Results. Although the muscles of the distal limb are often variable in occurrence, the lateral-CDE was present in both limbs of all but 1 of more than 50 pigs (mostly Poland Chinas) which were examined. Histochemical analysis showed a muscle of mixed fibre composition with 26% type I and 74% type II fibres as identified by the alkaline ATPase reaction. Type I fibres were nearly all high in oxidative capacity by the NADH-diaphorase reaction. The type II fibres were ⅓ intermediate and ⅔ low in oxidative capacity with only a few type II fibres being classified as high oxidative.

The muscle preparation remained viable at room temperature in physiological salt solution for at least 12–16 h. In a 38 °C bath over a period of 1–2 h (the longest examined), the maximum tetanic tension remained constant. The average maximum isometric tension (n=26) was 2.47 kg/cm^2 (SEM-0.1).

Discussion. The porcine lateral-CDE is a small muscle which can be dissected into several bundles of intact cells attached to both tendons. The muscle is composed of a mixed population of fibre types. It is intermediate in fibre composition between the porcine longissimus muscle (white)[4,5] and the trapezius (red)[4]. Physiological studies will therefore represent an average of the characteristics of the various types as is the case with the commonly studied rat EDL and gastronemius muscles. (In contrast, the external intercostal is similar in fibre composition to the red porcine trapezius[4] and exhibits physiological characteristics (unpublished data) similar to slow twitch muscles such as the rat soleus[5-7].) The lateral-CDE preparation has the advantages of easy access, small size and easy subdivision, and mixed fibre composition; and would be useful to others contemplating the study of porcine muscle physiology.

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OECOLOGICA HUMANA

Consideration on the effects of pollution at community and population level

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Summary. The effects of pollution at population level are considered in relation to demographic characteristics and overall to the birthrate. The direct and indirect effects of pollution on community structure is discussed. The influence of pollution may vary according to the food-chain structure; (as a consequence, the hazard 'ceteris paribus' will be greater in freshwater communities than in marine ones). Relations between 'diversity' and 'stability' are discussed. In addition, the advantages and difficulties in using 'diversity' and 'biotic' indices for monitoring polluted water are taken into account.

Pollution is commonly defined as the intror uction of toxic substances into a natural environment, without considering the relationship between the charge of pollutant and the self-purifying capacity of the environment. As a consequences, 'waste acceptability units' are calculated solely on the basis of pollutant concentration in the effluents.

There are, however, many substances which, although nontoxic, may profoundly alter an ecosystem (for instance phosphates, nitrates, clay, limestone powders and cement). Thermal energy can drastically modify community structure, productivity and biomass and may therefore also be considered a pollutant.

Several authors include within the terms of the definition any event, whether natural or induced by human activities, which alters the state of an ecosystem. This conflicts with the definition of pollution "sensu stricto" and it groups radioactive waste materials, heavy metals, hydrocarbons and biocides in the same category as earthquakes and volcanic eruptions. Consequently the damage done by man to his environment appears natural, and this concept can weaken the actions taken to reduce pollution.

In this work, the term 'pollution' includes any influence exerted on the ecosystem, by man or his activities, that is strong enough to produce harmful effects at the population level and hence upon the community.

Effects at population level

For ethical reasons man protects himself against pollution at both individual and population levels. The same criterion cannot be applied to the protection of animal and plant populations, because in these cases the value of an individual is inversely related to the reproductive capacity of the population to which it belongs. For instance, the destruction of 40–60% of an algal or bacterial population does not usually jeaopardise its survival, whereas the elimination of the same percentage of a low-fertility population (e.g. zebras) could severely damage or even lead to the extinction of the population.

Certain parameters are peculiar to the population, others are common to the population and individuals. Among the parameters typical of the population birth rate, spatial distribution, or density, may be mentioned. Population is not just a random group of individuals belonging to the same species and living in the same environment. It is rather a group of individuals differentiated from other groups by selective mechanisms and thus adapted to the environment it colonizes.

Consequently, by studying the effect of pollutants on individual cells, nuclei or enzymatic systems, it is very difficult to predict the effects that the same pollutant would have on a population. It therefore becomes evident that a knowledge of the effects of pollution at population level provides the only sound basis for protecting community and species.

Unfortunately, information on the effects of pollutants on natural populations is rather scarce when compared with the data available from tests carried out on single individuals in laboratory conditions. A great deal of laboratory work has been carried out on algal and bacterial populations, and there have been many studies of polluted environments; but results concerning the population density or the species characterizing the community are often scarce. There are very few data available concerning mechanisms regulating population density in either polluted or nonpolluted environments. Most of the work on aquatic organisms has been carried out on sea fish populations, but most of the research concerns fishery but not pollution effects.

The effects of low doses of polluting substances on populations are often difficult to identify against natural background fluctuations of various kinds; and similarly, modifications observed in communities from polluted environments are interpreted as direct effects of pollution, even though this may not be the cause or only partially so. Accurate research work is therefore difficult.

If characteristics of the ecosystem are significantly modified (either by climatic or edaphic changes or by immigration or emigration of species) we find a selection within the population in favour of a group of individuals capable of adapting to the new situation, with the rest being eliminated.

With the change in the ecosystem, the size of the population may be reduced; but if this does not jeopardise the survival of the population, then with time numbers may recover and even exceed the original density.

It is evident that the succeeding population will maintain the genetic characteristics of the more resistant types and will differ from the original population. Pollution may also cause a modification of the ecosystem, which the population may or may not be able to tolerate by reacting with the same defense mechanisms used against natural events. Survival of populations in heavily polluted areas, by a natural selection of adapted individuals, has been clearly demonstrated for several terrestrial plants. In heavy metal mining regions (e.g. zinc, copper, tin), even if inactive for decades, vegetation is usually sparse or lacking altogether. Some populations of herbaceous plants (i.e. *Festuca ovina, Plantago lanceotata, Sislene inflata*) are, however, able to establish themselves in such areas where the pollution level is too high to be tolerated by other strains of the same species. That a fraction of the population survives the pollution is thus the key factor. It is, however, impossible to assess a priori what the minimum size of the fraction must be to ensure survival of the population. This will vary with both the size and fecundity of the population, as well as the characteristics of the community and the physical environment. Since, as mentioned above, considerable reduction in population size can be tolerated by high fecundity but not by low fecundity species, the effects of a given dose of pollutant may differ greatly for different species, even though their sensitivity to the pollutant may be the same. These differences, therefore, result from demographic characteristics and not from differences in the sensitivity of the species.

To maintain a population of constant size, it is theoretically sufficient for only 2 offspring to survive out of the total progeny from a pair of animals. For high fecundity species, attempts to establish a relationship between number of reproducing adults and size of future generations, have met with little success. For such species, the size of the filial generation falls within specific limits irrespective of the number of adults. If the survival rate of offspring relates mainly to feeding, then the size of new generations will vary with food availability rather than with number of adults, as the number of offspring per adult is very high. The size of a generation of zooplanktophagous fish will therefore depend not so much on the number of adults, as the density of the zooplankton population. If the number of eggs (or newborns) is reduced, whatever the cause (i.e. strong climatic variation or pollution), competition for available food will diminish, and the probability of survival of individuals not already eliminated by the adverse conditions will increase. If, for example, mortality of a proportion of eggs (or newborns) is caused by a pollutant, this mortality may substitute for losses normally incurred due to food shortages. In this case, the mortality rate might not vary significantly and the next generation would maintain roughly the same size as the previous one, irrespective of the pollution. Results obtained from studies of the cause of death in several species of sea fish (IAEA, 1976), molluscs (Hancock, 1973) and Cladocerans (Marshall, 1967), seem to support this hypothesis.

The maximum birth and death rates needed to maintain a population at a constant size are not known, but it is evident that these will vary with selective pressure exerted by competition from other populations and by physical factors in the environments. In a polluted environment, if the mortality rate of a population depends on its density, its final value will be the sum of the natural mortality (reduced by the decrease in density of the population) plus that caused by pollution. If, however, the mortality caused by pollution exceeds that due to surplus population, it is improbable that the population will maintain a constant size. Consequently, if this situation persists for a sufficient number of generations (as, for example, in a chronically polluted system), the population will be eliminated from the environment.

For low fertility species, there is a relationship between the number of adults and the size of the successive generation, and this relationship becomes more precise as fertility decreases. In such species, natural selection is not so influential amongst the offspring and so even a small reduction in their numbers (from pollution or other causes) may severely reduce the probability of survival of the population. Intensive exploitation of fish species with high fecundity, and strong intraspecific competition for food, can crop up to 50% of all age groups. If we add to this mortality from other causes, estimated at around 10–20%, the total percentage of individuals eliminated from the population yearly will vary between 60–70%. It has been observed that such a reduction does not have any significant influence on the size of the population in subsequent years. Hence, this reduction does not endanger the survival of the population, whereas further exploitation could lead to elimination of the species (IAEA, 1976).

Similar conclusions have been reported for a fresh-water cladoceran *(Daphnia pulicaria)* which had an increased life expectancy when predation increased. Experiments carried out by Oppenheit (1975) on a salt-water copepod *(Tisbe holothuriae)* showed that the frequency of egg sac production, the mean number of eggs per sac and the viability of the young increased with increased predation.

It is apparent that populations with low fertility would not survive reductions of the magnitude previously mentioned; and the validity of this is proved by the number of species approaching extinction. We may conclude therefore that regulatory mechanisms, dependent of density, control the size of populations. Consequently, a population can survive by surmounting size reductions up to a term determined by its capacity to recover. If these principle are applied to the effects of pollution, we can predict that populations will be eliminated by pollution if their recovery capacity is lower than the number of individuals eliminated by the pollution. Pollution is usually considered harmful if it leads to a significant reduction in size of the population under study. In some case the contrary is true, since a very large and rapid increase in one population can result from imbalance among the various components of the community. For example, in an unpolluted environment a rapid increase in density of a population is limited to a relatively short period of time, and as a rule is followed by a rapid decrease. In other words the regulatory mechanisms in the community are working efficiently.

In contrast, a highly eutrophic water body (i.e. a lake that receives an excess of nutrients), favours the rapid growth of some species of algae to the detriment of other animal and plant species. As a result, the diversity and stability of the community may be significantly reduced. Limnologists are familiar with the explosive growths of some populations of algae ('water blooms', or 'flosaquae') which lower water quality and produce a marked oxygen depletion in deeper layers of the lake, often leading to extensive fish kill. Blooms of Cyanophyceae, Diatomeae and Peridineae can reach such proportions that the water becomes tinted with a brown, reddish or intense green colour. The macrophyte *Elodea canadensis,* introduced in Europe, has proved to be so invasive that serious problems are being encountered in many water bodies. The water hyacinth is so productive that it can obstruct navigation, even in very large rivers, such as the Congo.

In Lake Maggiore the water chestnut *Trapa natans,* originally found only in limited areas, has, during the last few decades, invaded many of the shore areas of the lake. The study of the genetic effects of pollution at a population level is obviously important. In natural populations, genetic variability is largely present in the heterozygote stage and many of these genetic characteristics are harmful to the homozygote stage. The degree of variability is controlled by such factors as time elapsing between successive generations, size of the population and environmental characteristics. A high degree of variability favours the adaptation of the population to ecosystem modifications, allows the area of distribution to be increased, and favourably influences competition with populations possessing a lower degree of variability.

The fitness of a population is the result of selective pressure exerted by the ecosystem via the genetic variability inherent to the population. The degree of fitness of a single individual (or of a population) depends on its capacity for survival and reproduction when compared with other individuals (or populations) in the same environment.

A great number of pollutants give rise to new mutations. As the frequency of these mutations increases, the capacity of the population to adapt may vary. While it is true that an increase in the mutation rate is usually harmful, the selective mechanisms reduce this effect on the population by eliminating or reducing the number of individuals carrying harmful mutations and favouring those with useful mutations. If the harmful effects produced by pollution are apparent in the first generation, they are termed 'short term' genetic effects. If these effects are frequent, the size of the population is generally reduced but mortality and sterility preclude the accumulation of large numbers of unfavourable genetic characteristics in the population. Long-term effects are the most harmful at a population level because they appear at the homozygote stage, as malformations or genetic diseases, for several successive generations. These factors are accepted generally, but not by all workers in this field. For example, Wallace (1957) and Crenshaw (1965) have shown that in some cases a slight increase in the frequency of natural mutation and variability may increase the degree of fitness of populations of *Drosophila* (Diptera) and *Tribolium* (Coleoptera). We may conclude that there is little information available on the factors regulating the size of populations and their variations, or on the relationships between population dynamics and pollution levels in the environment. Research with regard to the effects of pollution on populations, considered as pools of genetic variability, is almost nonexistent. It would, however, be useful to study these aspects, as they are fundamental in evaluating the real effect of pollution on populations and communities.

Effects at community level

It is not easy to establish a relationship between degree of pollution of an environment and alteration of one population structure. It is even more difficult to estimate the effects of pollution on an entire community*. With this aim (at least for the lacustrine environment) some microsystems have been contaminated by toxic substances and the effects at community level recorded. These microsystems are formed in lakes, by isolating columns of water from the surface to the lake bottom, using plastic cylinders. Results obtained are encouraging. To determine the effects of radiation on terrestrial communities, large areas have been exposed to gamma radiation under carefully controlled conditions.

Attempts have been made by various authors to produce numerical values, known as diversity indices to describe community structure* (Margalef, 1968; Shannon et al., 1963; Menhinick, 1964). These indices vary in complexity but are all based on the relationship between number of individuals and number of species comprising the community.

A comprehensive description of a community is obviously impossible because every component would have to be considered (i.e. all animals and plants including bacteria and fungi). In practice, only a few taxonomic groups or a single particularly significant group are considered. Consequently, 'diversity indices' never relate to the entire community.

On the other hand, Margalef (1968), while recognizing that diversity indices if calculated only for a few individual groups (i.e. Rotifera, Entomostraca, Diatomeae) have limited significance, states that, if the fish population has a high diversity, then phytoplankton and zooplankton populations are also likely to have a high degree of diversity. Other authors have attempted to combine concepts of biomass and productivity with diversity index. To date, however, most work employing diversity index uses only number of species and frequency of individuals.

A natural community tends to become more stable with time. During this evolution, net production (i.e. the difference between the organic matter produced and consumed) decreases, and the number of species and ecological niches increases, resulting in an increase in community diversity.

Any unexpected and significant variation in environmental conditions will influence a community, reducing its diversity and thus its stability. It therefore follows that the diversity index value calculated for a community can indicate the level of pollution to which the environment is subjected. In numerous cases, this application of the diversity index has given satisfactory results. Other authors have used less precise but more easy-to-handle indices for the same purpose. An example is the 'biotic index'. Biological indices combined with 'biological test' have been employed in various countries (U.K., Ireland, France, Germany) for determining the quality of surface waters.

When conditions created by polluting substances are acceptable for certain resistant species, their population density dramatically increases as competition from more sensitive species is reduced or abolished. For example, the bottom of several polluted water courses is reddish in colour due to dense populations of *Tubifex* (an Oligochaete, which is very resistant to many pollutants) and a significant increase in the biomass of several species of fish of little commercial value has been observed in some eutrophic lakes. In Lake Lugano, which has reached a high degree of trophy in the last few decades, certain species of phytoplankton, in certain seasons, multiply so rapidly that the density of their populations reaches extremely high values (tens of millions of cells per litre). During the same period, 4 species of zooplankton disappeared from this lake. In these cases, there is a reduction in the number of species, with predictable lowering of the diversity. On the other hand, in order to adapt the equation: diversity = stability = pollution, to practical problems, there are 1 or 2 important facts that cannot be ignored. For example, in an environment maintained at a constant level of pollution from a discharge of the same pollutant, the diversity of the community might be low, but its stability will be constant. Moreover, in the environments presenting extreme conditions (for example thermal sources, or the artic zones) the diversity value is generally low, but it certainly does not follow that these environments are necessarily polluted. The diversity of a eutrophic lake will be very low, compared with a mesotrophic lake, but the diversity of the latter might be higher than that of an extremely oligotrophic water body. Furthermore, it is well known that, even in unpolluted rivers, the diversity index calculated for the various hydrological areas from the source to the mouth diminishes progressively. The effects of pollution seem to be less marked in very complex food chains than in simpler ones, other factors being equal. If, in a high diversity level community, one species is eliminated due to its low resistance to pollution, its interactions with the other species will easily be substituted by other interactions. Consequently, the structure and stability of this community will not undergo great variation. In a simpler community, the elimination of just one species can create variations throughout the structure of the community. In fresh water communities with the same level of pollution, the effects will be more harmful where there is a low diversity and a low degree of stability, such as the eutrophic environments. Also, the same level of pollution will have greater influence on fresh water than on salt water communities, since the number of species in marine ecosystems is much higher than in fresh water ecosystems. As far as pollution is concerned, the marine ecosystem is further favoured by its high dilution capacity (due to its greater volume, currents, and tides) and by the greater possibility for organisms to emigrate from the more polluted to less polluted areas. So far, the open sea has not been affected by chemical pollution, and the modifications which have been observed are mainly due to climatic changes (IAEA, 1976).

In any ecosystem, size of populations can vary very widely, and fluctuations and oscillations in various species are not necessarily equivalent at a point in time. As a rule, after the reproductive season, the number of individuals increases, but the number of species remains constant, and consequently, diversity tends to diminish. In order to evaluate the diversity level of a community, it is therefore necessary to follow its pattern for at least a year.

In conclusion, the diversity index can be usefully applied to practical problems of pollution, if all likely causes of error (sampling, identification of material, elaboration of results) are taken into consideration. In my opinion, this method can give very satisfactory results, especially when the environments are studied before and after the commencement of pollutant discharge. It would therefore seem obvious that from an ecological point of view variation in diversity index value is more significant that its absolute value.

With this brief summary we have tried to demonstrate the need and the urgency for research into the effects of pollution on populations and communities. In order to tackle this problem, the need, first and foremost, is for reliable data on the factors controlling the size of natural populations and their fluctuations with time. The available knowledge is unfortunately not even satisfactory for those populations which are already the subject of much research, for example, populations of fresh water phytoplankton. The factors favouring or inhibiting the massive growth ('flos aquae') of various species of algae have not yet been identified with certainty. Moreover, little research has been carried out on the effects of pollution on populations considered as a pool of genetically variable material.

There is also an obvious need to extend studies on the alterations in community structure caused by both natural events and the introduction of nutritive and/or toxic substances in the ecosystem.

On the significance of certain community characteristics (i.e. diversity, stability) opinions vary. In my opinion these characteristics need to be investigated further and extended to more diverse environments, each for one or more years, before they may be used rationally as a method of controlling the quality of our waters.

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* By community we mean the animal and plant populations inhabiting the environment. For example, the pond community consists of phytoplankton, algae, hydrophytes, zooplankton, benthonic organisms, fish, fungi and bacteriae.