From Aloes to Zebras
&
5 new species
(from vital differences not perceivable by humans)

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From Aloes to Zebras (and five new species using vital differences not perceivable by humans)

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Abstract

South Africa is a signatory of the convention on biological diversity, in which three levels (genetic, species and ecological) are addressed. My field of research is mainly on the first level mentioned. Genetic data is useful since inferences about the past (e.g. time of divergence and population history), present (diversity, population size, reproductive mixing, hybridisation, inbreeding) and future (selection, conservation, management) can be made. In addition, the technique I use can be applied to plants and animals. Results of studies that range from aloes to zebras are discussed and also how five new species were discovered.

This is how Rachel Ashton (section editor, BBC Wildlife Magazine, Broadcasting House, U.K.) described one of our new electric fish: Species are traditionally defined by something we can perceive - be it size, shape, colour or song. But for *Pollimyrus marianne*, a snout fish from the Okavango-Upper Zambezi River System, the vital difference is something humans can't perceive at all - the discharge pattern from its electric organ.

P. marianne of the Zambezi River is virtually indistinguishable from another species, *P. castelnaui* of the Okavango River, both in looks and in habitat preference. But Herman van der Bank found significant genetic differences and Bernd Kramer discovered that the electric signals are very different, especially those used for mate choice. Comparisons of mitochondrial DNA also confirmed the new Zambezi species. Only individuals from one smaller river (the Kwando), which is running between and mostly in parallel to the two main rivers, have a specific, third electric pattern. Except for occasional very high flooding, this river has been isolated from the Zambezi for at least 60 years, too small a time for definable mitochondrial DNA differences to accumulate by random mutation. But in spite of the sporadic floodings *P. marianne* was capable of conserving its distinct species-specific signal to identify it in its new electric fish community.

The species mentioned above was named after professor Kramer's late mother (Marianne) and another new species was named after my late father-in-law (Pierre Wessels). These names (and people) are now fixed in history and will be remembered for eternity.

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From Aloes to Zebras (and five new species using vital differences not perceivable by humans)

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1. Introduction:

South Africa is a signatory of the convention on biological diversity, in which the genetic, species and ecological levels are addressed. My field of research is mainly on the genetic level of populations and species. It will be explained why genetic and species diversity is important. In addition, the technique I use can be applied to plants and animals. The technique will be described, and from the discussion that follows, it should be evident how genetic data can be applied to make inferences about the past (e.g. time of divergence and population history), present (diversity, population size, reproductive mixing, hybridisation, inbreeding) and future (selection, conservation, management). These studies were done in collaboration with students, inter- and national researchers.

2. Selected studies are discussed and also how five new species were discovered:

Aloes and crocodiles: We proposed the ecological theory to explain the low levels of variation in our study of the economically important *A. ferox* and *A. marlothii*. Aloes have a wide range of uses (e.g. *A. ferox* is commercially used in laxatives, skin and hair care lotions, food – jam can be made from the leafs. and *A. marlothii* is traditionally used in the treatment of round worm infections, for stomach problems and for hastening the weaning of infants by rubbing the green leaf pulp over the breasts). We would not have thought about the ecological theory if we did not encounter similar results for the crocodiles we've studied previously. This theory will be explained. We were also able to identify natural hybrids between *A. ferox* and *A. arborescens*, and we have synonymised *A. candelabrum* with *A. ferox*. It was clear that a clinal distribution from SW to NE occurred. Another contribution was to describe a different method to increase the diluted leaf samples for allozyme analyses.

Buffalo and elephants: We've compared the effects of culling on genetic variation in buffalo and elephants in the Kruger National Park because different methods are used. The interesting results we've obtained are discussed.

Catfish: We studied the effects of cryopreservation of semen on selection. Similar preservants used in human semen storage were tested and we found a definite selection for fittest catfish sperm. This could have an ethical implication.

Dogs: The Africanis dog breed of the local Zulu people is registered with the Kennel Union of South Africa and we were able to genetically characterize it. It is distinct from three other breeds (from Western descent: Maltese Poodles, Jack Russels, German Shepherds, Rottweilers, Staffordshire Terriers and crossbred dogs, and from the Middle East). Samples were obtained from the SPCA.

Freshwater fish: More than thirteen studies were done to describe natural variation in fish populations and to identify natural and artificially induced hybrids between various species. This is becoming very important today since the uncontrolled introductions of alien species hybridise with our endemic species and might replace them eventually to drive them to extinction. Results from a recent study showed that interrogressive hybridization between yellowfishes has occurred.

Game (kudu, impala, etc.): We have studied variation in game species of economical importance to establish relationships and to advise game farmers on the effects of inbreeding and how to prevent it.
Mopane worms, trees and mice: The worms are a good source of protein and powder from dried worms is added to porridge in hospitals in Botswana to supplement the diet. Two distinct groups were found (one that hatches in November-December, and the other in April). Our results showed no significant difference between them and rare variation occurred in some individuals. This must be considered when populations are selected for artificial breeding.
We've studied two morphological similar field mice species to be able to identify them on a routine basis. These mice are important because they are carriers of fatal diseases (e.g. bubonic plague or black death and lessa fever). It was used in the first accounts of biological warfare (the Romans used to catapult corpses into their enemies' camps). We are able to identify the species and are now busy with a study to determine which of the species is responsible for giving elephants heart diseases that kills them.
Orange roughy: These fishes are ranked third on the world's top five most delicious seafood products list and were recently discovered very deep (500-1090 m) in the sea. Different population structures occur (some with only juveniles and mixed groups) in Namibian four coastal areas. It was important to establish if they are distinct from each other in order to assign quotas correctly for sustainable harvesting. We were able to advice the Namibian Marine Fisheries authorities on how to proceed.
Products and popcorn: Some industries are mixing products (e.g. horse meat with cattle in some butcheries) or selling cheap caviar as expensive caviar. We are able to assist industries if necessary. I assist the CSIR on a regular basis to establish the purity of maize and popcorn seeds. If more than 5% is rejected, then the farmer is not paid and the whole silo degraded from seed to feed status with obvious economical implications.
Squeakers and sheep: Squeakers are beautiful fishes and popular aquarium pets. The name is derived from the sounds they make with their pectoral fins when removed from the water. We were able to construct an identification key to distinguish between the nine southern African species. This is important in fisheries, conservation, stock assessment and angling records. I produced hybrids artificially to show the importance of keeping stocks separate and we were able to describe hybrizymes.
We've reported genetic relationships between 19 sheep breeds and my current Ph.D. student is breeding the Meatmaster and will characterize it genetically as well.
Tilapia: Conservation authorities successfully saved *T. guinasana* from extinction based on our results that clearly showed that it is distinct from the Banded tilapia.

We've also reported results for many other species (see 3. below), including five newly described fish species. The new species were named in honour of my late father-in-law (Pierre Wessels, who was very fond of fish and who helped us to collect them on many occasions; 73), another species was named after professor Kramer's late mother (Marianne; 90), Thomas Szaboi (the late French founding father of electroreception; 94) and Luc De Vos (the late curator of the Nairobi Museum for contributions to African ichthyology; In prep.). These names (and people) will be remembered for eternity.

3. Organisms studied and references (numbers refer to the list in 5. below): Aloes (37, 45, 47), Aliens (71), *Barbus* (8, 27, 43, 49, 50, 55), *Barleria* (70, 88, 96), Blue wildebeest (16); Bream (1-6, 28, 29, 71, 100, 101, 108), Buffalo (46), Camels (97, 123), Catfish (10, 11, 14, 17, 21, 25, 26, 103, 105, 110), Cattle (72), Cycads (58, 79, 95, 118), Dogs (93, 114), Ecology (57, 65), Elephants (24, 68, 117), Freshwater fish (30, 33, 41, 42, 52, 56, 61, 75, 99, 113, 120, 124), Game (22, 31, 36, 106): Impala (31, 104), Kudu (104), *Labeo* (9), Marine fish (53, 63); Mice (76, 84, 115), Molluscs (32, 38, 89), Mopane trees (92) and worms (81, 119), Nile crocodile (69, 107), Orange roughy (64), Plants (34, 39, 40, 44, 48, 51, 60, 77, 85); Pigs (54); Rainbow trout (12, 15), Rooibos tea (35, 66), Reviews (77, 87), Sheep (67, 111), Squeakers (23, 74, 86, 91, 112), Stalk-boring moths (7), Tigerfish (62, 98, 109), Tilapia (18, 102), Turtles and Terrapins (122); Vultures (13, 19, 20, 59, 80, 82, 83), Wild ginger (51) and Zebras (78)

4. Context: Conservation has become a very serious issue. We have endangered other species through: 1) over-exploitation (e.g. the quagga was hunted to extinction merely because it competed for the same graze as the stock of our fore-fathers), 2) introductions of alien species (e.g. the Nile perch was introduced in Lake Victoria and has caused more than 200 fish species to disappear) and 3) destruction of habitat (e.g. the cutting of tropical rain forests, which is home to half of the world's species). Presently we are within the 6th largest extinction period ever recorded, with 50% of the world's species that will become extinct early in this century (Leakey & Lewin, 1999). This time it is caused entirely by humans (who are also destined for extinction). We should, therefore, value biodiversity at all three levels (economic, physical environment: gasses, chemicals, water and for esthetic reasons). In addition, we are not limited to the beneficial genes from individual species or closely related species anymore because we now have access to unlimited recombination of genetic libraries among unrelated species. The slogan of 50/50 ("We are the last generation that can make a difference") has never before been more relevant.

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