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MINISTRY OF AGRICULTURE AND FISHERIES
FISHERIES TECHNICAL REPORT
No. 147

INTRODUCTION OF RUDD *SCARDINIUS ERYTHROPHTHALMUS* INTO NEW ZEALAND

1. REVIEW OF THE ECOLOGY OF RUDD AND THE IMPLICATIONS OF ITS INTRODUCTION INTO NEW ZEALAND

P. L. CADWALLADER

2. FIRST SURVEY OF A RUDD POPULATION IN NEW ZEALAND

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FOREWORD

New Zealand has a rather chequered history in relation to introduced plants and animals. Some have proved most valuable, others, such as gorse and rabbits, have been disastrous. Now there is a new addition to the freshwater fish fauna of this country, the European rudd.

For many years the Ministry of Agriculture and Fisheries has allowed no introductions of new exotic fish species to natural waters due to an awareness of the potential hazard, well illustrated by the uncontrolled situation in Australia caused by the illicit entry of the European carp. Similarly, further imports of already established exotic species have been banned to avoid a possible introduction of a virus or other infectious diseases into the New Zealand stocks. Now the Ministry itself is evaluating the Chinese grass and silver carps as weed and algae control agents, but under conditions of long term strict isolation and quarantine. A considerable trade in imported ornamental aquarium fish exists but is limited to those species that require higher spawning temperatures than occur naturally in this country and imports are subject to rigid quarantine procedures.

The Government has therefore viewed the introduction of the rudd,without any investigation as to its ecological effect, with considerable alarm. While these fish were tried unsuccessfully many years ago the present introduction came to the attention of this Ministry through newspaper articles in 1973, the actual date of introduction being about 1969.

Since coming to our attention there have been continuous attempts to contain the spread of these fish and to close the legal loopholes which allowed the situation to continue. The rudd exist only in the northern part of the North Island and the brunt of the actual control of them has fallen on the Auckland Acclimatisation Society whose officers merit special acknowledgment and thanks. Information is slowly gathering about rudd in this country, besides this report. Dr Cadwallader has a paper on the geographical distribution in preparation, and the Ministry is supporting a PhD thesis on population dynamics and feeding habits of these new entrants.

For better or worse New Zealand has a new fish, unwanted by all but a few individuals who were willing to threaten the ecological balance of our waters by pandering to an individual whim. It is too early to know if the rudd poses any major threat but a containment programme seems to be working and it is a fervent hope of fisheries authorities that this is the last uncontrolled introduction into New Zealand.

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C O N T E N T S

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1. REVIEW OF THE ECOLOGY OF RUDD AND THE IMPLICATIONS OF ITS INTRODUCTION INTO NEW ZEALAND

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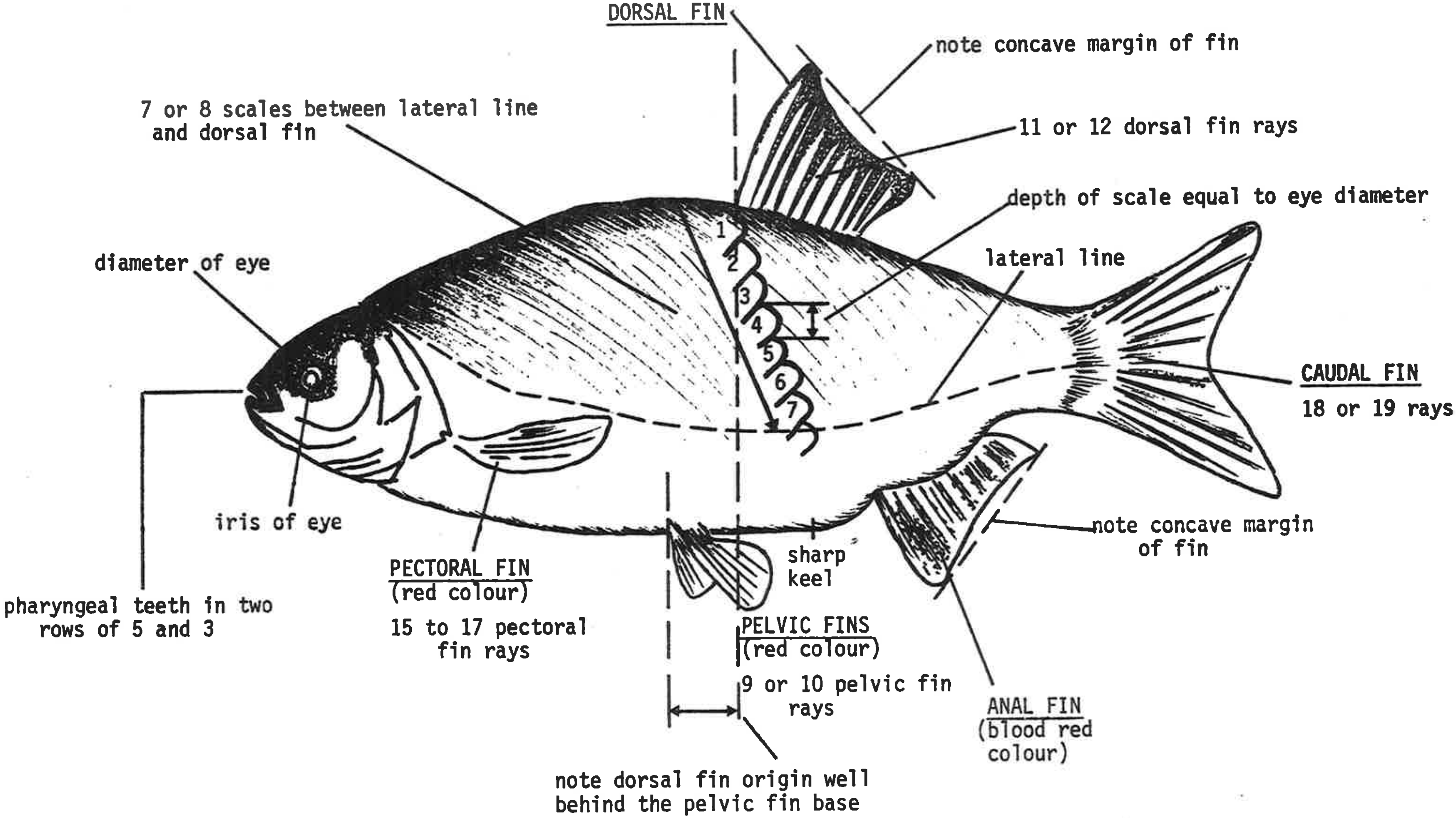
FIG. 1 : CHARACTERISTIC FEATURES OF RUDD



INTRODUCTION

Rudd, *Scardinius erythrophthalmus* (L.), have recently been introduced into some lakes in the north of the North Island (McDowall, Hopkins & Flain, 1975) and must now be regarded as an established part of the New Zealand freshwater fish fauna. This paper reviews present knowledge of the ecology of rudd in their natural range and discusses the possible ecological implications of their introduction into New Zealand.

Descriptions of rudd and its ecology may be found in most texts on European freshwater fishes, e.g. Wheeler (1969), Muus and Dahlstrøm (1971) and Maitland (1972).

DISTRIBUTION

Rudd occur throughout Europe, including north-eastern European U.S.S.R., but are absent from southern Italy and the Iberian peninsula. Their range extends through Asia Minor and central Asia and they have been reported from Siberia and Turkestan (Regan 1911, Taverner 1957, Sterba 1962, Solovkina 1969). However, Berg (1964) maintains that they are not found east of the Urals and states that reports of rudd in Siberia are based on confusion of rudd and roach, *Rutilus rutilus* (L.). In the British Isles rudd have a fairly widespread, but haphazard distribution (Maitland 1972). It is probable that they were introduced into Ireland, where they are common and usually miscalled roach (Went 1946, Kennedy & Fitzmaurice 1974).

Rudd inhabit still or slowly flowing waters, particularly where there is weed cover, and are common in the lowland plains of Europe, but also occur at altitudes up to 1829 m in Switzerland (Schindler 1957). A sub-species, *S.e. scardafa*, occurs in northern Italy and the Adriatic basin (Wheeler 1969), and another, *S.e. racovitzai*, is found in western Rumania (Muus and Dahlstrøm 1971).

SALINITY AND TEMPERATURE TOLERANCE

Darlington (1957) listed the Cyprinidae as primary freshwater fishes, i.e. "strictly confined to fresh water". Schindler (1957) reported that rudd occur in brackish water, and Schmitz (1956) found that they were able to survive in the polluted German River Werra, in which the chloride concentration occasionally exceeded 5g/l. Rudd inhabit estuaries in Kuban, U.S.S.R., where their spread is limited by salinities (in terms of chloride) of 6g/l (Karpenko 1966).

Rudd can tolerate wide variations in water temperature. Audige (1921) found that they grew continuously and regularly at 14-15°C, but after four years reached only half the size of wild fish and did not mature. At 20-21°C, they grew continuously and became sexually mature, and grew faster than wild fish; at 24-25°C, growth was irregular, periods of growth alternating with periods of rest, but after four years they were twice the size of wild fish; at 31-32°C, they showed precocious sexual maturity and growth was very irregular, their overall growth being less than that of wild fish. Karpenko (1966) found that rudd could tolerate a considerable rise in water temperature, and Varley (1967) suggested that their upper lethal temperature possibly may be higher than 34°C. Boytsov (1971) described rudd as thermophilous, and found that in areas of a reservoir affected by the warm water discharged from a power station their growth was six times greater than in areas of the same reservoir which were not affected by the discharge.

The sub-species S.e. racovitzai is found only in warm springs (28-34°C) and is killed by temperatures below 20°C (Muus & Dahlstrøm 1971). Pincher (1947) remarked that during an "average" British winter water temperatures were possibly below the "feeding limit" of rudd, so that they ceased feeding in winter. Nikolsky (1943) attributed the disappearance of rudd from the White Sea Basin to the gradual cooling which has occurred during the last 5,000 years. Fossil remains indicate that rudd were once common in the area.

BREEDING BIOLOGY

Rudd spawn in late spring and summer, from April to July in the Northern Hemisphere, when the water temperature rises above 16°C (Varley 1967, Wheeler 1969). Spawning may be "portional", with two batches of eggs produced in the spawning season, the first batch being larger than the second batch, e.g. 28,000-52,000 followed by 7,000-11,000 (Holcik 1967). The spawning season often is extended, and Wheeler (1969) suggested that this is possibly because of intermittent spawning caused by falls in temperature which inhibit spawning activities.

Hartley (1947 a) suggested that the two sexes mature at the same age, and reported 27% of males and 32% of females of the 3+ age group mature. In fish aged 4+, 90% of males and 94% of females were mature. In these first two age groups in which spawning occurs males were as numerous as females, but thereafter females predominated, with a sex ratio of 1.73 females:1 male in the spawning shoals. Similarly, Taverner (1957) reported that about a quarter of age 3+ fish and about 90% of age 4+ fish were mature. He found that the breeding stock was made up of fish aged 3+, 4+ and 5+, and that after the 7th year no males were present. At low population density, when food supply is not utilised fully, the proportion of females may exceed that of males by 12.9% (Nikolsky 1969). Karpenko (1966) found that in Kuban waters maturity was achieved at age 2+, and in Ireland Kennedy & Fitzmaurice (1974) found that age 1+ rudd of both sexes usually were immature, age 2+ females were immature whereas age 2+ males were approaching maturity, and all age 3+ fish were mature.

The fecundity of rudd varies widely. Berg (1964) reported 96,000-232,000 eggs per female, but did not indicate the size range of the fish examined. Other authors reported smaller numbers, e.g. 7,779-76,352 in fish 112-190mm long (Karpenko 1966), 9,482-25,028 in fish 128-162mm long (Sedlar & Stranai 1969) and 3,575-98,200 in fish 101-281 mm long .

(Kennedy & Fitzmaurice 1974). Wheeler (1969) and Bracken & Kennedy (1967) reported the diameter of rudd eggs as 1-1.4mm and 1.36-1.75mm respectively. Zhukinskii & D'Yachuk (1964) found that the diameter of rudd eggs decreased with an increase in the length of females whereas Kennedy & Fitzmaurice (1974) found that large fish produced bigger eggs than small fish.

The adhesive eggs are shed on submerged vegetation along the water margins or on the edges of reed banks. For example, Bracken & Kennedy (1967) found rudd eggs on Fontinalis, Callitriche, Juncus bulbosus and other similar plants, and Holcik (1967) found them deposited on Myriophyllum, Ceratophyllum and Potamogeton. Serebrov (1971) found rudd eggs attached to the submerged roots of trees, mainly willows Salix alba, in rivers of the Volga Delta.

Seeley (1886) and Berg (1964) reported that during the spawning season mature rudd males develop fine tubercles on the head and dorsal surface. However, other authors, e.g. Kennedy & Fitzmaurice (1974), have found no such structures present. Holcik (1967) mentioned that males appear first at the breeding sites and are followed 5-8 days later by the females. Svardson (1950) observed the pre-spawning behaviour of rudd in shallow water (0.1-0.9m) in a lake in Sweden. Large numbers of fish were involved, and an area from the shore line to 2-3m from land and extending 100m along the shore was "crowded with fish", with local aggregations near dense submerged stands of Ulotrichia, in which the eggs were laid. Females (recognised by a distended abdomen) were followed by several males who repeatedly nosed the base of the females' pectoral fins. Fish frequently broke the water surface, causing splashing throughout the courtship area. The shedding of eggs and sperm was not observed. Regan (1911) mentioned that spawning rudd make a characteristic noise by "pouting", i.e. emitting air bubbles at the water surface. The effect of parasitisation by plerocercoids of Ligula intestinalis (which cause castration in cyprinids) on the spawning behaviour of rudd was examined by Orr (1966). Of 200 adults taken from a courting shoal only one was infected with L. intestinalis, whereas of the 75 adults netted at random 56 were infected.

Fertilization of rudd eggs may be as high as 97-100% under natural conditions (Pliszka 1953a). Bracken & Kennedy (1967) described the eggs as colourless to pale yellow, and noted that melanophores were well developed before hatching. The eggs hatch after 3-18 days, depending on temperature (Wheeler 1969, Muus & Dahlstrøm 1971, Kennedy & Fitzmaurice 1974). Length at hatching varies from 4.5mm (Kryzhanovsky 1949) to 5.2-5.9mm (Bracken & Kennedy 1967). Newly hatched rudd possess adhesive organs on the head by means of which they hang on the vegetation for the first few days. They develop a swim bladder after about two days and the yolk sac is absorbed by the time the fish reach a length of about 8mm (Kennedy & Fitzmaurice 1974).

Rudd often spawn at the same times and in the same situations as a number of other cyprinids and hybridise naturally with roach Rutilus rutilus (L.), bream Abramis brama (L.), silver (or white) bream Blicca bjoerkna (L.), dace Leuciscus leuciscus (L.), bleak Alburnus alburnus (L.), and Danube bleak Chalcalburnus chalcoides (Guldenstadt) (Went 1944, Pincher 1947, Pavlov 1965, Pushkin 1971, Maitland 1972). In addition, Berg (1964) mentioned that hybrids of rudd and tench Tinca tinca (L.) have been produced artificially.

AGE AND GROWTH

Rudd are long-lived and have been recorded up to 17 years old (Kennedy & Fitzmaurice 1947), with females being somewhat longer lived than males (Pincher 1947). They can be aged by counting scale annuli. Hoffbauer (1905) established the annual nature of the annuli, and Steinmetz (1974) found that scale reading was reliable, and that back-calculated lengths and actual measured lengths were very similar.

Data on growth of rudd are available from throughout its range, in Austria (Kolder 1970), Czechoslovakia (Frank 1959, 1962, Holcik 1967), Denmark (Otterstrøm 1931), England (Hartley 1947a, b, Taverner 1957), France (Bourgeois 1961), Holland (Steinmetz 1974), Ireland (Kennedy & Fitzmaurice 1974), Poland (Frank 1962, Klimczyk-Janikowska 1970, Stronski 1971), Sweden (Alm 1922) and U.S.S.R. (Karpenko 1966, Boytsov 1971). Growth rate varies greatly with climatic conditions and habitat. An exceptionally good growth in a population is a mean length of 98mm in one year, 154mm in two years and 207mm in three years, whereas poor growth may result in a mean length of 75mm after three years and only 120mm after six years (Wheeler 1969). Overcrowding may result in stunted growth (Hartley 1947b, Kennedy & Fitzmaurice 1974). Holcik (1967) found that after the first year of life females grew faster than males, and that, when spring and summer generations were produced as a result of portional spawning, growth during the first year was greater in fish of the spring generation than in fish of the summer generation, although fish of the summer generation ultimately reached a larger size. The work of Gulin & Rudenko (1973) on the production of nine fish species in the eutrophic lake Demenets provides age-class data on growth in weight, population size, mortality and production of rudd (Table 1).

FOOD

On the basis of brain morphology, Evans (1931) designated rudd as visual feeders. Usually, they feed in mid-water or at the surface (Hartley 1940). In winter, they cease feeding or feed very little (Hartley 1947a, Pincher 1947), so that growth slows down or stops. Kudrinskaya (1966) reported that rudd fry have two maxima and two minima in feeding intensity over a 24h period, and that the daily food intake is about 12% of body weight.

TABLE 1 - Life History and Annual Production Data for Rudd in Lake Demenets (area 6ha, mean depth 3.3m), U.S.S.R. (After Gulin & Rudenko 1973)

Age Class	Calculated Mean Weight (g)	Weight Increment (g)	Population Estimate	Mortality Coefficient	Biomass Estimate (kg)	Production Estimate (kg)
0+	1.32	1.32	4,057*	0.374	5.4	15.5
1+	6.11	4.79	2,538	0.393	15.5	12.7
2+	12.46	6.35	1,540	0.413	19.2	8.9
3+	19.93	7.47	904	0.427	18.1	5.8
4+	28.29	8.36	549	0.439	14.7	3.6
5+	37.43	9.14	291	0.450	10.9	2.2
6+	47.26	9.83	160	0.459	7.6	1.3
7+	57.70	10.44	87	0.466	5.0	0.7
8+	68.72	11.02	46	0.473	3.2	0.4
9+	80.42	11.52	24	0.480	1.9	0.2
10+	92.40	12.46	13	0.485	1.2	0.12
11+	104.88	12.48	7	0.571	0.7	0.06
12+	117.75	12.85	3	-	0.4	-
TOTAL:	-	-	10,189	-	103.8	56.9
Maximum error of estimates(%)	-	-	6.1	3.0	9.3	12.3

* This figure does not include many of the smaller fish in this age group.

Hartley (1940, 1947a) found that the diet of rudd consisted mainly of insects and plants, together with small quantities of fish, molluscs, crustaceans and diatoms. Insects of terrestrial origin formed a substantial part of the diet of fish taken in tree-shaded ponds, with adult Lepidoptera making up 59% and adult Diptera 25% of the recognizable insects taken at one locality. Plants eaten included Cladophora, Spirogyra and Vaucheria (Chlorophyceae), and the phanerogams Potamogeton and Sparganium. Hartley (1940) remarked that rudd combine the roles of active carnivore and browsing herbivore. Of the 14 fish species inhabiting Lake Harsz in Poland, rudd fed the least on invertebrates (Pliszka 1953b). Phanerogams occurred in all rudd stomachs examined (fish lengths 92-220mm). Other food eaten included Chara, Elodea canadensis, phytoplankton and fish. Cihar and Frank (1958) found that planktonic animals were the principal food of rudd up to 70mm long, and that adults fed mainly on water plants. Klimczyk-Janikowska (1970) found that in two Polish reservoirs the food of rudd included a wide range of Cyanophyceae, Euglenophyceae, Chrysophyceae, Bacillariophyceae, Chlorophyceae, and also mosses, Chara, Equisetum, Potamogeton and Elodea canadensis. Animals eaten included insects, crustaceans and fish. In Ireland, recently hatched rudd begin to feed after about a week and take mainly unicellular algae (Kennedy & Fitzmaurice 1974). At a length of 10mm they begin to feed on Cladocera, which remain their main diet for the first two years of life, though chironomids and other invertebrates are eaten also. The diet of older rudd consists mainly of insects, filamentous algae and the young shoots of vascular plants, together with corixids, Gammarus, Asellus and caddis larvae (mainly picked off the weeds). In a laboratory study of predation on lake-dwelling triclads, Davies & Reynoldson (1969) found that the highest intensities of predation were by fish such as rudd, which were characteristic of weedy habitats. Wheeler (1969) stated that young rudd eat mainly diatoms, algae and copepods, and that larger rudd are wholly carnivorous, occasionally eating fish, usually young roach or bleak. However, detailed studies, such as those of Hartley (1940, 1947a), Pliszka (1953b), Klimczyk-Janikowska (1970) and Kennedy & Fitzmaurice (1974), indicate that rudd are omnivores.

PARASITES

Parasites found in rudd include Myxidium scardini, Myxobolus sp., Trichodina spp. (Protozoa); Dactylogyrus sp., Diplozoon paradoxum (Monogenea); Diplostomum spathaceum, Posthodisplostomum cuticola, Sphaerostoma bramae (Digenea); Caryophyllaeides fennica; Eubothrium sp., Ligula intestinalis (Cestoda); Camallanus lacustris (Nematoda); Acanthocephalus anguillae, A. lucii, Pomphorhynchus laevis (Acanthocephala) and Argulus foliaceus (Crustacea) (Kennedy 1974). In addition, Lucky (1955) recorded Neascus cuticola metacercariae as parasites of rudd in Czechoslovakia. In Ireland, the commonest parasites of rudd are acanthocephalans and the trematode Posthodisplostomum cuticola (black spot). Rudd appear to be relatively insensitive to most bacterial diseases (Kennedy & Fitzmaurice 1974).

BEHAVIOUR

Rudd are deep bodied and laterally compressed, a shape characteristic of fish inhabiting still or slow-flowing waters (Allee & Schmidt 1951). They are relatively slow swimmers (Ohlmer & Schwartzkopff 1959), but show considerable staying power (Young 1962). Regan (1911) mentioned that rudd form shoals and noted that often they would join shoals of bream or roach. Taverner (1957) stated that rudd shoal by day, but "seem to become solitary at night". From underwater observations, Karst (1968) found that rudd swim in pairs, small groups and occasionally in schools of up to 50 fish, the lengths of the fish in the large schools observed being 200-300mm. The shape of the school is not flat, but three-dimensional, with little space between fish. Movements of individuals in the school are in unison. Roach, tench and perch, Perca fluviatilis L., were observed occasionally in rudd schools, and individual rudd sometimes were observed with silver bream. Aquarium observations indicate that juvenile rudd (20-27mm long) swim in a school at the water surface during the day and, although dispersing and partly subsiding at night, remain within 0.6m of the surface (Girsa 1973). Rudd exhibit intra-specific mutual cleaning behaviour and also form interspecific facultative cleaning symbioses with various other cyprinids, such as roach, bleak and tench (Abel 1971).

Holcik (1967) found that in a reservoir rudd formed small groups which stayed near particular areas, usually near the previous spawning areas, for most of the year. However, in September there were migrations throughout the reservoir which brought about the mixing of different groups. Holcik explained this behaviour by suggesting that since rudd feed amongst vegetation their movements depend on the availability of submerged plants. In the reservoir under study there were only a few areas of submerged vegetation and these were separated by large unvegetated open areas. More extensive movements would be expected if the vegetation was more widespread.

RELATIONSHIPS WITH OTHER FISH SPECIES

Rudd occur in Huet's (1949, 1954) "grayling zone", "barbel zone" and "bream zone" of European rivers, so that cohabiting fish include mainly other cyprinids (such as roach; tench; bream; carp, Cyprinus carpio L.; barbel, Barbus barbus (L.); chub, Leuciscus cephalus (L.); and dace); pike, Esox lucius (L.); perch; eel, Anguilla anguilla (L.); and also trout, Salmo trutta (L.); and grayling Thymallus thymallus (L.). Species compositions of communities in both lotic and lentic habitats in which rudd occur are given by Pliszka (1953b), Zhadin & Gerd (1963), Boytsov (1971), Serebrov (1971), Gulin & Rudenko (1973), Troitskiy (1974) and Zhakov (1974). Possible food competion between rudd and roach has been reported by Podgornova (1962) and Karpenko (1966). Nasukhov (1974) found that since juvenile rudd fed on the invertebrate fauna of weed beds, their diet differed markedly from that of cohabiting perch, roach, and "kutum" Rutilus frisii

(Nordmann), all of which fed in open water and avoided weed beds. Seeley (1886) stated that perch and trout feed on rudd, and Schindler (1957) and Wheeler (1969) mentioned that rudd are an important food source for a number of predatory fish. In the Danube flood zone, rudd are eaten by pike, pike perch, wels Siluris glanis L., and asp Aspius aspius (L.) (Spataru 1968), and in Ireland they are taken by pike, perch and trout (Kennedy & Fitzmaurice 1974). Hoogland et al. (1957) found that rudd were taken readily by pike. In addition, they are eaten by piscivorous birds, comprising 6.6% of the diet of cormorants in the Volga delta (Nikolsky 1963).

ANGLING AND ECONOMIC IMPORTANCE

The flesh of rudd is bony and is not very palatable. However, rudd are taken in great quantities in eastern Europe, where they are of considerable local economic importance (Schindler 1957, Wheeler 1969, Opalatenko 1970). Annual catches of rudd in Akhtaro-Grivensk estuaries, U.S.S.R., comprise nearly 200,000 kg, and make up 30-35% of the catches of all freshwater fish (Karpenko 1966). They are taken commercially with seines, set-nets and traps. In western Europe their chief value is as a sporting fish and, because of their abundance, good size (the British record is 4 lb 8 oz (2.04 kg) - Graham 1974) and readiness to take a bait, they have considerable appeal to anglers (Wheeler 1969). Rudd take a variety of baits, but no coarse fish* more readily takes an artificial fly, either floating or sunk (Taverner 1957, Graham 1974).

IMPLICATIONS OF THE INTRODUCTION OF RUDD INTO NEW ZEALAND

Although it seems that the original intention of liberating rudd in New Zealand was to provide angling in areas devoid of game fish or (in many new farm dams) where there were no fish at all, it is practically inevitable that rudd will spread from these waters. This may occur either by natural dispersal or as a result of further liberations, as has happened with the mosquito fish Gambusia affinis (Baird and Girard) in the North Auckland area (Stokell 1963). Since rudd can tolerate wide variations in water temperature it seems inevitable that they will survive in most still or slow-flowing waters containing submerged vegetation suitable for their breeding. These include farm dams, ponds, lakes, canals and slow-flowing rivers and their backwaters. The work of Boytsov (1971) suggests that rudd will do particularly well in waters receiving heated outflows from power stations, and their salinity tolerance indicates that they will survive in slightly brackish waters. They thrive in weedy habitats, obtaining food, breeding sites and protection from predators amongst the weed, and are likely to do well in those New Zealand waters in which excessive weed growth has become a major problem.

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*In Europe the term "coarse fish" usually refers to those species of freshwater fish, excluding salmonids and eels, which are sought after by anglers for sport (Association of River Authorities 1974).

In New Zealand rudd have become established in habitats in which occur some members of the indigenous fish families, Galaxiidae, Retropinnidae, Eleotridae, Mugilidae and Anguillidae. The indigenous species are almost exclusively carnivorous, although Jolly (1967) found that algae form part of the diet of the lake-dwelling smelt Retropinna lacustris Stokell. The larger eels can be considered piscivorous to some extent, but the rest of the fish fauna feed almost entirely on invertebrates. Since rudd are omnivores, it is unlikely that there will be any great overlap in diets, although rudd and native species may compete for the invertebrate fauna. Should competition become severe, the ability of rudd to eat plant material would provide them with an alternative source of food not avilable to most native species. Rudd eggs laid on marginal vegetation may be consumed by eleotrids. Galaxiids, retropinnids, mugilids and eleotrids may take some rudd larvae, but eels probably will be the greatest indigenous predator of rudd, particularly when the latter overwinter on the bottom. On the other hand, rudd are likely to feed on free-swimming larvae, such as those of landlocked galaxiids. As a result of direct competition for food and, possibly, predation of young stages, it is likely that the open-living, shoaling galaxiids and retropinnids will be the native fish most adversely affected by rudd.

Considerable debate has arisen over the possible effects of rudd on the trout fishery in New Zealand. On the one hand, it is considered that rudd will be detrimental to the fishery because they will eat trout fry and compete with trout for food. In addition, since they will take a fly readily, it is considered that rudd will become a nuisance in trout waters by taking baits meant for trout. On the other hand, it is thought that rudd may benefit the fishery by supplying food fish for trout, although in waters in which there is abundant vegetation it has been suggested that trout will have great difficulty in catching rudd, since the latter are so adept at swimming amongst weeds.

From a study of a rudd-trout community in a Welsh reservoir, Siddiqui (1967) concluded that an increase in the rudd population was likely to adversely affect the growth of trout. He examined the food of 145 rudd (77-304mm long) and 129 trout (135-358mm) and found that there were many food items in common, including molluscs, zooplankton, corixids, Asellus, coleopteran adults and larvae, chironomid and trichopteran larvae and, occasionally, leeches and aerial insects. In addition, trout took dragonfly nymphs, plecopteran nymphs and fish, which rudd did not eat, whereas rudd ate algae (with larger fish eating relatively more algae than smaller fish) which trout did not eat. Feeding behaviour and catches of fish suggested that both species lived in close association and had common feeding grounds. However, in small Irish lakes containing both rudd and trout Kennedy & Fitzmaurice (1974) found that rudd fry were an important food for trout, and often became their staple diet.

Trout feed more frequently on fish which form shoals, either permanently or occasionally, than on solitary species (Frost & Brown 1967). In New Zealand, they take small galaxiids, retropinnids and eleotrids (Phillipps 1924, Smith 1959, Allen 1961, Percival & Burnet 1963), and it seems likely that small rudd will form another food source. Larger rudd probably will be too large to be eaten by trout and might themselves take trout fry. Research is necessary in order to predict the outcome of rudd-trout interactions in particular waters, but it seems probable that rudd will be more successful in waters in which trout populations are maintained artificially, e.g. Lake Waingata (Fish 1966), than in waters in which trout breed naturally. High water temperatures mark the northern limit of the range of trout in New Zealand (Allen 1957). Waters at the limits of the range and further north, and also some (including those in which trout are maintained artificially) within the range are more suited to cyprinids, which have higher temperature tolerances and lower oxygen requirements than salmonids (Downing and Merkens 1957, Alabaster 1971). These waters, which include the coastal dune lakes described by Cunningham _et al_. (1953) and Cunningham (1957) characteristically are shallow, or at least have shallow margins, have soft bottoms and usually contain abundant vegetation.

Rudd are not likely to do well in typical trout lakes, such as Taupo, which characteristically are deep and have rocky bottoms. However, it is possible that, if liberated, they may become established in shallow weedy bays of such lakes. Furthermore, eutrophication, by causing destabilisation of salmonid communities (Christie _et al_. 1972) will favour the success of such new introductions. Fish (1963) reported that eutrophication has produced "an inferior environment" for trout in Lakes Okaro and Ngapouri in the North Island. Development of lakes from oligotrophic through mesotrophic to eutrophic is followed by corresponding changes in the fish fauna. In Europe, coregonids and salmonids are characteristic of oligotrophic lakes, perch and pike are characteristic of mesotrophic lakes, whereas a wide variety of species, mainly cyprinids, are characteristic of eutrophic lakes (Allen 1949). Thus, in New Zealand it seems likely that eutrophication, while having an adverse effect on trout, is favouring the spread of coarse fish such as perch, tench and rudd.

Rudd are hardy and can survive in water of poor quality (Kennedy & Fitzmaurice 1974). Indeed, coarse fish generally are less sensitive than trout to pollution. For example, the threshold lethal concentration of zinc for rudd in hard water is 20-30mg/l, depending on temperature, which is four to six times greater than the threshold concentration for trout (Alabaster 1971). Consequently, in communities containing both coarse fish and trout, pollution is likely to adversely affect the trout population before it affects the coarse fish population.

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FISHERIES TECHNICAL REPORT

NO. 147

INTRODUCTION OF RUDD, SCARDINIUS ERYTHROPHTHALMUS INTO NEW ZEALAND

2. FIRST SURVEY OF A RUDD POPULATION IN NEW ZEALAND

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NOTE: A small number of copies of this report was duplicated soon after the survey in 1973 under the title "The location of Rudd (*Scardinius erythrophthalmus*) in New Zealand", (6 pp) now out of print. The report is reproduced here with minor editorial changes only.

INTRODUCTION

This report describes the first population of rudd (Scardinius erythrophthalmus (L.)) located in New Zealand by the Ministry of Agriculture and Fisheries. An investigation was carried out in two coastal dune lakes to the north-west of Auckland in July 1973. The aim was to locate rudd and identify any disease in them.

THE HISTORY OF RUDD IN NEW ZEALAND

The first reports of the existence of rudd in New Zealand occurred in 1968 but the species is thought to have been first introduced in 1964 (the New Zealand Herald, 25 August 1973). The introduction was illegal and the fish were not subjected to any quarantine procedure. The distribution is unknown but reports suggest that rudd are present in many North Auckland lakes. An investigation in 1970 by the Department of Internal Affairs failed to locate rudd in the Dargaville area.

IDENTIFICATION AND GENERAL BIOLOGY OF RUDD

The characteristic features of rudd are shown in Fig. 1 (see page 2). The head is dark green, the sides bronze and the belly white. The dorsal and caudal fins are brown, but the pectoral, pelvic and anal fins are red. The base of the pelvic fins is in front of the line of the origin of the dorsal fin. There are seven or eight transverse scales and 40-45 lateral line scales.

In Europe the rudd lives in shallow warm lakes or the slow running parts of rivers. It is a shoaling fish which over-winters in deeper water. Growth is slow and it matures at two or three years of age. Spawning is in May and June. The eggs numbering between 100,000 and 200,000 in each female are sticky, approximately 1.5mm in diameter and hatch in 3-10 days depending on the temperature. The eggs are deposited on submerged vegetation and the fry remain passively attached to the plants until the yolk-sac is consumed. The young rudd eat diatoms, algae and copepods. Adult rudd are omnivorous, feeding on the leaves of most aquatic plants, insects, snails and occasionally fish eggs. The diet varies with the time of the year (Siddiqui 1967). The rudd is well known for its habit of joining in the spawning of other species and hybridises with bream, roach, white bream and bleak. The flesh of rudd is tasteless and bony and they are not regarded highly as sporting fish. Except as specifed the above description of the biology of rudd is taken from Muus and Dahlstrøm (1971).

NETTING

(a) Lake Okaihau

Lake Okaihau is a dune lake 50 km north-west of Auckland. The lake is surrounded by steeply sloping hills on the southern and eastern sides and flat pasture land to the north and west. The lake is approximately 5.2 ha in area and has a maximum depth of

10-12 m (S. Haughton pers. comm.). A small inlet stream at the end of the lake appears to be the principal water source. No outlet was observed. The lake water was yellow-brown, possibly the result of run-off from the adjacent pasture.

Four gill nets were set in an attempt to catch rudd (Fig. 2). Two nets had 2.4 cm mesh and the other two 3.5 cm mesh. The nets were left in the lake overnight for a total of 16 hours each. A 10 cm mesh gill net was also set in an attempt to capture trout. Table 1 shows the number of fish caught by each gill net.

TABLE 1. The Number of Fish Caught in Gill Nets

	Gill Net 1	Gill Net 2	Gill Net 3	Gill Net 4	Gill Net 5
Rudd	12	8	3	5	0
Tench	2	3	0	1	0
Trout	0	0	0	0	2

The lengths and weights of 26 of the 28 rudd captured are shown in Table 2. Three hauls were also made with a 61 m long seine net (6 m depth); a single rudd fry was caught (last fish in Table 2). Difficulty was encountered dragging the seine net over the uneven and weedy bottom.

Unless new stocks have been released each year, Table 2 would suggest that several year classes of rudd exist in the lake and that this species is breeding. S. Haughton (pers. comm.) stated that no releases of rudd have been made since 1970. The stomachs of all rudd over 17 cm were empty but one smaller rudd was distended with vegetable matter. This consisted of filamentous algae, diatoms and phytoplankton.

All rudd captured were examined for disease by Dr M. Hine of the Fisheries Research Division. No parasitic or bacterial diseases were found.

In addition to the rudd, six tench, Tinca tinca (L.), were caught in the gill nets. The largest tench was 25.7 cm long and weighed 155 g. Several of the tench had parasitic nematode infections. Many small tench were captured in the seine net at the northern end of the lake. Two rainbow trout were caught in the large gill net (Table 3). One trout had a gill infection and shag worm in the body cavity. The trout stomach contents consisted entirely of fish including the remains of rudd.

FIG. 2 : LOCATION OF NETS IN LAKE OKAIHAU

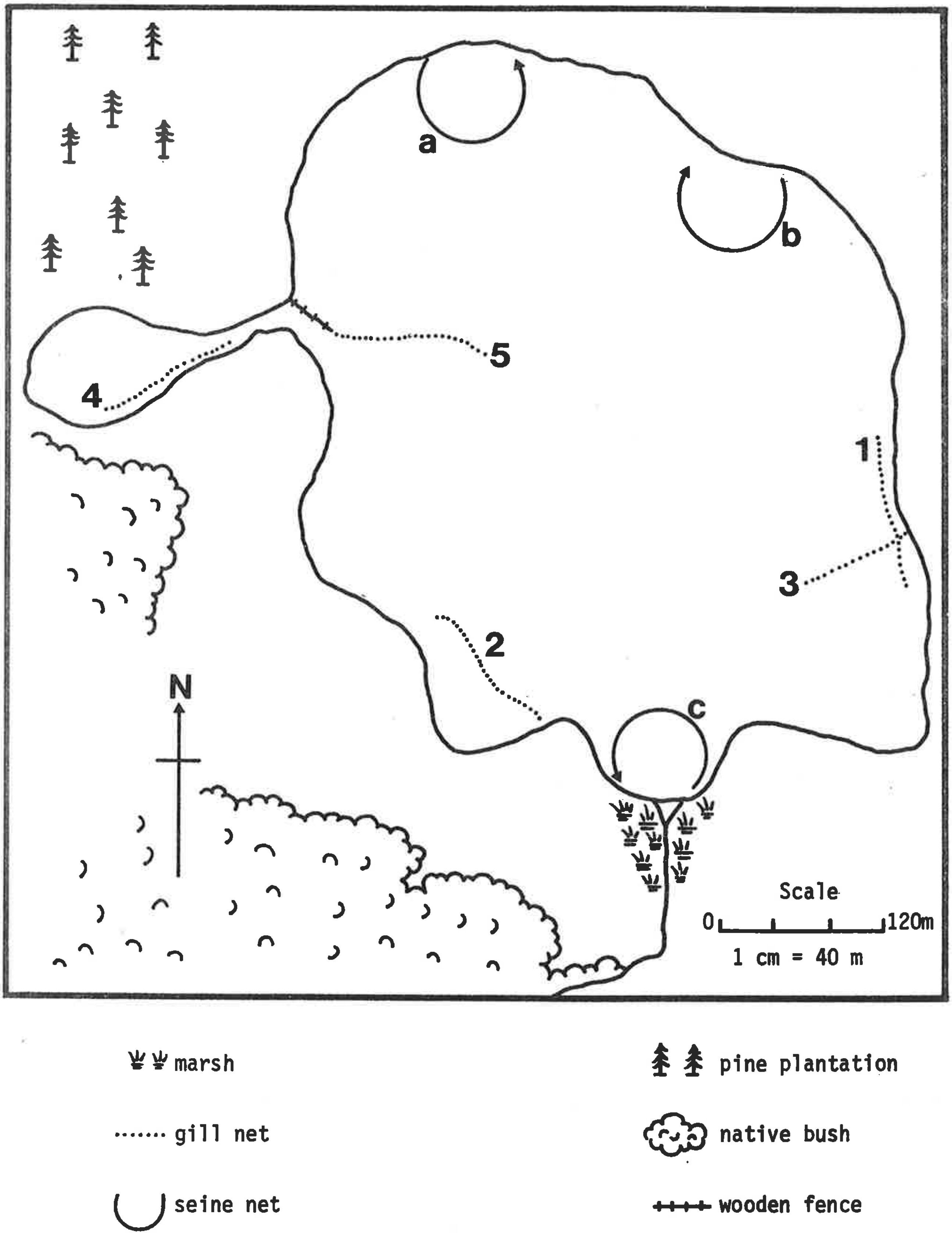

TABLE 2. Lengths and Weights of Rudd Caught in Lake Okaihau

Length (cm)	Weight (g)	Length (cm)	Weight (g)
28.5	481	14.5	56
26.4	339	14.5	50
26.4	335	14.3	50
23.7	254	14.0	28
23.0	250	13.9	28
22.6	228	13.5	27
22.4	226	12.7	26
19.0	141	12.6	26
18.7	113	12.4	26
18.5	113	12.1	26
18.4	112	12.1	25
18.3	112	12.0	22
17.8	102	11.8	20
		4.2	11

TABLE 3. Trout Caught in Lake Okaihau

	Trout 1	Trout 2
Length	44.4 cm	39.8 cm
Weight	1.49 kg	0.78 kg
Sex	Female	Female (reabsorbing eggs)
Stomach contents	one 4 cm rudd one bully	23 bullies

(b) Lake Kawaupaku

Lake Kawaupaku is the water reservoir for Bethells' Beach community, approximately 40 km north-west of Auckland. Two gill nets were set overnight in an attempt to capture rudd suspected of having been introduced. No fish were caught.

SUMMARY

A breeding stock of rudd is present in Lake Okaihau, North Auckland. No disease or parasitic infection was found in the rudd examined.

RECOMMENDATIONS

The redistribution of rudd should be prevented at least until a scientific study of the species is undertaken and its relationship with other species clarified. It has taken ten years for a positive confirmation of the presence of rudd in New Zealand and a repetition with other species could be disastrous. Strict adherence to the legal controls governing distribution, keeping or importing exotic fish must be enforced.

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