

# Living coelacanths: values, eco-ethics and human responsibility

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**ABSTRACT:** Coelacanths *Latimeria chalumnae* are the only living representatives of crossopterygian fish close to the roots of our own vertebrate history and therefore occupy a unique position among living fossils. *L. chalumnae* has become a synonym for long evolutionary age, timeless existence, tenacity, immortality and links to old roots, appearing in language, poetry, fiction and many art forms. It is a symbol of a new national identity in the Comoro Archipelago, Western Indian Ocean. I consider here the intrinsic and extrinsic value of coelacanths and the role of these fish in biodiversity conservation. The fate of coelacanths lies in our hands. It will be a measure of the success or failure of 'eco-ethics' as recently defined and called for by ecologists.

**KEY WORDS:** *Latimeria* · Conservation · Living fossil

## INTRODUCTION

The coelacanth *Latimeria chalumnae* is the sole survivor of an ancient Devonian lineage of crossopterygian fish which played a pivotal role in the evolution of land-living tetrapods. A species with an extremely slow evolutionary rate (e.g. White 1953), *L. chalumnae* is of high interest for evolutionary biology. It represents the classic text book example of a 'living fossil' (Forey 1984, 1990, Thomson 1991).

To our knowledge coelacanths now exist only in a small breeding population off 2 islands in the Comoro Archipelago, Western Indian Ocean. First field studies revealed that the small insular population is faced with the threat of extinction. There has been increasing concern about this as well as increasing activity aimed at ensuring its survival (Fricke et al. 1995).

J. L. B. Smith, the scientific discoverer of *Latimeria chalumnae*, called the fish a priceless heritage from the past (Smith 1963). Assigning intrinsic values to ecosystems, species or even genes in such a manner has become part of recent conservation attempts (i.e. Coulter & Mubamba 1993, Callicott 1994, Wallace 1994, More et al. 1996). There exist differences in philosoph-

ical and ethical argumentation focussing on such intrinsic-value concepts and their usefulness for biodiversity conservation (e.g. Oldfield 1995, Taylor 1996). I review here intangible and tangible values of the fish which should assist in improving concepts used in conservation.

This paper follows the classification of Oldfield (1995) and her definition of a species value: 'an estimation of general worth, usefulness, importance or monetary price of a good, amenity or service'. The future of *Latimeria chalumnae* depends acutely on human behavior. It may become a symbol of the effectiveness of 'eco-ethics' as defined and called for by Kinne (1997).

Coelacanths are caught with increasing intensity by deep-lining fishermen—the sole 'predator' of this fish (Millot et al. 1972, Stobbs & Bruton 1991, Plante et al. in press). The future of coelacanths depends now on immediate and sound economic, political and scientific policies and on the education and economic support of their main predator, the fishermen.

## HISTORY OF DISCOVERY AND RESEARCH

In 1938, the first living coelacanth was trawled off the east coast of South Africa (Smith 1939, 1940). The

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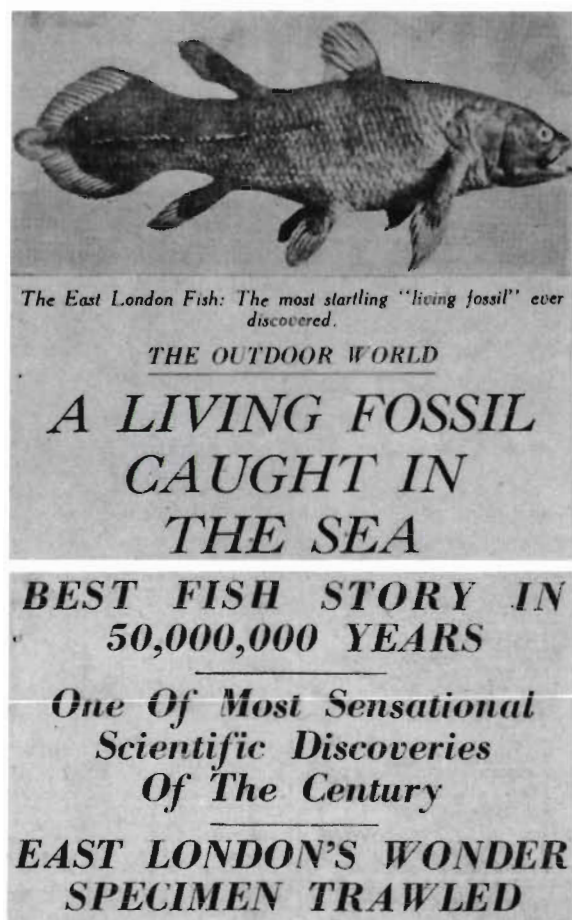


Fig. 1. A 1939 newspaper headline following discovery of the coelacanth off South Africa

discovery of a large mesozoic fish (1.5 m total length) made world news and was celebrated as one of the most significant findings of the century (Fig. 1). In 1952, a second specimen was found at a fishmarket on Anjouan, Comoro Islands, the present home of coelacanths (Smith 1956). Here the fish was known under the name 'gombessa' and was caught accidentally by deep-line fishing at depths between 100 and 400 m from outrigger canoes, mainly at night. The fish was considered inedible, was often discarded and had no market value.

Although zoologists had long been aware that coelacanths are not the direct ancestors of tetrapods (e.g. Forey 1988), the second coelacanth was celebrated as the 'missing link' to land-living tetrapods. At that time the Comores were part of the French overseas territories and all subsequent specimens were sent to France. Here their anatomy was studied by Millot & Anthony, and was subsequently summarized in several volumes—probably the last classic descriptive treatise of a vertebrate (Millot & Anthony 1958, 1965, Millot et al. 1978).

Table 1 lists the main international expeditions searching for coelacanths following the discovery of the second specimen. In the 1950s, due to French colonial politics, foreign expeditions were not allowed to enter Comorian waters. In 1954 Jacques Cousteau and his team used deep-diving techniques but failed to find a coelacanth. In 1969 and 1972, 2 joint expeditions were initiated by the Royal Society and by American and French scientists. Samples of 2 caught coelacanths were distributed to 30 laboratories. The first investigations of blood physiology, composition of body fluids, osmoregulation and other physiological aspects marked the beginning of research on the soft tissues (e.g. Forey 1980, Locket 1980). A special volume (McCosker & Lagios 1979) was devoted to studies from the 1972 expedition and a further expedition by the California Academy of Science in 1975.

Intensive field research started in the 1980s, with 13 expeditions from 5 countries (Table 1). Japanese expeditions (Japan Research and Study Committee on Coelacanth, JASEC) studied the shallow reefs and the Comorian fishery techniques and filmed a line-hooked coelacanth. The first attempts to catch a live coelacanth were unsuccessful (Explorer Club and New York Aquarium, and TOBA Aquarium, Japan) and triggered international campaigns against these commercial undertakings. Scientists in Canada, Germany, Japan, South Africa and the USA opposed the ventures. South Africa took the lead in the conservation campaigns (Stobbs 1989, Bruton & Stobbs 1991), and in Moroni, the capital of the Comores, the Coelacanth Conservation Council was founded (Bruton 1993).

In January 1987 the German research submersible 'Geo' succeeded for the first time in filming a living coelacanth in its natural habitat (Fricke et al. 1987). The utilization of deep-diving techniques allowed the first *in situ* studies on locomotion, vertical migration and activity patterns. Estimations of population size revealed a total of only 200 to 300 individuals at Grande Comore (Fricke & Hissmann 1994). Due to increasing fishing activity, a drastic population decrease was noted in 1994, making immediate conservation actions more urgent (Fricke et al. 1995).

In 1988, a series of papers honored the 50th anniversary of the discovery, reviewing the history of the coelacanth and reflecting upon its importance, the increased knowledge about the species and its conservation status (Balon et al. 1988, Forey 1988, Bruton 1989). Musick et al. (1991) and Thompson (1991) summarized trends in current research and again emphasized the need for conservation.

Bruton & Coutouvidis (1991) updated an earlier inventory of all known specimens (Millot et al. 1972) and commented on the annual catches. They also studied

Table 1. Expeditions in search for the coelacanth after its scientific discovery in the Comores in 1952

Year	Country	Institution	Aim	Source
1954	France	Jacques Cousteau Museum Nat. Historie	Survey, filming	Smith (1956)
1954	Italy	Spedizione Zoologica Italiane	Filming	Smith (1956)
1963	France	Jacques Cousteau	Filming	Bureau Cousteau, Paris
1964	USA	University of Southern California	Survey	
1969	England	Royal Society	Survey	Forster et al. (1970)
1972	England, France, USA	Royal Society	Survey, general biology, collection	Thompson (1973)
1975	USA	California Academy of Science	General biology, filming	McCosker & Lagios (1979)
1979	England	BBC	Filming	Thomson (1991)
1981	Belgium	Royal Museum	Survey	Thys van den Andenaerde (1984)
1981	Japan	JASEC	Survey, ecology	Suzuki et al. (1985)
1983	Belgium	Royal Museum	Survey	Thys van den Andenaerde (1984)
1983	Japan	JASEC	Survey, ecology	Suzuki et al. (1985)
1986	Japan	JASEC	Survey, filming	Suzuki (pers. comm.)
1986	S. Africa	JLB Smith Institute	Survey, conservation	Bruton & Stobbs (1991)
1986/87	Germany	Max Planck Institute	Survey, ecology	Fricke et al. (1987)
1987	S. Africa	JLB Smith Institute	Survey, conservation	Bruton & Stobbs (1991)
1987	Germany	Max Planck Institute	Ecology, filming	Fricke et al. (1987)
1987	S. Africa	JLB Smith Institute	Conservation	Bruton & Stobbs (1991)
1987/88	USA	Explorer Club and New York Aquarium	Collecting	Hamelin (1992)
1989	Japan	TOBA Aquarium	Collecting	Musick et al. (1991)
	Germany	Max Planck Institute	Ecology, filming	Fricke et al. (1991)
1990	S. Africa	JLB Smith Institute	Conservation	Bruton & Stobbs (1991)
1991	Germany	Max Planck Institute	Ecology, conservation	Fricke & Hissmann (1994)
1994	Germany	Max Planck Institute	Ecology, conservation	Hissmann et al. (in press)
1995	Germany, France	Max Planck Institute and Foundation N. Hulot	Conservation, filming	Plante et al. (in press)

the bibliography of the living coelacanth, analysing trends in the literature, controversies and the impact of this fish on popular literature (Bruton et al. 1991). Fig. 2 shows close links between 4 major events and maxima in the number of published accounts: (1) 1938, the discovery of the first living coelacanth, (2) 1952, the discovery of the second specimen, (3) 1972–75, the American-British-French expeditions, (4) 1987, expeditions of the Smith Institute and the German Max Planck Institute with the beginning of intensive submersible research. Today the coelacanth is one of the most intensively studied fish in the world.

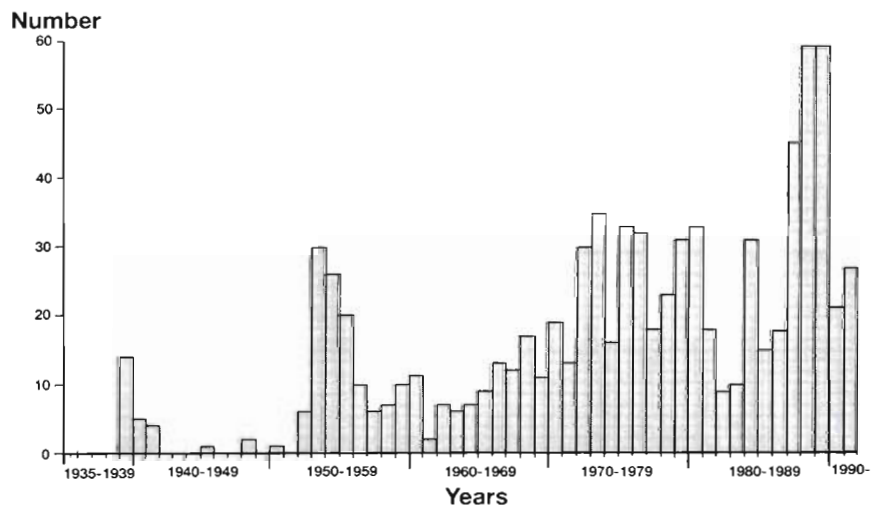


Fig. 2. Number of publications on coelacanths between 1939 and 1991 (Source: Bruton et al. 1991)

## ETHICAL AND AMENITY VALUES

Ethical and amenity values represent immaterial intangible benefits of biodiversity which satisfy mainly nonmaterial human needs.

## Evolutionary and educational value

The evolutionary and educational value of the coelacanth lies in the fish's contribution to our understanding of important evolutionary processes and phylogenies as well as in its role in the promotion of scientific and public education.

The coelacanth as an evolutionary ancient species was thought to play a prime role in the early history of vertebrates (Forey 1988). The traditional theory, based on ancestor-descendent relationships determined by identifying primitive characters, placed coelacanths as the closest living relative to tetrapods (Fig. 3) (Romer 1966). This model depicted coelacanths as the most important living fish, a witness of the water-land transition of early vertebrates. Although the scientific world knew that fossil rhipidistians were the true ancestors of tetrapods and that coelacanths were only carried with them, the false 'missing link' theory found wide public acceptance.

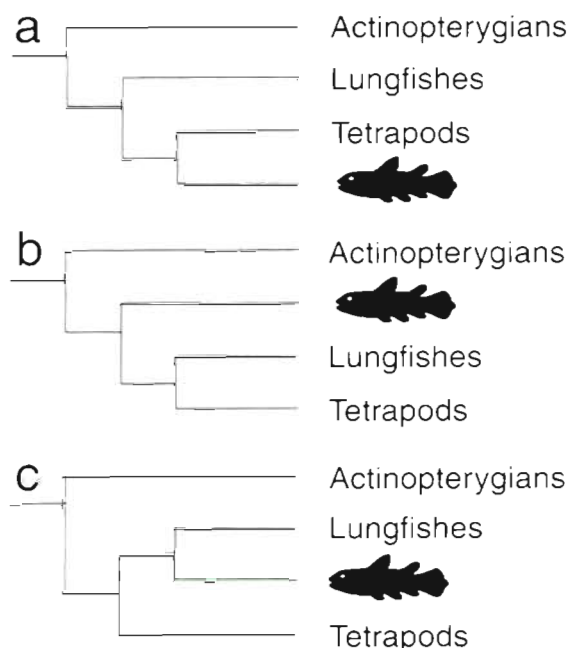


Fig. 3. Three models of the origin of coelacanths and their evolutionary position in relation to the tetrapods: (a) the classical model with close relationship to tetrapods, (b) lungfish are more closely related to tetrapods than are *Latimeria*, (c) most recent findings claiming that *Latimeria* is most closely related to lungfish

Ulrich (1959) criticized the overinterpreted role of *Latimeria chalumnae* and discussed the importance of new zoological discoveries. He differentiated between the 'height' of the systematic category ('a discovery of a new order, class or phyla is more important than a species or genus'), and the 'depth' of the phylogenetic relationship: discoveries near the roots of a phylogenetic tree are more important than discoveries along the periphery. Therefore the crossopterygians are of great importance for the phylogeny of vertebrates while coelacanths are only a side branch, merely a dead end, and less important for unraveling early vertebrate history. Forey (1990) wrote: 'So many of the features of *Latimeria* are unlike those expected in a tetrapod ancestor and, in this sense, the coelacanth has not lived up to its reputation as a "missing link".'

Currently the phylogenetic relationships of coelacanths to tetrapods and/or lungfishes are still unsolved. In modern cladistics, with the search for shared derived characters and sister-group relationships, the coelacanth either appears as a sister-group of lungfishes or lungfishes appear as a sister-group of tetrapods and the nearest living relatives to tetrapods (discussion in Forey 1988, Gorr & Kleinschmidt 1993) (Fig. 3). New findings in skull anatomy and molecular genetics (Meyer 1995, Zardoya & Meyer 1996) corroborate the hypothesis that lungfishes and coelacanths are a monophyletic group and together form a sister-group to tetrapods.

Coelacanths remain enigmatic for students of evolutionary biology. They are excellent models for testing modern cladistics (e.g. Cloutier 1991) or models of molecular evolutionary changes as exemplified by the controversy about the evolution of coelacanth haemoglobin (Gorr et al. 1991, and replies in 'Nature') or of DNA sequences (Zardoya & Meyer 1996). Coelacanth chromosomes are remarkably similar to those of ancient frogs (Bogart et al. 1994). Although the phylogenetic position of *Latimeria chalumnae* will be a matter of further debate, the high evolutionary value of the fish is beyond doubt even if it did not live up to early expectations that it is a direct ancestor of our own vertebrate history.

Besides this evolutionary value, coelacanths also have educational benefits. They became models for assessing the quality of fossil reconstruction and predictions of function in paleontology (e.g. Woodward 1940, Smith 1956, Thomson 1991), which can only rarely be tested on a living specimen. The appearance of the coelacanth was a triumph for modern paleontology (Millot 1955, Ulrich 1959). 'Reconstructions of the crossopterygian fishes are masterpieces of skill and insight' (Millot 1955).

However, one prediction proved to be wrong. Coelacanths are not seal-like benthic fish as earlier predicted (Fig. 4) (Millot 1955, Smith 1956, von Wahlert &



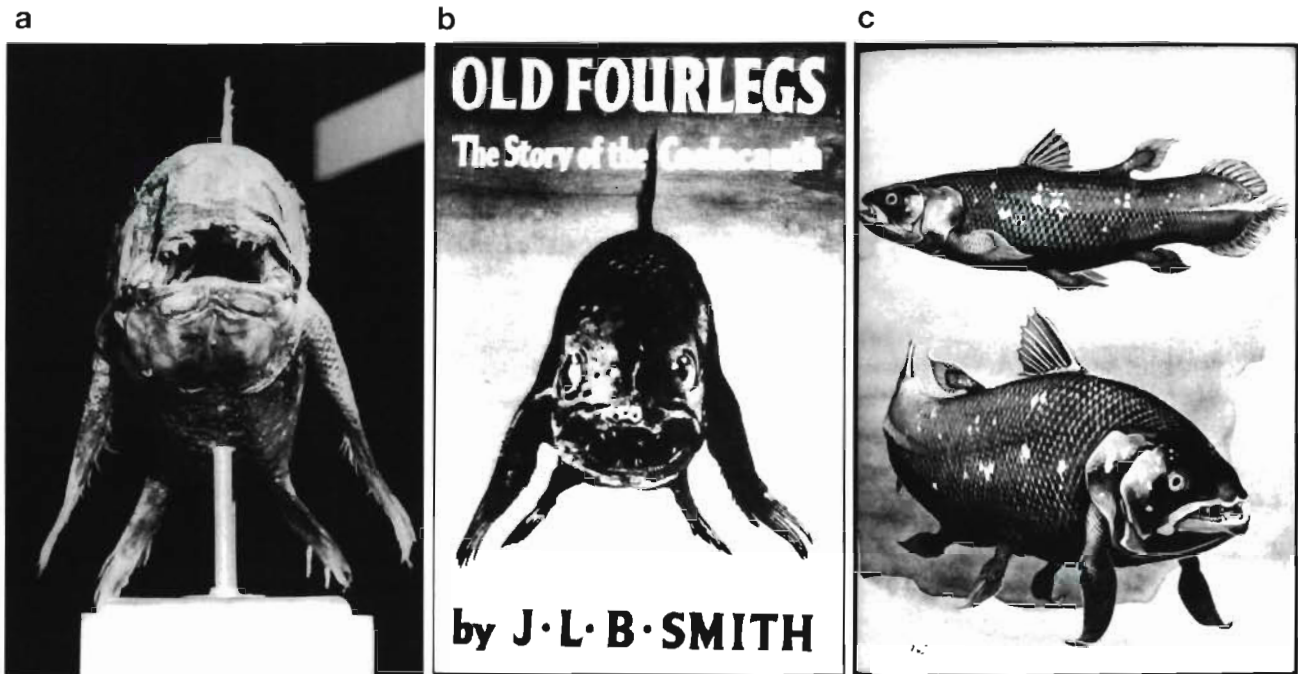


Fig. 4. The behavioural model, coelacanths as benthic fish, proved to be wrong. Paired fins of the holotype from 1938 were forcibly bent downwards (a), giving the impression of 'Old Fourlegs' (b) and the paradigm of a walking fish depicted later in zoological textbooks (c). Even during resting, *Latimeria* rarely touches the bottom and the large pectorals are used as hydrofoils

von Wahlert 1962). They are gentle benthopelagic drift hunters and do not touch the bottom. The alternating paired fins nevertheless move in a tetrapod fashion, originally connected to hydrodynamic functions but probably a preadaptation for the tetrapod's step (Fricke & Hissmann 1992).

Coelacanths share some unique morphological features with fossils which do not occur in any other living fish: the intracranial joint, the rostral organ and the small supplementary epicaudal fin. For the first time the functions of these features could be studied and older predictions tested: the intracranial joint by Thompson (1970), the rostral organ by e.g. Northcut (1980), the epicaudal fin by Hissmann & Fricke (1996). Also a first glance at the physiology of the soft tissues was possible (review in Locket 1980). *Latimeria chalumnae* maintains its body fluid osmolarity near that of sea water by urea retention similar to osmoregulation in chondrichthians (Griffith & Pang 1979). The respiratory physiology revealed the lowest values for resting oxygen consumption within the fish world (Hughes 1976), corroborating the first *in situ* observations: the extremely sluggish and energy-saving mode of life.

Coelacanths offer the possibility of testing several existing hypotheses in evolutionary biology on the existence and survival of living fossils and on the question of coexistence with modern fish. Thus they are of high educational benefit for students of diverse biological disciplines and for a wider audience.

### Sociohistory and socioculture

Sociohistorical and sociocultural values exist when species gain a cultural importance that promotes social cohesion or fosters social activities (Oldfield 1995). In coelacanths these kinds of immaterial values are rather recent but increasingly important social inventions.

**Sociohistory.** Before 1952, the coelacanth was considered a rather useless fish in the Comores and without value for the fishermen. This changed in the following decades. Foreign expeditions, scientists and tourists visited the remote and lonely islands in search of the fish (Table 1). The Comores as part of the French overseas territories became known as the archipelago of the coelacanth. The French President Charles De Gaulle, aware of the uniqueness of the fish, presented a coelacanth for the first time as an official governmental gift to Japan (Uyeno & Tsutsumi 1991). The local community, too, developed a sense of civic pride in the fish and honored its existence in many ways. On Anjouan, a main street was named 'Boulevard du Coelacanth' (Fig. 5a), in Moroni a hotel 'Hotel Coelacanth'. Coelacanths became a symbol for the new national identity. They appeared on several local stamps and on coins and banknotes (Fig. 5c). One specimen is permanently exhibited in the presidential hall (Fig. 5d). Coelacanths became an official governmental gift and were donated to the United Nations and, in 1989, to the French President François Mitterrand.

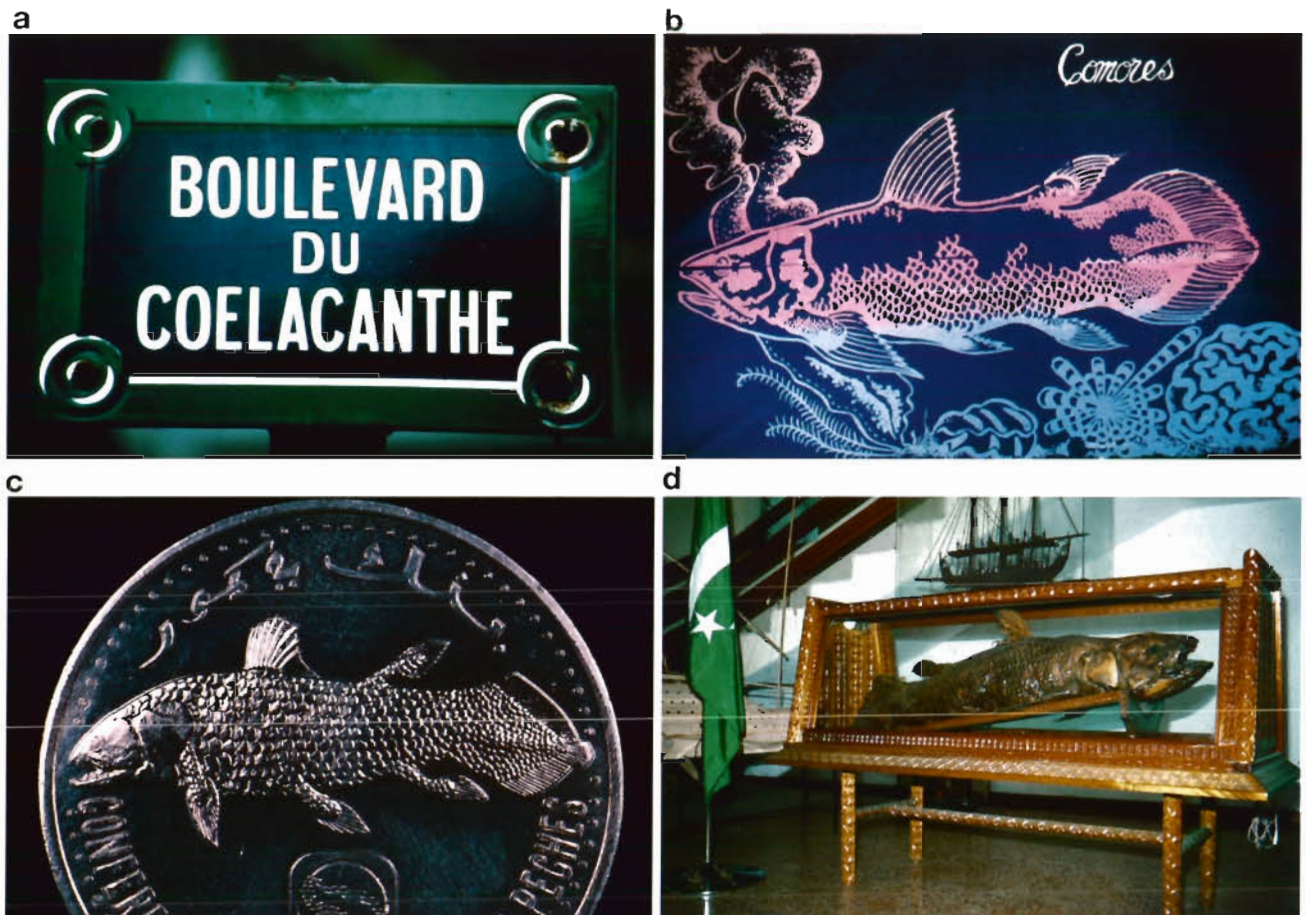


Fig. 5. Coelacanths and their significance as a symbol for a new national identity in the Comores. (a) Street name on Anjouan; (b) textile works as handicrafts; (c) coin from the Comores; (d) engraved wooden cabinet with a stuffed coelacanth in the presidential hall in Itsandra, Grande Comore

The new national identity was also expressed in many local art pieces and handicrafts (Fig. 5b), drawings, wood engravings, textile works and postcards. The increasing tourist traffic enhanced this new function. The growing sociohistorical value of the fish as a national symbol and part of the national identity was also of great benefit for conservation.

During the French occupation the trade in coelacanths was strictly controlled. In 1975, the Comorian parliament declared independence from France. Since that time, despite much political unrest, diverse governments have appreciated the importance of the fish with its well-known international reputation. In December 1986 the Minister of the Interior declared the coelacanth a heritage of humankind with the Comorians as the wardens of this treasure; a memorandum was signed. In 1989 a presidential decree introduced control of the burgeoning coelacanth trade; all coelacanths caught had to be sold to the government. In October 1989 the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) upgraded the coelacanth from Appendix II to Appendix I with full protection of the species.

In September 1994 the Comorian President M. Djohar signed the CITES convention; now coelacanths were strictly protected by law.

The Comorians realized the uniqueness of the fish and their own role as the guardians of a world heritage. In November 1995, in Dzahadjou, Grande Comore, an association for the protection of gombessa was officially inaugurated and a small house declared as a coelacanth center.

**Socioculture.** Ulrich (1959) mentioned 4 concomitant facts of the coelacanth discovery: (1) the surprise that an old branch of an extinct fish group suddenly appeared, with almost unchanged anatomy, (2) the impressive body size, (3) the great rarity, and (4) the enormous evolutionary age. These characteristics gave rise to a number of metaphors for surprise, rarity, tenacity, immortality and longevity which appeared in language, poetry, fiction, arts and music.

Surprisingly, coelacanths had not yet appeared in the local literature, poetry or fiction. They were used in linguistic expressions mainly in Western countries. For example: 'Time' magazine titled the former President



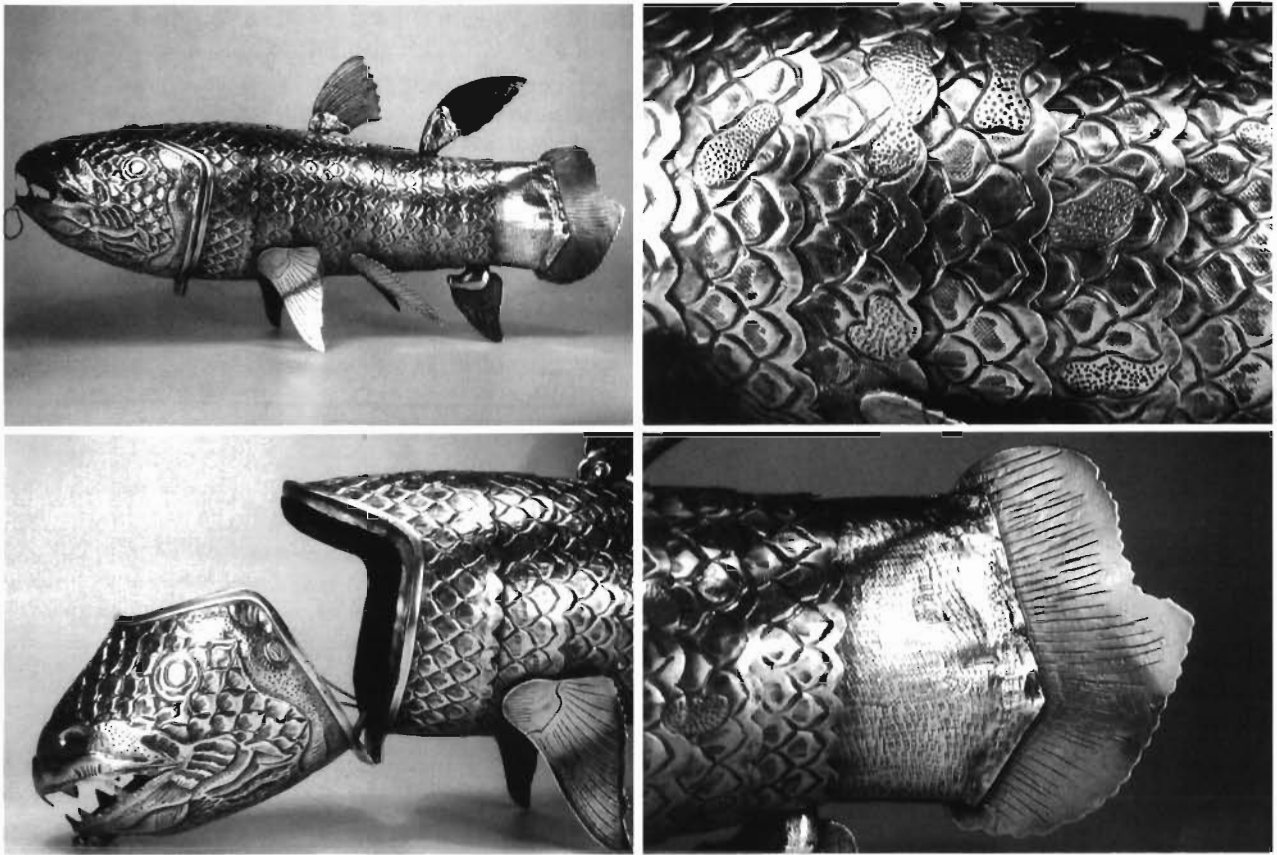


Fig. 6. Silver artifacts of probably Meso-American origin found by M. Steinert in an antique shop in Toledo, Spain. Note the fine forged joint connecting head and body, the strongest hint for an old origin. The caudal fin was probably repaired. The silver engravings show scales and dot marks typical of the live fish

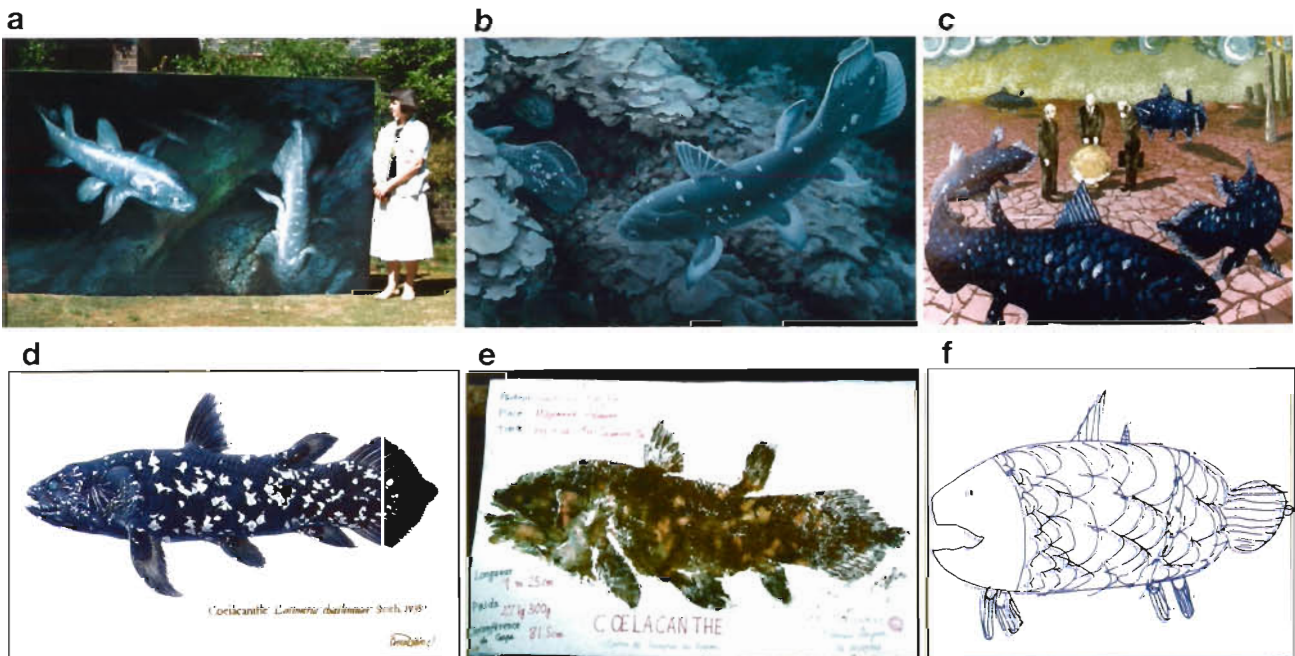


Fig. 7. Coelacanths in visual arts. (a) Painting by the illustrator R. Reynolds, England; (b) oil painting by D. Scott, England; (c) linocut 'Oncanthosphere' by H. Mann, South Africa; (d) illustration by B. Duhem, France; (e) Japanese gyotaku, produced in a Fishery School on Anjouan, Comores; (f) drawing by a boy, 7 years old, Germany

Nixon as a 'coelacanth of American anticommunism'; the 'Washington Times' described the political position, fossilized but still alive, of the African National Congress as the 'Coelacanth face of the ANC' and the German newspaper 'Süddeutsche Zeitung' compared the number of women in top positions of the German diplomatic corps with the rarity of coelacanths. In general, in ordinary linguistic usage, the term 'coelacanth' has been adopted to refer to rare, old-fashioned and conservative persons unable to cope with modern times but still alive due to their tenacity.

In poetry, F. M. Storey wrote about 'no progression' and 'no regression' in coelacanths and wondered how they survived. H. Shipp's stanzas in his dialogue on evolution explain why the coelacanth wants to stay as it is. Also O. Nash's 'Ode to a coelacanth' expresses adoration of the timeless existence of this old-fashioned genotype.

Fiction exploits the possible danger of a mesozoic creature surviving undetected in a hidden ecological niche. In 1954, coelacanths appeared as a model of the classic fictional film 'Monster of the Black Lagoon' directed by J. Arnold, while in 1992, L. J. Langley's writings created a society of vicious submarine vampires represented as coelacanths, a great danger for humans.

In the visual arts, coelacanths have a more positive appeal. Probably the oldest known coelacanth art works are 2 silver artifacts from Spain, one found in a church near Bilbao (this specimen is now lost), the other privately purchased in Toledo in 1964 (de Sylva 1966, Anthony 1976). The shape and position of the paired and unpaired fins clearly identify the work as a coelacanth (Fig. 6). Valdovinus (Prado Museum in Madrid; an authority on South American silver art) believes that the silver coelacanth is of Meso-American origin and was probably manufactured in the 17th or 18th century (pers. comm.). Spanish silversmiths of early centuries stamped their work to mark the date and place of origin. However, both silver coelacanths were without marks because Indian silversmiths were not allowed to stamp their work. R. Munoa, an expert on Spanish silver artwork, provided further evidence for the age (pers. comm.): (1) the minute forged joint below the head is typical for silversmithing of the 17th and 18th centuries (Fig. 6); later, such joints were cast and appeared heavier, (2) black silver oxides on the surface of the fish are old when compared to artifacts of recent origin.

Why was a coelacanth depicted? During purchase of the Toledo artifact by Steinert, other silver fish of probably identical origin were on display; all were unusual fish with exceptional body shapes which had probably inspired the artist. While the silver coelacanths are possibly the only works of art known from before the fish's scientific discovery, a variety of different works have been produced since (Fig. 7).

Inspired by the first films of coelacanths in their natural environment, the British illustrator R. Reynolds produced one of the largest known coelacanth paintings, measuring 180 × 280 cm, showing 2 coelacanths against a submerged lava slope (Fig. 7a). The painting was exhibited in South Africa. Numerous other naturalistic illustrations have been used as originals for popular and scientific books and articles or for other printing purposes, for example stamps, postcards or posters. Bruton (1995) focussed attention on a South African linocut by Hylton Mann entitled 'Oncanthosphere' (Fig. 7c), which, using coelacanths as a symbol for human excessive exploitation of fossil fuels, was characterized by 3 businessmen assembling around a coelacanth egg: the basis of life. The interruption of the coelacanth spiral (a spiral as a common feature in nature) with the fish disappearing into the background of an already desolated parched earth symbolizes the threat of extinction to both coelacanths and fossil fuels. In 1986, an exceptional Japanese gyotaku was produced, a whole-body-print documenting a caught coelacanth (Fig. 7e). The coelacanth has appeared also in many children's drawings. All of them depict the stalked fins and the little epicaudal fin (Fig. 7), visualizing 2 striking anatomical features unique to coelacanths.

The first caricatures and sketches with coelacanths as a motif appeared soon after the discovery. In Britain, a coelacanth was shown as an evolutionarily old and strange creature with the head of Neville Chamberlain and a swastika as caudal fin (Fig. 8a), illustrating the backboneless politician under the influence of the Nazis. Another sketch with a historical background appeared during the period of excessive nuclear tests. A group of coelacanths wonders '...why did our cousins bother to evolve into humans' (Fig. 8d). R. Day's famous drawing 'Because this is where the action is going to be' from 1966 (Fig. 8e) has a less threatening appeal and depicts the evolutionary transition of coelacanths from water to land on a lonely island. A number of private individuals have produced some fine graphics which were used as reminders of personal or annual events (Fig. 8f).

Coelacanths have not yet been used as a source of inspiration for local folklore music. However, Lagios & McCosker (1979) report on a song by C. Rand, and a South African blues song about coelacanths tells of the lonely existence of an old fish along the black lava slopes of the Comorian Islands.

## Psychology

Oldfield (1995) and others define psychological values of biodiversity for all cases of psychological and intellectual benefits deriving from experiences of



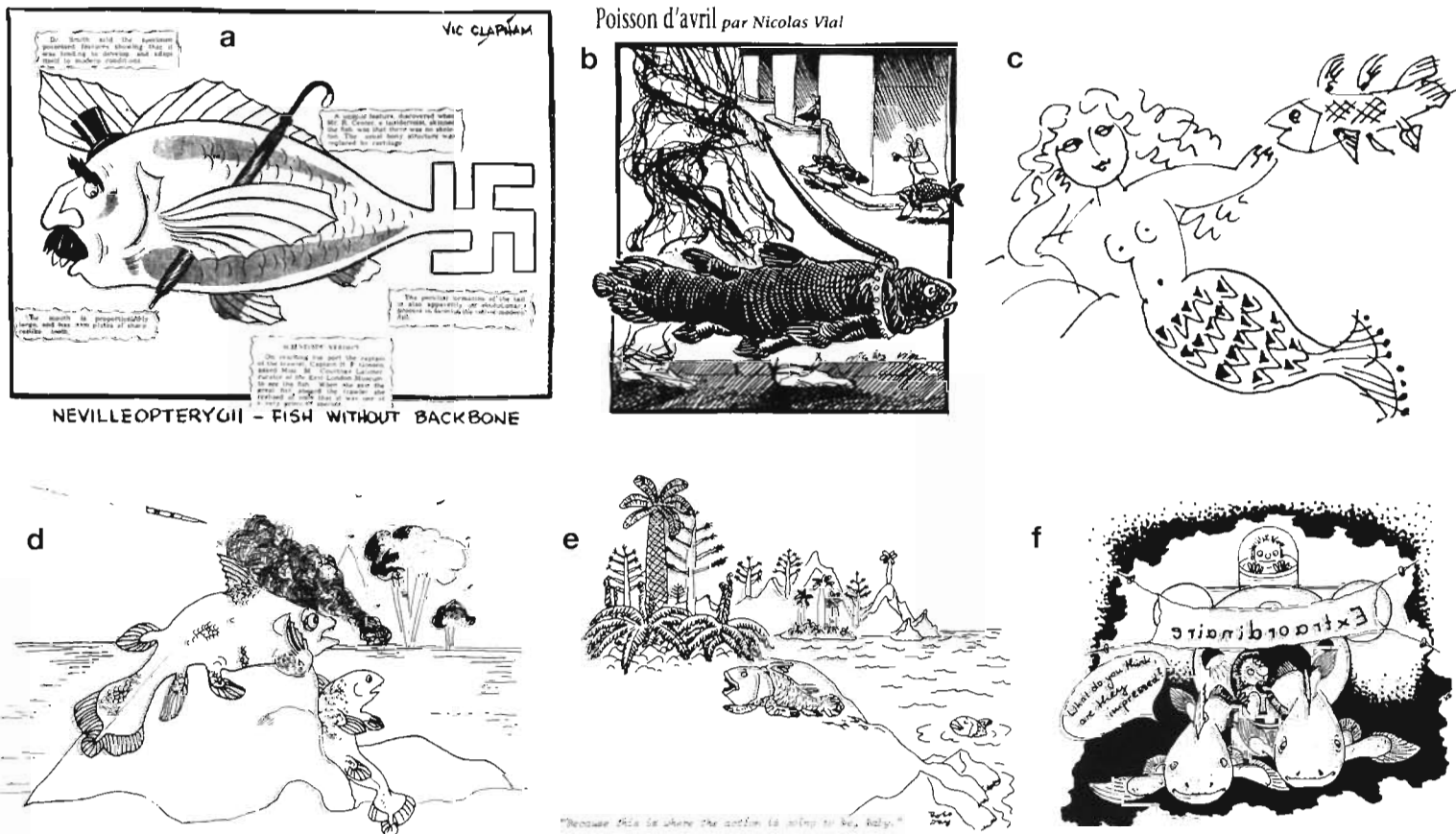


Fig. 8. Coelacanths in sketches and graphics. (a) Caricature in a newspaper before the outbreak of the Second World War, Britain; (b) French caricature depicting happenings on April 1, France; (c) private letter from R. Munoa, Spain; (d) sketch of a group of coelacanths and the fear of nuclear tests, South Africa; (e) the water-land transition of coelacanths in the 'New Yorker' magazine, USA; (f) personal letter by K. Hissmann, Germany

nature, e.g. inspiration from watching wild animals and plants, outdoor leisure, aesthetic appreciation or contemplation, which can help to strengthen our human health and well-being.

The long evolutionary existence and unchanged appearance of coelacanths since the Devonian provides spiritual insight into our own comparatively short human existence on earth. Furthermore, coelacanths are of interest not only because of their long evolutionary history but also because they remain for the public—and also for many scientists—the nearest living relatives close to our own tetrapod roots. This makes the coelacanth unique among living fossils. We appreciate the timeless existence of this 'old cousin' which provides a window into the past. This existence value was nicely expressed in a German youth magazine. Youngsters selected a hit list of reasons 'Why it is worthwhile living this week'. One entry contained the statement '...that coelacanths still exist'.

During their first encounter, the few submarine observers of coelacanths were deeply impressed by these peaceful and gentle creatures whose entire appearance seemed not to belong in our present marine world. Although an encounter is indeed a once in a life-time experience, watching videos or films is

also a rewarding and relaxing experience. Videos and films taken in the natural habitat were distributed worldwide; many TV viewers expressed their affection after seeing the live fish on the screen. A British viewer wrote: 'It was a wonderful privilege to share the Coelacanth with you'. During a public lecture in Grahamstown a film of the coelacanth was screened for the first time in South Africa. Many people in the audience were emotionally strongly affected and did not hesitate to express their feelings. Shortly before her death, Margaret Smith, wife of the coelacanth discoverer J.L.B. Smith, and an ill-fated cancer patient, was shown a coelacanth film on the white wall of her bedroom in the hospital. She had been devoted to coelacanths throughout her life. While watching the film, she was deeply emotionally touched and expressed her gratitude for finally being able to see a live coelacanth.

## COMMODITY VALUE

Commodity values describe various consumptive uses of biodiversity, including goods and services to satisfy material human needs.







Fig. 10. Philatelic utilization of coelacanths in the Comores and South Africa. Other countries have also used coelacanths as a motif for their stamps

It is impossible to give a full account of the existing diversity of handicrafts depicting coelacanths or estimate their monetary value. Parts of the revenue from the sale of handicraft articles have been donated for conservation purposes.

#### Advertisement and media presence

Recently a variety of buttons and stickers have been produced, mainly in the Comores, Germany and South Africa, advertising coelacanth conservation (Fig. 9).

Coelacanths have also appeared as labels on many utensils for daily use, for example napkins, mugs, pencils or even dinner charts (Fig. 9). A further commercial use is the naming and advertising of companies. A diving club in the Comores was named 'Gombessa plongee'. In 1986, the British 'Coelacanth Connection Limited' offered recreational expeditions. In the USA, 'Coelacanth Engineering' advertises products and services; 'Coelacanth Systems' provides consulting and computer services.

Coelacanths have also appeared on coins and banknotes of the Comores (Fig. 4) and in several countries are depicted on stamps (Bruton 1988) (Fig. 10). In South Africa, the 50th anniversary of the discovery was celebrated with an issue of 4 stamps depicting the history of and research on coelacanths. Several stamps honored expeditions searching for the fish.

Since 1938 coelacanths have appeared in a huge number of scientific publications, daily newspapers, magazines, journals, pamphlets and books (Fig. 11a). They were used in many comics mainly with the image of the sudden appearance of a prehistoric animal on a lonely island; 'The Big Fish Tin Lin' became one of the best known story books for children (Fig. 11b).

Coelacanths have also received worldwide media coverage. Since the historical radio speeches of J. L. B. Smith, many TV features have been produced in America, France, Germany, Great Britain, Japan and



Fig. 11. (a) Following the scientific discovery, pictures of and articles about coelacanths appeared worldwide. The first encounters in the natural habitat from on board a submersible again triggered wide attention. (b) The story of the coelacanth Tin Lin became a favorite subject for several children's books and has been published in several languages

South Africa, and commercial videos have been distributed in most of these countries. A coelacanth documentary received the 'Anglia Television Award for Revelation' during 'Wildscreen' in 1988. Thus coelacanths have had impressive exposure in print and audio-visual media, illustrating the statement of Forey (1990) that they have achieved a reputation that only few animals earn but most never attain.

### Future recreational use

Coelacanths are difficult to observe in their deep natural realm, which will probably prevent any commercial exploitation by tourist submarines. However the potential for an on-site encounter can be envisaged, which would have a high recreational and spiritual impact on the local population and also for visitors. Non-invasive methods could be applied to allow a view into the deep, for instance by installing permanent low-light cameras (Fricke et al. 1995). Therefore, a coelacanth information and visitor center has been planned (Graf 1995) which should provide the local community with some income and foster social cohesion among the villages and, at the same time, promote conservation of the fish. Furthermore, it would be of benefit for the fishing community. Fishermen are socially of low rank. A coelacanth fisherman gains in social prestige and better his own social status (Stobbs 1989). Coelacanth landings are rare events so fishermen cannot go specifically for the fish in order to purposely better their own social position.

### ECONOMIC VALUE

A caught coelacanth has no nutritional value. In earlier decades fishermen received approx. US\$300–400 from the government for each coelacanth caught; presently no incentives are being paid. The worldwide museum trade offered between US\$400 and 2000. The black market in the Comores offered formalin-fixed individuals for at most US\$1000. The coelacanth is a large fish and cannot be easily transported without being noticed; illegal trade probably takes place to only a limited extent. Since the Comores signed the CITES convention, unauthorized trade is strictly forbidden by law. Therefore, in 1994, 9 coelacanths were stored in Moroni in a deep freezer of a commercial fishing company and in the refrigerators of 2 hotels, a military camp and a governmental institution. In October 1995, due to an electricity failure, a large coelacanth was even thrown back into the sea. Presently the commercial market value of dead and preserved coelacanths is indeed negligible.

However in 1992, 2 live coelacanths were offered in Germany, each for US\$130 000, on a pricelist of the international illegal aquarium trade. The whereabouts of the fish could not be traced. Coelacanths cannot be caught on demand (Hamelin 1992) and line-hooked specimens usually die shortly after capture. Expensive deep-diving facilities are necessary to spot and catch a live specimen. Nevertheless, live coelacanths for display would be a great economic incentive. The danger arises that the deteriorating economic and political stability of the Comores (18 governments within 20 yr) will result in the failure to comply with existing CITES regulations. Private companies might be willing to pay high prices for live coelacanths as exemplified by the US\$2 million expedition by the TOBA aquarium (Japan) sponsored by Mitsubishi in 1989. A South African aquarium already claims to have the historical right to be the first to put a coelacanth on display. In 1996, during an international conference of zoo directors, the pros and cons of keeping coelacanths in captivity were discussed. In future, science will probably be used as an excuse for the first public display and this will be followed by an exponential increase in the market price. Nonetheless, it is to be hoped that CITES regulations and the rarity of the fish will not allow an expanding aquarium trade.

### CONCLUSIONS

Today we realize the importance and value of biodiversity of entire ecosystems, species or genes for the survival and well-being of our own human civilization (Wilson 1994). We acknowledge the economic importance of biodiversity, and we also recognize now the intangible values ('intrinsic value perspective'; Oldfield 1995). This view refers to a kind of innate entity of biodiversity, a universal right of existence for all living organisms independent of any human influences, visions or needs.

Coelacanths as a single advanced life form close to the roots of our own vertebrate history enter our human world in many ways not as creatures of high economic or nutritional value but as creatures of ethical, evolutionary and cultural significance which appear in language, poetry, fiction and diverse kinds of arts and crafts or as a symbol of a new national identity. Furthermore, they also have a psychological and intellectual value accessible by watching the fish in nature or on film and videos or by contemplating evolutionary age, timeless existence, tenacity, immortality and links to old roots. Their long evolutionary history gave rise to the curious fallacy of the existence of a life-prolonging elixir. Coelacanths occupy a unique place in our consciousness. Therefore the rich symbolism surrounding



them which has evolved in recent years should be utilized for future conservation attempts.

Detailed recommendations for immediate measures are available (Balon et al. 1988, Bruton & Stobbs 1991, Fricke et al. 1995). At the Max Planck Institute in Seewiesen, Germany, a tissue bank has been established and here coelacanths which have been accidentally caught are preserved for future research (Fricke 1992). More than 30 laboratories of diverse disciplines have made use of the available materials (Hissmann 1996). In the past, however, valuable materials were lost. The Comores had not yet signed the CITES convention and therefore CITES prevented the export of coelacanths (that had already been caught) to the Max Planck facility.

Although latest population estimates recorded a decrease in coelacanths of more than 30% within 3 yr and socioeconomic developments are very likely the sole cause for the decline (R. Plante, H. Fricke & H. Hissmann unpubl.), no financial support is in sight in the near future to slow down the increasing catch rates. The provision of Fish Attracting Devices (FADs) as an alternative fishing method in shallow water close to the shore but above the coelacanth depth was considered as the most promising measure to reduce the catch of coelacanths. Less than US\$ 1 million would be sufficient to install the FADs, which would help both the local fishermen and the coelacanth.

Various agencies, commissions and organizations have pretended to assist in coelacanth conservation, among them the World Bank, WWF, IUCN, and UNDP. So far, only well-paid consultants of first world countries have benefited from coelacanth conservation; the Comorian people and the fish have not. The World Bank published a cover page in its journal 'Bank's World' (Vol. 14, No. 7) with the subtitle 'Saving the Coelacanths' but not one dollar was spent in the Comores. The WWF has also used the coelacanth for its own publicity purposes, but no financial aid was given for conservation in the Comores.

Thus, high-profile endangered species such as the coelacanth are vulnerable to exploitation on behalf of conservation. Therefore coelacanth conservation in the Comores should focus on an increased local awareness of the need to protect a renewable natural resource for their own benefit. A coelacanth ecotourism administered by an information and visitor center might economically benefit the Comores as a result of a global inflow of tourists who wish to see the coelacanth which should in turn lead to the creation of employment. However the preservation of coelacanths also benefits the worldwide public. Many people who will never visit the Comores to see a coelacanth might derive satisfaction, spiritual enjoyment and other intellectual benefits, i.e. 'passive use values'. They are willing to

pay for knowing about the existence of a unique creature close to the roots of their own ancestry ('existence value') or for preserving coelacanths for future generations ('bequest value') (Krutilla 1967, Norton 1986, More et al. 1996). These intangible desires can be transformed into tangible values.

The coelacanth is well known, with an extraordinary media presence, and we are beginning to understand its unique existence and bequest value—a potential for economic quantification. These resources should be utilized not to cover maintenance costs of large agencies and organizations but for the good of the fish, managed through smaller nongovernmental bodies in the Comores. They might be the most powerful means of financing conservation measure and they would be also of direct monetary benefit for the Comorian population.

The coelacanth population is in decline. Today's generation has to act so that future generations can also rejoice in these gentle and peaceful survivors of our own vertebrate past.

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