Trout are not effective predators of midges.

Theory on the Number Of Links in Food Chain Is Upheld in River Test

Suprisingly strong effect on plants is detected.

By WILLIAM K. STEVENS

A NOVEL experiment with fish, insects and algae in a California river has uncovered new evidence in favor of a rather simple ecological theory involving the greening of the Earth. It holds that plants are suppressed when there are even numbers of levels in the food chain of a given habitat, but flourish when there are odd numbers.

The researchers experimentally manipulated a four-level food chain in which steelhead trout and smaller fish ate dragonfly and damselfly nymphs, which in turn preyed on the larvae of tiny, two-winged insects called midges, which in turn fed on algae. In this four-level arrangement, the river was rendered largely barren of algae each summer.

But when researchers removed the fish from the top of the chain, it was disrupted in such a way that the algae increased a hundredfold, carpeting the water with floating mats and thick green, five-yard-long braids of summer growth.

"I was very surprised at how strong this effect is," said Dr. Mary E. Power of the University of California at Berkeley, an expert in freshwater ecology who conducted the experiment in the Eel River in Mendocino County. It was reported last month in the journal Science.

Algae in Bloom

Normally, said Dr. Power, the fish at the top level of the food chain reduce the population of dragonflies and damselflies at the second level. This allows the population of midges, at the third level, to proliferate. They feed on the algae, keeping the river relatively free of the tiny plants.

With the fish removed and the food chain thereby reduced to three levels, the dragonfly and damselfly population soared. The midge population plunged. And with fewer midges to feed on the algae, the algae bloomed.

The results are considered to be one of the clearest tests of the odd-even theory because it was performed in a stable natural setting where the food chain could be readily altered.

The odd-even theory says that when plant eaters are added to a world where only plants exist, the herbivores will limit plant production and create a relatively barren world. But when predators are introduced to feed on the herbivores, adding a third level to the food chain, the plants rebound and the world becomes greener. This theory was advanced in the 1960's by Nelson Hairston Sr., an ecologist at the University of Michigan, and his colleagues, Frederick Smith and Lawrence Slobodkin.

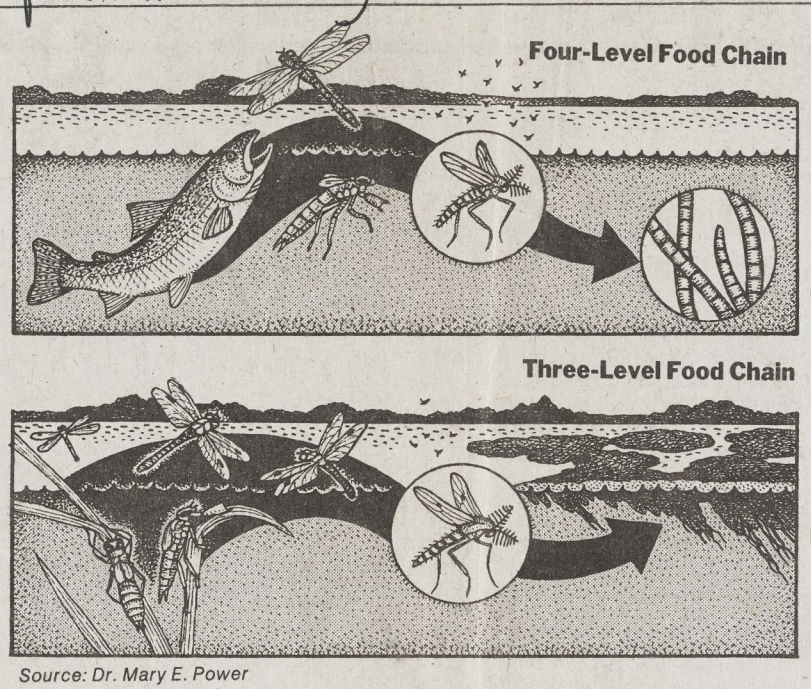
It was extended in 1977 by Stephen D. Fretwell, then at Kansas State University, who predicted that in ecosystems with four levels, plant eaters next to the bottom of the food chain would proliferate and decimate vegetation to produce habitats that look barren.

Most scientists, Dr. Power said, now "think the terrestrial world is a three-level world." At the same time, Dr. Hairston said, there is "more and more experimental evidence" that aquatic ecosystems are four-level systems like that of the Eel River.

The study by Dr. Power is "a very nice experimental demonstration" of the four-level aquatic system, said Dr. Hairston, who is now at the University of North Carolina at Chapel Hill. The Power experiment is the first demonstration of the principle in streams, he said.

The theory "is so tidy it's surprising it works," Dr. Power said in an interview. But she said, "It's a very good idea; a lot of the complexity of the world can be added to it, and it can still make sense as a backbone theory for community ecology."

In the Eel River experiment in the summer of 1989, Dr. Power installed a dozen 20-foot-square plastic mesh cages in a stretch of the river's south fork five-eighths of a mile long. The cages were constructed in the stream bed, around boulders to which large standing crops of algae clung. Half



Nature's Odds And Evens

An odd-even ecological theory says that when there is a two-level food chain of plants and plant-eaters, the plants are limited; that when predators that feed on herbivores add a third level to the chain, plants rebound, and that a fourth layer again limits plants. In a test of this theory, algae were scant at the bottom of a four-level food chain. But when the top layer, fish, was removed, the fish's prey, dragonfly and damselfly nymphs, soared; the next link, midges, declined, and algae thrived.

Source: Dr. Mary E. Power

The New York Times; Illustration by Patricia J. Wynne

Scientists Design Solar Oven to Dampen Use o

SOLAR ovens are a promising alternative for millions of people in the developing world who rely on firewood to cook their meals, a recent project in Central America has shown.

The rural poor in developing countries often live on the edges of swamps, deserts and rain forests fragile ecosystems that cannot withstand further stripping of trees and the consequent erosion. Wood-burning also increases carbon dioxide in the atmosphere and may contribute to global warming.

Wood Shortages Loom

For the past three years two American physicists and a handful of volunteers have been working in Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica to introduce a simple box-type solar oven that people can build in a few hours and use for most of their cooking.

The scientists, Daniel M. Kammen of California Institute of Technology and William F. Lankford, of George Mason University, report on their project in the Nov. 30 issue of the British journal Nature.

More than a third of the world depends primarily on wood for cooking, burning nearly half of the annual world wood harvest of three billion tons. According to the United Nations Food and Agriculture Organization, 84 percent of Africans will face wood shortages by the end of the decade.

In many countries women spend hours a day scavenging for firewood.

"Every year the forest moves further and further from my house," an Indian woman in Guatemala told a visiting American scientist.

Cooking over wood fires is also a health threat. Cooking fires in confined indoor spaces are a primary source of respiratory, skin and eye infections among women and children in developing countries.

Conservation and an increased reliance on alternative, renewable energy sources can reduce the demand for firewood. In sunny countries solar ovens are a feasible component to a solution, Dr. Kammen said.

The cooker that the scientists introduced in Central America is an insulated wooden box with a glass window. Pots rest on a conducting metal plate inside the box, and a flip-top lid covered in aluminum foil doubles as an extra solar-collecting panel.

Boil, Bake, Braise and Sauté

In strong sunlight the ovens can reach temperatures of about 350 degrees Farenheit. Unlike some other designs, box cookers can work even in partial sunlight, and they do need to be constantly moved to directly face the sun.

They can be used to boil, bake, simmer, braise, and sauté foods, and to kill germs in naturally contaminated water.

"They work like a Crock-Pot," Dr. Kammen said. "In some ways they are better than regular ovens, because they don't lose moisture, and the food retains more vitamins and minerals."

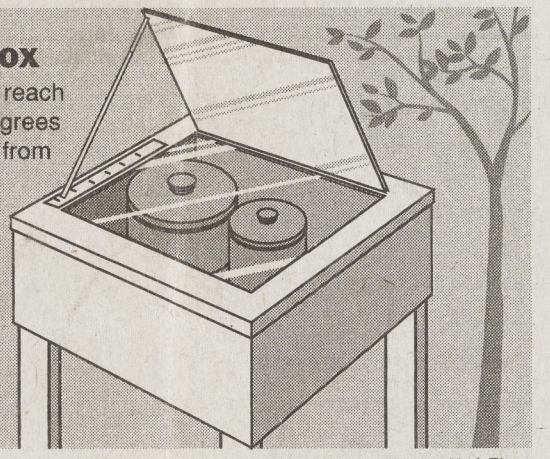
Solar cookers do have drawbacks. They cannot be used at night or in the rain or on very cloudy days. Cooking times are about twice as long in solar boxes as over fire.

Solar Box Cookers International, a nonprofit organization in Sacramento, Calif., publishes a pamphlet on building solar cookers, which can be

The Sun in a Box

A solar cooker that can reach temperatures of 350 degrees Fahrenheit can be built from cheap materials. It is basically an insulated box with a glass window to let in sunlight and hold in heat and a reflector to capture extra rays.

Source: Solar Box Cookers International



The New York Times

hackle is run from shoulder to tail.

These books are regarded as fly-dressers' bibles and few would question their contents, so it is quite clear that flies not palmered, and which depart from traditional dressings, are not Bumbles and must not be so named. It would only result in endless confusion to anglers in the years to come.

Professor Mundle did not really read my letter, published in June. I did not say Bumbles were useless, but that I found them useless, which is very different. The fly he is using may be excellent, but it is not a Bumble. I suggest he gives it a new name. How about "Jundle"?

I have been a fly-fisherman for more than 50 years and for a long time I have firmly believed, regarding sea-trout at night, that the presentation of the fly and the manner in which it is fished, plus quietness of approach, is often of greater importance than fly patterns — provided, of course, the fly is of reasonable size and shape according to the prevailing water conditions. This is possibly true of all fly-fishing.

Blue Bumble
Staffordshire

Blagdon Beauty

BLAGDON was at its most disconcerting: early August, mid-afternoon, clear blue skies, bright sunshine, flat calm and not a fish anywhere to be seen.

Imagine the shock when I glanced to the shore to view a particularly well-endowed young lady sunbathing nude! Her gentleman companion was happily casting away despite the lack of fish.

Before there is a rush to the West Country, I hasten to add that Bristol Waterworks assure me that they have no intention of allowing this to become a permanent attraction!

John Evans
Bristol

Why 'weeds' matter

AS A CHEMIST with considerable fieldwork experience in measuring oxygen (and CO_2) levels at the waterside, I would like to comment on Lister Bass's August letter, in which he described super-saturation as a "contradiction in terms". As he rightly says, if water which is saturated with oxygen becomes warmer, excess oxygen will be in solution. However, it is a mistake to continue "the excess is driven off". In sluggish water, very slow loss of oxygen will take place, the loss being much more rapid in turbulent flow, such as at a shallow weir. The natural degassing is a corollary to oxygen uptake by de-oxygenated water, which is also very slow except at weirs, but the most important influence on oxygen uptake by water is not turbulence (in summer), but plant-life.

In bright sunlight a stream with a good level of dissolved CO_2 can be as much as 50 per cent super-saturated with oxygen. This is why shallow weed-packed stretches are so essential for healthy waterways, and why ruthless weed-clearing and canalisation can be so ruinous. It may also help anglers to understand the days when the fish start to feed madly on a blazing sunny day. At the same time, another reason for the quality of life and the quantity of life in chalk and limestone streams may be seen. The springs have high concentrations of calcium-carbonate/hydrogen-carbonate and CO_2 in a complex equilibrium. The high CO_2 results in unusually vigorous photo-synthesis by the weeds, simultaneously producing carbohydrate for the food webs and pumping oxygen into the water.

R. D. Stenner, Dr
Weston-super-Mare, Somerset

☐ *Oxygen is the subject of an article by Dr Lindsay Laird and Dr Monty Priede on page 65. — Editor.*

LETTERS

The real Dolly Varden

I HAVE RECENTLY returned from working in Alaska and hence enjoyed Robin Ade's informative article, "Salmon of the Pacific".

However, I wish to disagree with him concerning the derivation of the name Dolly Varden. The particular Arctic char concerned may well have heard of Charles Dickens, but anglers all assure me that the fish is named after a certain lady of ill-repute who kept house in Dawson City during the period of the Yukon gold rush. By all accounts she was equally famous for her fighting qualities.

John Evans
Bristol

Learn to cast with cane

FOR MANY YEARS I have been reading with interest the numbers of letters concerning the virtues of cane fly-fishing rods.

As a professional instructor over the years I have taught a considerable number of fishermen the art of casting. Time and again I have found that when a fisherman is learning, or an experienced caster is having trouble with his timing, half-an-hour or so with a modern, light cane rod will put him right.

Once you can cast properly, of course, you can use any type of rod, but I find without doubt that I can teach people to cast more quickly with a cane rod than with any other type on the market.

Michael Hanford
Quorn, Leicestershire

Display rods or working rods?

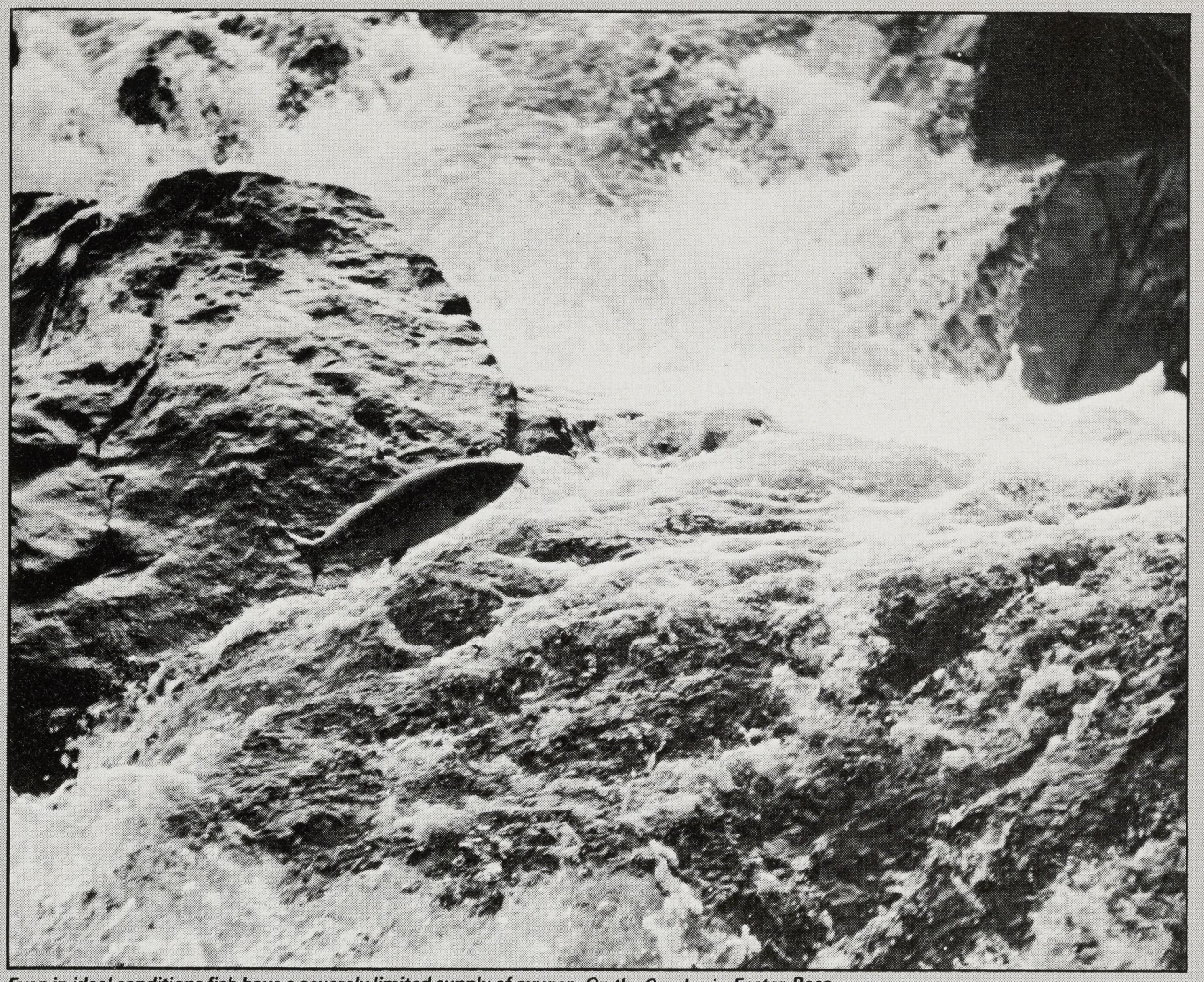
NO DOUBT the 'cane *v* carbon' correspondence will continue for some years to come, but meanwhile may I be permitted to put forward an English compromise which may go some way to satisfy the champions of both?

My first trout rod of quality was a delightful two-topped cane rod made and given to me by Richard Walker. With this I served an apprenticeship on the River Creedy in Devon. Used with a silk line, it was a joy for tackling wild browns in the ¾ lb range.

Unfortunately, my experience at that time didn't extend to the knowledge that you can overload any rod if you try. Although I wasn't trying to do so, I was in fact doing just that when I started double-hauling for considerably bigger fish on the then growing number of reservoirs. The rod finally broke at the handle, and it was then that I moved on to the Hardy 'Jet' glass rod, which was my first choice for years until a Hardy 'Graphite' and 'Farnborough' were pressed into service.

Apart from boat and bank fishing on stillwaters and the larger reservoirs, I fish a considerable amount on the chalk-streams and their tributaries, so I have opportunities to try different rods for different purposes. For example, only recently I was using another splendid cane rod of 7 ft, made and given to be by Charles Carfrae. With a lightweight reel and 3 AFTM line, it was in use on Frank Sawyer's favourite beats on the Avon. Most enjoyable!

In many ways I'm rather a traditionalist, perhaps as a result of my early days as a fellmonger and leather-dresser in our family tannery business at Hitchin. Not for me synthetics: give me wool, leather or parchment. So it is with cane; I love the look of cane rods, whereas I wouldn't give wall space for a display of carbon or glass rods. However, when it comes to a working rod, I now find myself reaching for my carbon rods all the while, for as far as I'm concerned they perform that much better. My rods of carbon are that much faster than my cane, and therefore it is probably true that one needs to reach a reasonable standard before the advantage of carbon is felt.



Even in ideal conditions fish have a severely limited supply of oxygen. On the Cassley in Easter Ross.

NO MYTH, NO MYSTERY...

...just facts about oxygen from LINDSAY LAIRD and MONTY PRIEDE

FISH, like all other animals, require oxygen to support life; salmon and trout are among the fish with the highest oxygen requirements. But in comparison with air-breathing animals, they find a severely limited supply of oxygen even in ideal conditions — such as a Scottish Highland river. Air contains 28 per cent oxygen by weight, whereas the water from which the fish must extract dissolved oxygen contains only one part in 100,000 by weight. The life of fish is thus characterised by a constant struggle to balance demand for oxygen against a limited supply.

Fish obtain oxygen by drawing in water through the mouth and passing it over the gills, which are able to extract up to 90 per cent of dissolved oxygen. The amount of oxygen available in the water varies greatly, and is a dominant factor in determining fish distribution. The maximum amount of oxygen present in the water is determined by the solubility, which decreases with increasing temperature so that the 100 per cent saturated water at 1 deg Cent (34 deg Fahr) contains 10 millilitres of oxygen per litre, while similar water at 15 deg Cent (59 deg Fahr) contains only seven millilitres. These are the maximum possible values in pure freshwater: seawater contains between 10 per cent and 20 per cent less.

In natural waters the amount of oxygen present will fall as fish and other organisms use it up — unless it is replaced. In shallow waters direct diffusion from the air takes place; this is aided by any agitation, such as waves, riffles and waterfalls. Otherwise the main source of oxygen is photo-synthesis by rooted aquatic plants and algae. Photo-synthesis can occur only near the surface, where sunshine can penetrate.

Deep, stillwaters, remote from sources of replenishment, are prone to oxygen depletion. Release of deoxygenated water from the bottom of deep reservoirs can therefore have disastrous consequences to fish in the river below the dam. Surface ice will also cut off the passage of oxygen into water.

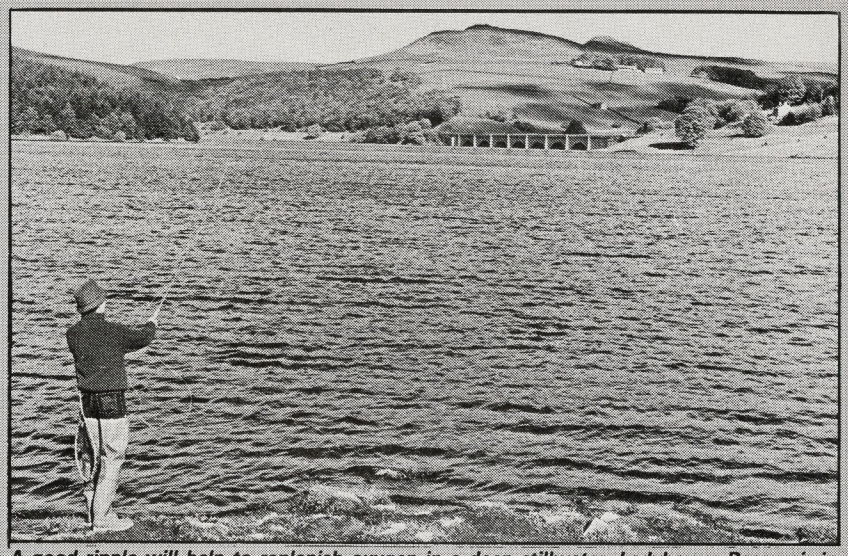
Although green plants produce oxygen, in the absence of sunshine they become nett consumers of it. In really thick, green algal blooms, shading occurs, which causes the plants to use up all the oxygen. Dying plants then make the situation even worse as the bacteria associated with decomposition consume the last vestiges of oxygen in the water. Any sewage, silage, dairy washings or other organic matter leads to a biological oxygen demand (BOD) which can render water totally fishless. Inorganic fertiliser run-off from farmland often stimulates excessive algal growth which leads to high BOD.

All energy-utilising activities in fish

create a demand for oxygen. Thus an actively swimming fish, including one swimming to stay in one place against a strong current, consumes more oxygen than a fish lying in still water. However, even in the absence of such activity, the fish still has a substantial oxygen demand which can vary greatly. Oxygen is required to break down food taken in and to convert it to body tissues.

Oxygen demands vary in magnitude over the year. Fish are cold-blooded animals; in general the fastest growth, supported by the greatest food intake, occurs when water temperatures are warm (in the region of 15 deg Cent for trout and salmon). This is when oxygen levels in the water are declining. At high temperatures, above 20 deg Cent, the prudent fish-farmer stops feeding his stock to reduce oxygen demand: oxygen levels in the water are dangerously low compared to the demands of fish. The summer growth check in wild trout occurs when the fish decrease their food intake in warm weather.

Swimming activity reaches a peak during migrations, although even then the use of currents and tides aids energy conservation and thus reduces oxygen requirements. Prey are captured by short bursts of swimming; normal 'cruising' uses little oxygen. Salmon and trout compensate for low oxygen availability by their highly-developed sprinting ability, which incurs an oxygen debt that is repaid by enhanced breathing during recovery. Thus a fish can fight vigorously when hooked, but if it escapes it may need up to 24 hours to return to normal and restore its muscles from a state of exhaustion.



A good ripple will help to replenish oxygen in a deep stillwater. Ladybower Reservoir in Derbyshire.

Salmon and trout are adapted to sustain high energy expenditure, but they are consequently highly susceptible to anything that impedes oxygen uptake. The gills are extremely delicate and may be damaged by silt in the water from activities such as quarrying, land-drainage, or road construction. Damage to gills may also be caused by bacteria or parasites. The former are often associated with deteriorating water conditions. The uptake of oxygen can be completely blocked by cyanide. In contaminated water fish are seen gasping at the surface in the same way as when oxygen levels are low.

Salmonids do have oxygen-sensing organs and are able to avoid patches of oxygen-depleted water such as sewage outflows. Given a choice, they are always found in water where oxygen saturation is close to 100%.

Oxygen is so important for salmon and trout that in nine out of ten cases of mortality the immediate cause of death can be traced to oxygen deficiency. This may be caused by insufficient oxygen in the water, reduced capability of the fish to take up oxygen, or excessive demand by the fish for oxygen.

☐ *Dr Laird and Dr Priede are both on the staff of the Department of Zoology at the University of Aberdeen. — Editor.*

A naturalist's notebook

A 'red-neck' on Rannoch

IF YOU HAVE READ Robert Louis Stevenson's novel, *Kidnapped,* you will have a fair idea of what the Moor of Rannoch looks like.

It stretches far and wide between Loch Tulla and Glencoe — a vast denuded tableland about 60 square miles in extent, with an average height of more than 1,000 ft, and with countless lochs and streams, bogs and peat-hags.

One of the biggest lochs is Loch Ba, a source-loch of the River Tummel, and it was in skirting the fringe of this loch that I was lucky enough to see one of those uncommon birds called phalaropes.

There are three types, and this one was of the red-necked variety. A few pairs of these nest in the Scottish Northern and Western Isles, but it is truly a bird of high latitudes and Arctic shores. In this instance, however, the nesting season was past, and probably the bird was moving south on a route that offered plenty in the way of lochs and estuaries.

Phalaropes are said to be very tame, and this bird certainly took little notice of me when I ventured nearer. Normally, the wader type of bird does not swim, but the phalarope does. This one rocked buoyantly on the ripples of a shallow inlet, and I was amused to see it spin round every now and again, probably in an effort to stir up insects from the bottom.

Red-necked phalaropes are also unusual in that the normal nesting habits are reversed. It is the female that sports the bright plumage, and after she has laid her clutch of eggs, it is the quietly-dressed male bird that incubates them and tends to the chicks.

Oddly enough, those plump little plover-birds of high altitudes called dotterel behave in a similar way — the male takes over the domestic duties, and allows the female to go traipsing over the mountain-tops with others of her sex, free to enjoy the almost perpetual summer daylight of the high tops.

Colin Gibson