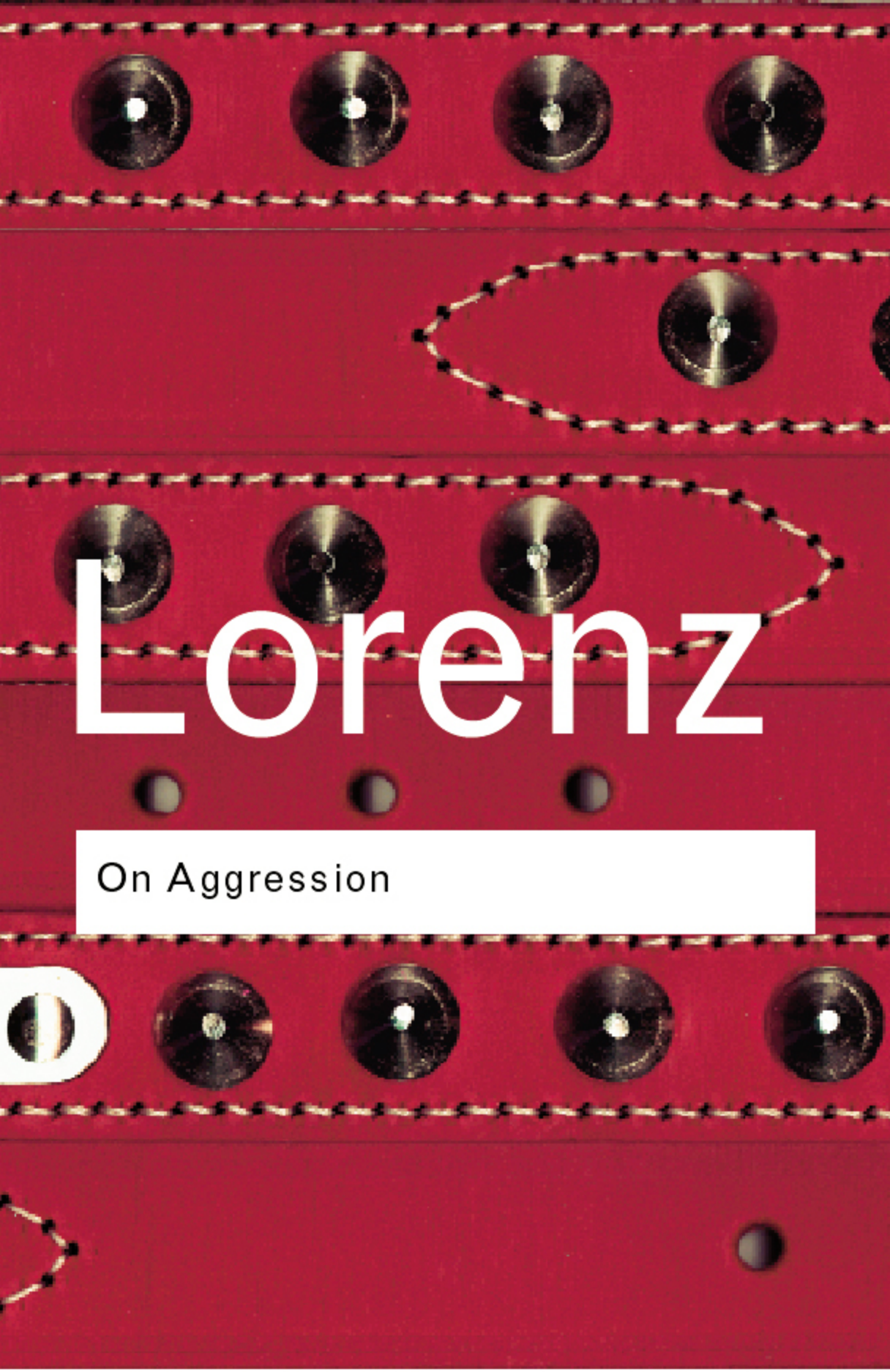
Lorenz
On Aggression

On Aggression

'No one concerned with animals, whether in the home, on the farm, or in the wild, whether with fish, lizards, birds, or cats; and above all no one concerned with the overriding dilemmas posed by population growth and by war can afford to neglect Konrad Lorenz's book.'

W.H. Thorpe

'His writing displays an unusually happy blend of erudition, wisdom and humour. He uses anecdote, illustration and aside, without one whit impairing his status as a distinguished man of science . . . There can be few biologists . . . who have handled, lived with, and made original observations upon so many different species of living creatures.'

Anthony Storr (1966)

'*On Aggression* is essential reading for all psychologists, psychoanalysts, sociologists and biologists – indeed for everyone who takes evolutionary theory seriously and is concerned with the danger to civilization implicit in our ignorance of the nature of aggression.'

Charles Rycroft, New Statesman

'Few men are better qualified than Professor Lorenz to show us how we could profit from animal behaviour studies . . . It would be deplorable if this product of unrivalled knowledge and rare intuition would be accepted merely as just another interesting story about animal behaviour.'

N. Tinbergen

Konrad

Lorenz

On Aggression

Translated by Marjorie Kerr Wilson

With a foreword by Julian Huxley

London and New York

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Contents

Foreword

by Sir Julian Huxley, F.R.S.

Konrad Lorenz is the father of modern ethology, that rapidly growing branch of science which is destined to provide a strong foundation for the science of human behaviour and psychology.

He has initiated a new interpretation of vertebrate behaviour. This is composed of 'behaviour-units', just as anatomy is composed of structural units. These have a genetic basis, and in the course of evolutionary time have been modified by Darwinian natural selection to act as specific signals for communicating emotional states. In the frequent cases where aggression and fear are involved they are modified so as to reduce the risk of intra-specific damage, and to permit close proximity between potential mates without arousing the aggression and fear which a close approach tends to elicit. Thus in the course of evolution all these behaviour-patterns tend to get ritualized or formalized, with exaggeration of prominent features, like grebes' ruffs and ear-tufts, and with enhanced variety and signalling efficiency.

In addition, when conflicting drives come into conflict, the pent-up nervous energy may spill over into quite irrelevant

behaviour, like the grebes' false wing-preening, or our own head-scratching when puzzled or undecided. And these displacement activities, as they are called, are often ritualized and modified, so as to become incorporated in the display, like the displacement wing-preening of ducks, culminating in the Mandarin Duck, where the preened region of the wing is picked out by exaggerated size and colour.

In many vertebrates, like grebes and Lorenz's geese, the energy of the aggressive drive may be recanalized to create an emotional bond between mates or comrades: this is most marked in higher groups.

In this book, Lorenz deals with the evolution of aggression in vertebrates. He points out that aggressivity is totally different from predation: that it is a biological necessity for defence of territory and for a cornered animal, and that it becomes mixed up with other innate drives, thus leading up towards reduction of intraspecific damage. This, be it noted, is most evident in fiercer social predators like wolves, where escape from the pack is virtually impossible and where co-operation without fighting is necessary for survival; whereas in the non-social but proverbially peaceful dove prevention of escape leads to violent and often fatal attacks on the weaker mate.

In a final chapter he advances some suggestion as to how in the human species, where evolution is primarily cultural, and not guided by Darwinian selection in the strict sense, the aggressive drive may be canalized into less dangerous channels. Man has innumerable ways of adaptively ritualizing his behaviour, many of them analogous, if not homologous, to those found in animals. In any event, *On Aggression* is a fascinating book by a master of his subject.

Introduction

A friend of mine who, like a true friend, had taken upon himself the task of reading through the manuscript of this book critically, wrote to me, when he was already more than half way through it: 'This is the second chapter I have read with keen interest but a mounting feeling of uncertainty. Why? Because I cannot see its exact connection with the book as a whole. You must make this easier for me.' His criticism was no doubt fully justified and the purpose of this Introduction is to make clear to the reader from the start the direction taken by the book as a whole and the way in which the individual chapters are related to its ultimate object.

The subject of this book is *aggression*, that is to say the fighting instinct in beast and man which is directed *against* members of the same species. The decision to write it came about through a chance combination of two circumstances. I was in the United States, first in order to give some lectures to psychiatrists, psycho-analysts and psychologists about some comparable behavioural theories and behavioural physiology and secondly

to verify through field observation on the coral reefs of Florida a hypothesis I had formed, on the basis of aquarium observations, about the aggressive behaviour of certain fish and the function of their colouring in the preservation of the species. It was at the clinical hospitals that for the first time in my life I came into conversation with psycho-analysts who did not treat the theories of Freud as inviolable dogmas but, as is appropriate in every scientific field, working hypotheses. Viewing them in this way I came to understand much in Sigmund Freud's theories that I had previously rejected as far too audacious. Discussions of his theories of motivation revealed unexpected correspondences between the findings of psycho-analysis and behavioural physiology, which seemed all the more significant because of the differences in approach, methods and above all inductive basis between the two disciplines.

I had expected unbridgeable differences of opinion over the concept of the death wish which, according to one of Freud's theories, is a destructive principle which exists as an opposite pole to all instincts of self-preservation. In the eyes of the behavioural scientist this hypothesis, which is foreign to biology, is not only unnecessary but false. Aggression, the effects of which are frequently equated with those of the death wish, is an instinct like any other and in natural conditions it helps just as much as any other to ensure the survival of the individual and the species. In man, whose own efforts have caused an overrapid change in the conditions of his life, the aggressive impulse often has destructive results. But so, too, do his other instincts, if in a less dramatic way. When I expressed these views on the theory of the death wish to my psycho-analytical friends I was surprised to find myself in the position of someone trying to force a door which is already open. They pointed out to me many passages in the writings of Freud which show how little reliance he himself had placed on his dualistic hypothesis, which must have been fundamentally alien and repugnant to

him as a good monist and mechanistically thinking natural scientist.

It was shortly afterwards, when I was making a field study of coral fish in warm seas, amongst which the function of aggression in the preservation of the species is plain, that the impulse to write this book came to me. For behavioural science really knows so much about the natural history of aggression that it does become possible to make statements about the causes of much of its malfunctioning in man. To achieve insight into the origins of a disease is by no means the same as to discover an effective therapy but it is certainly one of the necessary conditions for this.

I am aware that the task I have set myself makes excessive demands upon my pen. It is almost impossible to portray in words the functioning of a system in which every part is related to every other in such a way that each has a causal influence on the others. Even if one is only trying to explain a petrol engine it is hard to know where to begin, because the person to whom one seeks to explain it can only understand the nature of the crank-shaft if he has first grasped that of the connecting rods, the pistons, the valves, the camshaft and so on. Unless one understands the elements of a complete system as a whole one cannot understand them at all. The more complex the structure of a system is, the greater this difficulty becomes – and it must be surmounted both in one's research and one's teaching. Unfortunately the working structure of the instinctive and culturally acquired patterns of behaviour which make up the social life of man seems to be one of the most complicated systems we know on this earth. In order to make comprehensible the few causal connections which I believe I can trace right through this tangle of reciprocal effects, I must, for good or ill, go back a long way.

Fortunately the observed facts which are my starting point are fascinating in themselves. I hope that the territorial fights of the

coral fish, the 'quasi-moral' urges and inhibitions of social animals, the loveless married and social life of the night heron, the bloody mass battles of the brown rat and many other remarkable behaviour patterns of animals will engage the reader's interest up to the point when he reaches an understanding of the deeper connections between them.

I intend to lead him to it by following as closely as possible the route which I took myself, and this is for reasons of principle. Inductive natural science always starts without preconceptions from the observation of individual cases and proceeds from this towards the abstract law which they all obey. Most textbooks take the opposite course for the sake of brevity and clarity and set down the general before the particular. The presentation is thereby made more lucid but less convincing. It is only too easy first to evolve a theory and then to under-pin it with examples, for nature is so diverse that with diligent searching one can find apparently convincing examples to support wholly abstruse hypotheses. My book would really be convincing if the reader reached the same conclusion as myself solely on the basis of the facts which I set before him. But as I cannot expect him to follow such a thorny path, let me offer in advance, by way of a signpost, a brief account of the contents of each chapter.

I start in the first two chapters with the description of simple observations of typical forms of aggressive behaviour. Then in the third I proceed to the discussion of its function in the preservation of the species. In the fourth I say enough about the physiology of instinctual motivation in general and the aggressive impulse in particular to explain the spontaneity of the irresistible outbreaks which recur with rhythmical regularity. In the fifth chapter I illustrate the process of ritualization and show how the instinctive impulse newly created by it is made independent – in so far as is necessary for the later understanding of its effects in inhibiting aggression. The sixth chapter serves the same

purpose: here I have tried to give a general picture of the way instinctive impulses function. In the seventh chapter concrete examples are given to show what mechanisms evolution has 'invented' in order to channel aggression along harmless paths, the role played by ritual in this process and the similarity between the patterns of behaviour which arise in this way and those which in man are guided by responsible morality. These chapters give the basis for an understanding of the functioning of four very different types of social organization. The first is the anonymous crowd, which is free of all kinds of aggression but also lacks the personal awareness and cohesion of individuals. The second is the family and social life of the night heron and other birds which nest in colonies, the only structural basis of which is territorial – the defence of a given area. The third is the remarkable 'large family' of rats, the members of which do not recognize one another as individuals but by the tribal smell and whose social behaviour towards one another is exemplary, whilst they attack with bitter factional hatred every member of the species that belongs to a different tribe. The fourth type of social organization is that in which it is the bond of love and friendship between individuals which prevents the members of the society from fighting and harming one another. This form of society, the structure of which is in many ways analogous to that of men, is shown in detail by the example of the greylag goose.

After what has been said in these eleven chapters I think I can help to explain the causes of many of the ways in which aggression in man goes wrong. The twelfth chapter, 'Sermon on Humility' should provide a further basis by disposing of certain inner obstacles which prevent many people from seeing themselves as part of the universe and recognizing that their own behaviour too obeys the laws of nature. These obstacles come first of all from rejection of the idea of causality, which is thought to contradict the fact of free will, and secondly from man's spiritual pride. The thirteenth chapter seeks to depict the

present situation of mankind objectively, somewhat as a biologist from Mars might see it. In the fourteenth chapter I try to propose certain counter-measures against those malfunctions of aggression, the causes of which I believe I have identified.

1

PROLOGUE IN THE SEA

My childhood dream of flying is realized: I am floating weightlessly in an invisible medium, gliding without effort over sunlit fields. I do not move in the way that Man, in philistine assurance of his own superiority, usually moves, with belly forward and head upward, but in the age-old manner of vertebrates with back upward and head forward. If I want to look ahead, the discomfort of bending my neck reminds me painfully that I am really an inhabitant of another world. But I seldom want to do this, for my eyes are directed downwards at the things beneath me, as becomes an earthly scientist.

Peacefully, indolently, fanning with my fins, I glide over fairy-tale scenery. The setting is the coast of one of the many little islands of coral chalk, the so-called Keys, that stretch in a long chain from the south end of the Florida peninsula. The landscape is less heroic than that of a real coral reef with its wildly cleft living mountains and valleys, but just as vivid. All over the ground, which consists of ancient coral rubble, can be seen strange hemispheres of brain coral, wavy bushes of corgonia

and, more rarely, richly branched stems of staghorn coral, while between them are variegated patches of brown, red and gold seaweed, not to be found in the real coral reefs farther out in the ocean. At intervals are loggerhead sponges, man-broad and table-high, almost appearing man-made in their ugly but symmetrical forms. No bare surfaces of lifeless stone are visible, for any space between all these organisms is filled with a thick growth of moss animals, hydroid polyps and sponges whose violet and orange-red species cover large areas; of some organisms among this teeming assortment I do not even know whether they belong to the plant or the animal kingdom.

My effortless progress brings me gradually into shallower water where corals become fewer, but plants more numerous. Huge forests of decorative algae, shaped exactly like African acacia trees, spread themselves beneath me and create the illusion that I am floating not just man-high above Atlantic coral ground, but a hundred times higher above an Ethiopian steppe. Wide fields of turtle grass and smaller ones of eelgrass glide away beneath me, and now that there is little more than three feet of water beneath me, a glance ahead reveals a long, dark, irregular wall stretching as far as I can see to each side and completely filling the space between the illuminated sea-bed and the mirror of the surface: it is the border between sea and land, the coast of Lignum Vitae Key.

The number of fish increases rapidly, dozens shoot from under me, reminding me of photographs of Africa where herds of wild animals flee in all directions from the shadow of an aeroplane. In some places, above the fields of thick turtle grass, comical fat puffers remind me of partridges taking off from a cornfield zooming up only to glide down to land again in the next field or so. Other fish, many of which have incredible but always harmonious colours, do the opposite, diving straight into the grass as I approach. A fat porcupine with lovely devil's horns

over ultramarine blue eyes lies quite quietly and grins at me. I have not hurt him, but he – or one of his kind – has hurt me! A few days ago I thoughtlessly touched one of this species, the spiny boxfish, and the razor-sharp parrot-beak, formed by two opposing teeth, pinched me and removed a considerable piece of skin from my right forefinger. I dive down to the specimen just sighted and, using the labour-saving technique of a duck in shallow water, leaving my backside above the surface, I seize him carefully and lift him up. After several fruitless attempts to bite, he starts to take the situation seriously and blows himself up; my hand clearly feels the 'cylinder strokes' of the little pump formed by the pharyngeal muscles of the fish as he sucks in water. When the elasticity of his outer skin has reached its limit and he is lying like a distended prickly ball in my hand, I let him go and am amused at the urgency with which he squirts out the pumped-in water and disappears into the sea-weed.

Then I turn to the wall separating sea from land. At first glance one could imagine it to be made of volcanic tuff, so fantastically pitted is its surface and so many are the cavities which stare like the eyeholes of skulls, dark and unfathomable. In fact, the rock consists of coral skeletons, relics of the pre-Ice Age. One can actually see in the ancient formations the structure of coral species still extant today and, pressed between them, the shells of mussels and snails whose living counterparts still frequent these waters. We are here on *two* coral reefs: an old one which has been dead for thousands of years and a new one growing on the old, as corals, like cultures, have the habit of growing on the skeletons of their forebears.

I swim up to and along the jagged waterfront, until I find a handy not too spiky projection which I grasp with my right hand as an anchorage. In heavenly weightlessness, cool but not cold, a stranger in a wonderland far removed from earthly cares, rocked on gentle waves I forget myself and am all eye, a blissful breathing captive balloon!

All around me are fish, and here in the shallow water they are mostly small fish. They approach me curiously from a distance or from the hiding-places to which my coming had driven them; they dart back as I clear my snorkel by blowing out the water that has condensed in it; when I breathe quietly again they come nearer, swaying up and down in time with me in the gently undulating sea. It was by watching fish that, still with a clouded vision, I first noticed certain laws of animal behaviour, without at the time understanding them in the least, but ever since I have endeavoured to reach this understanding.

The multiplicity of the forms surrounding me – many so near that my long-sighted eyes cannot discern them sharply – seems at first overwhelming. But after a while their individual appearances become more familiar and my gestalt perception, that most wonderful of human faculties, begins to achieve a clearer, general view of the swarms of creatures. Then I find that there are not so many species as I thought at first. Two categories of fish are at once apparent: those which come swimming in shoals, either from the open sea or along the wall, and those which, after recovering from their panic at my presence, come slowly and cautiously out of a cave or other hiding-place – always singly. Of the latter I already know that even after days or weeks the same individuals are always to be found in the same dwelling. Throughout my stay at Key Largo I visited regularly, every few days, a beautiful ocellated butterfly-fish in its dwelling under a capsized landing-stage and I always found it at home. Among the fish wandering hither and thither in shoals are myriads of little silversides, various small herrings which live near the coast, and their untiring hunters, the needle-fish, swift as arrows. Then there are grey-green snappers loitering in thousands under landing-stages, breakwaters and cliffs, and delightful blue-and-yellow-striped grunts, so called because they make a grunting noise when removed from the water. Particularly numerous and particularly lovely are the blue-striped, the white,

and the yellow-striped grunts, misnomers because all three are blue and yellow striped, each with a different pattern. According to my observations, all three kinds swim frequently in mixed shoals. These fish have a buccal mucous membrane of a remarkable burning-red colour, only visible when, with widely opened mouth, a fish threatens a member of its own species, which naturally responds in the same manner. However, neither in the aquarium nor in the sea have I ever seen this impressive sparring lead to a serious fight.

One of the charms of these and other colourful grunts, and also of many snappers, is the fearless curiosity with which they accompany the snorkel diver. Probably they follow harmless large fish and the now almost extinct manatee, the legendary sea-cow, in the same way, in the hope of catching little fish or other tiny creatures that have been scared out of cover by the large animal. The first time I swam out from my home harbour, the landing-stage of Key Haven Motel in Tarvenier on Key Largo, I was deeply impressed by the enormous crowd of grunts and snappers which surrounded me so densely that it obscured my view, and which seemed to be just as strong in numbers wherever I swam. Gradually I realized that I was always escorted by exactly the same fish and that at a modest estimate there were at least a few thousand. If I swam parallel with the shore to the next pier about half a mile away, the shoal followed me for about half this distance and then suddenly turned round and raced home as fast as it could swim. When the fish under the other landing-stage noticed my coming, a startling thing happened: from the darkness of the stage emerged a monster several yards high and wide, and many times this length, throwing a deep black shadow on the sunlit sea bottom as it shot towards me, and only as it drew very near did it become resolved into a crowd of friendly grunts and snappers. The first time this happened to me, I was terrified, but later on these fish became a source of reassurance rather than fear, because while they

remained with me I knew that there was no large barracuda anywhere near.

Entirely different are those daring little predators, needlefish and halfbeaks, which hunt in small bands of five or six just under the surface. Their whip-like forms are almost invisible from my submarine viewpoint, for their silver flanks reflect the light in exactly the same way as the under-surface of the air, more familiar to us in its Janus face as the upper surface of the water. Seen from above, they are even more difficult to discern, since they shimmer blue-green just like the water surface. In widely spread flank formation they comb the highest layers of water hunting the little silversides which frequent the water in millions, thick as snowflakes in a blizzard and gleaming like silver tinsel. These dwarfs, the silversides, are not afraid of me, for fishes of their size would be no prey for fishes of mine. I can swim through the midst of their shoals and they give way so little that sometimes I hold my breath involuntarily to avoid breathing them in, as if I were passing through an equally dense cloud of mosquitoes. The fact that I am breathing through my snorkel in another medium does not in the least inhibit this reflex. If even the smallest needle-fish approaches, the little silversides dart at lightning speed in all directions, upward, downward, and even leaping above the surface, producing in a few seconds a large clear space of water, which only gradually fills up again when the predator has passed.

Although the shapes of the fat-headed grunts and snappers are so different from those of the fine, streamlined needle-fish, they have one thing in common: they do not deviate too much from the usual conception of the term 'fish'. Among the resident cave-dwellers the situation is different: the blue angel-fish, decorated in youth with yellow vertical stripes, can still be called a 'normal fish', but this thing pushing its way out of a crevice between two coral blocks, weaving with hesitating backward and forward movements, this velvet-black disc with bright yellow semi-

circular transverse bands and a luminous ultra-marine-blue border to its lower edge, is this really a fish? Or those two little round things, the size and shape of a bumble-bee, hurrying by and displaying on their *rear* end a round eye bordered with blue? Or the little jewel shining from that hollow, whose body is divided by a diagonal line from the lower anterior to the upper posterior end into a deep violet-blue and a lemon-yellow half? Or this unique little piece of dark-blue starry-sky, strewn with tiny pale blue lights, which in paradoxical inversion of space is emerging from a coral block *below* me? On closer examination, all these fairy-tale figures are of course perfectly ordinary fishes, not too distantly related to my old friends and collaborators, the cichlids. The starry-sky, the marine jewel fish, and the little fish with the blue head and back and the yellow belly and tail, called beau gregory by the Floridians, are in fact close relations. The orange-red bumble-bee is a baby of the 'rock beauty', and the black and yellow disc is a young black angel-fish. But what colours, and what incredible designs: one could almost imagine they were planned to create a distant effect, like a flag or a poster.

The great, rippling mirror above me, starry-skies – if only tiny ones – below; swaying weightlessly in a translucent medium, surrounded by angels, lost in contemplation and awed admiration of the creation and its beauty, I thank the creator that I am still able to observe essential details: of the dull-coloured fishes or the pastel-coloured grunts I nearly always see several of the same species at once, swimming in close shoal formation; but of the brightly coloured species within my field of vision, there is *one* blue and *one* black angel-fish. Of the two baby rock beauties that have just raced by, one is in furious pursuit of the other.

I continue to observe, although, in spite of the warmth of the water, my captive-balloon position is making me feel cold. Now in the far distance – that is, only ten or twelve yards even in clear water – I see a beau gregory approaching, in search of food. The other beau, which is close to me, sees the intruder later than I do

from my lookout post, and he only notices him when he is within about four yards. Then he shoots towards him furiously, whereupon the stranger, although he is a little bigger than his adversary, switches round and flees with vigorous strokes in wild zig-zags, trying to avoid the ramming movements of his pursuer; these, if they met their mark, could inflict severe wounds, and indeed one of them does for I see a glinting scale flutter to the bottom like a wilted leaf. As soon as the stranger has disappeared into the dusky blue-green distance, the victor returns to his hollow, threading his way calmly through a dense shoal of young grunts who are in search of food in front of the entrance, and the absolute equanimity with which he passes through the shoal gives the impression that he is dodging stones or other inanimate obstacles. Even the little blue angel-fish, not unlike himself in shape and colour, rouses not the least sign of his aggression.

Soon after I observe a similar altercation between two black angel-fish, scarcely a finger in length; but this time it is even more dramatic. The anger of the aggressor and the panicky flight of the intruder are even more apparent – though perhaps this is because my slow human eye is better able to follow the movements of the angel-fish than those of the far swifter beau gregorys, whose performance is too quick for me.

I now realize that I am rather cold, and as I climb the coral wall into the warm air and golden sun of Florida, I formulate my observations in a few short sentences: the brilliant 'poster-coloured' fish are all local residents and it is only these that I have seen defending a territory. Their furious attack is directed towards members of their own species only, except, of course, in the case of predatory fish in which, however, the motive of the pursuit is hunger and not real aggressiveness. Never have I seen fish of two different species attacking each other, even if both are highly aggressive by nature.

2

CORAL FISH IN THE LABORATORY

In the previous chapter I made use of poetic licence: I did not mention that I already knew from observations in the aquarium how furiously the brightly coloured coral fish fight their own species, and that I had already formed an opinion on the biological meaning of these fights. I went to Florida to test this hypothesis and if the facts disproved it I was ready to throw it overboard – or rather to spit it out through my snorkel, for one can hardly throw something overboard when one is swimming under water. It is a good morning exercise for a research scientist to discard a pet hypothesis every day before breakfast. It keeps him young.

Some years ago I began to study brightly coloured reef fish in the aquarium, impelled not only by my aesthetic pleasure in their beauty but also by my 'flair' for interesting biological problems. The first question that occurred to me was: why are these fish so colourful? When a biologist asks 'What is the aim or purpose of something?' he is not trying to plumb the depth of

meaning of the universe or of this problem in particular, but he is attempting much more humbly to find out something quite simple and, in principle, open to solution. Since we have learned, through Charles Darwin, about evolution and even something about its causes, the question, 'What for?' has, for the biologist, a sharply circumscribed meaning. We know that it is the *function* of an organ that alters its form, in the sense of functional improvement; and when, owing to a small, in itself fortuitous, hereditary change, an organ becomes a little better and more efficient, the bearer of this character, and his descendants, will set a standard with which other, less talented members of his species cannot compete; thus in the course of time those less fit to survive will disappear from the earth's surface. This ever-present phenomenon is called natural selection and is one of the two great constructors of evolution. The other constructor is mutation, which, together with the recombination of hereditary characters through sexual reproduction, provides the material for natural selection. With remarkable foresight, Darwin postulated mutation as a necessity at a time before even the term had been coined.

All the innumerable, complex and expedient structures of plant and animal bodies owe their existence to the patient work performed in the course of millions of years by mutation and selection. We are even more convinced of this than Darwin was, and, as we shall soon see, with more justification. To some people it may seem disappointing that the many forms of life, whose harmonious laws evoke our awe and whose beauty delights our aesthetic senses, have originated in such a prosaic and causally determined way. But to the scientist it is a constant source of wonder that nature has created its highest works without ever violating its own laws.

Our question 'What for?' can receive a meaningful answer only in cases where both constructors of evolution have been at work in the manner just described. Our question simply asks

what function the organ or character under discussion performs in the interests of the survival of the species. If we ask 'What does a cat have sharp, curved claws for?' and answer simply by saying, 'To catch mice with', this does not imply a profession of any mythical teleology, but the plain statement that catching mice is the function whose survival value, by the process of natural selection, has bred cats with this particular form of claw. Unless selection is at work, the question 'What for?' cannot receive an answer with any real meaning. If we find, in a central European village, a population of mongrel dogs some of whom have straight tails and others curly ones, there is no point whatever in asking what they have such tails for. This random variety of forms – mostly more or less ugly – is the product of mutation working by itself, in other words, pure chance. But whenever we come upon highly regular, differentiated and complicated structures, such as a bird's wing or the intricate mechanism of an instinctive behaviour pattern, we must ask what demands of natural selection caused them to evolve, in other words, what they are for. We ask this question with assurance, in the confident hope of an intelligible answer, for we have found that we usually get one provided the questioner perseveres enough. This is not disproved by the few exceptional cases where scientific research has not yet been able to solve some of the most important of all biological problems, such as the question of what the wonderful forms and colours of mollusc shells are for, as the inadequate eye of these animals cannot see them, even when they are not – as they often are – hidden by the skin-fold of the mantle and in the darkness of the deep-sea-bed.

The loud colours of coral fish call loudly for explanation. What species-preserving function could have caused their evolution? I bought the most colourful fishes I could find and, for comparison, a few less colourful and even some really drab species. Then I made an unexpected discovery: in the case of most

of the really flamboyant poster-coloured coral fish, it is quite impossible to keep more than one individual of a species in a small aquarium. If I put several members of the same species into the tank, there were vicious fights and within a short time only the strongest fish was left alive. Later, in Florida, it impressed me deeply to watch in the sea the same scene that I had always observed in my aquarium after the fatal battles: several fish, but only one of each species, each brightly coloured but each flying a different flag, living peaceably together. At a small breakwater near my hotel, *one* beau gregory, *one* small black angel-fish and *one* butterfly-fish lived in peaceful association. Peaceful coexistence between two individuals of a poster-coloured species occurs, in the aquarium or in the sea, only among those fish that live in a permanent conjugal state. Such couples were observed, in the sea, among blue angel-fish and beau gregory, and in the aquarium among brown, and among white-and-yellow butterfly-fish. The partners are inseparable and it is interesting to note that they are more aggressive towards members of their own species than single fish are. I shall explain the reason for this later.

In the sea, the principle 'Like avoids like' is upheld without bloodshed, owing to the fact that the conquered fish flees from the territory of his conqueror, who does not pursue him far; whereas in the aquarium, where there is no escape, the winner often kills the loser, or at least claims the whole container as his territory and so intimidates the weaker fish with continual attacks that they grow much more slowly than he does; and so his dominance increases till it leads to the fatal conclusion.

In order to observe how territory 'owners' normally behave, one needs a container big enough for at least two territories of a size normally commanded by the species under examination. We therefore built an aquarium six feet long, holding more than two tons of water and big enough for several such territories of various species of smaller, coastal fish. In the poster-coloured

species, the young are nearly always not only more colourful and fiercer but also more firmly attached to their territories than the adults are. Since the young are small, we could observe their behaviour in a comparatively limited space.

Into this aquarium my co-worker Doris Zumpe and I put small fish, one to two inches in length, of the following: seven species of butterfly-fish, two species of angel-fish, eight species of demoiselles (the group to which the starry-skies and the beau gregory belong), two species of trigger-fish, three species of wrasse, one species of doctor fish, and several species of non-'poster-coloured', non-aggressive fish, such as trunkfish, puffers, and others. Thus there were about twenty-five species of poster-coloured fish, with an average of four per species, more of some, only one of others, a total of roughly a hundred individuals. They settled in very well, with almost no losses; they started to flourish – and according to programme, they began to fight.

Now came the chance of counting something. When the 'exact' scientist can count or measure something, he experiences a pleasure which, to the outsider, is hard to understand. Admittedly we would know only a little less about intra-specific aggression if we had not counted but our results would be much less convincing if we could only say, 'Brightly coloured coral fish hardly ever bite any other species than their own'; however, we, or to be more exact, Doris counted the bites, with the following result: since there were about one hundred fish in the aquarium and each species was represented by an average of four, the chances of a fish biting one of its own species were three to ninety-six; but the proportion of bites inflicted on members of the same species to the bites given to other species was roughly eighty-five to fifteen. And even this small number of fifteen was misleading, because these bites came almost entirely from the demoiselles which in the aquarium stay in their caves all the time, invisible from without, and attack every intruder

regardless of the species. In nature, they, too, ignore fishes of other species. Later on we omitted this group and obtained much more impressive figures.

A further proportion of the bites inflicted on fishes of different species came from those individuals which had no members of their own species in the container and therefore had to discharge their anger on other objects. Their choice of objects confirmed the correctness of my supposition as convincingly as did the more exact figures. For example, there was a single member of an uncertain species of butterfly-fish whose form and markings were so exactly intermediate between the white-and-gold and the white-and-black butterfly fish that we called him the white-gold-black, and he evidently shared our opinion of his classification for he divided his attacks almost equally between the representatives of those two species and was never seen to bite a member of a third species. The behaviour of our single blue trigger (*Odonus niger*) was even more interesting. The zoologist who gave this fish its Latin name can only have seen it as a corpse in formalin, for the live fish is not black but luminous blue, suffused with a delicate violet and pink, particularly evident at the edges of the fins. I bought only one specimen of this fish because I realized, from the fights in the dealer's tank, that my own tank would be too small for two of these two-and-a-half-inch fish. In the absence of a fellow member of his species, my blue trigger-fish behaved peaceably for a time, administering only a few bites, significantly between two quite different species. First he pursued the so-called blue devils, near relations of the blue gregory, which had the same beautiful blue colour as himself; and secondly he attacked the two members of another trigger-fish species, the so-called Picasso fish. As its name indicates, the markings of this fish are extraordinarily colourful and bizarre, but it resembles the blue trigger in its outward form if not in its colour. After a few months, the stronger of the two Picassos had dispatched the weaker into the realm of formalin,

and a strong rivalry sprang up between the survivor and the blue trigger. Doubtless the increased aggression of the latter towards the Picasso was influenced by the fact that his old enemies, the blue devils, had meanwhile changed from the bright blue of their youth to their drab, dove-grey adult dress which had a less fight-eliciting effect. Finally, the blue trigger killed the Picasso. I could quote many more such cases where, in similar experiments, only one fish survived. In cases where, as a result of pairing, two fishes behaved as one, one pair remained, as in the brown, and the white-and-gold butterfly-fish. Numerous cases are also known where other animals, besides fish, in the absence of a member of their own species, discharged their aggression on other objects, choosing for the purpose close relations or species with colouring similar to their own.

These aquarium observations, confirmed by my sea studies, prove the rule that fish are far more aggressive towards their own species than towards any other.

Now there are, as I have already described, a number of species which are not nearly so aggressive as the coral fish of my experiments. When one examines the aggressive and the more or less non-aggressive species, it is evident that there is a connection between colouring, aggressiveness, and sedentary territorial habits. Among the fish that I examined in the free state, extreme aggressiveness, associated with territorial behaviour and concentrated on members of the same species, is found almost exclusively in those forms whose bright poster-like colour patterns proclaim their species from afar. In fact, it was this extraordinary kind of colouring that aroused my curiosity and drew my attention to the existence of a problem. Fresh-water fish can also be beautifully colourful and in this respect many of them can hold their own with marine fish, but apart from their beauty they contrast oddly with the coral fish.

The charm of the colouring of most fresh-water fish lies in its changeability: cichlids, labyrinth-fish, the red, green and blue

male stickleback, the rainbow-coloured bitterling of our home waters, and many other forms well known to us through the home aquarium, illuminate their jewels only when they are glowing with love or anger. In many of these fish the degree of their emotion can be measured by their colouring which also shows whether aggressiveness, sexual excitement or the flight urge is uppermost. Just as a rainbow disappears when a cloud covers the sun, so the beauty of the fish fades when the emotion that produced it wanes or is superseded by another conflicting emotion, such as fear, which quickly covers the fish with drab protective colouring. In other words, the colours of all these fish are a means of expression, only appearing when they are needed. Correspondingly, the young and often the females of these species have plain camouflage colouring.

The situation is different among the aggressive coral fish. By day their glorious dress is as constant as if it had been painted on them in fast colours. It is only before going to sleep that most of them show their capacity for changing colour by putting on a night-dress whose design is amazingly different from their day attire, but as long as they are awake and active, they keep their flamboyant colours at all costs, whether they are hotly pursuing a fellow-member of their species or are themselves escaping in wild zig-zags from a pursuer. They would no more think of lowering their flag than would an English battleship in a novel by Forrester. And even in transport containers, where they are certainly not at ease, and during illness, their gorgeous colours remain unchanged; even after death it is a long time before they disappear entirely.

In all typical poster-coloured coral fish, not only are male and female both brightly coloured but even the tiny babies show brilliant colours which, strangely enough, are often quite different from those of the adults, and sometimes even more striking. Most amazing of all: in several forms only the babies are multi-coloured, for example the starry-skies mentioned on page 7,

and the beau gregories (page 7), both of which change with sexual maturity into drab dove-grey fish with pale yellow tail fins.

The colouring of coral fish is distributed in large sharply contrasting areas of the body. This is quite different to the colour patterns not only of most fresh-water fish but of nearly all less aggressive and less territorial fish, whose charm lies in the delicacy of their designs, the harmony of their soft colouring, and the careful 'attention to detail'. When you see a grunt from a distance, you see an insignificant, greenish-silver fish, and only when he is right in front of you – a thing that may easily happen with these inquisitive creatures – do you notice the gold and sky-blue hieroglyphs clothing his body like an attractively designed brocade. Without any doubt these patterns are signals for the recognition of the species by its own members, but their design is such that it can be seen only at very close quarters by members of the species in the immediate vicinity. Conversely, the poster-colours of the territorially aggressive coral fish are so arranged that they can be seen and recognized from the greatest possible distance, and we know only too well that recognition of their own species provokes furious aggression in these fish.

Many people, even those with an understanding of nature, think that we biologists show a strange desire for superfluous knowledge when we want to know what functions every single coloured patch on an animal fulfils in the preservation of the species, and what causes could have led to its evolution. Indeed this curiosity is often attributed to materialism and a distorted sense of values. But every question that has a reasonable answer is justifiable, and the value and beauty of a natural object is in no way affected by our finding out why it is made in this and no other way. The scientist's attitude cannot be better expressed than as William Beebe once formulated it in his quaint manner: 'The isness of things is well worth studying; but it is their whyness that makes life worth living.' The rainbow is no less

beautiful because we have learnt to understand the laws of light refraction to which it owes its existence, and the beauty and symmetry of design, colour and movement in our fishes must excite our admiration even more when we know that their purpose is preservation of the species that they adorn. We know, with tolerable certainty, the species-preserving function of the glorious war-paint of coral fish: it elicits furious reactions of territorial defence in every fish of the same species – and only of the same species – when the reacting individual is in its own territory; and to the intruder encroaching on foreign ground it proclaims fear-inspiring readiness to fight. Both functions are practically identical with those of another natural phenomenon whose beauty has inspired our poets – bird song.

If we test this theory by comparing the fighting behaviour of poster-coloured and non-poster-coloured fishes of the same genera and in the same environment, it proves itself particularly impressively when a poster-coloured and plain-coloured fish belong to the same genus; for example, the sergeant-major, with its plain transverse bands, is a peaceful schooling fish, while its generic relation, the sharp-toothed abudefduf, a gorgeous velvet-black fish with bright blue stripes on head and thorax and a yellow transverse band on its body, is about the fiercest of all the fierce territory owners that I met with during my coral fish studies. Our large aquarium proved too small for two tiny youngsters, scarcely an inch long, of this species; one claimed for itself the whole container and the other eked out its existence in the left upper front corner behind the bubbles of the air generator which hid it from the view of its disagreeable brother. Another good example is provided by comparing fish of the butterfly-fish genera. The only peaceful one I know is the four-eyed butterfly, and this is the only one whose characteristic design is broken up into such small details that it can be recognized only at very close quarters.

The most remarkable thing of all is that coral fish which are