species. In the smaller immature specimens the oil content of the head exceeds that of the trunk, but with the larger immature specimens the reverse is true. In the migrant eel the situation in regard to the relative oil content of the head and trunk is shown to revert back to that of the smaller immature eel.

In considering the ratios T/F and T/H in Table 2, immature long-finned specimens of over 38 in. have been excluded, as such specimens may contain appreciable proportions of ovary. The ratios T/F and T/H show a much greater uniformity in the migrant eels as compared with immature eels, as well as a more uniform distribution of oil in the former as compared with the latter. The results shown in Figs. 1 and 2 are consistent with the hypothesis that greater uniformity in the distribution of oil in the migrant, as compared with the immature eel, is achieved by means of a considerable movement of oil from the tail to the trunk, followed by a further movement of oil from the trunk to the head. In the long-finned species, however, the situation is complicated by the development of the ovary as an important oil reserve (cf. Fig. 1), and it is suggested that, comparing long-finned species with short-finned, the relatively low proportion of oil in the trunk and head sections of the migrant as compared with the immature long-finned eel is due to a further considerable diversion of the trunk oil into the ovary.

In Figs. 3 and 4 the oil contents of the tissues are expressed as a percentage of the total oil reserves and compared with the proportions of these tissues in the fish, which, in the case of the short-finned eels were not significantly different as between migrant and immature eels, apart from the replacement in the former of the viscera by ovary. As no significant differences in oil distributions were found between groups of long-finned eels below 38 in. used in this work, the results for these groups have been combined as shown in Fig. 4.

In the immature short-finned eel, the tail, comprising 46 % of the total weight, contained 75 % of the total oil in the fish. With the onset of maturity the amount of oil in the tail was reduced to 57 % of the total oil reserves. In the immature long-finned

SUMMARY

1. It was found that commencing with eels of c. 50 cm. length and proceeding to fully adult migrant eels the oil content of the immature eels

Fig. 3. Distribution of oil in the tissues of *A. australis* expressed as a percentage of the total oil. (Shaded portions include $\pm$ standard error.)

eel the tail portion amounted to 41 % of the total weight and contained 68 % of the total oil reserves. At maturity the tail was slightly reduced in amount to 37 % with a spectacular reduction in oil content to 41 % of the total oil reserves, coinciding with the appearance of the ovary as an important oil depot, which accounted for 20 % of the total oil reserves in the fish as compared with only 7 % in the mature short-finned eel. Although the proportion of trunk (42-43 %) in both the short-finned and long-finned eels did not change as the fish matured, the oil reserves of this section of the fish, expressed as a percentage of the total oil reserves, increased respectively from 19 to 32 % and from 23 to 33 %.

tended to increase continuously with length from approximately 7 to 17 % in *A. australis* and from 7 to 23 % in *A. dieffenbachii*.

2. The largest size of immature eel was found to approximate in oil content to that of the migrant eel, the oil content of which was not found to vary appreciably with the length of the fish.

3. Considering the tissues separately, however, it was found that whereas the distribution of oil was fairly uniform in the migrant eel as between the head, trunk and tail, this was not so in the case of the immature eel which contained approximately 70 % of the total oil reserves in the tail comprising but 42-43 % of the total weight of the fish.

4. The observed results are consistent with the theory now put forward that just prior to migration a more uniform distribution of oil is attained by a partial transference of oil from the tail into the trunk and from thence into the head and ovary.

We wish to thank Mr A. E. Hefford, M.Sc., formerly Chief Inspector of Fisheries and Mr D. F. Hobbs, Senior Fresh Water Biologist to the Marine Department for encouragement and for generous assistance in the collection of samples.

Fig. 4. Distribution of oil in the tissues of *A. dieffenbachii* expressed as a percentage of the total oil. (Shaded portions include $\pm$ standard error of the mean.)

REFERENCES

- Cunningham, M. M. (1935). *N.Z. J. Sci. Tech.* **17**, 563.
 Denz, F. A. & Shorland, F. B. (1934). *N.Z. J. Sci. Tech.* **15**, 327.
 Edisbury, J. R., Lovern, J. A. & Morton, R. A. (1937). *Biochem. J.* **31**, 416.
 Lovern, J. A. (1938). *Biochem. J.* **32**, 1214.
 McCance, R. A. (1944). *Biochem. J.* **38**, 474.
 Shorland, F. B. & McIntosh, I. G. (1936). *Biochem. J.* **30**, 1775.
 Weeber, E. R. (1945). *Biochem. J.* **39**, 264.