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ON THE FOOD HABITS

OF

SOME FISH-EATING BIRDS IN DENMARK

DIVERS, GREBES, MERGANSERS, AND AUKS

BY

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INTRODUCTION

This report on the food habits of Divers, Grebes, Mergansers and Auks in Denmark is based on an investigation of the stomach contents of about 900 birds of 14 different species.

A general idea of the food habits of these birds was available from notes scattered in the literature and from a few, more detailed reports on some of the species. COLLETT (1877—94) has reported upon stomach contents of birds in Norway; COLLINGE (1924—27) has reported upon stomach contents from Great Britain; and various authors have reported upon stomach contents of birds from Germany and Central Europe, especially of mergansers and grebes. Contributions are also available on the food habits in America of some of those species which also occur there. Valuable notes and compilations of information on the food habits of all the species are given in NAUMANN's Naturgeschichte der Vögel Mitteleuropas (ed. 1902—03), and in WITHERBY's Handbook of British Birds (1939—44)—the food notes in this edition prepared by JOURDAIN.

A detailed and exact knowledge of the food habits of any of the said birds in Denmark, however, has hitherto not been available. The present contribution will fill this gap in our knowledge, at least concerning the more common species of which a larger material has been examined. The report may also claim a general interest, since several of the species treated have not before been subject to systematic stomach analyses, and none in similar habitats as the Danish.

Nine of the investigated species breed in Denmark, but only five of them commonly. Otherwise the species occur in Denmark mostly as winter-visitors. Consequently the examined material was mainly from the winter months, and it is thus primarily the food-habits during winter which have been elucidated.

The greater part of the material has been obtained by purchasing the birds from game dealers (during the years 1940—1947). Therefore detailed information of the locality and the condition under which the birds were taken usually lacks, but all the same the investigation is considered giving a reasonably reliable picture of the food-habits, at least of the more common species. Thanks are due to some private persons who have helped in securing material for examination,

especially to Mr. LUDVIG SVENDSEN for some large stomach contents, and to Mr. C. M. POULSEN for stomachs of some of the more rare species sent him for taxidermy.

The results of the investigation are represented in such a way that the food items are listed with information of how frequently recorded, that is in how many stomachs they are found. When a larger material has been available the frequency of occurrences is also computed into percentages. Further there is stated in how many stomachs the different food items have formed the sole content of food remains, or, in other words, how many meals have been made exclusively on that particular food item, which is an important information when trying to estimate the quantitative composition of the total diet of a species. Every stomach content has been considered a meal, though in general it only represents the remains of a meal, and sometimes may comprise only secondary items, for instance remains of insects derived from the stomachs of completely digested fishes.

The digestion in the stomach continues for some time after the death of the bird, and since the birds have not come to hand immediately the stomach contents have almost always been in an advanced state of disintegration. The food items of the investigated birds, however, all have hard parts which remain in the stomachs for some time and by which they may be identified. The dental bones of fishes thus are usually of diagnostic value and are often among the last bones to be comminuted enough for passing into the intestine. Other fishes may be recognized by their vertebrae alone, and thus it is possible in the majority of cases, even on the smallest quantity of food remains, to determine the kind of fishes eaten, and often also to state how many individuals the remains represent.

Some information is also given of the number and sizes in which the food items have been present in the stomachs, which information gives some idea of their importance in relation to other food items in the same meals. It is of course only in the case of full meals (gullets and gizzards gorged with food) that these figures definitely tell how much is really eaten, or may be eaten, in the single meal.

Fragments of the chitinous parts of insects and crustaceans and the hard chitinous jaws of polychaetes are the remains on which these foods are recorded. Some of these items, for instance the jaws of polychaetes, are very resistent to the destruction in the stomachs and, therefore, their frequency of occurrences may exaggerate their importance in the diet. An illustration of the different resistence to the decomposition of chitinous or horny items and of bone is given by the cyprinoid fishes where a number of the horny pads from the bases of the skulls (as many as 30 in a single stomach content) are often the only remains of the fishes eaten. It is also possible that sometimes the remains of crustaceans,

insects and polychaetes found in the stomachs of the birds are in reality only secondary, being derived from the stomachs of the fishes eaten.

One other fish-eating bird, the Southern Cormorant, has previously been studied with regard to its food-habits in Denmark (Danish Review of Game Biology 1.3. 1950). In view of the economic importance which is attributed this species as a potential competitor to fishermen a very large material of stomach contents was examined, and this allowed a rather detailed analysis of the composition of the diet. The smaller materials available of the species treated here—as also the fact that these species eat fishes even of the smallest sizes, and often also crustaceans and insects, whereas the cormorant proved to be exclusively fish-eating and taking only fairly large prey—make a similar detailed representation of the composition of the diet much more uncertain here. In the present report, therefore, only a rough estimation of the quantitative role of the different food items or groups of food items has been made.

The food items recorded in the literature for each of the species dealt with are also listed in the following, though only the European ones in detail.

BLACK-THROATED DIVER

Gavia arctica (L.)
(*Colymbus arcticus* L.)

The black-throated diver (in Danish: Sortstrubet Lom) occurs in Denmark as a fairly common winter-visitor from the Arctic, and also as a rare summer-visitor. It stays on the sea in the coastal regions, diving after its food at depths of about 3 to 6 m. Normally it is submerged for about ¾ minute, but it may stay under the water for up to 2 minutes.

A total of 145 birds collected during the winter months October to February were examined. Food remains were found in the stomachs of 123 of them, collected in the following areas: 3 in the North Sea area (Ringkøbing); 2 in Limfjorden; 29 in the Kattegat area (Samsø 19, Kalundborg 4, Sejerø 2, Rørvig 1, Sjællands Odde 1, Hadsund 2); 77 in the Belt Sea (Little Belt 33, Great Belt 19, The Sound, Køge Bay and Fakse Bay 25); and 12 from Bornholm in the Baltic.

All these 123 stomach contents contained remains of fishes. Traces of crustaceans, polychaetes, and molluscs were also included in a few instances, but probably these items have always been secondary in the present material, derived from the stomachs of fishes eaten.

Gobies (*Gobiidae*). These are the kind of fish most frequently recorded in the examined material. In all, 68 of the birds (55 %) had fed on gobies (viz. 2 birds from Ringkøbing, 15 from Kattegat, 43 from the Belt Sea, and 10 from

Bornholm), and 22 of them (18 %) had taken gobies as their only food (traces of minute blue-mussels and snails found in one instance being disregarded as having probably come from the stomachs of the fishes eaten). Great numbers of these small fishes may be included in the single meals. One black-throated diver collected at Bornholm in January had thus in its gullet about 140 sand-gobies (*Gobius minutus*), from 2½ to 5 cm long, and in its gizzard the remains of a hundred more. Another bird, collected in the Sound in January, had about 180 sand-gobies in its gullet, between 22 and 55 mm long, and the remains of about half a hundred in its gizzard. The Sand-goby (*Gobius minutus*) and the Two-spotted Goby (*Gobius flavescens*) appear to be by far the most frequently caught, but also the Black Goby (*Gobius niger*) has been identified.

Common Cod (*Gadus callarias*). This kind of fish is second in number of occurrences in the examined material, and relatively (by weight) it has been as important a source of food as the gobies. A total of 58 birds (47 %) had fed on cod (viz. 1 from the Limfjord, 8 from Kattegat, 33 from the Belt Sea, and 4 from Bornholm) and 26 of the birds (21 %) appear to have made their meals exclusively on this fish, since some other animal items found in 8 stomachs probably came from the stomachs of the cods eaten (viz. a few jaws of polychaetes in four instances, single crustaceans in three instances, and a bivalve, presumably, in one instance). Usually only one or two cods are recorded from each stomach content, but one stomach contained the bones of at least 13 small individuals. The largest cods taken by the examined black-throated divers have been 20—25 cm long.

Sticklebacks (*Gasterosteus spp.*). These ranked third in importance for the diet of the black-throated diver in Denmark. They had been taken by 41 (33 %) of the birds (viz. Ringkøbing 1, the Kattegat area 8, the Belt Sea 29, and Bornholm 3), and had been the sole food for 15 of them (12 %). Sticklebacks may be taken in great numbers in the single meal. One bird had 76 individuals in its gullet and the bones and flesh of at least 35 more in the gizzard. Another stomach content comprised the bones of about 200 individuals. The Three-spined Stickleback (*Gasterosteus aculeatus*) is by far the species most frequently caught, corresponding to, of course, that it is the most common one in the marine habitats. It was identified in 38 of the 43 stomach contents, whereas the Ten-spined Stickleback (*Gasterosteus pungitius*) was identified with certainty only in six instances. This species may, however, have been represented also in some of the other stomach contents, but overlooked. When both species have been found together in the same stomach the three-spined stickleback usually has been the most numerous, for instance 75 individuals of *G. aculeatus* together with 1 *G. pungitius*, or 22 *G. aculeatus* and 7 *G. pungitius*, or 11 *G. aculeatus*

and 1 *G. pungitius*. One bird only (from Køge Bay) had taken *G. pungitius* alone; and only one other bird had caught more individuals of *G. pungitius* (30) than of *G. aculeatus* (6).

Cod, gobies, and sticklebacks supply the principal food of the black-throated diver in Denmark, together accounting for about $^{9}/_{10}$ of its total diet. In all, 98 of the examined 123 birds (80 %) had fed exclusively on these fishes, 62 birds having taken each a single kind of them, 14 birds having taken cod and gobies, 11 gobies and sticklebacks, 6 cod and sticklebacks, and 5 birds having included individuals of all three kinds of fishes in their meals. (When small fishes are recorded in stomachs containing cod of a fair size the possibility exists, of course, that they may have come from the stomach of this fish). Only five of the examined black-throated divers have not included any of the said fishes in their meals.

Viviparous Blenny (*Zoarces viviparus*). This fish had been food for 6 (5 %) of the birds (1 from Kattegat and 5 from the Belt Sea) and supplied in three instances the entire meal. One to about half a dozen individuals were included per meal, both small individuals as well as such which have been at least 20 cm long.

Flatfishes (*Pleuronectidae*). Five of the examined black-throated divers (4 %) had caught flatfishes. In four instances (birds from Kattegat and the Belt Sea) the species was the Flounder (*Pleuronectes flesus*). One bird had gorged itself with about 25 individuals, 4—6 cm long, together with half a hundred gobies and a few sticklebacks. In the remaining instance (a bird collected in the Limfjord) a single small individual of either Turbot or Brill (*Rhombus sp.*) was part of a meal comprising in addition a small cod.

Herring (*Clupea harengus*). One to a few individuals, 15 cm long, or more?, constituted part of the meals of four of the birds (3 from Kattegat and 1 from Bornholm).

Fifteen-spined Stickleback (*Spinachia spinachia*). Three birds (2 from Kattegat and 1 from Little Belt) had eaten one to a few, up to 15 cm long, individuals.

Butterfish (*Pholis gunellus*). Two birds from Kattegat had included a few individuals in their food.

Sand-eels (*Ammodytes spp.*). Two birds collected in the Sound had fed on sand-eels. The bones of about 10 individuals, about 15 cm long, were the sole food remains in one of them.

Mackerel (*Scomber scombrus*). One individual of a comparatively large size had been swallowed by a bird from the Little Belt.

Eel (*Anguilla anguilla*). One bird from the Great Belt had in its gullet an

18 cm long eel, and, in addition, 16 *Gobius niger*, 5—7 cm long, and a number of other gobies, *G. minutus* presumably, up to 4 cm long. In the gizzard the bird had some vertebrae of another, smaller eel, a few bones of a stickleback, and the bones and flesh of half a hundred gobies, mainly *Gobius niger*.

Rock-Wrasse (*Ctenolabrus rupestris*). One bird (from Ringkøbing) had in its stomach the remains of 9 small individuals, together with bones of 40 gobies and a few vertebrae of an unidentifiable fish.

Horse-mackerel (*Caranx trachurus*). The bones of a small individual formed together with an *Idothea* the sole food remains in a bird taken in the Little Belt in December.

Father-lasher (*Cottus scorpius*). A very small individual was found in a stomach together with a few small cod and some gobies.

In a few instances the stomach contents have included—in addition to identifiable fish remains—also traces of fish bones which must have belonged to other species, but are too disintegrated to be identified. Such remains have been disregarded.

In the examined material about half the birds (69) had made their entire meals on a single kind of fish only (*Gobius spp.* and *Gasterosteus spp.* each considered one kind). About a third (39 birds) had taken two kinds of fish, about a tenth (15 birds) three kinds of fish, and a very small percentage (2 birds) four kinds of fish per meal.

Some other animal items, besides fish, have been identified in the examined stomach contents of black-throated diver, viz. various crustaceans, polychaetes, and molluscs, but in all cases they may have been derived from the stomachs of fishes eaten.

Crustaceans are recorded from 6 of the 123 stomachs. Traces of single individuals of *Idothea* in two stomachs, and traces of a *Gammarus*, a *Mysis* presumably, a prawn probably, and an undeterminable one, in one stomach each. In four instances the crustaceans are found together with remains of cod, and in the two other instances together with remains of viviparous blenny.

Polychaetes. The chitinous jaws of *Polynoidae* and *Nereidae* are recorded from 5 and 4 stomachs respectively, (8 stomach contents in all), in one instance together with a flat-fish, in all other instances together with cod.

Molluscs. Six stomach contents included remains of very small bivalves and gastropods. The blue mussel (*Mytilus*) is found in single individuals, about 1 mm large, in three stomachs, traces of an undeterminable minute bivalve in one stomach, a few minute *Hydrobia* in one stomach, and an 8 mm large periwinkle (*Littorina obtusata*) in one stomach (in this stomach also remains of cod).

Insects. A bird from Samsø had in its stomach the remains of a few small

beetles, but probably they came from the stomachs of the half a hundred gobies which the bird had fed on.

Vegetable matter. About 10 % of the examined stomach contents have also contained traces of sea-grasses and algae, which have been considered consumed accidentally along with the fishes. Also a few of the stomachs disregarded in the percentage representation of food occurrences, since they have been considered without food remains, really have contained traces of vegetable matter, and one bird, collected in the Great Belt in December, contained five pieces of leaves of eel-grass, 1½ to 10 cm long. In one stomach was found a lump of plant-fibers, about 2 × 3 cm large, which may have been a piece of rope.

Gravel. All examined stomachs, whether without or full of food remains, have contained a number of pebbles, from a few to about 30, in sizes from about 3 to 13 mm in diameter.

Conclusion: The food of the black-throated diver in Denmark (the winter food) is according to the present investigation exclusively made up of fishes, from small ones (about 2½ cm) taken in shoals (as gobies and sticklebacks) to about 25 cm large ones caught singly. The common cod, gobies, and sticklebacks (primarily the three-spined one) are by far the principal food items. They constitute together about $^{9}/_{10}$ of the total food consumed by the examined material. Cod and gobies are qualitatively of about equal importance, each supplying about a third (or somewhat more) of the total diet, but the gobies of course being caught in a much greater number of individuals than the cod, a full meal requiring more than a hundred individuals of the small gobies but only a single fair sized cod. Sticklebacks contribute about $^{1}/_{5}$ of the food. Any other kind of fishes occuring in suitable sizes near the bottom within the feeding sphere of the black-throated diver may be included in its bill of fare, flat-fishes as well as round ones, but the half a score of different kinds recorded in the present material have together formed only little more than $^{1}/_{10}$ of the total food.

Remarks: Published data show that crustaceans and other items in places (for instance on the breeding grounds) may form part of the food of the black-throated diver. Crabs and prawns are recorded eaten on the sea, and crayfishes in freshwater, the former as part of meals including fishes, but crayfishes at times as the principal food. Worms too are mentioned as food items, including leeches. Molluscs have been reported from a small percentage of examined stomach contents. Aquatic insects such as large water-beetles and larvae of caddisflies have been found in the stomachs of birds from freshwaters. — Such items, however, may in part have been derived from fish stomachs. Vegetable matter,

such as sea-weeds, have formed the bulk (or whole) of some stomach contents examined. Fish, however, are everywhere reported as the principal food (apart from the exceptional instances where crayfish (*Astacus fluviatilis*) in a period may be fed on freely). The following fishes are recorded taken: Gobies (*Gobiidae*), herring and sprat (*Clupeidae*), and sand-smelt (*Atherina*) in marine habitats; trout (*Salmo trutta*), perch (*Perca*), bleak (*Alburnus*), dace and roach (*Leuciscus*), and carp (*Cyprinus*) in freshwater. Also frogs have been noted as food items.

COLLETT, 1894 p. 332, reports that the black-throated diver in Norway may be caught on fishing lines put out in deep water after cod.

RED-THROATED DIVER

Gavia stellata Pontoppidan
(*Colymbus stellatus* L.)

The red-throated diver (in Danish: Rødstrubet Lom) is in Denmark a common winter-visitor from Northern Scandinavia, and occurs also as a rare summer-visitor. It stays in marine localities near the coast and in the fjords, diving after its food at depths of 2 to about 9 m. It may be submerged for as long as 1½ minute, but normally not for more than 1 minute.

A material of 203 birds collected during the winter months October to February has been examined. As was the case in the former species a certain percentage (about 15 %) did not contain food remains in their stomachs. The remaining 173 birds were obtained in the following areas: 9 in the North Sea area (Rømø, Ringkøbing Fjord, Nissum Fjord), 6 in Limfjorden, 95 in the Kattegat area (Læsø, Mariager Fjord, Aarhus Bay, Samsø, Sejerø Bay), 61 in the Belt Sea (Little Belt, Great Belt, The Sound, Køge Bay, Fakse Bay, Møen), and 2 at Bornholm in the Baltic.

Fish are the principal, if not exclusive food of the red-throated diver. Only one of the examined stomach contents has contained comminuted traces of an undeterminable crustacean, but no remains of fishes, and since the chitinous items remain longer in the stomachs than do bones, this crustacean probably was derived from the stomach of a fish eaten.

Common Cod (*Gadus callarias*). This kind of fish has been by far the most important food item for the present material. No less than 123 (71 %) of the birds had fed on cod, and 65 of them (38 %) had made their entire meal on this fish. Cod was taken equally frequent in all areas from which red-throated divers have been available. Usually only a single or a few individuals are recorded in each stomach content, but more may be included in the single meals. A bird taken in the Great Belt had thus in its stomach the bones and flesh of 11 indi-

viduals, from a very small one to such which may have been about 12—15 cm long, and, in addition, bones of a few herrings. The largest cods caught have measured at least 25 cm.

Gobies (*Gobius spp.*). These are second in frequency of occurrences in the present material of red-throated divers, but their importance in the total diet have been less than a third of that of the cod. Gobies had been eaten by 41 (24 %) of the birds (the North Sea area 4, the Limfjord 1, Kattegat 17, the Belt Sea 19), and by 9 of them (5 %) as the sole food. The gobies (presumably mainly *Gobius flavescens* and *G. minutus*) were present in only small numbers in many of the stomach contents, but about a hundred have been recorded in a few instances. Small ones of only 1½ cm length are registered eaten.

Sticklebacks (*Gasterosteus spp.*). These are third in frequency of occurrences in the present material. In quantitative importance, however, they follow after the herring. They have formed food for 32 (19 %) of the birds (1 from the North Sea area, 18 from Kattegat, 13 from the Belt Sea), and the sole food for 6 of them (3 %). The Three-spined Stickleback (*G. aculeatus*) has been identified in every stomach content comprising *Gasterosteus*. The Ten-spined Stickleback (*G. pungitius*) was identified in three instances, together with larger numbers of the other species, and perhaps may have been present in more instances, but overlooked. The number of individuals recorded in the single stomach contents has varied from one to almost a hundred. One red-throated diver from the Great Belt had thus in its gullet 16 three-spined sticklebacks about 4½ cm long, 12 ten-spined sticklebacks about 3½ cm long, besides 25 gobies between 2½ and 3½ cm long; and in the gizzard the bones and flesh of half a hundred individuals of the same species.

Herring (*Clupea harengus*). In the total food of the present material of red-throated diver the herring has been third in quantitative importance. Nine of the birds (5 %) had drawn their meals exclusively from this fish, and 31 birds (18 %) in all had fed on it (viz. 1 from Limfjorden, 7 from Kattegat, 11 from the Belt Sea, and 1 from Bornholm). Some meals have consisted of many small individuals, others of a few, up to 4, fairly large ones.

The greater part of the examined red-throated divers, viz. 142 birds (82 %) has subsisted exclusively on these four kinds of fish, cod, gobies, sticklebacks, and herring: 89 birds having made their meals on a single kind of them; 15 having taken cod and gobies, 14 cod and herring, 11 cod and sticklebacks, 4 gobies and sticklebacks, 3 gobies and herring, 3 herring and sticklebacks, 2 herring, gobies and cod, and one bird having taken all four kinds. The stomach content of this latter bird, from the Great Belt, consisted of: Some bones of at least 4 sticklebacks, many bones of about a dozen small herrings, and of at least a dozen small

gobies, a single otolith of a small common cod, and about 30 gravel. One or more of these four kinds of fishes have also been included in the greater part of the remaining stomach contents; and, disregarding the three instances where the fish remains have been unidentifiable, only four stomach contents have consisted solely of other kinds of fishes.

Flatfishes (*Pleuronectidae*). The Flounder (*Pleuronectes platessa*) formed the sole food for two birds, and had, in all, been fed on by 9 (5 %) of the birds (1 from Limfjorden, 1 from the Little Belt, and 7 from Kattegat). Up to 6 individuals, always small, have been recorded in a single meal.

Father-lasher (*Cottus scorpius*). Single individuals were included in the meals of five (3 %) of the birds (viz. 3 from Kattegat and 2 from the Belt Sea).

Perch (*Perca fluviatilis*). Three red-throated divers which had been feeding in brackish water habitats (Hadsund in Mariagerfjord, Issehoved in Samsø, and at Langeland in the Great Belt) had made part of their meals on a single or two individuals of the perch. In one case the bird had in addition fed on sticklebacks, in the two other cases on sticklebacks, gobies and cyprinoids.

Sand-eels (*Ammodytes spp.*). Two birds from Kattegat had derived part of their food from sand-eels.

Fifteen-spined Stickleback (*Spinachia spinachia*). Two birds from Kalundborg in the Southern Kattegat had made their entire meal on up to about 10 individuals of this fish.

Eel (*Anguilla anguilla*). Two birds (from Samsø in Kattegat and Møen in the Belt Sea) had caught a single eel each, in addition to gobies and sticklebacks.

Cyprinoids (*Cyprinidae*). Two birds which had fed in brackish water habitats, partly on perch, had also each eaten a single cyprinoid, viz. a bird from Hadsund a very small individual of Roach (*Leuciscus rutilus*) presumably (only a few bones are left), and a bird from the Great Belt a small Rudd (*Leuciscus erythropthalmus*).

Mackerel (*Scomber scombrus*). One red-throated diver from Samsø had made its whole meal on a single, fairly small mackerel.

Viviparous Blenny (*Zoarces viviparus*). This had been food for a bird from Kattegat.

Gar-fish (*Belone bellone*). A single, small individual supplied part of the meal of a bird from Aarhus Bay, Kattegat, the remaining meal consisting of sticklebacks and cod.

Horse-mackerel (*Caranx trachurus*). One bird from the Little Belt had eaten a single individual together with sticklebacks.

Three stomach contents comprised only unidentifiable remains of bones of fish.

More than half of the examined red-throated divers (100 birds or 58 %) has subsisted on a single kind of fish, almost a third (61 birds or 35 %) has fed on two kinds of fishes, a few (7 birds or 4 %) have made their meals on three kinds of fishes, and another few (5 birds or 3 %) have included four different kinds of fishes in their meals.

Crustaceans. A few stomach contents included crustaceans. Traces of a prawn and an amphipod, respectively, were thus recorded in two stomachs which also contained remains of cod, and probably they were derived from the stomach of the fish. One bird had in its gullet 3 *Idothea*, among 70 gobies, and in its gizzard traces of a few more *Idothea* and a few *Gammarus* besides a great many fish bones. Thus these small crustaceans were evidently swallowed accidentally along with the fishes. (Remains of the cod parasite *Lernaea branchialis* was recorded in a stomach together with some bones of cod).

Polychaetes. Jaws of Nereids were found in three stomachs, and jaws of Polynoid worms in one stomach. They were found together with remains of cod and sticklebacks and presumably came from the stomachs of these.

Molluscs. The bivalves noted in two instances, small *Mytilus* and *Cardium*, must also have come from the stomachs of the cods together with which they are recorded.

Vegetable matter. Traces of red algae, and sea-grasses, *Zostera* and *Ruppia*, are noted in about 10 % of the stomach contents. They must have been swallowed accidentally in the gathering of such food as gobies and sticklebacks. Only a few stomachs have contained more than a trace of vegetable matter. Two stomach contents of many gobies included about half a hundred ½—2½ cm long pieces of red algae. Also one stomach content consisting of remains of gobies, sticklebacks, perch and common bream comprised a certain quantity of vegetative growth.

Gravel. Every stomach contained at least a few pebbles, usually about 10, and exceptionally more. Thus one stomach contained 75 pebbles in sizes from 3 to 13 mm in diameter, in addition to some bones of cod and flounder. The largest pebbles found were up to 19 mm in diameter.

Once a piece of a fish hook was found in a stomach together with remains of a small cod.

Conclusion: According to the present investigation the food of the red-throated diver in Denmark (the winter food) consists exclusively of fish, from small ones to at least 25 cm long ones (though such large prey only taken exceptionally). The common cod appears to be by far the most important food, having supplied quantitatively about 54 % of the total food of the present mate-

rial. The next most important food items are, in order of importance in the present material, gobies, herring and sticklebacks, supplying about 14 %, 12 %, and 11 %, respectively, of the total food. The 11 other kinds of fishes registered caught by the examined birds have together contributed less than 10 % of the diet.

Remarks: That fish supply the principal food of the red-throated diver is evident also from the literature. Marine species recorded are primarily herring and sprat (*Clupeidae*), further sand-eels (*Ammodytes*), flounder (*Pleuronectes*), coal-fish (*Gadus virens*), butterfish (*Pholis gunellus*), and in the Arctic such species as polar-cod (*Boreogadus*) and capelin (*Mallotus*). Fresh-water species recorded are trout and salmon (*Salmo*), roach and dace (*Leuciscus*), bleak (*Alburnus*), perch (*Perca*), and gudgeon (*Gobio*). Spawn of fish is mentioned eaten, as also frogs are noted. Reported included in the diet are further the following invertebrates: Crustaceans, such as shrimps and amphipods; molluscs, such as the bivalve the blue-mussel, and the snails *Valvata* and *Limnaea;* insects, such as caddis-fly larvae (*Trichoptera*); and worms, such as nereids and leeches. Vegetable matter has formed the whole stomach content of birds in the Arctic. Other animal items than fish, even vegetable matter, may thus sometimes be taken as a substitute food.

GREAT NORTHERN DIVER

Gavia immer (Brünnich)
(*Colymbus glacialis* L.)

The great northern diver (in Danish: Islom) occurs in Denmark in marine habitats as a rare winter-visitor from the Artic and as a very rare summer-visitor. It dives after its food at depths from about 4 m to about 10 m, and may stay under the water for up to 3 minutes, though usually not for more than ¾ minute.

Only three birds of this species have been available for an examination of their stomach contents. They were collected in December and January.

One bird from Ribe in the North Sea area had made its entire meal on a number of small Flounders (*Pleuronectes flesus*).

Another bird, from the Little Belt, had eaten three kinds of fishes, viz., 2 small Common Cods (*Gadus callarias*), 3 Father-lashers (*Cottus scorpius*), and some Viviparous Blennies (*Zoarces viviparus*).

The last bird, obtained in the Kattegat area, had included four kinds of fishes in its meal, viz., 1 Father-lasher (*Cottus scorpius*), 1 Eel (*Anguilla anguilla*),

1 Viviparous Blenny (*Zoarces viviparus*), about 20 cm long, and a few Three-spined Sticklebacks (*Gasterosteus aculeatus*).

Besides the bones and other remains of the fishes all three stomach contents also comprised a number of pebbles.

Remarks: Fishes are the principal food of the great northern diver. In the literature the following marine species are recorded as eaten: Haddock (*Gadus aeglefinus*), whiting (*Gadus merlangus*), herring (*Clupea harengus*), sprat (*Clupea sprattus*), gurnard (*Trigla gurnardus*), father-lasher (*Cottus scorpius*), sand-eels (*Ammodytes*), pipe-fish (*Syngnathidae*), gobies (*Gobiidae*), flatfishes (*Pleuronectidae*)—apparently flatfishes constitute a frequent food—. The fresh-water species recorded are trout (*Salmo trutta*), and other salmonids, perch (*Perca*), and roach (*Leuciscus rutilus*) and related species. Also frogs and newts are mentioned as eaten. The largest size recorded of a fish caught is 28 cm.

Other animal food reported as eaten are crustaceans such as crabs, shrimps, prawns and amphipods; molluscs such as razorshell, *Planorbis*, and small cephalopods; annelids such as polychaetes and leeches; and aquatic insects such as caddis-fly larvae, water-boatmen and dragon-fly nymphs.

Vegetable matter is occasionally found in quantities in the stomachs. Roots of fresh-water plants and small seeds are mentioned; and a bird taken in an Arctic locality had green shoots of willow in its stomach.

Fishes are the prime food of the great northern diver, but, as appears from this compilation of food records, they may exceptionally be substituted by other animals, or even vegetable matter. MUNRO (1945) mentions that the species in British Columbia occurs also in lakes where no fish are found, and reports meals on at least 150 amphipods together with 60 water-boatmen, on molluscs alone, and on caddis-fly larvae alone.

RED-NECKED GREBE

Podiceps griseigena (Boddaert)

The red-necked grebe (in Danish: Gråstrubet Lappedykker) is a common breeding bird in Denmark in fresh-water habitats, marshes and small lakes. During winter it stays mainly in the coastal regions, preferably where there is much vegetation. When diving it may be submerged for up to a minute, but less than ½ minute is the normal.

A material of 30 birds has been available, 25 from marine or brackish-water localities, and 5 from fresh-water localities. The birds were collected mainly during the months October to January, only one being from April.

The most conspicuous item in the stomachs of this grebe is feathers. Usually the stomachs are completely filled with feathers, sometimes only partially, the feathers being found in a varying state of disintegration, but only a single stomach content did not include this item. The stomach content in the latter case consisted of a great many bones of 15 fishes of different kinds.

Feathers are a normal stomach content of several species of grebes. In the present investigation feathers were found also in every stomach of 54 great crested grebes examined, varying from a lump of intact ones filling the whole stomach cavity to a mass of fragments of disintegrated ones. A mass of feathers was also found in the stomach of the single sclavonian grebe examined, and in the stomach of one of the two black-necked grebes available. Only one of the seven examined little-grebes, however, contained in its stomach some traces of feathers. These findings agree with the information in literature. Thus MADON (1926) in a table including records from various papers gives the number of occurrences of feathers in the stomachs of grebes as: in 64 of 65 red-necked grebes, in 115 of 122 great crested grebes, in all of 123 sclavonian grebes, in 27 of 33 black-necked grebes, and in only 5 of 31 little-grebes.

The role of the feathers in the stomachs of the grebes has puzzled scientists ever since the elder NAUMANN called attention to them one and a half century ago. And as yet this peculiar feather-eating habit of the grebes has not been quite satisfactorily explained. This is not the place to enter into a detailed discussion of the problem, but a few remarks may be appropriate. That the feathers in the stomachs should come from birds eaten was an explanation readily dismissed when it became clear that the feathers were the bird's own. Any explanation considering the feathers a food item, or e.g. a necessary source of vitamin D, must also be rejected. The function of the feathers in the digestion can only be mechanical. It has been postulated that the feathers should help in the digestion in a similar way as the pebbles found in some other birds' stomachs, but the pebbles serve in crushing the hard parts of the food, which is a function the feathers cannot have. It has also been postulated that the feathers should protect the stomach walls against the sharp fish bones, but other fish-eating birds have had no need in such a protection.

A suggestion which perhaps contains something of the truth is that the feathers should serve in keeping the stomach comfortably full as the food is digested and passed on into the intestine. The single stomach of red-necked grebe found without feathers during this investigation was completely extended by a filling of fish bones; and in the only instance where there are but a few feathers in the stomach there is instead of the usual wad of feathers a similar ball of vegetative material (sea-grasses). The feathers are probably disintegrated

rapidly in the stomachs, but new feathers are continually swallowed to take up the formers' place. If the stomach is filled (whether with feathers or food), the inducement to eat feathers is lacking perhaps.

It has also been suggested that the ball of feathers in the stomachs should serve as a plug for retaining the food in the stomach so that it might be completely digested and the bones and insect chitin completely disintegrated before passing into the intestine. MADON (1926) has suggested that the principial function of the feathers should be to act as a strainer for retaining minute algae and eggs in the stomach so that they might be utilized as food, such items otherwise passing undigested into the intestine. The mass of feathers or fragments of feathers in the stomachs of the grebes indisputably retain small items for a longer time than they are found in other birds of similar size. Thus lenses of fishes may be found in great numbers among the feathers in the stomachs of the grebes, whereas they are rarely recorded, and never in large numbers, in the stomachs of other fish-eating birds. Microscopic eggs are also frequently recorded in the present material, and in NAUMANN's handbook is mentioned that minute thread-like algae are commonly found in the stomachs.

Another explanation of the role of the feathers is that they should act in producing a felt-like substance, enveloping the sharp parts of the food ejected from the stomach. HANZÁK (1952) regards this as the correct explanation.

HARRISON & HOLLOM (1932) state that they "are inclined to believe that the habit of eating feathers is partly a psychological one, a development of preening and perhaps of the curious weed-presentation phases in display".

That the feather-eating habit is a development of preening seems a logical conclusion, that the feather-masses in the stomachs retain minute objects is indisputable, and that the disintegrated feathers when passing out of the stomach act in the pellet formation is evident. It may be of some advantage to the grebes to be able to utilize minute organisms as food, and it may also be a convenience to have soft pellets, but is it necessary to seek a physiological function in the digestion for the feathers? May a sufficient explanation of the feather-eating habit not be that after having been developed of preening it did not hinder the grebes in the struggle for existence?

Food of the red-necked grebe in marine habitats.

The 25 birds available from salt or brackish water localities were obtained in the following places: Kattegat area 11 (Samsø, Mariager Fjord, Aarhus Bay, Kalundborg, Sejerø), the Belt Sea 15 (Kolding, Assens, and Helnæs in the Little Belt, Svendborg in the Great Belt, Køge Bay, Fakse Bay, and Møen).

Remains of fishes are recorded from all 25 stomachs, but in three instances

they consist merely of a number of lenses, in another instance there are besides lenses only some of the horny pads of cyprinoid skulls, and in still another instance, besides several hundreds of lenses, only unidentifiable bones of a very small fish.

The pearl-like lenses of fish eyes, green-coloured through the gastric juices, are a typical item in the stomach contents of the feather-swallowing grebes. In the literature lenses have been mentioned from the stomachs of grebes, but usually they appear to have been overlooked. In the present material every stomach has contained a number of lenses, from about half a hundred to some hundreds in the single stomachs, usually of microscopic sizes, larger lenses being present only in a number of up to a score per stomach content. This corresponding to that a full meal may consist of a hundred small fishes, whereas larger individuals naturally are taken in only small numbers at a time. The lenses found in the stomach contents thus appear to have become accumulated through some meals. They may stay in the stomachs for days perhaps.

Gobies (*Gobius spp.*). Thirteen of the 25 birds from marine habitats (52 %) had consumed these fishes in numbers from a single one to a little more than a hundred per meal. Very small individuals have often been caught. Sandgoby (*Gobius minutus*) was identified once, otherwise the species have not been determined. The lenses found in the stomach must have come mainly from gobies.

Cod (*Gadus sp.*). Eleven of the birds (44 %) had taken cod, usually in single small or very small individuals; only once three specimens were recorded in a stomach. The species taken, when definitely identifiable, has always been the Common Cod (*Gadus callarias*). In a single instance the species may have been Poor-Cod (*Gadus minutus*), but in this case, a bird from Samsø, the record is based solely on a fragmentary otolith.

Viviparous Blenny (*Zoarces viviparus*). One to three individuals of this fish were included in the meals of five birds (from Samsø and Køge Bay).

Fifteen-spined Stickleback (*Spinachia spinachia*). Five birds (from Køge Bay and the Little Belt) had consumed from one or a few, about 15 cm long, individuals to almost half a hundred small ones per meal.

Sticklebacks (*Gasterosteus spp.*). These were fed on by four birds (from the Belt Sea) in numbers of up to half a score per meal. The Ten-spined Stickleback (*G. pungitius*) is identified in two stomachs; the Three-spined Stickleback (*G. aculeatus*) in other two stomachs.

Sand-eels (*Ammodytes sp.*). Three birds (from Samsø, Køge Bay and Fakse Bay) had caught one or two individuals of this kind of fish.

Rock-Wrasse (*Ctenolabrus rupestris*). Three birds (from Samsø and Kalundborg) had eaten from one to three small individuals.

Butterfish (*Pholis gunellus*). Two birds (from Samsø and the Little Belt) had taken one and two individuals, respectively.

Eel (*Anguilla vulgaris*). One and two small individuals, respectively, were eaten by two birds (from Little Belt and Møen).

Pipe-fishes (*Syngnathidae*). Two of the birds have included these in their meals; one from the Great Belt having taken a single *Siphonostoma* or *Syngnathus*, and one from Køge Bay an about 25 cm long *Nerophis*.

Father-lasher (*Cottus scorpius*). A single small individual was swallowed by a bird from Samsø.

Herring (*Clupea harengus*). One stomach content, of a bird from Kalundborg, included some skeletal remains which may have been of a few small clupeids.

A Cyprinoid was recorded from the stomach content of a bird from Køge Bay, the remains, however, only consist of a few more or less decomposited horny pads of the skull bases. The remaining stomach content comprised only lenses of fish eyes, jaws of polychaetes, and insect eggs.

More than half the examined birds had included more than one kind of fish in their meals, 6 birds had taken two kinds, 7 birds three kinds, 2 birds four kinds, and 2 birds five and six kinds respectively. The composition of the two latter stomach contents are the following: In a bird having fed in Køge Bay: 1 *Nerophis*, 1 *Spinachia*, 1 *Zoarces*, some *Gasterosteus* and *Gobius*, some shrimps, traces of insects, and some feathers. In a bird from Samsø: 3 *Pholis*, 2—3 *Zoarces*, 2 *Ammodytes*, 2 *Ctenolabrus*, 1 *Gadus*, 1 *Cottus*, and no feathers.

Crustaceans are recorded from 18 (72 %) of the 25 stomach contents of birds secured in marine habitats.

Shrimps and Prawns (*Crangonidae* and *Palaemonidae*). Twelve of the birds (48 %) had caught these crustaceans. One had included about 35 individuals in its meal, the others from one to a dozen individuals. *Crangon sp.* and *Palaemon sp.* are identified.

Smaller crustaceans are recorded from 12 stomach contents. In two instances there are only finely comminuted, undeterminable traces. Seven stomachs include from one to about a dozen *Idothea*, two of them (birds from Køge Bay) also from a few to a dozen individuals of the very small Isopod *Jæra*. Traces of amphipods are recorded in three stomachs, in the two instances probably *Gammarus*, in the third one another kind. Traces of a *Mysis* are found in one bird. Some *Daphnia* ephippia are found in a bird from Mariager Fjord.

Polychaetes. Remains of these worms were represented in 16 stomach contents. In one instance (a bird from Samsø) there were only some undeterminable bristles. Jaws of *Nereis* are found in 12 instances, in numbers from a single one (the usual) to a little more than a hundred, mainly of small or very

small individuals, only in one instance of a fairly large worm. Jaws of *Polynoidae* are recorded from 8 stomachs in numbers from one to 11. Probably jaws of polychaetes accumulate in the stomachs of the grebes among the feathers as do the lenses of fish eyes, further they may be derived from fish stomachs, their frequency of occurrence may thus give an exaggerated impression of their importance in the diet.

Molluscs are noted in five stomachs, in three instances a few 1 mm large blue mussels (*Mytilus*), in the fourth instance a single small *Hydrobia*, in the fifth instance merely the chitinous lid af a small gastropod. They may all have come from fish stomachs.

Fragments of a Hydrozoan colony is an accidental stomach content of a bird from Sejrø.

Insects. Twelve (48 %) of the 25 birds having remains of marine meals in their stomachs also contained remains of insects, though in five instances only detritus of single undeterminable specimens.

Beetles (*Coleoptera*) were noted in four stomachs. In one instance (the bird from Møen) they include dung-beetle (*Aphodius*), leaf-beetle (*Donacia*), rove-beetles (*Staphylinidae*), weevils (*Sitona*), and lady-bird (*Coccinellidae*). Two dung-beetles are also recorded from a bird from Svendborg. A dozen dung-beetles, some weevils (*Curculionidae*) and undeterminable ones are found in a bird from Præstø. One bird from Mariager Fjord contains a fair quantity of crushings of beetles, being undeterminable, however.

Other insects recorded are: Water-boatmen (*Corixa*) in three instances (birds from Køge Bay, Mariager Fjord and Kolding). Flies (*Diptera*) in single individuals in the two birds from Samsø and Svendborg. An ant (*Formicidae*) and two other *Hymenoptera* in the stomach content of the bird from Møen. A spider (*Araneida*) was taken by the bird from Mariager Fjord.

Eggs of microscopic sizes are commonly found in the stomach contents of the feather-swallowing red-necked grebe. Black and oval eggs of the mosquito (culicid) type were recorded in numbers of up to a few hundred from four stomachs (birds from the Little Belt, Køge Bay and Fakse Bay). Round and whitish (and smaller) eggs of the midge (chironomid) type occurred in at least 11 stomachs (birds from Køge Bay, Kalundborg and Samsø) in numbers of up to many hundres, but of course not forming any appreciable volume percentage of the stomach content.

Vegetable matter. Traces of brown algae and sea-grasses (*Ruppia, Zostera, Potamogeton*) are found in about half the stomachs, probably always as an accidental content. In a single stomach there were several, a few cm long, pieces of sea-grass, but in the same stomach were remains of many fishes, and

the vegetable matter thus was undoubtedly swallowed by accident along with the fishes.

Seeds. Five stomachs, of birds from Fakse Bay, Køge Bay, Kalundborg, and Samsø, contained one or two seeds, *Potamogeton*, *Ruppia*, *Zannichellia*, and an undeterminable one. One stomach content also included a few fruiting bodies of Musk-grass (*Chara*).

A little quantity of sand is present in most stomachs and sometimes also a few gravel, up to 3 mm in diameter.

Food of the red-necked grebe in fresh water habitats.

The five birds available from fresh-water localities were obtained at Skallingen in W. Jutland, Svendborg on Fyn, Kirke Værløse and Fakse on Sjælland.

All five birds had remains of both fishes and insects in their stomachs. In the two birds from Skallingen the remains of fishes, however, merely consist of lenses, in one of them in a number of about 200.

Sticklebacks (*Gasterosteus* spp.) were found in three stomachs, viz. several individuals of the Ten-spined Stickleback (*G. pungitius*) in two instances, and about 15 Three-spined Sticklebacks (*G. aculeatus*) in one instance.

Perch (*Perca fluviatilis*). A small individual was taken by the bird from Fakse together with sticklebacks.

Molluscs. Sveral small snails, *Bythinia*, are found in the bird from Kirke Værløse, but form only an insignificant part of the meal in comparison with the ten-spined sticklebacks also fed on.

Crustaceans. The bird from Svendborg had included in its stomach content some ostracods, and a number of *Daphnia* eggs.

Polychaetes. Jaws of *Nereis* are found in the stomach of the bird from Fakse.

Beetles (*Coleoptera*) are recorded from all five birds, viz. one and two dung-beetles (*Aphodius*) in two instances, a weevil (*Curculionidae*) in one instance, a rove-beetle (*Staphylinidae*) in one instance, about a dozen whirligig-beetles (*Gyrinidae*) in one instance, a large water-beetle (*Dytiscus*) in one instance, and undeterminable traces in two instances.

Aquatic Bugs (*Hemiptera*). Some water-boatmen (*Corixa*) are found in two stomachs, and half a dozen back-swimmers (*Notonecta*) in one stomach.

Diptera. Adults and larvae of mosquitoes (*Culicidae*) are found in some number in the bird from Kirke Værløse, but the insect remains, including beetles and water-boatmen, though of some quantity, form only a small percentage of the stomach content, the bulk of it being formed by a number of ten-spined sticklebacks.

Caddis-fly larvae (*Trichoptera*) in a number of about 10 and midge larvae (*Chironomidae*) in a number of about 20 formed, besides some water-boatmen, half a dozen back-swimmers, half a score of whirligig beetles, some unidentified insects, and a spider (*Araneida*) part of the stomach content of the bird from Svendborg, a negligible part, however, in comparison with the 15 three-spined sticklebacks also included in the meal.

The microscopic eggs of the mosquito type were recorded in some number from two birds; those of the midge type were recorded from four birds, in numbers from about a hundred to several thousands, the latter, however, merely constituting a volume of about one half cubiccentimetre.

Some vegetative growth was present in the stomach content of the bird from Kirke Værløse, no doubt taken accidentally in the gathering of the many fishes, insects, and snails taken in the meal. A trace of vegetative matter was found in the bird from Fakse.

A little quantity of sand is usually included in the larger stomach contents.

Conclusion: Fish supply the principal food of the red-necked grebe, being taken in sizes from the smallest ones to about 15 cm long ones (25 cm in the case of pipe-fishes). In the marine habitats gobies, small cod, and sticklebacks (*Gasterosteus* and *Spinachia*) probably account for about half the food or sligthly more, other kinds of fish constitute about one fourth of the food. The remaining part of the diet in marine habitats is supplied primarily by crustaceans such as shrimps and prawns, but polychaetes and also molluscs are included.

Insects are also taken where accessible, e.g. when blown out on the water, but are also picked off the vegetation or caught in the air. In fresh water habitats aquatic insects and their larvae supply a similar part of the diet as do crustaceans in marine habitats, and probably they may be fed on almost exclusively if fish are absent. Vegetative matter inclusive of seeds may also be consumed. Minute eggs (and algae) appear regularly included in the meals, but they can only supply an insignificant part of the food.

Remarks. The following fishes are reported in the literature as eaten by the red-necked grebe in marine habitats: Sticklebacks (*Gasterosteus* and *Spinachia*), young herring (*Clupea*), rock-wrasse (*Ctenolabrus*), pipe-fish (*Siphonostoma*), and sculpins (*Cottus*). As food items in marine habitats are further recorded crustaceans such as prawns (*Palaemon*) and small crabs. In fresh-water habitats such fishes are reported fed on as sticklebacks (*Gasterosteus*), perch (*Perca*), roach (*Leuciscus rutilus*), and eel (*Anguilla*). Also frogs are noted as food; and molluscs such as fresh-water snails are mentioned.

Insects are a regular food in fresh-water, and the red-necked grebe apparently may subsist on such alone. In NAUMANN's handbook insects are stated to form the main food. ECKSTEIN (1907) found fish only in 3 of 13 stomachs, but found insects in all of them; and NEHRING (1894) did not find fish in several stomach contents examined. Insects reported as foods are: Dragon-flies and water-nymphs (*Odonata*) and their larvae. Aquatic bugs (*Hemiptera*): Water-boatmen (*Corixa*) and back-swimmers (*Notonecta*). Many different beetles (*Coleoptera*): Ground-beetles (*Carabidae*) such as *Amara, Harpalus*; true water-beetles (*Dytiscidae*) such as *Agabus, Colymbetes, Dytiscus, Hydroporus, Noterus, Rhantus*; click-beetles (*Elateridae*); leaf-beetles (*Chrysomelidae*) such as *Donacia, Haemonia;* silver water-beetles (*Hydrophilidae*) such as *Helophorus, Hydrobies; Scarabaeidae* such as *Cetonia,* Cockchafer (*Melolontha*), *Rhizotrogus*. Further such insects are mentioned as *Hymenoptera*. Also Myriapods are noted.

Vegetable matter recorded from stomach contents comprises portions of water plants, algae (e.g. *Conferva*), and mosses.

GREAT CRESTED GREBE

Podiceps cristatus (L.).

The great crested grebe (in Danish: Stor Lappedykker) is in Denmark a common breeder in fresh-water lakes. During winter it stays preferably in the coastal marine regions, and occurs also as a winter-visitor from Scandinavia. It usually takes its food at depths to 2—3 m, but may dive to depths of a least 5½ m. It is usually submerged for ¼ minute or less, but may be submerged for about 1 minute.

A material of 54 stomach contents were available of this species, 25 from birds having fed in freshwaters (lakes and streams), and 29 from birds having fed at least partly in marine localities.

All examined stomach contents have comprised feathers, usually as a dominating part.

Food of the great crested grebe in fresh-water habitats.

The 25 birds from fresh-water localities were collected in the following areas: Jutland 7 birds (Ringkøbing, Vemb, Alken); Fyn 4 birds (Odense, Nyborg), Sjælland 13 birds (Sjælsø, Arresø, Sorø Sø, Esrom Sø, Vordingborg, Præstø); and Bornholm 1 bird (Neksø). The birds were taken mainly during the months September to January, but five from Esrom Sø were taken in March/April, and one from Fyn in May.

Fishes. All 25 birds having fed in fresh-water habitats had remains of fishes in their stomachs, in two instances, however, these remains merely consisted of some lenses of fish eyes; and in seven other instances only of a number of the horny pads from the skull-bases of cyprinoids, besides a number of fish-eye lenses. Such lenses being a usual content of all examined stomachs in a number of up to half a hundred.

Cyprinoids (*Cyprinoidae*). Remains of such fishes are recorded in 22 (88 %) of the examined stomach contents, but in ten instances the remains consist merely of a varying number (from 2 to 28) of the horny pads from the bases of the skulls (in seven instances as the only fish remains). In the other 12 instances there are also bones and sometimes flesh of from one to about 20 individuals. The Roach (*Leuciscus rutilus*) is the commonly taken species. Eleven birds (from Ringkøbing Fjord, Sorø Sø, Sjælsø, Arresø, Esrom Sø, and Fakse Bay) had in their stomachs bones of up to more than half a dozen individuals of this fish, in sizes up to at least 15 cm (20 cm?). The Bleak (*Alburnus alburnus*) was eaten in a number of up to a dozen, in sizes between 3 and 6 cm, by three birds from Esrom Sø. In two instances together with roach.

Perch (*Perca fluviatilis*). One to about half a dozen individuals, from about 4 to 10 cm long, were included in the meals of 3 birds (from Sorø, Esrom, Neksø). In all three instances remains of cyprinoids were also present, though in two instances only some of the horny pads.

Sticklebacks (*Gasterosteus spp*). Three birds (from Ringkøbing and Nyborg) had taken such fishes. The remains of a single Ten-spined Stickleback (*G. pungitius*) was in one instance the only food content in addition to some microscopic eggs. In another instance the stomach content consisted of a single ten-spined stickleback together with some horny pads of cyprinoids and some insect remains. In the third instance there were single specimens of both ten-spined stickleback and Three-spined Stickleback (*G. aculeatus*), in addition to 4 small roaches and some insects.

Frog (*Rana*). One bird, from Arresø, had included a small frog in its meal.

Insects. Microscopic eggs are found in many of the stomachs; oval black ones of the mosquito (culicid) type in numbers up to about some hundreds are recorded from about half the stomachs, and round whitish ones of the midge (chironomid) type are recorded from about one third of the stomachs. Remains of imagines and larvae are recorded in 23 of the 25 stomach contents of birds from fresh-water habitats (in the remaining two were insect remains in the form of eggs). Partly the insect remains found in the stomachs of the great crested grebe, however, must be secondary items, being derived from the stomachs of fishes eaten. Midge larvae (*Chironomidae*) have thus been found in the stomachs

of half digested cyprinoids. Chitinous detritus of insects probably also may become accumulated in the stomach contents among the feathers in a similar way as do e. g. the fish-eye lenses. These facts should be considered when attempting to estimate the role of insects in the total diet of this grebe. The remains of insects have formed the major part of the stomach content in three birds (from Odense in May, and from Ringkøbing in December). In the eight instances where the fish remains have consisted solely of the horny pads of cyprinoid skulls and of lenses, the remains of insects and of fishes have been about equal. Otherwise, however, the fishes have formed the bulk of the stomach contents.

Beetles (*Coleoptera*) were recorded from 16 stomachs (64 %). Dung-bettles (*Aphodius spp.*) were identified in 15 instances in numbers from one to at least 11. Weevils (*Curculionidae*), mainly *Sitona*, were found in 11 stomachs, and in some in large numbers. A bird from Sorø thus contained 76 individuals of one species and a few more individuals of two other species (the bulk of the stomach content, however, is formed by 29 fishes, perches and roaches). Another bird, from Ringkøbing, had in its stomach about 110 weevils of two species, together with other insects and some horny pads of cyprinoid skulls. Other kinds of beetles are recorded in smaller numbers and have usually been undeterminable. Remains are thus recorded of single small *Haliplidae* in two instances, also, in two other instances, a few larvae of same. One to half a dozen rove-beetles (*Staphylinidae*) are recorded in four instances, Ground-beetles (*Carabidae*) in two instances, and, in one instance each, a few large silver-waterbeetles (*Hydrophilinae*), leaf-beetles (*Donacia*), and a lady-bird (*Coccinellidae*).

Various Diptera are recorded from 11 stomach contents, viz. 1—20 flies from seven stomachs, a number of imagines of crane-flies (*Tipulidae*) and mosquitoes (*Culicidae*), respectively, in three birds, a few larvae of crane-flies in another bird, in still another bird about 20 larvae of mosquitoes; and in one stomach an undetermined dipter.

Water-Boatmen (*Corixa*) were recorded in numbers of up to half a dozen in three birds. Other bugs (*Hemiptera*) were traced in two stomachs.

Ants (*Formicidae*) (*Formica* and *Myrmica*) were recorded from six birds (4 of which collected at Ringkøbing). In two stomachs they were present in a number of more than half a hundred. Other *Hymenoptera* were traced in two birds.

Water-nymphs (*Odonata*) were found in one stomach in a number of about half a dozen. A moth (*Microlepidoptera*) was noted in one stomach. One to a few spiders (*Araneida*) were recorded from two stomachs.

In four stomach contents there are only an unidentifiable detritus of insect chitin, and also the other stomachs may have included undetermined detritus of insects.

Crustacea. These have been of no importance as food for the examined material of great crested grebe from fresh-water habitats. Remains of a *Gammarus*, presumably, were traced in one instance. Ostracods were found in one stomach; and ephippia and eggs of *Daphnia* were found in eight stomachs.

Polychaetes. Six birds had jaws of *Nereis* in their stomachs, in numbers from a single to about half a hundred.

Molluscs. The chitinous lids of a few small snails, but no remains of shells, are recorded from four birds (Esrom Sø and Ringkøbing), and an undeterminable shell fragment from a bird from Bornholm.

A gemmula of a fresh-water sponge was found in a stomach of a bird from Sorø.

Vegetable matter. Vegetative growth, often in some quantity, e. g. up to half a hundred ½—2 cm long bits of reeds (*Phragmites*) and the like, are found in 13 of the 25 stomach contents of great crested grebes from fresh-water.

Seeds, Bulrush (*Scirpus*) and unidentified, in a number of from one to 20, are noted in five of the stomachs. Fruiting bodies of musk-grass (*Chara*) are found in three birds, in one of them in a fairly large number.

Food of the great crested grebe in marine habitats.

The 29 birds having fed, in part at least, in marine habitats (brackish or salt water) were collected in the following areas: North Sea area 2 (Ringkøbing, Vemb), Limfjord area 9, Kattegat area 10 (Hadsund 1, Aar hus2, Samsø 6), and the Belt Sea 8 (The Great Belt, the Sound, Køge Bay, Fakse Bay, Møen).

Fish remains were found in all the 29 stomach contents. In four instances there were, however, only lenses, but in numbers of up to a few hundred, mainly of gobies, presumably, but also including some of larger fishes. (One stomach content consisted, besides of feathers, of only a few lenses and a number of microscopic midge eggs).

Gobies (*Gobius spp.*). These fishes appear to be the prime food of the great crested grebe in marine habitats. Eighteen birds (62 %) had fed on gobies, and four of them had done so exclusively. The number of gobies included in the single meals varies from one only to between 100 and 125, and usually were more than twenty. The sizes recorded vary from very small ones to about 8 cm long ones. The Black Goby (*Gobius niger*) was identified in one instance, otherwise the species taken mainly seem to have been Sand-Goby (*Gobius minutes*) and Two-spotted Goby (*Gobius flavescens*). The fish-eye lenses generally found in every stomach content must mainly originate from gobies.

Herring (*Clupea harengus*). Three birds (from Ringkøbing, the Limfjord, and Samsø) had taken from one to about a score of individuals, up to about 10 cm long.

Sticklebacks (*Gasterosteus spp.*). Three birds had eaten these fishes; one had taken half a dozen Ten-spined Sticklebacks (G. *pungitius*), the two others a few Three-spined Sticklebacks (*G. aculeatus*).

Common Cod (*Gadus callarias*). One bird from Køge Bay had eaten three small individuals.

Sand-eel (*Ammodytes sp.*). One bird from the Limfjord area had included a single small individual in a meal on many gobies.

Fifteen-spined Stickleback (*Spinachia spinachia*). Two individuals formed the major part of the stomach content of a bird from Køge Bay; the remaining content consisting of 14 horny pads of cyprinoid skulls and a little vegetative growth.

Cyprinoids. A number of the horny pads of the skull bases were included in the stomach content mentioned above.

Some eggs (of fishes presumably) were found in a bird from Møen.

The greater part of the great crested grebes examined had made their meals on one kind of fish only, about 10 % had taken two kinds of fishes, but none more.

Crustaceans. Thirteen of the great crested grebes having fed in marine habitats had remains of crustaceans in their stomachs, but in two instances there were only traces of small unidentifiable individuals (the one of them a mysid perhaps).

Shrimps and Prawns (*Crangonidae* and *Palaemonidae*) were included in the meals of 10 of the birds (31 %) in numbers from one to a dozen individuals, and in sizes up to 5 cm. Two birds had remains of a few, respectively many isopods (*Idothea*) in their stomachs.

Polychaetes are recorded from 11 of the stomachs (34 %). In ten instances there are from a few to about 150 jaws of *Nereis*, partly of fairly large individuals; and in three instances there are from two to more than 40 jaws, together with many bristles, of *Polynoidae*.

Molluscs. Remains of molluscs are noted in four stomach contents and may possibly in all instances have come from the stomachs of fishes eaten. Remains of a few very small periwinkles (*Littorina*) and of an undeterminable small bivalve are found in a stomach content of a bird from Ringkøbing together with many gobies. A very small bivalve (*Spisula*) was found in another stomach together with gobies. Small snails are recorded in two stomach contents, in one a *Planorbis* or the like, in the other only an undeterminable lid.

Insects are recorded from 15 of the 29 stomach contents including remains of marine food items; and a few of the birds have in reality taken most of their meal in fresh-water habitats. In three instances (birds having fed on gobies) there are only undeterminable traces of insects. Beetles (*Coleoptera*) were recorded in all the remaining stomach contents, viz. dung-beetles (*Aphodius*) in eight instances, in numbers from a few to about 30; weevils (*Curculionidae*), from a few to a dozen, in four instances, *Sitona* being identified; leaf-beetles (*Chrysomelidae*) in three instances; ground-beetles (*Carabidae*) in two instances; dor-beetle (*Geotrupes*) and rove-beetle (*Staphylinidae*) in one instance each, Undeterminable fragments of a beetle were the only insect remains in one stomach. Other insects recorded are a few ants (*Formicidae*) in three instances, single flies (*Diptera*) in two instances, a few water-boatmen (*Corixa*), another bug (*Hemiptera*), and a caterpillar (*Lepidoptera*) in one instance each.

Microscopic eggs of the mosquito type were found in eight stomachs, in numbers from a few to several hundred, and eggs of the midge type in seven stomachs.

Vegetable matter. Traces of vegetative growth as Seagrasses (*Ruppia* and *Zostera*) are found in 11 of the stomachs and have probably been taken accidentally in the gathering of fishes and crustaceans.

Seeds are recorded from five stomachs, *Scirpus spp.*, *Potamogeton spp.*, *Zannichellia*, and unidentified, in numbers from one to six per stomach content. Some fruiting bodies of musk-grass (*Chara*) were found in one stomach.

Conclusion. The food of the great crested grebe in Denmark appears, according to the present investigation, to consist primarily of fishes, in the coastal marine regions mainly gobies, in fresh-waters mainly cyprinoids, but comprising also crustaceans as shrimps and prawns in marine habitats, and insects in fresh-water habitats. A fair estimate may be that these latter items may account for about one fourth of the total diet, and fishes for at least ¾ of the total diet. Polychaetas and vegetable matter may be included in the diet, but in no large percentage in general.

The insects fed on are both aquatic ones taken below the surface and terrestrial ones taken when blown out on the surface of the waters (or picked off the vegetation, or even caught in the air).

Remarks: It is evident also from the literature that fishes are the principal food of the great crested grebe. Harrison & Hollom (1932) thus state about the diet in fresh-water habitats in Great Britain that "it is clear that fish are the main food by a long way". Marine fishes recorded as taken are: Herring (*Clupea*), cods (*Gadus*), and viviparous blenny (*Zoarces*). A long list of fresh-

water fishes included in the diet of the bird can be compiled from HARRISON & HOLLOM's paper of 1932 and HANZÁK's paper of 1952: Trout and char (*Salmo spp.*), pike (*Esox*), carp (*Cyprinus*), gudgeon (*Gobio*), dace, chub, roach, rudd (*Leuciscus spp.*), bleak (*Alburnus*), bream (*Abramis*), *Spirlinus*, tench (*Tinca*), minnow (*Phoxinus*), stone loach (*Nemacheilus*), pond loach (*Misgurnus*), burbot (*Lota*), perch (*Perca*), pikeperch (*Lucioperca*), ruff (*Acerina*), eel (*Anguilla*), sticklebacks (*Gasterosteus*), miller's thumb (*Cottus*). Any fish occurring in fresh-water thus may be a potential food item for the great crested grebe. Individuals up to 25 cm long are reported swallowed. Spawn of fish when available may apparently be eagerly sought for. Also frogs, tadpoles, and newts are mentioned as food items.

Crustaceans recorded as food in the literature includes shrimps and prawns in salt water, and *Gammarus* and crayfish (*Astacus*) in fresh water, the latter seemingly during the time when they are soft after having shed the old shell. Molluscs are also reported fed on, the birds thus may be observed picking small aquatic snails off red-stems. Polychaetes such as *Lepidonotus* are also mentioned as included in the diet.

Insects are regularly eaten by the great crested grebes, but form in general only a small part of the meals in comparison with the fishes also taken. Insects and their larvae are taken in the water, on its surface, picked off the vegetation, and even snatched from the air. A great variety of insects consequently become included in the diet. The following are reported: May-flies (*Ephemeroptera*). Dragon-flies and water-nymphs (*Odonata*) inclusive of nymphs and larvae such as *Aeschna, Libellula, Sympetrum, Agrion*. Bugs (*Hemiptera*) such as water-boatmen (*Corixa*), back-swimmers (*Notonecta*), creeping water bugs (*Naucoris*), shore bugs (*Salda*), water striders (*Gerris*). Caddis-flies and their larvae (*Trichoptera*) such as *Phryganea, Rhyacophila*. Moths, and cater-pillars (*Lepidoptera*). *Diptera*, flies, midges and their larvae, such as *Chironomidae, Muscidae, Simuliidae*. *Hymenoptera* such as ants (*Formica, Myrmica*), Bees (*Anthophora* and other *Apidae*), wasps (*Tiphia*). *Orthoptera* such as crickets (*Gryllus*). Many Beetles (*Coleoptera*), including ground beetles (*Carabidae*) such as *Amara, Anchomenus, Calathus, Feronica, Harpalus, Pterostichus*; true water beetles (*Dytiscidae*) such as *Colymbetes, Dytiscus, Hydaticus, Hyphydrus, Rhantus*; whirligig beetles (*Gyrinidae*); silver-waterbeetles (*Hydrophilidae*) such as *Hydrobius, Hydrous*; leaf-beetles (*Chrysomelidae*) such as *Cassida, Chrysomela, Clytra, Donacia, Haemonia, Lema, Macroplea*; *Dermestidae* such as *Anthrenus*; weevils (*Curculionidae*) such as *Alophus, Chlorophanus, Cleonus, Hylobius, Lixus, Otiorrhynchus, Phyllobius*; *Scarabaeidae* such as *Anomala*, dung-beetles (*Aphodius*), cockchafer (*Melolontha*), *Rhizotrogus*; lady-birds (*Coccinellidae*); click-beetles (*Elateridae*); *Ptinidae*.

Vegetable matter recorded taken are: Algae (allegedly a common food item); bits of mosses, musk-grass, quillwort, and grasses; buds of reeds (*Phragmites*) and pond-weeds (*Potamogeton*). Also seeds are noted, for instance of water plantain (*Alisma*).

SCLAVONIAN GREBE
(Horned Grebe)
Podiceps auritus (L.)

The sclavonian grebe (in Danish: Hornet Lappedykker) occurs in Denmark only as a fairly rare winter-visitor from Scandinavia, preferably in coastal, though also sometimes in inland waters. When diving it is usually submerged for ¼ to ½ minute, but may stay under for at least 1 minute and probably longer (3 minutes being alleged).

Only a single stomach has been available, belonging to a bird collected in an undefined locality in the Kattegat area ultimo October.

The stomach was filled with a great mass of feathers among which were found the following items: Bones of one or two small Fifteen-spined Stickleback (*Spinachia spinachia*), and of 10—20 small Gobies (*Gobius sp.*). A single jaw of the polychaete Nereis. Some detritus of Insects, among which were noted traces of a few small wasps (*Hymenoptera*), a plant-Bug (*Hemiptera*) and some beetles (*Coleoptera*), viz. dung-beetle (*Aphodius*), water-beetles (*Helophorus* and unidentified), weevils (*Curculionidae*) and a small ground-beetle (*Carabidae*). In addition there were found about 30 microscopic eggs of the mosquito type and some hundred microscopic eggs of the midge type.

Remarks: This single stomach content illustrates well the food tendencies of the sclavonian grebe as they also appear from the scanty information in the literature. Fishes as sticklebacks, and also small frogs, newts and tadpoles, supply part of the diet, but the main part evidently consists of insects, —and in marine habitats crustaceans instead. Insects recorded as food are: Caddis-fly larvae (*Trichoptera*); *Diptera* such as larvae of midges (*Chironomidae*) and of crane-flies (*Tipulidae*); aquatic bugs (*Hemiptera*); dragon-fly nymphs (*Odonata*); beetles (*Coleoptera*) such as water-beetles (*Dytiscus*) and whirligig beetles (*Gyrinidae*). Spiders (*Araneidae*) are noted among the food items. Molluscs such as the fresh-water snail *Planorbis*, and worms such as leeches (*Hirudinidae*) and polychaetes (*Nereis*) are also reported to be fed on. The crustaceans eaten are such as the cray-fish (*Astacus*), shrimps (*Crangonidae*), amphipods (*Gammarus*), and mysids. Vegetable matter recorded from stomach contents comprises *Conferva*, water-weeds, and sea-weeds, also grasses (and in one instance grass-seeds in large quantity).

BLACK-NECKED GREBE

Podiceps nigricollis Brehm

The black-necked grebe (in Danish: Sorthalset Lappedykker) is a fairly common breeder in Denmark in fresh-water habitats, marshes and small lakes. During winter it occurs in the coastal regions. It dives to about 5½ depth and may be submerged for nearly a minute, though less than half a minute is the usual.

Two birds were available for a suggestion of the food-habits; the one collected in a coastal locality (Kalundborg) in January, the other in a fresh-water locality in May.

The black-necked grebe from the coastal locality had in its stomach, besides a large quantity of feathers, a single small individual of a goby (*Gobius sp.*), a small quantity of bones of some more, several lenses of fish-eyes, a fairly large quantity of crushings of a number of *Mysis*, about 2 cm long, several hundred microscopic eggs of the midge type, and also some underterminable detritus of insects.

The bird from a fresh-water locality had in its stomach a mash of insect remains, but no feathers. The content comprises some hundred mosquito larvae (*Culicidae*), a few large flies and about a hundred small ones (*Diptera*), some water-boatmen (*Corixa*), a few caddis-fly larvae (*Trichoptera*), many beetles (*Coleoptera*) among which about 20 of the small *Haliplidae* and several large leaf-beetles (*Haemonia*). There are furthermore about a dozen large spiders (*Araneida*), a large water-mite (*Hydrachnidae*), and a quantity of quite undeterminable chitinous crushings.

Remarks: The two meals of black-necked grebes examined here have been sufficient for demonstrating that both small fishes as well as crustaceans in marine habitats, and insects in fresh-water habitats, may serve as food.

According to information in the literature this grebe subsists largely on insects (in marine habitats on crustaceans) whereas fish should be only an unimportant food. Small perchs (*Perca*) are recorded fed on, and also small frogs and tadpoles.

The insects, imagines and larvae, recorded as food items comprise: Caddis-flies (*Trichoptera*) such as *Hydropsyche, Phryganea, Rhyacophila* (e. g. about 200 *Phryganea grandis* larvae in one meal); water-bugs (*Hemiptera*) such as water-boatmen (*Corixa*), back-swimmers (*Notonecta*), and water-striders (*Velia*); dragon-flies (*Odonata*) such as *Gomphus* and *Libellula*; earwigs (*Forficula*); may-flies (*Ephemeroptera*); *Hymenoptera* such as ants (*Formicidae*); *Diptera* such as midges (*Chironomidae* and *Simuliidae*) and flies (*Muscaria*); beetles (*Coleoptera*)

of many kinds; ground-beetles (*Carabidae*) such as *Agonum, Amara, Badister, Harpalus, Notiophilus*; water-beetles (*Dytiscidae*) such as *Dytiscus* and *Noterus*; *Haliplidae*; rove-beetles (*Staphylinidae*); silver water-beetles (*Hydrophilidae*) such as *Helephorus*; *Scarabidae* such as dung-beetles (*Aphodius*); leaf-beetles (*Chrysomelidae*) such as *Donacia* and *Cassida*; *Cantharidae* such as *Drilus*; *Tenebrionidae* such as *Phylan*; weevils (*Curculionidae*) such as *Apion, Gymnetron,* and *Sitona*. Water-mites (*Hydrachnidae*) are also noted.

The crustaceans recorded to be eaten by the black-necked grebe are: Shrimp (*Crangon*), e. g. 72 individuals in one meal; *Gammarus*, e. g. 150 individuals in one meal; *Asellus*, and *Mysis*. Molluscs such as small bivalves are also mentioned as included in the diet.

Various water plants are recorded to be fed on to some extent, mentioned from stomach contents are for instance algae, mosses, musk-grass, and also grasses.

LITTLE GREBE

Podiceps ruficollis (Pallas)

(*Podicipes minor* Gmelin)

The little grebe (in Danish: Lille Lappedykker) breeds fairly commonly in Denmark in fresh-water habitats, marshes and small lakes. During winter it occurs in the coastal regions. When diving it may be submerged for about ½ minute, but about ¼ minute is the usual.

Seven birds were examined, all from fresh-water localities, viz. at Odense and Svendborg on Fyn, and at Hadsund, Arden, and Haderslev in Jutland. One bird was obtained in May, one in September, and the others in November/December.

Feathers are not a common stomach content in the little grebe, and were found in the present material in only one of the stomachs, viz. some barbs.

Remains of insects were recorded in all seven stomach contents, and remains of fishes in three of them.

Ten-spined Stickleback (*Gasterosteus pungitius*). A bird collected in Jutland in December had made the major part of its meal on a hundred or more individuals of this fish, and had in addition taken a number of insects.

Cyprinoids? Some bones of small indeterminable fishes, *Cyprinoidae* presumably, were found in the stomach of a bird from Odense which had in addition fed on some back-swimmers.

In another bird from Odense there are merely remains of a few disintegrated vertebrae, in addition to some crushings of water-boatmen.

Water-Boatmen (*Corixa*). Four birds had included water-boatmen in

their food. Two of them (from Haderslev and Hadsund) had taken about 75, or more, individuals, in one instance as the major part of a meal comprising in addition half a dozen other insects of various kinds, and in the other instance together with about a hundred caddis-fly larvae. The two remaining birds (from Svendborg and Odense) had merely the crushings af one to a few individuals in their stomachs which, however, in addition contained only traces of fish vertebrae in one instance, and in the other instance only traces of a beetle and of a seed.

Caddisfly-larvae (*Trichoptera*). Two birds had fed on these insects. The one, from Hadsund, mentioned above, had taken a hundred individuals of two kinds, in addition to may water-boatmen; the other, from Arden, Jutland, had eaten half a hundred individuals as a small part of a meal consisting mainly of sticklebacks.

Back-swimmers (*Notonecta*). A few individuals were included in the meal on sticklebacks, and traces were also found, as mentioned, in the stomach containing traces of cyprinoids.

Other insects recorded are: Trace of a single waterbeetle in the stomach containing in addition only traces of a single water-boatman and a seed. Trace of a single dipter, presumably, as the only stomach content of a bird from Odense in addition to a few fragments of chaffs and a small quantity of sand. The bird from Haderslev, which had made most of its meal on about 75 water-boatmen, had in its stomach also the remains of four beetles, a small and a larger species of water-beetles (*Dytiscidae*), and two whirligig beetles (*Gyrinidae*), further traces of a back-swimmer and a dipter larva, and also some large water-fleas (*Daphnia*).

The vegetable matter recorded from the examined seven stomach contents has comprised the traces of chaffs mentioned, and fragments of a single undeterminable seed in one instance.

Sand in a small quantity, or up to a few gravel, was found in four stomachs.

Remarks: The small material examined shows that the little grebe feeds on fishes as well as on aquatic insects, and that it may feed on insects alone. Fishes are here recorded from three out of the seven stomachs (of which, however, a few ought to be disregarded since they were almost empty, only containing detritus of chitin, which is the item most resistent to the decomposition in the stomachs). RÖRIG (1900) found fish remains in 4 out of 14 stomachs, and ECKSTEIN (1907) in 11 out of 15 stomachs. The kind of fish taken has usually not been specified; besides sticklebacks, only miller's thumb (*Cottus gobio*) is recorded. Small frogs and tadpoles are also mentioned as food items.

Insects apparently supply the staple food for the little grebe (though ECK-

STEIN found only insects in 9 out of the 15 stomach contents he examined). The following are recorded as eaten: Flies and midges (*Diptera*) such as *Bibio, Eristalis,* larvae of *Chironomidae.* Aquatic bugs (*Hemiptera*) such as water-boatmen (*Corixa*), back-swimmers (*Notonecta, Plea*), *Naucoris, Aphelocheirus,* and water-striders (*Gerris*). Dragon-flies (*Odonata*), imagines and larvae, e. g. *Agrion.* Caddis-fly larvae (*Trichoptera*) such as *Hydropsyche* and *Rhyacophila.* Stone-fly larvae (*Plecoptera*) such as *Perla.* Various beetles (*Coleoptera*): *Haliplidae* such as *Cnemidotes Brychius,* and *Haliplus*; water-beetles (*Dytiscidae*) and their larvae, *Agabus, Colymbetes, Hydroporus,* and *Hyphydrus*; ground-beetles (*Carabidae*) such as *Amara, Calathus, Harpalus,* and *Pterostichus*; silver water-beetles (*Hydrophilidae*) such as *Spercheus*; *Scarabaeidae* such as dung-beetles (*Aphodius*); *Cantharidae* such as *Drilus;* weevils (*Curculionidae*) such as *Dorytomus, Phytonomus,* and *Sitona.* Spiders (*Araneida*) and water-mites (*Hydrachnidae*) are also mentioned from stomach contents.

Food items recorded include also various fresh-water crustaceans such as *Gammarus pulex, Asellus,* and *Palaemonetes varians*; further molluscs such as a number of brackish-water and fresh-water snails, *Lacuna, Littorina, Rissoa, Bythinia, Valvata, Physa, Planorbis, Limnaea,* and *Paludina.* Worms too are mentioned as food items.

Vegetable matter has also been recorded from stomach contents, for instance bits of algae, musk-grass, mosses, and also seeds.

SMEW

Mergus albellus L.

The smew (in Danish: Lille Skallesluger) occurs in Denmark as a regular, though rare winter-visitor from Scandinavia and Russia, staying in the fjord areas and in freshwater habitats. When diving it may be submerged for up to ¾ minute, though normally not for more than ½ minute.

Seventeen birds were examined, one of which, however, had a completely empty stomach. The other 16 smews were collected during the winter months October to February, 11 in coastal or fjord localities with salt or brackish water (Langeland in the Great Belt 1, Roskilde Fjord 1, Køge Bay 8, unknown 1), and 5 in fresh-water localities (Holmsland and Nørre Nebel in the Ringkøbing Fjord area, Silkeborg in Mid-Jutland, Ruds Vedby and Vordingborg in Seeland.

Food of the smew in marine habitats.

Fishes were recorded from the stomachs of 8 of the 11 smews obtained in marine localities. The remaining three birds had in their stomachs merely small

quantities of vegetable remains and in two cases also jaws of *Nereidae*. Since these items remain for a longer time in the stomachs than do bones of fishes, the meals from which they are the remains may have included fish too.

Gobies (*Gobius spp.*). Six of the smews had eaten up to a dozen individuals of these fishes, in sizes from 3 to 6 cm, together with such other food as sticklebacks and/or prawns. The Black Goby (*Gobius niger*) and the Two-spotted Goby (*Gobius flavescens*) have been identified.

Sticklebacks (*Gasterosteus spp.*). Four birds had taken one to a few individuals of these fishes besides gobies and other foods. The Three-spined Stickleback (*G. aculeatus*) was identified in two stomach contents, the Ten-spined Stickleback (*G. pungitius*) in one.

Fifteen-spined Stickleback (*Spinachia spinachia*). A single individual formed together with a few *Nereis* the whole meal of a smew from the Køge Bay.

Viviparous Blenny (*Zoarces viviparus*). A single, small individual was included in the meal of another bird from Køge Bay, together with gobies, sticklebacks, and prawns.

Herring (*Clupea harengus*). One smew (locality uncertain) had made its whole meal on small herrings, a 9 cm long individual being found in the gullet and some bones and flesh of a few more individuals in the gizzard.

Crustaceans. Five of the 8 smews with larger stomach contents available from marine localities had made part of their meals on crustaceans.

Prawns (*Palaemonidae*, and others?). Every one of the 5 meals on crustaceans has included prawns in numbers varying from one to about 10. *Palaemon fabricii* was identified in a few instances.

Smaller crustaceans: One smew (from Roskilde Fjord) had in its gullet two *Mysis*, caught together with a few gobies. A small isopod, probably an *Idothea*, and further some ostracods were traced in a stomach content comprising also remains of sticklebacks and gobies. The ostracods, at least, probably came from the fish stomachs, if they were not swallowed accidentally.

Polychaetes. Remains of *Nereidae* were recorded in the stomachs of 8 of the 11 smews obtained from marine localities. In some cases there were in addition to the jaws also bristles and in two cases also some flesh of the worms, showing that they have been purposely taken by the birds. Some of the jaws af *Nereis*, however, may have come from the stomachs of fishes eaten. The number of *Nereis* traced in the single stomach content have been up to about 15 small individuals or half a dozen fairly large ones.

Molluscs. A few small snails (*Hydrobia*) were recorded in the stomach content of a smew from the Great Belt. This bird had made the major part of its meal

on sticklebacks and gobies, and the snails may have come from the stomachs of these.

Vegetable matter. Nine of the 11 Smews from marine localities had small quantities of vegetative growth in their stomachs; and traces of sea-grass were the only content in a bird obtained in Køge Bay in January. *Zostera*, *Ruppia*, and presumably *Potamogeton* have been identified. Three of the birds had in addition also seeds in their stomach contents, viz. two birds from Køge Bay, in each of which were found a single seed of pond-weed (*Potamogeton*), traces of sea-grass, and jaws of *Nereis*, and one bird from Langeland in the Great Belt, which—besides remains of some fishes and prawns—also contained traces of sea-grass, one seed of widgeon-grass (*Ruppia*), and five seeds of *Potamogeton*.

Food of the smew in fresh-water habitats.

Fishes constituted part of the food taken by four of the five smews available from fresh-water localities. In one instance, however, the remains consist merely of some unidentifiable, small vertebrae.

Roach (*Leuciscus rutilus*). This cyprinoid was fed on by the two birds from the Ringkøbing Fjord area. Bones and flesh of 23 small individuals constituted in one instance the bulk of the stomach content, comprising in addition a few seeds and traces of insects. In the other instance there were remains of a few small individuals together with a very small perch, some seeds, and many caddis-fly larvae, which latter constituted the major part of the stomach content.

Perch (*Perca fluviatilis*). This fish was taken by two of the birds. One very small individual was included in one of the meals referred to above; and two small individuals were included in the meal of the bird from Silkeborg.

Pike (*Esox lucius*). One young individual, about 10 cm long, was eaten by the smew from Silkeborg, which bird in addition had swallowed two perches, a small bleak, a ten-spined stickleback, a small frog, a beetle, and traces of grass-like growth.

Bleak (*Abramis blicca*). One small individual was included in the meal mentioned above.

Ten-spined Stickleback (*Gasterosteus pungitius*). One individual in the same meal.

Frog (*Rana sp.*). One small individual in the same meal.

Insects. All the five smews obtained in fresh-water localities had remains of insects in their stomachs. In two instances there are, however, only unidentifiable traces.

Caddis-flies (*Trichoptera*). The remains of more than a hundred large larvae constituted more than half of the stomach content of a bird from Ringkøbing, which bird in addition had fed on roach and perch.

Water-boatmen (*Corixa*). The remains of between 50 and 100 individuals constituted almost the whole stomach content of the smew from Ruds Vedby, in addition there were only traces of a beetle, presumably, and some vertebrae of a very small fish.

Beetles (*Coleoptera*) of various kinds, and other insects, constituted the major part of the meal of the smew collected at Vordingborg ultimo October. Its stomach content comprised the following items: Remains of at least four large water-beetles (*Dytiscus marginalis*?), remains of at least two individuals of another water-beetle (*Acilius sulcatus*?), and of one *Haliplus*, also traces of leaf-beetles (*Chrysomelidae*), remains of at least nine back-swimmers (*Notonecta glauca*) and of one water-boatman (*Corixa*), some midge larvae (*Chironomidae*), further remains of four pond-snails (*Limnaea*), and some eggs of *Daphnia* and midges, in addition also some vegetable matter, viz. a small quantity of duck-weed (*Lemna*), two seeds of bulrush (*Scirpus*) and four unidentified seeds.

Molluscs. A few pond-snails (*Limnaea*) were included in the meal referred to above.

Vegetable matter. All five smews from fresh-water localities had either a small quantity of vegetative growth and/or some seeds in their stomachs. The vegetative growth were duck-weed (*Lemna*), unidentified grass-like pieces, and presumably pond-weed (*Potamogeton*), each in one stomach. Seeds were found in four of the stomachs: *Potamogeton*, *Scirpus*, and unidentified ones (only fragments), in two instances each.

Sand or Gravel. A small quantity of this item is usually included in the stomach contents. There may be up to about 40 gravel of 3 to 6 mm in diameter, or a few pebbles as large as 12 mm.

Conclusion: The food of the smew in Denmark consists largely of fishes (in marine habitats primarily gobies and sticklebacks, in fresh-water habitats cyprinoids), but includes in the marine habitats a considerable amount of crustaceans (prawns), and also polychaetes, and in fresh-water habitats a similar amount of insects, besides a certain amount of vegetative growth and seeds. A fair estimate may be that fishes supply ½ to ⅔ of the total food.

Remarks: In the literature the following marine fishes have been recorded as food for the smew: Sticklebacks (*Gasterosteus*), flounder (*Pleuronectes platessa*), sand-eels (*Ammodytes*), and sand-smelt (*Atherina*). Of fresh-water fishes are

mentioned salmon and trout (*Salmo spp.*), gudgeon (*Gobio*), roach (*Leuciscus rutilus*), bleak (*Alburnus alburnus*), loaches (*Cobitidae*), minnow (*Phoxinus*), burbot (*Lota*), and eel (*Anguilla*), from elvers to 29 cm long ones. Frogs are mentioned as not uncommonly eaten. Crustaceans stated to be eaten are shrimps (*Crangon*) and amphipods (inclusive of the fresh-water *Gammarus*). The aquatic insects mentioned are water-bugs (*Hemiptera*) and water-beetles (*Dytiscidae* and others). Also fresh-water molluscs are mentioned as food. Vegetable matter (grass, and green vegetative growth) are recorded as a rare food item.

RED-BREASTED MERGANSER

Mergus serrator L.

The red-breasted merganser (in Danish: Toppet Skallesluger) is a common breeding bird in Denmark in the coastal regions and, more rarely, in inland waters. It is also a common winter-visitor from Scandinavia, staying predominantly in the coastal regions. It dives for its food to depths of up to 5½ m, though normally not over 3½ m, and can stay under the water for 2 minutes, though less than ½ minute is the usual.

A material of 189 birds has been examined, collected during the winter months November to March, A small percentage of the birds had no food remains in their stomachs. Eight other birds (from Samsø, Læsø, and Sejerø) contained besides the usual gravel only traces of red algae or sea-grasses, and in so small quantities that they have not been considered food. Three birds from Læsø did contain remains of meals on fishes in their stomachs, but in unidentifiable traces only, wherefore also they have been disregarded in the following computation of food frequencies.

The remaining 158 stomach contents were of birds obtained in the following localities: 8 in the North Sea area (Ringkøbing), 3 in the Limfjord area (Brovst), 107 in the Kattegat area (Randers Fjord 8, Læsø 16, Sejerø Bay 18, Samsø 65), 38 in the Belt Sea (Great Belt 1, The Sound and Drogden 9, Køge Bay 4, Fakse Bay 5, Møen 19), and 2 from Bornholm in the Baltic.

Fish is the most frequent food of the red-breasted merganser, being recorded from 145 (92 %) of the stomach contents examined. Fishes supplied in 68 instances (43 %) the sole food remains in the stomachs (negligible quantities of vegetable matter such as pieces of algae or sea-grasses found in 13 instances being disregarded as having been swallowed accidentally). In some other instances the stomach contents have besides fishes only consisted of jaws of *Nereis* or fragments of chitin of small crustaceans, which items may have been derived from the stomachs of the fishes eaten.

Sticklebacks (*Gasterosteus spp.*). In all localities these fishes constitute an important food for the red-breasted merganser. They are by far the most frequently recorded food item of the present material, having been eaten by 97 of the birds (61 %), and by 23 of them (15 %) as their sole food (traces of eel-grass found in seven instances being disregarded). The Three-spined Stickleback (*G. aculeatus*) was identified in 73 stomachs (46 %), and the Ten-spined Stickleback (*G. pungitius*) in 17 stomachs (11 %). In twelve instances these two species of sticklebacks were recorded in the same stomachs. A large number of these fishes often was included in the single meal; thus one bird had 44 three-spined sticklebacks in its gullet and the flesh and bones of a similar number in the gizzard.

Gobies (*Gobius spp.*). Also these fishes constitute an important food in all the investigated areas. Only in three instances (2 %) they have been the sole food recorded, but they have been included in the meals in 63 other instances, often as a major part. (Frequency of occurrences, in all, 43 %). One bird had about 210 otoliths and a large quantity of bones in its stomach. Another bird had 44 gobies in the gullet besides 25 sticklebacks and in the gizzard the bones and flesh of many more. Half a hundred Two-spotted Gobies (*Gobies flavescens*), 2½—3 cm long, were swallowed by a bird from Samsø. Two birds from Møen had eaten similar numbers of the Sand-Goby (*Gobius minutus*), varying in length from 1½ to 8 cm. Two Black Gobies (*Gobius niger*), 5 and 8 cm long, were identified in a bird from the Sound.

In the examined material of red-breasted merganser 125 birds (78 %) had eaten sticklebacks and/or gobies, and 64 of the birds (41 %) had made their entire meals on these fishes.

Viviparous Blenny (*Zoarces viviparus*). Twenty of the birds (13 %) had included from one to three individuals of this fish in their meals, usually small ones, but also some about 20 cm long. One stomach content comprised in addition to the remains of viviparous blennies only a few seeds of *Scirpus*.

Butterfish (*Pholis gunellus*). This fish had been taken by 16 birds (10 %), eleven of which were obtained in the Sejerø Bay, whereas the others were collected at Læsø, Samsø, and in the Sound. Four birds (2½ %) had fed exclusively on butterfishes. The number taken varies from one to seven at least, the largest recorded one measured about 20 cm, but usually they were smaller.

Rock-Wrasse (*Ctenolabrus rupestris*). Eleven birds (7 %), from Sejerø Bay and the Sound, had taken this fish, the two of them as their sole food. One bird had eaten 13 individuals up to 12 cm long, another bird had in its gullet one of about 10 cm and eleven of 4—5 cm, and in its gizzard the bones and flesh of some middle-sized ones and several small ones.

Flatfishes (*Pleuronectidae*). This kind of fish, in all cases, when identifiable, the Flounder (*Pleuronectes platessa*), and always small individuals, less than 10 cm long, had been taken by eleven (7 %) of the red-breasted mergansers examined (birds from Randers Fjord, Læsø, Samsø, and Møen). One bird (from Møen) had made its meal on a large number of flounders, seven individuals, 3—6 cm long, were found in its gullet, and the bones of at least ten more in its gizzard; the stomach content, in addition, comprised some bones of one or a few gobies and a single jaw of *Nereis*.

Sculpins (*Cottidae*). Eight (5 %) of the birds (from Læsø, Sejerø, and the Sound) had taken from one to three, up to fair-sized individuals of these fishes, one of them as its only food. The Father-lasher (*Cottus scorpius*) is the usually taken species, but one bird from the Sound had eaten a small Cobbler (*Cottus bubalis*).

Sand-eels (*Ammodytes sp.*). This kind of fish was eaten by seven (4 %) of the birds (from Sejerø Bay, Samsø, and Læsø), by three of them their sole food.

Eel (*Anguilla vulgaris*). Six (4 %) of the birds (from Randers Fjord, Samsø, and the Sound) had included eels in their meals, usually only a single small or fairly small individual, but one bird from the Sound had taken nine individuals, about 10 to 23 cm long, six of them being found in the gullet. The latter stomach content comprised in addition to the eels only a single spine of a stickleback, which may have come from an eel stomach.

Fifteen-spined Stickleback (*Spinachia spinachia*). One to two individuals, 10—15 cm long, were recorded in six stomachs (birds from Samsø, the Sound, and Køge Bay), in one instance as the sole content.

Cods (*Gadus sp.*). Bones of single, small individuals were recorded in five stomachs (birds from Læsø, Samsø, and the Sound). In the only case where an identification of the remains was possible the species was the Common Cod (*Gadus callarias*).

Herring (*Clupea harengus*). Four individuals, 15—20 cm long, formed the entire meal of a bird from Læsø.

In general only one kind of fish has been fed on in each meal; 39 birds (19 %) had two kinds of fishes in their stomachs (in more than half the instances sticklebacks and gobies), 12 birds (7 %) three kinds, and three birds four kinds viz., *Gasterosteus*, *Gobius*, and *Spinachia*, besides *Pholis* and *Zoarces* respectively; and *Gasterosteus*, *Gobius*, *Pleuronectes* and *Anguilla*.

Crustaceans. These animals are regularly included in the diet of the red-breasted merganser. They were recorded from 58 of the stomachs examined (37 %), in four instances they constituted the sole content (besides the usual gravel), in another instance there were in addition only traces of vegetative matter.

Shrimps and Prawns (*Crangonidae, Palaemonidae*). These are the crustaceans primarily fed on by the red-breasted merganser. They were included in the meals of 37 (23 %) of the birds (from the Kattegat area and the Belt Sea) in numbers from one only up to about a hundred in some instances where the stomach contents represented full meals. The Common Shrimp (*Crangon vulgaris*) was identified in 19 stomachs, the Prawn (*Palaemon sp.*) in one instance.

Shore Crab (*Carcinus maenas*). Two birds (from Køge Bay and Fakse Bay) had each eaten a single crab, the breadth of the carapace measuring 3 and 4 cm, respectively. Both crabs apparently were caught when soft just after having shed their old shell.

Smaller crustaceans were recorded from 17 stomach contents (11 %), inclusive of a case with only some *Daphnia*-ephippia which must have come from a fish stomach, if not swallowed accidentally. The crustacean remains may also in other cases have been a secondary stomach content, but generally the small crustaceans must have been taken purposely.

Amphipods (*Amphipoda*) ,are recorded from eight stomachs (5 %). In six instances at least they were *Gammarus sp.* The only two red-breasted mergansers available from Bornholm in the Baltic had remains of single individuals of *Gammarus* as the only food items in their stomachs. No large meal of amphipods has been recorded.

Isopods (*Isopoda*), always *Idothea* were identified in six stomachs. One bird (from Samsø) had 12 individuals in its gullet and the crushings of some more in its gizzard, its meal in addition comprising some sticklebacks, a few gobies and a viviparous blenny.

Mysids (*Mysidae*). A single to a few individuals have been included in the meals of three birds (from Samsø, Sejerø Bay, and Fakse Bay), in two cases together with shrimps and *Idothea*.

Unidentifiable fragments of chitin were in two instances the only remains of crustaceans recorded. *Daphnia*-ephippia were found in the stomachs of birds from Randers Fjord and Fakse Bay.

Polychaetes were recorded from 32 of the examined red-breasted mergansers (20 %), always jaws of *Nereis*, in one instance also some bristles. In two instances there were in addition 1—5 jaws of *Polynoidae*. One bird from Møen had 85 jaws of fairly small *Nereis* in its stomach, but otherwise 1—7 jaws in each stomach content was the usual. The jaws of *Nereis* have, with one exception, always been found in stomachs containing remains of fishes, and have nearly always been of small or very small individuals. Possibly the jaws of *Nereis* have partly come from fish stomachs, but their frequency of occurrence in the examined

material shows that polychaetes are regularly fed on by the birds. A jaw of a large individual was recorded in a single instance, in a stomach also containing remains of eels from a stomach of which the *Nereis* jaw may have been derived.

Molluscs. Small Gastropods and Bivalves were recorded from 14 stomach contents (9 %). Small individuals of the snails *Hydrobia* and *Littorina* were found in seven and two instances, respectively, and undeterminable remains of gastropods in two other instances. Remains of small individuals of the bivalves *Mytilus*, *Cardium*, and *Mya* were found in 5, 2, and 2 stomachs, respectively. These small molluscs, in sizes up to about 5 mm, were always found together with remains of fishes, from the stomachs of which they, at least partly, may have been derived; but no doubt molluscs are also taken as food by the red-breasted merganser.

Insects (adults, larvae, and eggs) are recorded in seven stomachs. In one instance, a bird from Fakse Bay, the whole stomach content merely consisted of some undeterminable traces of chitin together with some *Daphnia*-ephippia. Single individuals of midge larvae (*Chironomidae*) were recorded in two instances, two 7 mm long larvae of waterbeetles in one instance, and traces of a beetle in one instance. All these four birds were from Samsø and had for the major part made their meals on sticklebacks or gobies. One bird from Møen had several hundred, microscopic eggs (of *Chironomidae* presumably) in its stomach together with the remains of more than half a hundred gobies and sticklebacks. One bird from Samsø had about a hundred eggs of the mosquito type in its stomach together with remains of gobies and flounders. Possibly these insects or eggs recorded have been accidentally consumed or are derived from the stomachs of fishes eaten.

Vegetable matter, vegetative growth and seeds, is recorded in all from 55 stomachs (35 %), but have in general been a secondary content, swallowed accidentally in the catching of fishes and shrimps.

Vegetative growth is found in 47 stomachs (30 %), and in one instance the whole content consisted of a small quantity of fragments of stalks and leaves (all dead ones) of *Zostera*, *Potamogeton* and *Chara*, in addition to the usual gravel. Also a few red-breasted mergansers from Samsø had included a small quantity of vegetative growth in their meals (by accident probably), thus in one instance some fragments of leaves and stalks of *Ruppia*, half a dozen pieces of rhizoms of *Zostera*, and also half a dozen pieces of leaves of the same, one of them 8 cm long, in addition to shrimps and sticklebacks. Another bird (from Randers Fjord) had in its stomach some fragments of stalks of *Scirpus* together with many sticklebacks and other fishes. Usually only a trace of vegetative growth has been present in the single stomach content, and probably it has

in the present material always been swallowed accidentally in the catching of the fishes and crustaceans fed on.

Seeds were found in 16 (10 %) of the examined stomachs of red-breasted merganser (birds from Ringkøbing Fjord, Randers Fjord, Samsø, the Great Belt, the Sound, and Møen), viz. *Scirpus* in eight instances, *Ruppia* in three instances, and *Potamogeton, Zostera, Carex, Potentilla, Sueda, Atriplex, Empetrum,* and *Zannichellia,* in one instance each. A single or two seeds per stomach content is the usual; the largest number found is 11, viz. 5 of *Ruppia* and 6 of *Zostera,* in a bird from Samsø.

Sand and gravel in a small quantity, sometimes also a few pebbles up to 10 mm in diameter, but normally not more than 5 mm, are a usual stomach content, but may be totally absent in some stomachs.

Parasitic Nematods were found in about a third of the stomachs examined, in a few instances in a number of about a hundred individuals, usually, however, in small numbers only.

Conclusion: The food of the red-breasted merganser in Denmark (during winter) consists according to the present investigation primarily of fish, but includes also an amount of crustaceans. A fair estimate will probably be that fish account for about $^3/_4$ to $^4/_5$ of the total diet, and crustaceans (mainly shrimps) for most of the remaining part, whereas polychaetes and molluscs, and also vegetable matter, though included, form only a small percentage of the food. More than half the total food is supplied by the small shoal fishes, sticklebacks and gobies.

Remarks: In the literature the food of the red-breasted merganser is reported to consist principally of fish, but comprising also crustaceans, and a smaller part of annelids, insects, and molluscs; the latter items primarily being summer food. Fishes reported as food are such marine species as sticklebacks (*Gasterosteus*) viviparous blenny (*Zoarces*), sand-eels (*Ammodytes*), plaice and flounder (*Pleuronectidae*), cod, coal-fish, and hake (*Gadidae*), (in the Arctic polar cod (*Boreogadus*)), eel (*Anguilla*), up to 28 cm long, sculpins (*Cottidae*), gobies (*Gobiidae*), pipe-fishes (*Syngnathidae*), and sand-smelt (*Atherina*). Fresh-water species reported as food are e. g. (besides sticklebacks and eel) salmon and trout (*Salmonidae*), roach, dace, and chub (*Leuciscus spp.*), perch (*Perca*), pike (*Esox*), gudgeon (*Gobio*). Various other species are included in the diet in America. Also frogs are mentioned as food items.

The crustaceans reported as food are crabs, crayfish, shrimps, and amphipods (*Gammarus*).—Sometimes crustaceans may form the principal food. Robinson

(1909) found that a red-breasted merganser taken "off a shore swarming with coal-fish fry" had fed exclusively on small crabs. This shows that the bird has preferred the food items obtainable at the bottom to the free-swimming ones.

Annelids taken as food items include earth-worms (*Lumbricus*) according to NAUMAN's handbook. Molluscs such as water snails are reported to be fed on. Insects recorded from stomach contents comprise caterpillars (*Lepidoptera*), dragonfly-larvae (*Odonata*), caddis-flies (*Trichoptera*), ephemerid nymphs (*Ephemeroptera*), various beetles (*Coleoptera*) as water-beetles and also cock-chafers.

Vegetable matter is recorded as an occasional food. CAMPBELL (1947) records this item in 2 of 6 birds, with leaves of *Ruppia* identified, but COLLINGE found no vegetable remains in 16 birds examined, and in NAUMAN's handbook it is stated that vegetable matter is never found as food.

GOOSANDER

Mergus merganser L.

The goosander (in Danish: Stor Skallesluger) breeds in some number in the eastern part of Denmark, in the brackish coastal regions and in fresh-water habitats. It is otherwise a common winter-visitor from Scandinavia, staying in the coastal regions and also frequenting fresh-waters inland. It dives after its food to depths of about 3½—4 m, and may be submerged for up to 2 minutes, though normally not for more than ½ minute.

A material of 64 birds has been examined, and, disregarding some empty stomachs and a few with only unidentifiable traces of food items, 55 stomach contents were available for the food analysis, almost exclusively from birds collected during the winter months October to February, only a single one from a bird taken ultimo March, in Esrom Lake. Coastal localities with salt or brackish water have furnished 48 birds, viz. the Kattegat area 5 (Læsø 1, Sejerø 1, Samsø 3) and the Belt Sea 43 (Little Belt 11, The Sound and Drogden 20, Køge Bay and Fakse Bay 12). Inland freshwater localities have furnished 7 birds (Ringkøbing fjord area 2, Samsø 4, Esrom Sø 1).

Food of the Goosander in marine habitats.

Fishes are by far the most important items in the stomach contents of the goosander. Remains of fishes were found in every stomach examined of birds from marine habitats except one, which merely contained the comminuted remains of a few small amphipods. Since the chitinous items are more resistent to the decomposition in the stomach than are bones of fish, the meal of which they are the remains may have included fish too.

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Eel (*Anguilla vulgaris*). This fish supplies the principal food of the goosander. It has been eaten by 26 of the 48 birds from marine localities (54 %) and was in 19 instances (37 %) the sole food taken. In more than half the cases only a single eel is recorded from each stomach content, 5 individuals being the largest number found. The eels caught have usually been small ones, less than 20 cm long, but one goosander had swallowed a 35 cm long individual, which was found bent thrice in the gullet (this meal in addition consisted of a few sticklebacks and gobies). Large eels, about 30 cm in length, are recorded in a few other instances. One bird, for instance, had made its whole meal on three eels of which the largest was about 28 cm long. Eels were fed on in all the coastal localities from where goosanders have been available.

Sticklebacks (*Gasterosteus spp.*). These fishes ranked second in importance in the diet of the examined goosanders from marine habitats. Seventeen (35 %) of the birds (2 from Læsø and Samsø, 3 from the Little Belt, 12 from the Sound and Køge Bay) had fed on sticklebacks, and 8 of them (17 %) exclusively. The Three-spined Stickleback (*G. aculeatus*) was included in every meal on sticklebacks, in numbers from one to half a hundred, often many individuals per stomach content, and in three instances the sole food item. The Ten-spined Stickleback (*G. pungitius*) was included in six of the meals on sticklebacks (birds from the Sound and Køge Bay) and in five instances they constituted, together with the three-spined species, the whole meals.

Fifteen-spined Stickleback (*Spinachia spinachia*). Four birds (1 from Læsø and 3 from Køge Bay) (8 %) had fed on one to 4 individuals of this fish, in addition to two or three other kinds of fishes, one of which in all four cases was the viviparous blenny.

Viviparous Blenny (*Zoarces viviparus*). Nine (18 %) of the birds (1 from Læsø, 2 from Samsø, 3 from Little Belt, and 3 from the Sound) had made one to 4 individuals of this fish part of their meals. The remaining part was in one instance merely some jaws of *Nereis*, otherwise it consisted of two or three other kinds of fishes. The viviparous blennies eaten usually were small ones, only once a fairly large individual was recorded.

Gobies (*Gobius spp.*). Eight (17 %) of the birds (2 from Samsø, 4 from the Little Belt, and 2 from the Sound) had eaten from one to 10 sobies. In at least three instances the species taken was the Black Goby (*Gobius niger*), in individuals 8 to 14 cm long. In three other instances the gobies have constituted only an insignificant part of the meal in relation to the other fishes, cods and eels, also included.

Common Cod (*Gadus callarias*). Remains of this fish were recorded in five stomach contents (1 bird from Læsø, 1 from Sejerø, and 3 from the Little Belt).

In two instances (4 %) they may be regarded as having constituted the sole food item, in one stomach being found together with only some dead vegetative matter, plant stalks, and in the other stomach only together with some fragments of sea-lettuce (*Ulva lactuca*), which may likewise be an accidental stomach content.

Rock-wrasse (*Ctenolabrus rupestris*). Two individuals formed the meal of a bird from Køge Bay together with two viviparous blennies and one fifteen-spined stickleback.

Flounder (*Pleuronectes platessa*). One bird, from Samsø, had eaten a small flounder together with a few gobies and a shrimp.

Sand-eel (*Ammodytes sp.*). A single, about 15 cm large individual, was caught by a bird from Læsø together with a viviparous blenny, four fifteen-spined sticklebacks, and a few three-spined sticklebacks.

Spawn of fish. A small quantity formed the entire stomach content of a bird from the Sound.

More than half the examined meals of the goosander has been made on a single kind of fish only, about one fifth (11 birds) on two kinds of fish, one tenth (5 birds) on three kinds, and two meals have included four and five different kinds, respectively. One meal has thus included eel, cod, viviparous blenny, stickleback, and goby.

Crustaceans have been recorded from only three of the examined stomach contents (6 %), viz., a single Shrimp (*Crangon vulgaris*) in a bird from Samsø together with flounder and gobies; remains of a single *Gammarus* in a bird from Køge Bay which had fed on viviparous blenny and other fishes; and a few very small amphipods in a bird from the Sound, as the only content besides the usual gravel.

Polychaetes. Jaws of *Nereis* were recorded in two stomach contents (birds from Samsø and Køge Bay) together with such fishes as eel and viviparous blenny, from the stomachs of which they may have been derived.

Other animal matter includes traces of a beetle found in a bird from Læsø, the stomach content of which in addition consisted of remains of a viviparous blenny, besides other fishes, pieces of brown-algae and a few seeds of *Ruppia*.

Vegetable matter. Some stomach contents include in addition to the remains of fish also small quantities of red algae, brown algae, or sea-grasses such as *Zostera*; for instance many small pieces of leaves and rhizoms of eel-grass, or some fragments of the sea-lettuce (*Ulva lactuca*), or several small pieces of the bladder wrack (*Fucus vesiculosus*). This vegetable matter, however, has probably always been accidentally swallowed together with the fishes caught.

A few seeds of *Ruppia* were included in the stomach content of a bird from Læsø together with the remains of several marine fishes.

Sand and Gravel in a small quantity, sometimes also a few pebbles up to 14 mm in diameter, is a normal part of the stomach contents.

Fish hooks were found in the stomachs of two of the birds having taken eels.

Parasitic Nematods were found in some stomachs, in a number of up to about 50, but are much less frequent in the examined material of goosander than they were in that of the red-breasted merganser.

Food of the goosander in fresh-water habitats.

Fishes supply also in fresh-water habitats practically the whole food of the goosander, judging from the seven birds examined. The Danish vernacular name for the merganser, viz., Skallesluger, also simply means "swallower of roach". Fishes, cyprinoids and sticklebacks, were recorded from five stomach contents, in two of which there were also traces of other animal matter, which, however, may have come from the fish stomachs. The two remaining stomachs did not contain any remains of fish, but were practically empty, one containing a single seed of grass and some plantfibres besides some gravel, the other a trace of an insect and a small lump of grass-like vegetative growth besides the usual gravel. None of these stomach contents can be said to represent meals without fish.

Dace (*Leuciscus grislagine*). Two goosanders collected in the Ringkøbing Fjord area in September had gorges themselves with small, 3 to 6 cm long daces. One contained about 80 only partly digested individuals besides bones of some more. The other contained 66 more or less digested individuals and the bones of at least 20 more. In the latter was also found some bones of a single stickleback.

Rudd (*Leuciscus erytrophthalmus*). A single, about 15 cm long individual was eaten by a bird from Samsø together with a single ten-spined stickleback.

Bleak (*Alburnus alburnus*). The goosander obtained in Esrom Lake in March had fed for the major part on this fish, having in its gullet 36 individuals, about 5½ to 8½ cm long, and in its gizzard the bones and flesh of some more. In addition the meal comprised 4 roaches and traces of insects.

Roach (*Leuciscus rutilus*). This cyprinid formed part of the meal referred to above.

Ten-spined Stickleback (*Gasterosteus pungitius*). This fish was recorded from three of the five stomach contents with fresh-water fishes; in two instances single individuals included in large meals on cyprinoids; in the third instance, a bird from Samsø, about half a hundred individuals, 3½ to 5 cm long, as the

bulk of the stomach content, which in addition comprised merely traces of insects, and small molluscs, a few jaws of *Nereis*, and some vegetative growth.

Other animal matter. Detritus of undeterminable insect chitin were recorded in the stomach content of bleaks and may have been derived from the stomachs of these fishes. Remains of two snails about 3 mm large, a *Limnaea* and a *Planorbid*, the head of a *Chironomid* larva, a piece of chitin of a water-bug, and two jaws of *Nereis*, the one of a fairly large individual, were found in the stomach content comprising many sticklebacks. Partly, at least, these items may have come from the fish stomachs.

Vegetable matter. Two stomachs, as mentioned above, had some vegetative growth, partly grass-like, and in one instance also a grass seed, as the only organic content. One bird had, besides many fishes, also some pieces of vegetative growth in its stomach, probably swallowed accidentally in the catching of the fishes.

Conclusion: The food of the goosander in Denmark (the winter food) consists almost exclusively of fishes, primarily eels, which in the investigated material have supplied about $^2/_5$ of the total food consumed in marine habitats. Sticklebacks are the next most important food, accounting for about one fifth of the total diet. Viviparous blenny and gobies appear important food fishes in salt-water, and cyprinoids in fresh-waters.

Remarks: The information available in the literature confirms that the food of the goosander consists almost entirely of fishes and that eels are a favoured food. COLDWELL (1938) reports eel as the principal food in Casperau River in Nova Scotia, and as taken in individuals up to 55 cm in length. COLLETT (1877) found a 4 cm thick eel swallowed by a goosander, and in another bird a 34 cm long trout. Other fishes mentioned as food are herring (*Clupea*), viviparous blenny (*Zoarces*), sculpins (*Cottidae*), butterfish (*Pholis*), sand-eels (*Ammodytes*), flounder (*Pleuronectes*), and pipefishes (*Syngnathidae*). Of fresh-water fishes are mentioned as food such as salmon and trout (*Salmo*), roach and dace (*Leuciscus spp.*), carp (*Cyprinus*), perch (*Perca*), etc. MUNRO & CLEMENS (1937) found fishes in 363 of 402 examined stomachs of the American Goosander in British Columbia, and identified 27 different species. Spawn of fish is reported to be consumed in quantities when available. Also frogs are mentioned as food items.

Evidently other animal matter than fish is of little importance in the diet of the goosander. Crustaceans recorded fed on include crayfish (*Astacus*), in America, and GRENQUIST (1942) found regularly remains of *Gammarus*, *Idothea*, and *Palaemon* in 500 pellets of goosander in the inner Baltic in August. Insects

mentioned as food items are, in NAUMANN's handbook, caterpillars, dor-beetles, cockchafers, water-beetles and their larvae, and waterstriders. Also earthworms (*Lumbricidae*) are included in the list of food items given in NAUMANN's handbook.

Vegetable matter has been mentioned as accidentally consumed, for instance *Sparganium*.

BLACK GUILLEMOT

Cepphus grylle (L.).

(*Uria grylle* L.).

The black guillemot (in Danish: Tejst) breeds in small numbers in Denmark, and is otherwise a fairly common winter-visitor from Scandinavia and the Baltic, staying on the sea, but keeping in sight of the coast. It dives after its food at depths between 1 and 8 m, at most, usually staying under the water for ½—1 minute, but sometimes for up to ¼ minute.

The stomach contents of 26 birds collected in the winter from ultimo October to February have been available. Twenty-one of the birds were collected in the Kattegat area (Læsø 9, Mariager Fjord 1, Samsø 5, Sejerø 3, Kalundborg 3), 3 in the Belt Sea (the Great Belt 2, Fakse Bay 1), and 2 at Bornholm in the Baltic. A few other birds examined had empty stomachs.

More than half of the birds (16 = 63 %) had included both fishes and crustaceans in their meals, and four of them had in addition taken polychaetes. Three birds had made their meals exclusively on fishes, another three exclusively on crustaceans, two on fishes and molluscs. and two on fishes and polychaetes.

Fish in all constituted a more or less important part of the food of 23 of the birds (89 %).

Gobies (*Gobius spp.*). Nineteen birds (73 %) had fed partly on gobies, and gobies were the only kind of fishes included in the meals in nine instances. Remains of up to about a hundred small individuals have been counted in a single stomach content.

Viviparous Blenny (*Zoarces viviparus*). Four birds from Samsø had eaten single small individuals together with other kinds of fish.

Ten-spined Stickleback (*Spinachia spinachia*). Four birds (from Samsø, Læsø, the Great Belt, and Bornholm) had included from one to half a score of individuals of this fish in their meals.

Butterfish (*Pholis gunellus*). Three birds (from Læsø and the Great Belt) had eaten 2—5 individuals together with other fishes and crustaceans.

Common Cod (*Gadus callarias*). This fish was eaten by two birds (from the Kattegat area) together with gobies and crustaceans.

Gar-fish (*Belone bellone*). A single small individual was the only food found in a bird from Læsø.

Eel (*Anguilla vulgaris*). One bird from Bornholm had eaten a single small individual besides gobies, ten-spined sticklebacks and shrimps.

Pipe-fish (*Nerophis sp.*). One bird from Læsø had taken a few individuals together with crabs.

Herring (*Clupea harengus*). Two birds from Samsø had fed on herrings in addition to gobies.

Rock-Wrasse (*Ctenolabrus rupestris*). One bird collected in the Kattegat area had in its stomach remains of half a dozen small individuals of this fish besides of three butterfishes, one gobies, one swimming crab, and one *Nereis*.

More than half the birds examined (13) had included but a single kind of fish in their meals. Eight birds had taken two kinds of fish, and two birds three kinds.

Crustaceans. Nineteen stomachs (73 %) contained remains of crustaceans, in 16 instances found together with remains of fish, in three instances as the only content.

Crabs (*Brachyura*). Nine birds from Læsø and Sejrø in the Kattegat area (33 %) had eaten crabs. Three of them had undeterminable remains of crabs as their only stomach content. The others had in addition eaten various fishes, viz., gobies, pipe-fish, butterfish, ten-spined stickleback, and rock-wrasse, respectively. In the three only instances where the remains were identifiable they proved to be of Swimming Crabs (*Portunus sp.*). Up to three individuals have been recorded in a single stomach content.

Shrimps and Prawns (*Crangonidae* and *Palaemonidae*). Such crustaceans were found in eight of the examined stomach contents (31 %), from traces of a single one to remains of about a dozen. They had been fed on in all the localities from which black guillemots have been obtained.

Isopods were recorded in six (23 %) of the stomach contents (birds from the Kattegat area, the Belt Sea, and Bornholm). In four instances they were *Idothea sp.* in numbers from one to three.

Squat Lobster (*Galathea sp.*). A bird from Læsø had eaten a single individual together with swimming crabs, gobies, and butterfish.

Polychaetes. Six of the black guillemots (23 %) had remains of polychaetes in their stomachs. In one instance the record is based only on the jaw of a small *Nereis* found in a stomach content comprising also remains of several fishes. In the five other instances (birds from Samsø, Sejerø, Fakse Bay, and Bornholm)

there are jaws of *Polynoidae*. The black guillemot collected in Fakse Bay had taken at least 50 polynoid worms, a hundred jaws and many bristles being recorded in the stomach, and, in addition, a dozen shrimps (*Crangon*) and many gobies.

Molluscs. A small *Neretina fluviatilis* is recorded in a stomach content including viviparous blenny; a small *Hydrobia* in a stomach containing many gobies; and a few very small blue mussels (*Mytilus edulis*) in a stomach containing both eel, ten-spined stickleback and gobies. Possibly the molluscs recorded in the present material have all been derived from the stomachs of fishes eaten.

Vegetable matter. Traces of red algae were recorded in some stomach contents. They must have been swallowed accidentally in the gathering of fishes and crustaceans.

Gravel. Only a few of the stomachs have contained a single or two small pebbles, the largest being 9 mm in greater diameter.

Conclusion: The total food taken by the examined material of wintering black guillemots may be estimated to consist of about ⅔ fishes, about ⅓ crustaceans, and a few per cent of polychaetes. Gobies constitute the principal food, the other fishes taken include free-swimming forms as well as bottom forms, the crustaceans eaten are primarily crabs and shrimps.

Remarks: Various fishes are reported in the literature as food for the black guillemot: Sculpins (*Cottus scorpius* and also *Cottus bubalis*), sand-eels (*Ammodytes*), butterfish (*Pholis gunellus*), and also cod (*Gadus*) and herring (*Clupea harengus*). In the Arctic is fed on capelin (*Mallotus villosus*).

The butterfish (*Pholis gunellus*) evidently constitutes one of the most important food items for the black guillemot. Along the Swedish coast the vernacular name of the butterfish, viz., tejstefisk, simply refers to the black guillemot or tystie. The butterfish is reported to be fed on almost exclusively in the Faroes, and it is recorded as the principal food also in the Western Atlantic, on the coast of Maine, WINN (1950) estimated that the butterfish in 1946 formed about 90 % of the food consumed by the birds of Kent Island, Bay of Fundy, watched by him, and in 1947 about 50 %. The remaining food consisted of the Little Sculpin (*Myoxocephalus aeneus*).

Sand-eels (*Ammodytes*) apparently is a common food in the Baltic area, since here the vernacular name of the bird in Swedish (tobis-grissla) refers to that of this fish (tobis = sand-eels).

It is also from the literature evident that crustaceans are an important food for the black guillemot. In NAUMANN's handbook (1903) its diet is estimated

to consist more of crustaceans, and worms and molluscs, than of fish. COLLETT (1894) notes that the young ones are fed with fishes caught in the region of sea-weed vegetation, but that the food in winter is made up largely of crustaceans and molluscs. The crustaceans recorded to be eaten by the black guillemot are crabs (f. inst. *Carcinus maenas*), hermitcrabs (*Eupagurus*), squat-lobster (*Galathea nexa*), shrimps (as *Crangon vulgaris* and *Pandalus*), prawns (*Palaemon squilla*), amphipods, isopods, and mysids. Nine birds from Norway examined by COLLETT had all taken large individuals of squat-lobster (*Galathea*) as their only or major food. BENT (1919) mentions that several stomach contents of birds from Labrador were found to consist exclusively of *Mysis*.

The other animal items reported as food for the black guillemot are polychaetes such as the lug-worm (*Arenicola*), and molluscs, both bivalves and gastropods, (COLLETT, 1894, thus records a stomach content consisting exclusively of nine different species of gastropods: *Lacuna, Margarita, Bela, Admete, Natica, Purpura,* and *Amauropsis*). Also pteropods (*Clio borealis*) have been mentioned as food, and also coelenterates and ctenophores. Further accidentally drowned crane-flies (*Tipulida*). Vegetable matter, seaweed, is mentioned too as a stomach content.

COMMON GUILLEMOT

Uria aalge (Pontoppidan)

The common guillemot (in Danish; Lomvie) is in Denmark a common winter-visitor from Scandinavia, but has also a single breeding colony on Ertholmene, in the Baltic near Bornholm. It stays on the sea and usually it keeps away from the coasts. It dives mostly at depths of 4—5 m, and reaches bottom at least to 8 m; it also dives pelagically, and some very large diving depths recorded (90 m for instance) may be misinterpretations of pelagic dives.

Fourteen birds, collected in the winter months November to February, were examined. One stomach was completely empty, another contained only a trace of brown algae, and a third only a small pebble and some undeterminable detritus (of crustaceans?). Five of the remaining 11 birds were collected in the Kattegat area (Læsø 2, Holstebro 2, Sejerø 1) and the other six from the Belt Sea (Little Belt 2, Great Belt 1, The Sound 1, Fakse Bay 2).

All 11 common guillemots examined had fed on fishes, and no other food was recorded in the material, except the possible crustacean remains mentioned above.

Herring (*Clupea harengus*). This fish has constituted the greater part of the food consumed by the examined birds. Nine of them (82 %) had fed on herring,

and five (46 %) of them exclusively. In all cases the herrings taken have been small ones, (up to about 6 cm long?) The number of individuals included in the single stomach content has varied from a single one to about half a hundred.

Gobies (*Gobius spp.*). Two birds from the Belt Sea had taken this kind af fish, respectively a single small individual together with herrings, and several very small and some up to about 5 cm long individuals together with sticklebacks.

Sticklebacks (*Gasterosteus spp.*). The Three-spined Stickleback (*G. aculeatus*) formed part of the meals of three birds from the Belt Sea, taken together with herrings and gobies, respectively, and in numbers from one to half a dozen.

Viviparous blenny (*Zoarces viviparus*). A small individual constituted part of the meal of a bird from the Little Belt.

Mackerel (*Scomber scombrus*). An about 20 cm long individual constituted the remaining part of the meal mentioned above.

Cod (*Gadus sp.*). Traces of a small cod, probably *Gadus callarias*, were the sole stomach content of a bird from Læsø.

Out of the 14 common guillemots examined ten had fed on one kind of fish exclusively, and four on two kinds.

Conclusion: The food of the common guillemot in Denmark (during winter) appears, judging from the available material, to consist almost exclusively of fishes, primarily herring,—but as appears from the literature some other animal food especially crustaceans may be included in the diet.

Remarks. Fish are reported also in the literature as the principal food of the common guillemot. Herring and sprat (*Clupeidae*), and sand-eels (*Ammodytes*) are recorded, also small cods (*Gadidae*), sculpins (*Cottidae*), in the Arctic capelin (*Mallotus*), and in fresh-water e.g. the crucian carp (*Carussius*). COLLETT (1881) records a 28 cm long herring as food for a common guillemot. He also mentions that the bird is sometimes caught on fishing lines, and that captures on hooks at depths of 60 fathoms are alleged.

The diet of the common guillemot is further reported to include crustaceans such as shrimps, amphipods, and isopods; annelids such as *Nereidae*, and also molluscs (these latter eaten more commonly in the Arctic), further some vegetable matter.

RAZORBILL

Alca torda L.

The razorbill (in Danish: Alk) breeds in Denmark in a colony on Ertholmene, in the Baltic near Bornholm, and occurs otherwise as a common winter-visitor from Scandinavia and the Baltic region. It stays mainly on the open sea. When diving it may reach bottom at depths of about 5 m, but 2—3 m are the preferred depths for bottom-diving, otherwise it dives pelagically. It may be submerged for about ¾ minute.

A total of 120 birds, collected during the winter months November to February, were examined, but more than one third were completely empty, and two contained only a pebble and a fragment of a cockle, respectively, so that only 71 stomach contents were available for the food analysis. These were from 47 birds collected in the Kattegat area (Læsø 8, Samsø 30, Sejerø 9) and 24 collected in the Belt Sea (Little Belt 9, Great Belt 5, The Sound 1, Køge Bay 1, Præstø Bay 7).

The greater part of the examined razorbills, 69 birds or 97 %, had included fishes in their meals, 59 of them (83 %) having fed exclusively on fish, the other 10 having in addition eaten crustaceans. One stomach contained only remains of crustaceans, and another one only remains of polychaetes.

Sticklebacks (*Gasterosteus spp.*) had been food for 28 birds (40 %) and the sole food in 11 instances (16 %). Six of the birds had fed in the Belt Sea, and 22 in the Kattegat area. Every meal on sticklebacks, except one, has included the Three-spined Stickleback (*G. aculeatus*), and in at least 14 instances this was the only species taken, thus in all cases where sticklebacks constituted the only food. The Ten-spined Stickleback (*G. pungitius*) was included in at least seven instances, and in one instance it was the only kind of stickleback caught; viz. a bird from Langeland in the Great Belt which had made its meal on a few ten-spined sticklebacks together with many gobies. Great numbers of these small fishes have been counted in some stomach contents. One razorbill from Langeland had in its gullet 48 ten-spined sticklebacks, 2½—3 cm long, and in its gizzard the bones and flesh of about 30 more and of a few three-spined sticklebacks. Another bird, from Samsø, had swallowed 49 three-spined sticklebacks, about 5 cm long, and in addition a few gobies.

Herring (*Clupea harengus*). This fish was found in 24 (34 %) of the stomachs (14 birds from Kattegat and 10 from the Belt Sea) and in 19 instances (27 %) it was the only food, thus in every one of all the eight birds collected near Læsø ultimo November, and in all the five birds obtained in Præstø Bay in February. Numerous small herrings might be included in the single meal. The largest

individuals caught by the present birds may have been about 15 cm long. Herring is in the present material second in frequency of occurrences, but qualitatively it has been the most important, accounting for about 30 % of the total food, whereas sticklebacks can be estimated to have supplied about 25 % of the food.

Gobies (*Gobiidae*). This kind of fish had been fed on by 23 of the razorbills examined (32 %), and was in eleven instances (16 %) the only food taken. *Gobius spp.* have been recorded in 13 stomach contents, and the White Goby (*Aphya pellucida*) in 10 stomachs. This latter species was thus fed on by nine out of 11 birds collected at Samsø in January, by eight of them exclusively, and further it was included in the meal of a single bird from the Little Belt. *Gobius spp.* were taken by five birds from the Kattegat area and by eight from the Belt Sea, in three instances as the sole food. The Two-spotted Goby (*Gobius flavescens*) was identified in one instance.

Cods (*Gadidae*). Seven of the razorbills (10 %) had eaten cods. The Poor-cod (*Gadus minutus*) was recorded in three instances, viz., small individuals included in the meals of two birds from Samsø, and remains of a single, about 20 cm long individual as the major part of the stomach content of a bird from the Little Belt, in addition comprising only traces of a prawn which may have come from the stomach of the fish. The Common Cod (*Gadus callarias*) formed the bulk of the meal of a bird from Samsø, ten small individuals being taken together with some sticklebacks. In the three remaining instances the species may also have been the common cod, but the bones have been too disintegrated to be identified with certainty.

Garfish (*Belone bellone*). Three razorbills from the Belt Sea (4 %) had caught this fish, the two of them as their sole food item, in one instance a 15 cm long individual, in the other instance two individuals up to about 25 cm long.

Flatfishes (*Pleuronectidae*). Two birds (from the Little Belt and Samsø) have had unidentifiable traces of flatfishes in their stomachs.

Unidentifiable bones and fragments of bones were the only remains of the fishes eaten in four instances.

Generally only a single kind of fish is included in each meal, but 6 of the birds had fed on two kinds, 5 on three kinds, and a single one had remains of four kinds in its stomach, viz. herring, cod, gobies, and flatfish (though of the latter only an otolith).

Crustaceans. Eleven of the examined razorbills (16 %) had remains of crustaceans in their stomachs. One of them had a small quantity of comminuted undeterminable crustacean chitin as the only content.

Mysids (*Mysidae*) had been fed on by four out of six birds obtained at Samsø in January, and had partly been consumed in large quantities. One of the birds had thus made its meal on about 1400 mysids together with 2 amphipods, 2 three-spined sticklebacks, and 1 ten-spined stickleback.

Amphipods, probably always *Gammarus*, had been taken by 3 birds (from Samsø and Køge Bay) in numbers from one to about 75 individuals.

Traces of a Prawn were recorded from one stomach content, but in this case the crustacean may have been derived from the stomach of the fish eaten (a gadid).

Polychaetes. Remains of a few large worms (not nereids) constituted the sole stomach content of a bird from Samsø.

Molluscs. A single stomach had as its only content a very small fragment of a cockle (*Cardium sp.*). This stomach content was disregarded in the computation of food frequencies.

Gravel. Pebbles or fine gravel are only exceptionally found in the stomachs of the razorbills examined. A small pebble, 6 mm in diameter, was the only content of one stomach. One stomach content of sticklebacks and *Gammarus* comprised also a small quantity of gravel.

Conclusion: The food of the razorbill in Denmark (the winter food) consists, according to the present material, largely of fishes (about $^{9}/_{10}$ of the total food) but includes also small crustaceans, primarily such as mysids and amphipods (accounting for about $^{1}/_{10}$ of the total food), and a small percentage of polychaetes. The three kinds of fishes, herring, sticklebacks and gobies, have together constituted almost $^{4}/_{5}$ of the total food.

Remarks. The published data support that fish are the principal food of the razorbill. The fishes recorded taken are herring and sprat (*Clupeidae*), sticklebacks (*Gasterosteus* and *Spinachia*), sand-eels (*Ammodytes*) (in the Faroes "almost exclusively"), and in the Arctic primarily capelin (*Mallotus villosus*). The food is further reported to comprise crustaceans such as amphipods, annelids, and, as a lesser part, various small molluscs (these not being specified).

SUMMARY AND GENERAL CONCLUSIONS

The present paper reports on the food habits in Denmark of Divers, Grebes, Mergansers, and Auks, which species have in common that they dive after their food and make fish a more or less important part of their diet. (The other Danish species which feeds in a similar way, the Cormorant, was reported upon 1950,

in vol. 1 of this series). Almost 900 birds were examined, but only about 750 of them had food remains in their stomachs.

Several of the species are represented by breeding birds in Denmark, viz., Red-necked Grebe, Great Crested Grebe, Black-necked Grebe, Little Grebe, Red-breasted Merganser, Goosander, Black Guillemot, Common Guillemot, and Razorbill. While some of them are only rare as breeders, most of them are common as winter-visitors. The non-breeding species, Black-throated Diver, Red-throated Diver, Great Northern Diver, Sclavonian Grebe, and the Smew, occur mainly as winter-visitors, some of them being very common. The material of stomach contents examined, therefore, has largely been from the winter months. This, however, should be immaterial since any significant seasonal variation in the diet of the species is not to be expected, but of course such food items as crustaceans and insects may be of largest importance during summer.

While the investigation gives a fair idea of the composition of the diet of the birds treated, it does not tell how much they actually eat. But probably their daily food consumption will be about one fourth to one third their own body weight.

The grebes and the goosander occur in part in fresh-water habitats, lakes, streams, and marshes, but during winter—when ice closes the fresh-waters—all of them stay in the coastal regions along with the other mergansers, the divers, and the black guillemot. The other auks, the common guillemot and the razorbill, may occur in the coastal region too, but preferably they keep away from the coasts.

The common guillemot and the razorbill feed, besides in bottom-diving, also in pelagic diving, whereas the other species are bottom-divers, feeding generally in shallow water, only the larger species reaching depths of about half a dozen metres.

Divers.

The black-throated diver and the red-throated diver have essentially the same food-habits. They take fishes from the smallest ones (when occurring in shoals) to individuals about 25 cm long. The common cod has in the examined material constituted about one third of the food of the black-throated diver and about half the food of the red-throated diver. Gobies and sticklebacks are the next most important food items, of about equal value. Together these three kinds of fishes alone formed $^{9}/_{10}$ of the food of the black-throated diver, and $^{8}/_{10}$ of the food of the red-throated diver. Cod, gobies and sticklebacks are the staple foods of these divers in Denmark. According to the present investigation it is evident however, that also the herring at times may be fed on to a

large extent. In the examined materials it formed only a small percentage of the food of the black-throated diver, but more than one tenth of the food of the red-throated diver. The remaining $^1/_{10}$ of the food af these two divers is formed by a variety of fishes, preferably bottom-forms such as viviparous blenny, sculpins, sand-eels, flounder, eel, but occasionally also pelagic species such as mackerel and gar-fish.

The food af the great northern diver consists, as far as can be judged from the small material available, to a lesser extent of gobies and sticklebacks than does the food of its smaller relatives. Cod is an important food, and flounder, viviparous blenny, and sculpins appear to be the principal other food items.

Other animal matter than fishes has been only rarely recorded in the stomach contents of divers examined here, and may have been derived partly from the stomachs of fishes eaten, or swallowed accidentally in the catching of the fishes. Whereas the divers subsist during winter on an almost exclusive fish diet, they change in summer, on their breeding grounds, according to published information, to a mixed diet of fishes and crustaceans and other aquatic invertebrates. Such crustaceans as shrimps and amphipods are recorded as food items, also worms, aquatic insects such as caddis-fly larvae, and sometimes molluscs. It was also to be expected from the present investigation that such items might be included in the diet, since the divers often feed on very small fishes, not larger than amphipods and many aquatic insects. The divers are also used to pick up from the bottom small stones to add to their stomach contents (serving in crushing the fish bones) and therefore will not have to adopt any unnatural behaviour in taking molluscs from the bottom. In places where fishes are scarce, or perhaps totally absent, other animal objects may thus form a more or less important part of the diet.

Vegetable matter such as small pieces of algae and sea-grasses are regularly recorded from the stomach contents, swalloved accidentally in the gathering of the fishes. Whole stomach contents of vegetable matter, even of land plants, have been recorded from the Arctic. Such matter thus may serve as a substitute food (or at least as a stomach filling) for birds which for instance on account of ice cannot feed in their natural way.

Grebes

The four larger grebes, red-necked grebe, great crested grebe, sclavonian grebe, and black-necked grebe, have the peculiar feature in common that they have in their stomachs almost invariably a great mass of feathers which they have picked from their own body or taken on the surface of the water and swallowed. This has always puzzled the observers, and several explanations

have been attempted. The present author thinks that the theory advanced that the feather-eating habit should be a development of preening is a logical conclusion. It is, however, also indisputable that the feather masses in the stomachs retain such minute objects which in other bird's stomachs pass rapidly into the intestine, e.g. insect eggs, so that they may be utilized as food, though they can only form an unimportant part of the total diet. The disintegrated feathers form in the intestine a felt-like substance in the pellets, and also this may be advantageous. But otherwise a sufficient explanation of the feather-eating habit may be that—after having been developed from preening—it has not hindered the grebes in their struggle for existence.

All the grebes eat, in addition to small fishes, also crustaceans and insects. The insects recorded from the stomach contents are not only aquatic ones, which the grebes probably largely take near the surface, merely by dipping down their head, but include all other kinds, dung-beetles for instance commonly. Even when enough fishes, or crustaceans and aquatic insects are at hand the grebes continually take insects found blown out on the surface of the water, pick off insects from the vegetation above the water, may even catch insects in the air.

The two larger species, red-necked grebe and great crested grebe, feed primarily on fishes, such accounting for at least $^3/_4$ of the food of the materials examined here.

Gobies, small cod, and sticklebacks supply the most important food for the red-necked grebe in the coastal regions. In fresh-waters it feeds on sticklebacks and perch (and roach and eel are mentioned in the literature).

Gobies, primarily, but also sticklebacks, herring, and cod, have formed the main food for the examined great crested grebes. In fresh-water the food has mainly been cyprinoids. Information in the literature on the food of the great crested grebe based on large material of birds from Great Britain and Central Europe shows that its bill of fare comprises a long series of fresh-water fishes. This in accordance with the obvious fact that any fish of a suitable size when occurring within the feeding sphere of a particular bird may be a potential food.

The remaining $^1/_4$ of the food af the red-necked and the great crested grebes consists in the coastal regions primarily of shrimps and prawns, but includes also polychaetes. In fresh-water insects form this part of the food, but also aquatic snails may be taken. Sometimes these two grebes may subsist entirely on other animal matter than fishes. Vegetable matter, inclusive of seeds, forms only an insignificant percentage of the total diet, at least in winter.

The three other, smaller species of grebes (of which, however, only a few

stomach contents have been examined), sclavonian grebe, black-necked grebe, and little grebe, feed also on such fishes as gobies and sticklebacks, but to a lesser extent than do the larger species. Insects (in marine habitats crustaceans) supply about as large a part of the diet as fishes, and may be fed on exclusively. These grebes stay also generally more hidden among the vegetation than do the larger species. Vegetable matter probably may be a substitute food if animal matter is scarse.

A small quantity of sand is often found in the stomachs of the grebes, probably being taken accidentally and accumulated among the feathers as are for instance fish-eye lenses.

Mergansers

The largest species, the goosander, feeds principally on fishes, from the smallest ones to eels about 35 cm long. The birds examined here from the coastal regions have made eel $^2/_5$ of their total diet. Gobies, sticklebacks, and viviparous blenny constitute the next most important food items. When frequenting fresh-water habitats the goosander feeds to a considerable extent on cyprinoids.

The red-breasted merganser includes crustaceans, shrimps and prawns especially, but also amphipods and isopods, and also polychaetes, in its food. The greater part of its diet, $^3/_4$ to $^4/_5$ in the examined material, however, is made on fishes. Sticklebacks and gobies supply more than half the food; and also viviparous blenny, butterfish, eels up to 28 cm, cod and herring are taken. In brackish or fresh waters some insects may be included in the diet, and also some vegetable matter inclusive of seeds.

The smew, the smallest of the mergansers, makes $^1/_2$ to $^2/_3$ of its diet on small fishes, in the coastal regions primarily gobies and sticklebacks (29 cm long eels are reported as food in the literature). Shrimps, prawns, and also polychaetes supply the remaining part of the diet in the coastal regions, and aquatic insects in fresh-water. Small quantities of vegetable matter, inclusive of seeds, may be included in the diet.

Usually the mergansers have a small quantity of sand or gravel in their stomachs.

Auks

The three auks are exclusively marine. The black guillemot feeds inshore to depths of about half a dozen metres; the common guillemot feeds preferably offshore in pelagic diving; and also the razorbill may feed in that way.

The black guillemot feeds largely on fishes, and this kind of food constitutes $^2/_3$ of the diet of the examined material. Gobies and sticklebacks, and various bottom forms such as viviparous blenny, butterfish, and eel are taken. Crus-

taceans such as shrimps, prawns and swimming crabs supply most of the remaining part of the diet, but also a percentage of polychaetes is included.

The common guillemot, which feeds preferably out at sea, takes primarily herring, which accounts for more than half the food of the examined birds. Gobies and sticklebacks are important too, and also crustaceans are, according to published information, included in the diet.

The Razorbill feeds also largely on herring, which formed about $\frac{1}{3}$ of the food of the examined material. Gobies and sticklebacks were almost as important. Small crustaceans such as amphipods and mysids supplied $^1/_{10}$ of the diet.

The auks have only exceptionally pebbles in their stomachs.

Remarks on the fishes fed on.

The fishes which supply most of the food for the diving inshore fish-eaters in Denmark are the small shoal fishes, gobies and sticklebacks, which occur in innumerable swarms in the shallow coastal waters among the vegetation of seagrasses and seaweeds, and of which a hundred or more individuals are often included in a single meal.—These are also the fishes fed on by those diving ducks (especially golden-eye and longtailed duck) which include a percentage of fish in their diet. Only to the cormorant the gobies and the sticklebacks are of no importance, being too small to be accepted normally as a food item by that bird. Gobies, which lead all other fishes in importance for the fish-eating birds in general, were thus never recorded in the more than 400 meals of cormorants examined.

The other fishes which are of importance in the diet of these fish-eating birds are mainly bottom forms. The common cod supplies $\frac{1}{3}$ to $\frac{1}{2}$ of the food of the two common species of divers, and is also very important in the food of the red-necked grebe, and regularly taken by the two larger mergansers and the auks. The common cod is a bottom dweller from a size of about 5 cm, and stays when young all the year round among the vegetation in the shallow coastal waters. The pelagic poor-cod (*Gadus minutus*) was recorded as food for the pelagically diving razorbill.

The eel forms a main food for the goosander ($^2/_5$ in the material examined here) and for the cormorant (about $\frac{1}{4}$) and is also fed on by the other species, though here not forming any large part of their food.

Other bottom fishes commonly fed on are: Viviparous blenny, which is especially important as food for the eel-eating goosander and cormorant (about $\frac{1}{4}$ of the food of the latter); sand-eels and butterfish, these being especially important for the black guillemot; sculpins and flounder, these especially being

important for the larger birds such as the divers. Also the rock-wrasse is a frequent food for the Danish fish-eating birds.

The only pelagic fish of importance as food is the herring, but this seems eagerly taken by all of them when available—that is when coming in shoals near the coasts; and the herring is a most important food to the two pelagically diving auks, especially to the common guillemot, which follows the shoals out at sea. During summer also mackerel and gar-fish—when going near the coasts to spawn—may be fed on, but since they are absent from the shallow water during winter they are of little importance in the diet in general.

Sticklebacks, perch, roach and other cyprinoids are important foods in fresh-water.

It is clear that the birds by eating for instance cod really do not show any real predilection for this fish, but the young cod is normally found within their feeding sphere, and at the bottom where they take most of their food. The diet of the birds of course reflects the types of habitats they frequent and the fish fauna there. The species most numerous in individuals are fed on to the greatest extent, but any fish or other animal of an acceptable size may be a potential food for the fish-eating birds if coming within their range. Food items which are of only little importance in the total diet therefore may be fed on in quantity or even exclusively in some areas (when plentiful there) or in some periods. Crayfishes for instance may be the prime food for fish-eating birds during the time when they are soft after having shed their old shell. Spawn of fish may be a preferred food when available. Of course the most easily obtained acceptable food will be preferred. When a bird takes small crabs from the bottom instead of feeding on the fry of fish at the same time swarming in the water it shows a predilection for feeding on food from the bottom.

Remarks on other animal food than fish.

All the fish-eating birds treated here (divers, grebes, mergansers, and auks) include fishes of very small sizes in their meals. Crustaceans such as prawns and shrimps (for some of them also amphipods) and in fresh-water insects may correspondingly be included in the diet, and also marine worms. Such other animal matter supplies a regular part of the diet for all the grebes (from about $\frac{1}{4}$ of the food of the larger species to about $\frac{1}{2}$ the food of the smaller species), also for the smaller species of merganser (from $^1/_5$ to $\frac{1}{2}$ of their diet), and among the auks for about $\frac{1}{3}$ of the diet of the black guillemot, and $^1/_{10}$ of the food of the razorbill (but are apparently of no importance to the common guillemot, which is a specialist on herring).

Other animal matter than fish is rarely fed on during winter by the large species, the divers and the goosander, but published data indicate that these birds in summer may change from the exclusive fish diet to a diet comprising also crustaceans and, when frequenting fresh-water habitats, aquatic insects; such other animal food of course entering most prominently into the diet where fishes are scarce.

The role of insects in the diet is, of course, largest when the birds stay in fresh-water habitats, as many do in the breeding period. Crustaceans such as shrimps and prawns are probably also fed on to the largest extent during summer when they are most abundant in the shallow coastal waters.

The cormorant, unlike the other diving, fish-eating birds, apparently never eats anything else than fishes, and this bird is also distinguished from the others in only taking prey of a certain size, fishes less than about 15 cm long generally not being accepted as food.

It seems as if the fish-eating birds treated here generally require that the objects they feed on shall shove movements. Thus crustaceans and worms are normally included among the food items of most of them whereas molluscs are only exceptionally taken. However, that molluscs are not normally fed on may also be due to their hard shells.

Vegetable matter is of little importance in the diet of the fish-eating birds, and the bits of vegetative growth recorded in the stomachs examined here appear mainly to have been swallowed accidentally in the gathering of fishes or crustaceans living among the vegetation of sea-grasses and sea-weeds. The quantities recorded in a few stomachs, however, appear to indicate that some vegetable matter has been taken purposely. Published data also show that vegetable matter sometimes may be taken as a substitute food.

Influence on the fishery of man.

When dealing with fish-eating animals the question will always arise, whether they in their fishing compete with man?—This investigation clearly shows that the birds treated, divers, grebes, mergansers, and auks, primarily take their food from valueless kinds of fish. The goosander might be regarded as harmful in eating eels, but it takes mainly small individuals, and the quantity it consumes in the coastal regions can impossibly be of any importance. Similarly applies to the feeding on the cod by the divers. Only small individuals are caught and the number taken can have no influence on the stock of cod of the sizes at which this fish is taken by man. The herring is so numerous that the feeding on it by

the auks and others cannot be thought to affect the fishery of man in any way.

It is only when feeding inland that the fish-eating birds may be attributed any adverse influence on the fisheries of man, and it is really only when fishing e.g. in fish-ponds that the birds can be declared harmful. In their natural fresh-water habitats the fish-eating birds here treated feed on such fishes that their influence on the stock of fishes of commercial value can only be negligible.

After this paper went to press, A. LINDROTH has published a report: Mergansers as Salmon and Trout Predators in the River Indalsälven. — Inst. Freshw. Res., Drottningholm. Rep. 36, 1955. The 23 goosanders and 2 red-breasted mergansers examined from this river in northern Sweden had fed mainly upon salmon, trout, and miller's thumb, the two former species contributing at least 50 % of the food.

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This list comprises only the most important literature in relation to the present report, and the papers directly referred to. But a hundred papers with remarks on the food habits of the birds treated have been consulted.

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