Chapter 19
Animals Traded for Traditional Medicine at the Faraday Market in South Africa: Species Diversity and Conservation Implications

Martin J. Whiting, Vivienne L. Williams and Toby J. Hibbitts

Abstract In South Africa, animals and plants are commonly used as traditional medicine for both the healing of ailments and for symbolic purposes such as improving relationships and attaining good fortune. The aim of this study was twofold: to quantify the species richness and diversity of traded animal species and to assess the trade in species of conservation concern. We surveyed the Faraday traditional medicine market in Johannesburg and conducted 45 interviews with 32 traders during 23 visits. We identified 147 vertebrates representing about 9% of the total number of vertebrates in South Africa and about 63% of the total number of documented species (excluding domestic animals) traded in all South African traditional medicine markets. The vertebrates included 60 mammal species, 33 reptiles, 53 birds and one amphibian. Overall, species diversity in the Faraday market was moderately high and highest for mammals and birds, respectively. Evenness values indicated that relatively few species were dominant. Mammal body parts and bones were the most commonly sold items ($n = 453$, excluding porcupine quills and pangolin scales), followed by reptiles ($n = 394$, excluding

Published in Journal of Zoology, 2011, 284: 84–96.

M. J. Whiting (✉)
Department of Biological Sciences, Macquarie University,
Sydney, NSW 2109, Australia
e-mail: martin.whiting@mq.edu.au

M. J. Whiting · V. L. Williams · T. J. Hibbitts
School of Animal, Plant and Environmental Sciences,
University of the Witwatersrand, Private Bag 3,
2050 Wits, South Africa

T. J. Hibbitts
Department of Wildlife and Fisheries Sciences,
TexasA&M University, College Station,
Texas, TX 77843-2258, USA

R. R. N. Alves and I. L. Rosa (eds.), *Animals in Traditional Folk Medicine*,
DOI: 10.1007/978-3-642-29026-8_19,

osteoderms), birds ($n = 193$, excluding feathers and ostrich eggs), and amphibians ($n = 6$). Most (87.5%) species traded were of Least Concern using IUCN criteria, although 17 species were of conservation concern. However, a higher than expected proportion of traders (62.5%) were selling listed species, which is a matter for concern and should be monitored in the future.

Keywords Biodiversity · Threatened species · Ethnozoology · Mammal · Bird · Reptile

19.1 Introduction

Burgeoning human populations not only put pressure on biodiversity through competition for space and limited resources (Ehrlich 2009), but also through direct harvest for human consumption (Wilson 1988). Much of the focus relating to the current global biodiversity crisis is on habitat destruction and the unsustainable use of resources. Conservation practices tend to focus on arresting or ameliorating habitat destruction because biodiversity is conserved as a by-product. What has received far less attention from ecologists and conservation biologists is the harvest of animals for use in traditional medicine. Where rare and endangered species are concerned, the use of biodiversity for traditional medicine can have potentially significant impacts on local populations that are already under pressure (Simelane and Kerley 1998; Still 2003; White et al. 2004; Mander et al. 2007; Williams et al. 2007a). Some of the more notable examples of harvest for traditional medicine include rhino horns, bear gall bladders and tiger penises for the Asian market (But et al. 1990; Li et al. 1995; Still 2003). Many species of high value in traditional medicine may have low reproductive rates, be long-lived, and occur at relatively low densities in the wild. Species with these life history traits are considered more prone to extinction (McKinney 1997) and may therefore be less resilient to harvest.

The use of animal parts for the treatment of ailments affecting both humans and livestock has a long and rich history (Lev 2003). For example, bear gall bladders have been used to treat a variety of ailments in China for over 1,300 years (Li et al. 1995) while rhino horn has similarly been used in China for over 2,000 years (But et al. 1990). Traditional medicine in southern Africa falls into two categories: treatment of medical afflictions "white medicine" and dealing with ancestral conflict or "black medicine" (Bye and Dutton 1991). Traditional healers in southern Africa view health and welfare issues as being tightly linked to supernatural forces, social relationships and an individual's relationship with their ancestors (Bye and Dutton 1991; Simelane 1996). As such, a significant component of traditional healing makes use of the "magical" properties of plants or animal parts. For example, skins and parts from lions, leopards (Fig. 19.1a) and cheetah confer strength to the bearer, while other animal parts may be used to

Fig. 19.1 Images of trader's stalls from the Faraday market in Johannesburg. **a** leopard paws; **b** a typical stall, selling a variety of animal parts including southern African python and southern ground hornbill; **c** a stall with mainly cowrie shells, crocodile osteoderms, porcupine quills, assorted bones and teeth; **d** a stall with an assortment of marine fauna including star fish, coral and a variety of fish; **e** a stall selling mainly tortoise shells (*Kinixys* sp.), pieces of elephant skin, giant land snails (*Achatina* sp.) and assorted bones; **f** assorted animals, including pangolin scales and an aardvark foot. Photo credits: MJ Whiting—**a**, **c**, **d**, **e** and VL Williams—**b**, **f**)

provide protection against enemies, as a charm in a court case, for intelligence in school children, prosperity and good fortune, to strengthen a relationship, or even to aid an individual committing a crime (Simelane 1996; Cocks and Dold 2000;

White et al. 2004; Mander et al. 2007). A large proportion of South Africans believe in the efficacy of traditional medicine and have at some time purchased traditional medicine or consulted a traditional healer (Cunningham and Zondi 1991; Mander et al. 2007). Furthermore, South Africa has a very low ratio of western doctors to patients (Williams 2007), particularly in rural areas, which leaves very little opportunity for consultation with university trained medical doctors. By comparison, traditional healers are far more accessible to most of the population (Bye and Dutton 1991).

The trade in animal parts in southern Africa is thought to be extensive, but is currently poorly understood and only baseline data has been collected for select areas. Furthermore, many of these studies are internal, unpublished reports. Herbert et al. (2003) report a comprehensive assessment of the invertebrate trade at the Warwick Triangle traditional medicine market in Durban and also briefly review the trade in animal parts for traditional medicine. Specifically, they report on diversity, monetary values and rough quantities of taxonomic groups that were traded and identify a few select marine invertebrates of conservation concern. Simelane and Kerley (1998) interviewed traditional healers in the Eastern Cape Province of South Africa and found that 31% of vertebrates traded were listed in South African Red Data books. Mander et al. (2007) focused on the trade in vultures and identified the demand for traditional medicine as a significant threat to the future viability of several species of vulture. All these studies point to the growing need for baseline data and proper quantification of the trade in animal parts for traditional medicine and whether this trade makes significant use of species of conservation concern.

The purpose of this study was to investigate the trade in animals for traditional medicine at the Faraday traditional medicine market (hereafter Faraday) in Johannesburg, South Africa. We quantified species richness, diversity and quantity of vertebrate and marine invertebrate fauna sold by traders. Finally, we examined the trade of animals in relation to their conservation assessment using IUCN criteria.

19.2 Methods

Faraday is the largest informal wholesale and retail market for traditional medicine within the province of Gauteng (Williams 2003), and the second largest outlet for traditional medicine in South Africa after the Warwick Junction market in Durban (Herbert et al. 2003). Previous studies at Faraday have focused on the trade in plant material (Williams 2003; Williams et al. 2005, 2007a b, c), but until now, the trade in animal material has not been assessed. A Faraday survey in 2001 revealed that 5% of traders sold only animal parts while 10% sold a combination of plant and animal material (Williams 2003).

19.2.1 Market Survey

We used undergraduate students proficient in local languages (isiZulu, Sesotho) to conduct 45 interviews with 32 traders during 23 visits to Faraday to compile an inventory of animal species available for sale. The survey was conducted between June 2004 and November 2005. Animal identifications were made at the market, although photographs were also taken at most of the stalls as documentary evidence and for identifying some species. Identification to species was further aided by field guides for the major vertebrate groups (birds: Sinclair et al. 1997; reptiles: Branch 1998; mammals: Stuart and Stuart 2001). When we totalled species in a particular taxonomic group, we conservatively counted the minimum number of potential species. For example, in the case of "scrub hare, rock rabbit and unidentified rabbit." we would only count two species. We recorded all domestic animals for sale, but do not include them in any taxonomic counts or in any of the analyses. We treated marine fishes and invertebrate species separately to mammals, birds, reptiles and amphibians, primarily because of the difficulty in identifying the individual species of molluscs, echinoderms, corals and dried fishes. These species were also not included in the diversity analyses, but are discussed separately. Our primary approach was to record observable data and to limit the questioning of the traders due to the difficulties expected with obtaining honest/reliable information, especially concerning the origin of the material. We designed a survey form to list the species, quantities (number of individual organisms) and carcass parts sold. We did not record data on the origin or monetary value of the material. The animal fats and mixtures separately sold in bottles were not recorded since there was no way to verify the identity of the material (Fig. 19.2a). Furthermore, some wholesalers of traditional medicine sell "imitation" fat (often domestic animal fat) to consumers (Cunningham and Zondi 1991).

19.2.2 Sampling Performance

Complete enumeration of species within a study area is generally not feasible and consequently a number of methods have been devised for estimating total species richness from a sample (Chiarucci et al. 2003). A challenge for ethno-ecological surveys is establishing the completeness of an inventory and how many more species might be recorded with further sampling of the market (Williams et al. 2007c). We used incidence-based species richness estimators calculated by the public-domain software *EstimateS* (Version 7.5.1, Colwell 2006; viz. ICE, Chao 2, first-order jackknife, second-order jackknife, bootstrap and Michaelis–Menton Means) to estimate the number of species that may have been recorded with further sampling. Incidence based rather than abundance-based estimators are more suitable for market data because inventories mostly record the presence or absence of species rather than the abundance or quantity present. Furthermore, certain body parts such as porcupine quills, pieces of skin and feathers may be highly abundant, but at the

Fig. 19.2 Examples of raw materials derived from medicinal animals sold in the Faraday market in Johannesburg. **a** assorted animal fats sold in bottles; **b** assorted birds: **c** CMR Bean Beetles (*Mylabris oculata*); **d** assorted animals, including pangolin scales and an aardvark foot; d) trader with a peacock. Photo credits: VL Williams—**a**, **b**, **c** and MJ Whiting—**d**

same time may be harvested from a few individual animals, making quantity an unsuitable abundance variable for calculating the estimators.

We assessed the "best" estimator based on its ability to reach a horizontal asymptote (Toti et al. 2000; Williams et al. 2007c). Furthermore, the richness estimates were compared with a list of species compiled from other studies of animals

traded for traditional medicine. The list indicated how many more species have been recorded for sale in other markets in South Africa compared to Faraday. A good species richness estimator would therefore not under estimate the total number of potential species in trade and the richness estimate should be at least greater than or equal to the total number of taxa recorded in all current and previous studies. The literature examined to compile the extended list of animals traded was based on Cunningham and Zondi (1991), Simelane (1996), Derwent and Mander (1997), Marshall (1998), Simelane and Kerley (1998), Ngwenya (2001), Crump (2003), Herbert et al. (2003), White et al. (2004), Mander et al. (2007). The study by Crump (2003) was a rapid assessment of nine traders selling animal parts in Faraday in 2001.

19.2.3 Species Richness, Similarity and Diversity

We calculated species richness, the percentage similarity of species sold by different traders (using the Sørenson index for incidence-based data), species accumulation functions and species diversity indices using EstimateS. These techniques have previously been effective in analysing and interpreting ethnobotanical inventories derived from assessments of resource use in South Africa and South America (e.g. Williams et al. 2005, 2007c; Begossi 1996; Hanazaki et al. 2000). We randomised the sample order (i.e. trader order) 50 times to compute the mean statistic at each sample accumulation level and thereby generated smoothed accumulation curves. EstimateS directly computes the Shannon (H'), Simpson ($1/\lambda$) and Fisher's α diversity indices. We used the $-\ln \lambda$ form of Simpson's index (see Williams et al. 2005), hence the data were transformed accordingly. The software does not directly compute Hill's numbers or evenness values; however, the appropriate variables for calculating these indices are an output of EstimateS and these values were subsequently derived using the appropriate formulae indicated in Table 19.1. Because the values for the diversity indices are computed at each sample accumulation level, it was possible to plot cumulative diversity curves that indicate how the indices perform as more traders were sampled.

Diversity measures take into account two factors: species richness (the number of species, S, in a sample of a specified size) and evenness/equitability (i.e. how uniformly abundant species are in a sample) (Magurran 1988). S is related to the total number of individuals (n) summed over all S species recorded (Williams et al. 2005). As sampling effort increases (e.g. more traders, n, are sampled) more individuals are encountered and more species are likely to be recorded (Hayek and Buzas 1997). An "index" of diversity (also called an index of heterogeneity, e.g. Simpson's index) incorporates both richness and evenness into a single value, and is based on the proportional abundance of species in a sample (Ludwig and Reynolds 1988; Magurran 1988). Part of the rationale behind calculating species diversity is that the more singletons (species occurring once) there are in a sample, the more one would expect to find at a site and therefore the greater the expected species diversity. The Shannon (H') diversity index measures the average degree

Table 19.1 Comparisons of selected measures of diversity between animals sold in the Faraday market

Index/Measure	Animals ($n = 32$ traders) $n = 608$	Mammals ($n = 32$ traders) $n = 305$	Reptiles ($n = 31$ traders) $n = 178$	Birds ($n = 22$ traders) $n = 123$
Species richness (S or N_0 or e^{Hmax})	147	60	33	53
Mean S per trader ± SD	25.1 ± 14.7	13.3 ± 7.6	7.1 ± 4.0	4.7 ± 5.2
Shannon (H')	4.49	3.67	2.92	3.67
Simpson (–ln λ)	4.22	3.49	2.68	3.60
Fisher's α	61.6	22.4	11.9	35.3
Evenness E_1(Shannon J') (H'/H'_{max})[a]	0.90	0.90	0.84	0.92
Evenness E_5 (N_2-1/N_1-1)	0.76	0.83	0.77	0.93
Hill's N_1 ($e^{H'}$)	89.1	39.3	18.5	39.3
Hill's N_2 ($1/\lambda$)	68.3	32.9	14.5	36.4
Hill's N (N/N_{max})[b]	26.4	13.9	7.7	8.8
Singletons (no. of species occurring once)	57	18	13	26
Mean number of shared species	7.1 ± 4.8 (range = 0–23) $n = 496$	4.1 ± 3.1 (range = 0–15) $n = 496$	2.5 ± 1.8 (range = 0–6) $n = 496$	0.8 ± 1.0 (range = 0–6) $n = 300$
Mean percentage Sørenson similarity of species sold by traders	26.7 ± 11.7% (0–62.5%) $n = 496$	28.0 ± 15.5% (0–80%) $n = 496$	33.4 ± 17.8% (0–85.7%) $n = 496$	13.1 ± 14.8% (0–65.7%) $n = 300$

[a] $H_{max} = \ln S$ (maximum value of the Shannon index)
[b] N_{max} = the number of individuals of the most abundant species

of "uncertainty" in predicting the identity of a species chosen at random from a sample (Ludwig and Reynolds 1988). The greater the uncertainty, the more difficult it is to predict the identity of a species and therefore the higher the diversity of the sample. The index is sensitive to the abundance of the rarest or least recorded species (Magurran 1988). Simpson's diversity index (–ln λ) also increases as diversity increases and indicates the likelihood that two species chosen at random are the same species. The higher the diversity, the less likely two species chosen at random will be the same species. Simpson's index is sensitive to the abundances of the commonest or most recorded species (Magurran 1988). Fisher's α is a diversity index sensitive to sample size, the number of species and the number of species of intermediate abundance. When the number of species is low, alpha is lower and therefore smaller samples with fewer species usually have smaller values of α (Williams et al. 2005). Fisher's α is also a number close to the number of species expected to be represented by one individual (Hayek and Buzas 1997). Hill's numbers represent the number of species that are abundant (N_1), very abundant (N_2) and most abundant (N_∞) in a sample. These numbers are derived from the Shannon, Simpson and Berger–Parker indices, respectively. Hill's numbers, especially N, can help indicate which species may be dominant in the market. To objectively determine the number of species which are of rare, intermediate or common abundance in the market, Williams et al. (2005) recommended transforming Hill's numbers in the following way: the number of common species $= N_\infty$; the number of species of intermediate abundance in the market $= N_1 – N_\infty$; the number of "rare" species (i.e. of low incidence) $= S – N_1$.

Evenness (or equitability) measures are another way of quantifying species dominance in a market. If all species are equally abundant throughout the market, then evenness values would be at a maximum of 1. The evenness value would decrease towards zero if the relative abundances of some species increased and they dominated the stalls in the market. The overall relative abundances of species thus determine the value of an evenness index. We used two evenness indices primarily to better differentiate between data sets if the resultant values from one index were the same. E_1 (also called the Shannon J') is the most commonly used index but is sensitive to species richness and singletons (Ludwig and Reynolds 1988). E_5, however, tends to remain constant with sampling variations and tends to be independent of sample size (Ludwig and Reynolds 1988). The dispersion of species throughout the market (i.e. uniform, aggregated or random) was calculated using software called "Species diversity and richness" (version 3.02, 2002; Pisces Conservation Ltd., New Milton, UK).

19.2.4 Species of Conservation Concern

All vertebrates were checked against 2001 IUCN Red List Categories and Criteria version 3.1 and used in conjunction with the following sources: Minter et al. (2004) for amphibians; IUCN (2009, Version 2009.1) for reptiles; Barnes (2000)

and Hockey et al. (2005) for birds; and Friedmann and Daly (2004) for mammals. We tested whether species of conservation concern (IUCN categories: Critically Endangered [CR], Endangered [EN], Vulnerable [VU] or Near-Threatened [NT]) were proportionally as prevalent among traders as species of Least Concern (LC) (IUCN category) using χ^2 tests (two-tailed). Because of low sample sizes we combined all species of conservation concern to meet the assumptions of the χ^2 tests. A total of 136 species were scored for conservation status and of these, 119 were of LC while 17 were of conservation concern. Our expected values for the χ^2 test were therefore 0.875 and 0.125, respectively. We also tested for a significant difference in the abundance of body parts (including entire animals) that were being sold, between species of conservation concern and species of LC. For this test, a total of 922 body parts were assigned to 136 species of which 17 were of conservation concern (64 items) while the remaining 119 species (865 items) were scored as LC. Therefore, we used expected values of 6.78 items/species under the null hypothesis that species were equally abundant, regardless of their conservation status. For this latter test, we excluded porcupine quills, eggs, feathers, crocodile osteoderms, pangolin scales and teeth, all of which could inflate values for a particular species. In the case of antelope horns we used the minimum number of individuals necessary to constitute the number of horns (i.e. we divided by two or used half the number plus one if it was an odd number of horns). Because of these measures, the total number of species was less than what was used for the first χ^2 test. All means are reported $\pm$ 1 SD.

19.3 Results

19.3.1 Trade in Vertebrates

Excluding domestic animals, we identified 147 vertebrate species traded at Faraday, representing one species of frog, 33 species of reptile, 53 species of bird and 60 species of mammal (Table 19.2). Seven domestic mammals were sold by traders: goat, cattle, sheep, horse, donkey, pig and cat (Table 19.2). Of the species identified at Faraday, 41% were mammals (excluding domestic animals), 36% were birds and 22% were reptiles. For South Africa alone, these species counts represent 8% of the reptile fauna (417 taxa, WR Branch, pers. comm.), 6% of the bird fauna (841 taxa, Birdlife International 2009) and 20% of the mammal fauna (299 taxa, Skinner and Chimimba 2005).

The most taxonomically widespread groups were birds (15 orders, 35 families) (Fig. 19.2b) and mammals (15 orders, 24 families). Perching birds (order Passeriformes) had the highest number of recorded bird families and species (nine families, 14 species), with each family within this order only represented by one to three species. Among raptors, members of the family Accipitridae were the most frequently recorded in the market (>5 species). The most common mammals identified in the market were carnivores (seven families and 24 species), of which, cats were the

Table 19.2 Checklist of Vertebrate Species: Threat Status and Market Frequency

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
CLASS: AMPHIBIA				
ANURA				
Bufonidae	*Schismaderma carens*	Toad, Red	LC	2
	-	Frog, unidentified	-	1
CLASS: REPTILIA				
CROCODYLIA				
Crocodylidae	*Crocodylus niloticus*	Nile crocodile	LC	22
SQUAMATA				
Pythonidae	*Python natalensis*	Python, Southern African	LC	23
Colubridae	*Lamprophis aurora*	House Snake, Aurora	LC	1
	Dispholidus typus	Boomslang	LC	6
	Philothamnus sp.	Green Snake, unidentified	-	1
	Pseudaspis cana	Mole Snake	LC	2
	Psammophis phillipsii	Grass Snake, Olive	LC	2
	Psammophis sp.	Sand Snake, unidentified	-	1
	Amblyodipsas sp.	Purple-glossed Snake, unidentified	-	1
	Psammophylax rhombeatus	Skaapsteker, Spotted	LC	1
	P. tritaeniatus	Skaapsteker, Striped	LC	1
Elapidae	*Dendroaspis polylepis*	Mamba, Black	LC	7
	Dendroaspis angusticeps	Mamba, Green	LC	5
	Dendroaspis sp.	Mamba, unidentified	-	2
	Naja mossambica	Spitting Cobra, Mozambique	LC	5
	Naja sp.	Cobra, unidentified	-	1
	Hemachatus haemachatus	Rinkhals	LC	1
Viperidae	*Bitis arietans*	Puff Adder	LC	18
	Bitis sp.	Adder, unidentified	-	1
Agamidae	*Acanthocercus atricollis*	Agama, Southern Tree	LC	9

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
Chamaeleonidae	*Chamaeleo dilepis*	Chameleon, Flap-necked	LC	2
		Chameleon, unidentified	-	3
Varanidae	*Varanus albigularis*	Monitor, Rock	LC	16
	Varanus niloticus	Monitor, Water	LC	19
	Varanus sp.	Monitor, unidentified	-	7
Scincidae	*Acontias plumbeus*	Skink, Giant Legless	LC	4
Cordylidae	*Cordylus* cf. *vittifer*	Girdled Lizard, Transvaal	LC	1
	Cordylus giganteus	Giant Sungazer	VU	5
	Cordylus tropidosternum	Girdled Lizard, Tropical	LC	1
	Cordylus warreni	Girdled Lizard, Warren's	LC	2
Gerrhosauridae	*Gerrhosaurus major*	Plated Lizard, Rough-scaled	LC	1
	Gerrhosaurus flavigularis	Plated Lizard, Yellow-throated	LC	1
-	-	lizard, unidentified	-	3
-	-	snake, unidentified	-	13
Unidentified squamates	-	-	-	1
TESTUDINES				
Pelomedusidae	-	Terrapin, unidentified	-	6
Cheloniidae	*Eretmochelys imbricata*	Turtle, Hawksbill	CR	1
	-	Turtle, unidentified	-	1
Testudinidae	*Chersina angulata*	Tortoise, Angulate	LC	1
	Kinixys belliana	Hinged Tortoise, Bell's	LC	2
	Kinixys speckii	Hinged Tortoise, Speke's	LC	1
	Kinixys sp.	Hinged Tortoise, unidentified	-	1
	Stigmochelys pardalis	Leopard Tortoise	LC	8
	Homopus sp.	Padloper, unidentified	-	2
	-	Tortoise, unidentified	-	10

(continued)

Table 19.2 (continued)

Classification (*CLASS*, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
CLASS: AVES				
ANSERIFORMES				
Anatidae	*Thalassornis leuconotus*	Duck, White-backed	LC	1
-	-	Duck, unidentified	-	3
BUCEROTIFORMES				
Bucerotidae	*Bycanistes bucinator*	Hornbill, Trumpeter	LC	1
	-	Hornbill, unidentified	-	1
Bucorvidae	*Bucorvus cafer*	Ground-hornbill, Southern	VU	3
Musophagidae	*Tauraco corythaix*	Turaco, Knysna	LC	1
CAPRIMULGIFORMES				
Caprimulgidae	*Caprimulgus* sp.	Nightjar, unidentified	-	1
CHARADRIIFORMES				
Burhinidae	*Burhinus capensis*	Thick-knee, Spotted	LC	4
	Burhinus sp.	Thick-knee, unidentified.	-	1
Charadriidae	*Vanellus armatus*	Lapwing, Blacksmith	LC	1
Laridae	*Sterna caspia*	Tern, Caspian	NT	1
CICONIIFORMES				
Ardeidae	*Bubulcus ibis*	Egret, Cattle	LC	7
	Casmerodius albus	Egret, Great	LC	1
Scopidae	*Scopus umbretta*	Hamerkop	LC	2
Ciconiidae	*Ciconia ciconia*	Stork, White	LC	3
	-	Stork, unidentified (red bill)	-	2
COLIIFORMES				
Coliidae	*Colius striatus*	Mousebird, Speckled	LC	2
	-	Mousebird, unidentified	-	1

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
COLUMBIIFORMES				
Columbidae	*Stigmatopelia senegalensis*	Dove, Laughing	LC	6
	Streptopelia semitorquata	Dove, Red-eyed	LC	1
	Columba livia	Dove, Rock	LC	3
CORACIIFORMES				
Alcedinidae	*Alcedo cristata*	Kingfisher, Malachite	LC	1
	Ceryle rudis	Kingfisher, Pied	LC	2
	-	Kingfisher, unidentified	-	1
CUCULIFORMES				
Cuculidae	*Centropus superciliosus*	Coucal, White-browed	LC	5
FALCONIFORMES				
Accipitridae	*Buteo rufofuscus*	Buzzard, Jackal	LC	1
	Haliaeetus vocifer	Fish-eagle, African	LC	2
	Polyboroides typus	Harrier-hawk, African	LC	1
	Elanus caeruleus	Kite, Black-shouldered	LC	1
	-	Eagle, unidentified	-	2
	Gyps africanus	Vulture, White-backed	VU	3
	-	Vulture, unidentified	-	3
Falconidae	-	Kestrel, unidentified	-	1
	-	hawk/eagle, unidentified	-	2
GALLIFORMES				
Phasianidae	*Coturnix coturnix*	Quail, Common	LC	2
Numididae	*Guttera pucherani*	Guineafowl, Crested	LC	2
	Numida meleagris	Guineafowl, Helmeted	LC	2

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
GRUIFORMES				
Rallidae	*Amaurornis flavirostra*	Crake, Black	LC	1
	Gallinula chloropus	Moorhen, Common	LC	1
	Gallinula sp.	Moorhen, unidentified	-	1
	Porphyrio porphyrio	Swamphen, Purple	LC	2
PASSERIFORMES				
Malaconotidae	*Laniarius ferrugineus*	Boubou, Southern	LC	1
	Prionops plumatus	Helmet-shrike, White	LC	1
Corvidae	*Corvus capensis*	Crow, Cape	LC	1
	Corvus albus	Crow, Pied	LC	3
Laniidae	*Lanius collaris*	Fiscal, Common	LC	3
Pycnonotidae	*Pycnonotus tricolor*	Bulbul, Dark-capped	LC	1
Zosteropidae	*Zosterops virens*	White-eye, Cape	LC	2
Cisticolidae	*Cisticola* sp.	Cisticola, unidentified	-	1
	Prinia subflava	Prinia, tawny-flanked	LC	1
Muscicapidae	*Melaenornis pammelaina*	Flycatcher, Southern Black	LC	2
	Cossypha natalensis	Robin-chat, Red-capped	LC	1
Turdidae	*Turdus olivaceus*	Thrush, Olive	LC	1
Sturnidae	*Lamprotornis nitens*	Starling, Cape Glossy	LC	3
	Lamprotornis sp.	Starling, unidentified	-	1
Passeridae	*Passer domesticus*	Sparrow, House	LC	1
PELICANIFORMES				
Threskiornithidae	*Threskiornis aethiopicus*	Ibis, African Sacred	LC	3
	Bostrychia hagedash	Ibis, Hadeda	LC	5

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
Pelecanidae	*Pelecanus onocrotalus*	Pelican, Great White	NT	1
	-	Pelican, unidentified	-	1
STRIGIFORMES				
Tytonidae	*Tyto alba*	Owl, Barn	LC	4
Strigidae	*Bubo africanus*	Eagle-owl, Spotted	LC	5
	Asio capensis	Owl, Marsh	LC	3
-	-	Owl, unidentified	-	3
STRUTHIONIFORMES				
Struthionidae	*Struthio camelus*	Ostrich	LC	14
Unidentified birds	-	-	-	**9**
CLASS: MAMMALIA				
CARNIVORA				
Hyaenidae	*Proteles cristatus*	Aardwolf	LC	3
	Hyaena brunnea	Hyaena, Brown	NT	1
	Crocuta crocuta	Hyaena, Spotted	NT	4
	-	Hyaena, unidentified	-	5
Felidae	*Felis silvestris*	Cat, African Wild	LC	1
	Felis catus	Cat, Domestic	-	3
	Caracal caracal	Caracal	LC	1
	Panthera pardus	Leopard	LC	8
	Panthera leo	Lion	VU	3
	Leptailurus serval	Serval	NT	2
Viverridae	*Civettictis civetta*	Civet, African	LC	1
	Genetta tigrina	Genet, Large-spotted	LC	6
	Genetta genetta	Genet, Small-spotted	LC	4
	Genette sp.	Genet, unidentified	-	4

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
Herpestidae	*Mungos mungo*	Mongoose, Banded	LC	2
	Herpestes ichneumon	Mongoose, Large Grey	LC	1
	Galerella sanguinea	Mongoose, Slender	LC	3
	Ichneumia albicauda	Mongoose, White-tailed	LC	2
	Suricata suricatta	Meerkat	LC	1
	-	Mongoose, unidentified	-	8
Canidae	*Otoycyon megalotis*	Fox, Bat-eared	LC	1
	Vulpes chama	Fox, Cape	LC	1
	Canis mesomelas	Jackal, Black-backed	LC	1
	Canis sp.	Jackal, unidentified	-	8
	Lycaon pictus	Wild Dog, African	EN	1
Mustelidae	*Mellivora capensis*	Badger, Honey (Ratel)	NT	1
	Aonyx capensis	Otter, Cape Clawless	LC	3
	-	Otter, sp.	-	3
	Ictonyx striatus	Polecat, Striped	LC	14
Otariidae	*Arctocephalus pusillus*	Seal, Cape Fur	LC	1
-	-	unidentified, small carnivore	-	1
CHIROPTERA				
-	-	bat, unidentified	-	7
ERINACEOMORPHA				
Erinaceidae	*Atelerix frontalis*	Hedgehog, South African	NT	8
HYRACOIDEA				
Procaviidae	*Procavia capensis*	Rock Hyrax	LC	11

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
LAGOMORPHA				
Leporidae	*Lepus saxatilis*	Hare, Scrub	LC	7
	Pronolagus sp.	Rabbit, Rock	LC	6
	-	hare/rabbit, unidentified	-	1
MACROSCELIDEA				
Macroscelididae	*Elephantulus* sp.	Elephant Shrew, unidentified	-	2
PERISSODACTYLA				
Equidae	*Equus asinus*	Donkey	-	3
	Equus caballus	Horse	-	13
	Equus burchellii	Zebra, Plains	LC	6
PHOLIDOTA				
Manidae	*Smutsia temminckii*	Pangolin, Ground	VU	2
PRIMATES				
Galagidae	*Otolemur crassicaudatus*	Bushbaby, thick-tailed (Greater Galago)	LC	6
	-	Bushbaby, unidentified	-	9
Cercopithecidae	*Papio ursinus*	Baboon, Chacma	LC	22
	Cercopithecus mitis ssp.	Monkey, Samango	VU/LC[a]	2
	Chlorocebus pygerythrus	Monkey, Vervet	LC	16
PROBOSCIDEA				
Elephantidae	*Loxodonta africana*	Elephant, African	LC	15
RODENTIA				
Bathyergidae	-	Molerat, unidentified	-	2
Hystricidae	*Hystrix africaeaustralis*	Porcupine, Cape	LC	22
-	-	Rodent, unidentified	-	1

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
RUMINANTIA				
Giraffidae	*Giraffa camelopardalis*	Giraffe	LC	4
Bovidae	*Damaliscus pygargus*	Blesbok/Bontebok	VU (Bontebok)	1
	Syncerus caffer	Buffalo, African	LC	12
	Tragelaphus scriptus	Bushbuck	LC	4
	Sylvicapra grimmia	Duiker, Common	LC	2
	Cephalophus natalensis	Duiker, Red	LC	9
	-	Duiker, unidentified	-	8
	Taurotragus oryx	Eland	LC	7
	Oryx gazella	Gemsbok	LC	3
	Capra hircus	Goat, Domestic	-	1
	Aepyceros melampus	Impala	LC	7
	Oreotragus oreotragus	Klipspringer	LC	1
	Tragelaphus strepsiceros	Kudu, Greater	LC	7
	T. angasii	Nyala	LC	3
	Bos taurus	Cattle	-	2
	Redunca arundinum	Reedbuck	LC	1
	Ovis aries	Sheep	-	3
	Antidorcas marsupialis	Springbok	LC	3
	Kobus ellipsiprymnus	Waterbuck	LC	4
	Connochaetes taurinus	Wildebeest, Blue	LC	1
	Connochaetes sp.	Wildebeest, unidentified	-	9
	-	ungulate, unidentified	-	11

(continued)

Table 19.2 (continued)

Classification (***CLASS***, **ORDER**, Family)	Species	Common name	IUCN category	Number of traders
SUIFORMES				
Suidae	*Potamochoerus larvatus*	Bushpig	LC	2
	Phacochoerus africanus	Warthog, Common	LC	16
	Sus domesticus	Pig	-	2
TUBULIDENTATA				
Orycteropodidae	*Orycteropus afer*	Aardvark	LC	7
WHIPPOMORPHA				
Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	LC	11
Unidentified mammals				25

[a] Depending on species

Check list of vertebrate species, the number of traders recorded selling each species at the Faraday market, and each species' conservation status. The classification follows Minter et al. (2004; frog); Zug et al. (2001); Alexander and Marais (2007) (reptiles); Hockey et al. (2005; birds); and Skinner and Chimimba (2005; mammals). See text for details of conservation assessment (2001 IUCN Red Data Lists v 3.1). *LC* least concern, *NT* Near Threatened, *VU* Vulnerable, *EN* Endangered, *CR* Critically Endangered. We did not identify marine organisms and invertebrates to a sufficient level to assign IUCN categories, but see Table 19.4 for the quantities of these organisms at Faraday

most prevalent (five species). The bovids (antelopes and buffalo) were the next most abundant group of mammals (15 species) (Table 19.2). Among reptiles, the squamates (snakes and lizards) were the most common (10 families; 25 species), of which the colubrids (typical snakes) were recorded the most frequently.

The mean number of vertebrate species sold per trader was 25.1 ± 14.7, and ranged from 4.7 ± 5.2 bird species sold per trader to 13.3 ± 7.6 mammal species sold per trader (Table 19.1). The mean number of "shared" species (i.e. species that two traders have in common at their stalls) was 7.1 ± 4.8 species per trader (Table 19.1); hence, the similarity of species sold by traders was relatively low. The Sørenson similarity measure confirms this finding and indicates that species composition at the different traders' stalls is on average only 26.7 ± 1.2% similar for all vertebrates recorded (Table 19.1). However, there is greater similarity of reptiles sold (33.4%) between traders compared to birds (13.1%; Table 19.1). Hence, one is unlikely to find the same bird species being sold by the traders in the market, except for ostriches, owls and a broad spectrum of species from the order Falconiformes. Twelve of the most commonly occurring species were uniformly present throughout the market (Table 19.3, shaded species; including monitors, python, crocodile and baboon), whereas the remaining species occurred randomly at traders' stalls.

19.3.2 Commonly Traded Species

The following species were sold by more than 50% of traders: reptiles: rock (50%), and water monitor (59%); Nile crocodile (69%); southern African python (72%) (Fig. 1b); puff adder (56%); mammals: chacma baboon (69%); Cape porcupine (69%); vervet monkey (50%); warthog (50%) (Table 19.3). African elephants were also commonly traded (47%, 15 traders). Bird species were not as prevalent as mammals and reptiles, but ostriches and owls were the most commonly recorded avian species (44% and 28% of traders respectively).

19.3.3 Marine Fauna and Invertebrates

We recorded an array of invertebrates and fishes that we could only identify at a much higher taxonomic level (Table 19.4). Most invertebrates recorded were marine, representing at least four phyla (Table 19.5). The only non-marine invertebrates were two species of insect and the giant land snail (Table 19.4). Among the marine invertebrates, most were unidentified marine molluscs. Among the fishes, only two were freshwater species (barbel, catfish) while the remainder were marine. The most common of these were sole (seven traders, 70 individuals). We also recorded relatively low numbers of sharks, rays, skates and eel, and 46 unidentified ray-finned fishes (Table 19.4). Of the marine taxa, ray-finned fish, mollusc and echinoderm shells were sold by 56% of traders (Table 19.5). Ninety-one percent of traders sold some marine fauna.

Table 19.3 Percentage of 32 traders recorded selling species of vertebrates in Faraday

Mammals		Reptiles		Birds	
Common name	% traders (>20%)	Common name	% traders (>10%)	Common name	% traders (>10%)
Chacma baboon	68.8	Monitor spp. (rock and water)	84.4	Common ostrich	43.8
Cape porcupine	68.8	Nile crocodile	71.9	Owl spp.	37.5
Vervet monkey	50.0	Southern African python	71.9	Dove spp.	25.0
Common warthog	50.0	Tortoise spp.	62.5	Egret spp.	25.0
Duiker spp.	46.9	Puff adder (snake)	56.3	Vulture spp.	18.8
African elephant	46.9	Elapids (snakes)	43.8	Coucal, Burchell's	15.6
Bush baby spp.	43.8	Southern tree agama (lizard)	28.1	Ibis spp.	15.6
Mongoose spp.	43.8	Colubrids (snakes)	28.1	Duck spp.	12.5
Striped polecat	43.8	*Cordylus* spp. (girdled lizards)	21.9	Starling spp.	12.5
Horse	40.6	Terrapin spp.	18.8	Thick-knee spp.	12.5
African buffalo	37.5	Chameleon spp.	15.6		
Rock hyrax	34.4	Giant legless skink (lizard)	12.5		
Hippopotamus	34.4				
Wildebeest spp.	31.3				
Genet spp.	28.1				
Hyaena spp.	28.1				
Jackal spp.	28.1				
Southern African hedgehog	25.0				
Leopard	25.0				
Aardvark	21.9				
Bat spp.	21.9				
Eland	21.9				
Scrub hare	21.9				
Impala	21.9				
Greater kudu	21.9				

Table 19.2 lists the incidence of all individual vertebrate species. Species in grey shading were uniformly distributed throughout the market; the remaining species were randomly dispersed

19.3.4 Species Richness

The species accumulation curves for mammals, birds and reptiles approached an asymptote and indicate that further sampling of traders would not yield many more new species for the individual vertebrate classes (Fig. 19.3), hence sampling effort was sufficient. The rate of accumulation of new species was 0.4 new species per trader for reptiles, 0.6 new species per trader for mammals and 1.2 new species per

Table 19.4 Checklist of Vertebrate Species: Animal Part and Quantity in the Market: Check list of vertebrate species according to the animal part traded and the number of body parts sold by all traders combined, at the Faraday market

INVERTEBRATES				
Classification (**CLASS**, Order)	Family	Common name	Animal part	Number of parts
ANTHOZOA				
Scleractinia	-	Coral	-	3
MALACOSTRACA				
Decapoda	-	Marine crab	Whole	2
CEPHALOPODA				
Sepiida	Sepiidae	Cuttlefish (*Sepia* spp.)	Whole	45
Octopoda	Octopodidae	Common octopus (*Octopus vulgaris*)	Whole	2
			Tentacle	2
BIVALVIA	-	Clam	Shell	5
GASTROPODA				
Sorbeoconcha	Cypraeidae	Cowrie (*Cypraea*)	Shell	84
Archaeogastropoda	-	Limpit	Shell	16
-	-	Mollusc (various marine)	Shell	21
Pulmonata	-	Ocean slugs	Whole	20
Clade: Stylommatophora	Achatinidae	Giant land snail (*Achatina*)	Shell	72
-	-	Various unidentified Mollusca	Shell	934
ECHINOIDEA				
Cidaroida	Cidaridae	Pencil urchin (*Prionocidaris pistillaris*)	Shell	75
Echinoida	-	Sea urchin	Shell	65
ASTEROIDEA				
Valvatida	-	Star fish	Whole	34
INSECTA				
Coleoptera	Meloidae	CMR Bean Beetle (*Mylabris oculata*)	Whole	200
Orthoptera	Pyrgomorphidae	Grasshopper (*Taphronota* sp.)	Whole	25

Table 19.4 (continued)

FISHES				
Actinopterygii				
Anguilliformes	Muraenidae	Eel, Moray	Whole	2
		Eel, unidentified	Whole	2
Cypriniformes	Cyprinidae	Barbel	Head	1
Tetraodontiformes	Ostraciidae	Box fish	Whole	30
Tetraodontiformes	-	Puffer fish/porcupine fish	Whole	14
Siluriformes	-	Catfish	Head	1
Pleuronectiformes	-	Sole (*Austroglossus pectoralis*)	Whole	70
-	-	Fish, unidentified	Whole	46
Chondrichthyes				
Rajiformes	-	Rays	Whole	3
	Rajidae	Skate	Whole	1
Selachimorpha	-	Shark	Jaw	1
			Skin	1
AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
CLASS: AMPHIBIA				
ANURA				
Bufonidae	*Schismaderma carens*	Toad, Red	Whole	2
	-	Frog, unidentified	Whole	5

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
CLASS: REPTILIA				
Crocodylia				
Crocodylidae	*Crocodylus niloticus*	Nile crocodile	Skin	24
			Skull	9
			Osteoderms	65
			Lower jaws	4
			Egg	20
			Bone	1
Squamata				
Pythonidae	*Python natalensis*	Python, Southern African	Skin	22
			Body parts	16
			Skull	1
Colubridae	*Lamprophis aurora*	House Snake, Aurora	Skin	1
	Dispholidus typus	Boomslang	Whole	5
			Skin	1
	Philothamnus sp.	Green Snake, unidentified	Whole	1
	Pseudaspis cana	Mole Snake	Whole	3
	Psammophis phillipsii	Grass Snake, Olive	Whole	2
	Psammophis sp.	Sand Snake, unidentified	Whole	1
	Amblyodipsas sp.	Purple-glossed Snake, unidentified	Whole	1
	Psammophylax rhombeatus	Skaapsteker, Spotted	Whole	1
	Psammophylax tritaeniatus	Skaapsteker, Striped	Whole	1

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
Elapidae	*Dendroaspis polylepis*	Mamba, Black	Whole	10
			Skin	1
	Dendroaspis angusticeps	Mamba, Green	Whole	5
			Skin	2
	Dendroaspis sp.	Mamba, unidentified	Skin	2
	Naja mossambica	Spitting Cobra, Mozambique	Whole	10
	Naja sp.	Cobra, unidentified	Skin	1
	Hemachatus haemachatus	Rinkhals	Whole	1
Viperidae	*Bitis arietans*	Puff Adder	Skin	11
			Whole	28
	Bitis sp.	Adder, unidentified	Whole	1
Agamidae	*Acanthocercus atricollis*	Agama, Southern Tree	Whole	20
Chamaeleonidae	*Chamaeleo dilepis*	Chameleon, Flap-necked	Whole	2
		Chameleon, unidentified	Tail	1
			Whole	3
Varanidae	*Varanus albigularis*	Monitor, Rock	Head	3
			Skin	10
			Whole	9
	Varanus niloticus	Monitor, Water	Foot	2
			Skin	9
			Whole	18
	Varanus sp.	Monitor, unidentified	Head	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Skin	8
			Whole	3
Scincidae	*Acontias plumbeus*	Skink, Giant Legless	Whole	6
Cordylidae	*Cordylus* cf. *vittifer*	Girdled Lizard, Transvaal	Whole	7
	Cordylus giganteus	Giant Sungazer	Whole	11
	Cordylus tropidosternum	Girdled Lizard, Tropical	Whole	1
	Cordylus warreni	Girdled Lizard, Warren's	Whole	10
Gerrhosauridae	*Gerrhosaurus major*	Plated Lizard, Rough-scaled	Whole	2
	Gerrhosaurus flavigularis	Plated Lizard, Yellow-throated	Whole	1
-	-	Lizard, unidentified	Whole	7
-	-	Snake, unidentified	Head	2
			Skin	15
			Whole	42
Testudines				
Pelomedusidae	-	Terrapin, unidentified	Shell	8
			Head	1
			Plastron	1
Cheloniidae	*Eretmochelys imbricata*	Turtle, Hawksbill	Head	1
	-	Turtle, unidentified	Shell	2
	-	Terrapin/Turtle/Tortoise	Shell	1
Testudinidae	*Chersina angulata*	Tortoise, Angulate	Shell	1
	Kinixys belliana	Hinged Tortoise, Bell's	Carapace	2
			Shell	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
	Kinixys speckii	Hinged Tortoise, Speke's	Shell	1
	Kinixys sp.	Hinged Tortoise, unidentified	Shell	1
	Stigmochelys pardalis	Leopard Tortoise	Foot	2
			Plastron	3
			Shell	11
	Homopus sp.	Padloper, unidentified	Shell	1
	-	Tortoise, unidentified	Shell	14
			Carapace	3
			Egg	2
			Foot	2
			Neck	1
			Plastron	4
CLASS: AVES				
Anseriformes				
Anatidae	*Thalassornis leuconotus*	Duck, White-backed	Head	1
-	-	Duck, unidentified	Foot	2
			Whole	2
Bucerotiformes				
Bucerotidae	*Bycanistes bucinator*	Hornbill, Trumpeter	Whole	1
	-	Hornbill, unidentified	Beak	1
Bucorvidae	*Bucorvus cafer*	Ground-Hornbill, Southern	Beak	1
			Skull	1
			Whole	1

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
Musophagidae	*Tauraco corythaix*	Turaco, Knysna	Whole	1
CAPRIMULGIFORMES				
Caprimulgidae	*Caprimulgus* sp.	Nightjar, unidentified	Wing	1
Charadriiformes				
Burhinidae	*Burhinus capensis*	Thick-knee, Spotted	Whole	4
	Burhinus sp.	Thick-knee, unidentified.	Whole	1
Charadriidae	*Vanellus armatus*	Lapwing, Blacksmith	Whole	1
Laridae	*Sterna caspia*	Tern, Caspian	Whole	1
CICONIIFORMES				
Ardeidae	*Bubulcus ibis*	Egret, Cattle	Head	1
			Whole	9
	Egretta alba	Egret, Great	Whole	1
Scopidae	*Scopus umbretta*	Hamerkop	Whole	2
Ciconiidae	*Ciconia ciconia*	Stork, White	Head-neck	1
			Skull	1
			Whole	4
	-	Stork, unidentified (red bill)	Head-neck	2
COLIIFORMES				
Coliidae	*Colius striatus*	Mousebird, Speckled	Whole	6
	-	Mousebird, unidentified	Whole	1
COLUMBIFORMES				
Columbidae	*Streptopelia senegalensis*	Dove, Laughing	Whole	4
	Streptopelia semitorquata	Dove, Redeyed	Whole	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS

Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
	Columba livia	Dove, Rock (Feral Pigeon)	Whole	3
			Head	1
CORACIIFORMES				
Alcedinidae	*Alcedo cristata*	Kingfisher, Malachite	Whole	1
Cerylidae	*Ceryle rudis*	Kingfisher, Pied	Whole	2
-	-	Kingfisher, unidentified	Whole	1
CUCULIFORMES				
Centropodidae	*Centropus burchellii*	Coucal, Burchell's	Whole	7
FALCONIFORMES				
Accipitridae	*Buteo rufofuscus*	Buzzard, Jackal	Whole	1
	Haliaeetus vocifer	Fish-Eagle, African	Whole	4
	Polyboroides typus	Harrier-Hawk, African	Whole	1
	Elanus caeruleus	Kite, Black-shouldered	Whole	1
	-	Eagle, unidentified	Whole	2
	Gyps africanus	Vulture, White-backed	Whole	5
	-	Vulture, unidentified	Foot	2
			Head	1
			Whole	1
Falconidae	-	Kestrel, unidentified	Whole	1
	-	hawk/eagle, unidentified	Claw	1
			Skull	1
GALLIFORMES				
Phasianidae	*Coturnix coturnix*	Quail, Common	Whole	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
Numididae	*Guttera edouardi*	Guineafowl, Crested	Whole	7
	Numida meleagris	Guineafowl, Helmeted	Whole	2
GRUIFORMES				
Rallidae	*Amaurornis flavirostra*	Crake, Black	Whole	2
	Gallinula chloropus	Moorhen, Common	Whole	1
	Gallinula sp.	Moorhen, unidentified	Whole	2
	Porphyrio madagascariensis	Swamphen, African Purple	Whole	2
PASSERIFORMES				
Malaconotidae	*Laniarius ferrugineus*	Boubou, Southern	Whole	2
	Prionops plumatus	Helmet-Shrike, White-crested	Whole	1
Corvidae	*Corvus capensis*	Crow, Cape	Whole	1
	Corvus albus	Crow, Pied	Whole	7
Laniidae	*Lanius collaris*	Fiscal, Common	Whole	3
Pycnonotidae	*Pycnonotus tricolor*	Bulbul, Dark-capped	Whole	1
Zosteropidae	*Zosterops virens*	White-eye, Cape	Whole	2
Cisticolidae	*Cisticola* sp.	Cisticola, unidentified	Whole	1
	Prinia subflava	Prinia, tawny-flanked	Whole	1
Muscicapidae	*Melaenornis pammelaina*	Flycatcher, Southern Black	Whole	2
	Cossypha natalensis	Robin-Chat, Red-capped	Whole	2
	Turdus olivaceus	Thrush, Olive	Whole	1
Sturnidae	*Lamprotornis nitens*	Starling, Cape Glossy	Whole	4
	Lamprotornis sp.	Starling, unidentified	Whole	1
Passeridae	*Passer domesticus*	Sparrow, House	Whole	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
PELICANIFORMES				
Pelecanidae	*Pelecanus onocrotalus*	Pelican, Great White	Whole	1
	-	Pelican, unidentified	Head	1
Threskiornithidae	*Threskiornis aethiopicus*	Ibis, African Sacred	Whole	3
	Bostrychia hagedash	Ibis, Hadeda	Whole	6
			Head	1
Strigiformes				
Tytonidae	*Tyto alba*	Owl, Barn	Whole	4
Strigidae	*Bubo africanus*	Eagle-Owl, Spotted	Whole	9
	Asio capensis	Owl, Marsh	Whole	3
-	-	Owl, unidentified	Foot	1
			Leg	1
			Whole	1
STRUTHIONIFORMES				
Struthionidae	*Struthio camelus*	Ostrich, Common	Beak	1
			Egg	28
			Feather	30
			Leg	2
			Skin	2
			Skull	2
			Toe	2
Unidentified birds	-	-	Beak	1
	-	-	Feather	21

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
	-	-	Egg shells	2
	-	-	Head-skull	2
	-	-	Leg	7
	-	-	Whole	5
CLASS: MAMMALIA				
CARNIVORA				
Hyaenidae	*Proteles cristatus*	Aardwolf	Skin	3
			Whole	1
	Hyaena brunnea	Hyaena, Brown	Skin	1
	Crocuta crocuta	Hyaena, Spotted	Skin	3
			Skull	1
	-	Hyaena, unidentified	Skin	2
			Skull	3
Felidae	*Felis silvestris*	Cat, African Wild	Skin	1
	Caracal caracal	Caracal	Skin	1
	Felis catus	Cat, Domestic	Skin	3
	Panthera pardus	Leopard	Bone	1
			Foot/paw	6
			Skin	5
			Skull	3
	Panthera leo	Lion	Bone	1
			Skin	1
			Skull	1

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
	Leptailurus serval	Serval	Skin	2
Viverridae	*Civettictis civetta*	Civet, African	Skull	1
	Genetta tigrina	Genet, Large-spotted	Skin	3
			Whole	9
	Genetta genetta	Genet, Small-spotted	Skin	4
			Whole	1
	Genetta sp.	Genet, unidentified	Skin	3
			Whole	2
Herpestidae	*Mungos mungo*	Mongoose, Banded	Skin	2
			Whole	4
	Herpestes ichneumon	Mongoose, Large Grey	Skin	1
	Galerella sanguinea	Mongoose, Slender	Skin	5
			Whole	1
	Ichneumia albicauda	Mongoose, White-tailed	Skin	3
	Suricata suricatta	Meerkat	Whole	2
	-	Mongoose, unidentified	Head	1
			Skin	6
			Whole	5
Canidae	*Otoycyon megalotis*	Fox, Bat-eared	Whole	1
	Vulpes chama	Fox, Cape	Whole	2
	Canis mesomelas	Jackal, Black-backed	Skin	2
	Canis sp.	Jackal, unidentified	Skin	6
			Skull	1

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Whole	1
	Lycaon pictus	Wild Dog, African	Skull	1
Mustelidae	*Mellivora capensis*	Badger, Honey (Ratel)	Skin	3
	Aonyx capensis	Otter, Cape Clawless	Whole	1
	-	Otter, sp.	Skins	4
	Ictonyx striatus	Polecat, Striped	Skin	11
			Whole	15
Otariidae	*Arctocephalus pusillus*	Seal, Cape Fur	Skin	1
-	-	Unidentified, small carnivore	Skull	2
CHIROPTERA				
-	-	Bat, unidentified	Whole	13
ERINACEOMORPHA				
Erinaceidae	*Atelerix frontalis*	Hedgehog, South African	Skin	2
			Whole	7
HYRACOIDEA				
Procaviidae	*Procavia capensis*	Rock Hyrax	Skull	1
			Whole	8
LAGOMORPHA				
Leporidae	*Lepus saxatilis*	Hare, Scrub	Head	1
			Skin	1
			Whole	7
	Pronolagus sp.	Rabbit, Rock	Foot	1
			Leg	2

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Skin	4
			Whole	1
	-	Unidentified	Whole	1
MACROSCELIDEA				
Macroscelididae	*Elephantulus* sp.	Elephant Shrew, unidentified	Whole	4
Perissodactyla				
Equidae	*Equus asinus*	Donkey	Hoof	2
			Skull	2
	Equus caballus	Horse	Hoof	2
			Leg	26
			Penis	1
			Skull	3
			Tail	1
	Equus burchellii	Zebra, Plains	Hoof	1
			Skin	4
			Skull	3
PHOLIDOTA				
Manidae	*Smutsia temminckii*	Pangolin, Ground	Foot	2
			Scale	72
PRIMATES				
Galagidae	*Otolemur crassicaudatus*	Bushbaby, thick-tailed (Greater Galago)	Skin	1
			Whole	8
	-	Bushbaby, unidentified	Skin	1

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Skull	3
			Whole	13
Cercopithecidae	*Papio ursinus*	Baboon, Chacma	Bone	4
			Foot/hand	8
			Skin	10
			Skull	20
			Whole	14
	Cercopithecus mitis ssp.	Monkey, Samango	Skin	2
	Chlorocebus pygerythrus	Monkey, Vervet	Skin	3
			Skull	12
			Whole	10
PROBOSCIDEA				
Elephantidae	*Loxodonta africana*	Elephant, African	Bone	3
			Foot	1
			Penis	1
			Skin	25
			Tooth	1
RODENTIA				
Bathyergidae		Molerat, unidentified	Whole	2
Hystricidae	*Hystrix africaeaustralis*	Porcupine, Cape	Foot	4
			Intestine	1
			Nose	1
			Quill	388

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Skin	11
			Skull	1
			Whole	1
-	-	Rodent, unidentified	Whole	1
RUMINANTIA				
Giraffidae	*Giraffa camelopardalis*	Giraffe	Bone	15
			Skin	1
			Skull	1
			Tail	1
Bovidae	*Damaliscus pygargus*	Blesbok/Bontebok	Skulls	6
	Syncerus caffer	Buffalo, African	Horn	10
			Skin	3
			Skull	2
	Tragelaphus scriptus	Bushbuck	Horn	4
			Skull	2
	Sylvicapra grimmia	Duiker, Common	Horn	30
			Skin	1
	Cephalophus natalensis	Duiker, Red	Baby/ whole	1
			Horn	47
			Skin	11
			Skull	3
	-	Duiker, unidentified	Horn	30

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Leg	1
			Skin	1
			Skull	3
	Taurotragus oryx	Eland	Horn	5
			Scrotum	1
			Skin	1
	Oryx gazella	Gemsbok	Horn	3
	Capra hircus	Goat, Domestic	Skin	1
	Aepyceros melampus	Impala	Horn	5
			Skin	7
			Skull	1
	Oreotragus oreotragus	Klipspringer	Skin	1
	Tragelaphus strepsiceros	Kudu, Greater	Horn	8
			Skull	2
	Tragelaphus angasii	Nyala	Horn	2
			Skin	2
	Bos taurus	Cattle	Belly	1
			Horn	1
	Redunca arundinum	Reedbuck	Horn	1
	Ovis aries	Sheep	Jaw	2
			Skin	2
	Antidorcas marsupialis	Springbok	Hoof	1
			Horn	4
	Kobus ellipsiprymnus	Waterbuck	Hoof	1

(continued)

Table 19.4 (continued)

Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
			Horn	3
			Skin	1
	Connochaetes taurinus	Wildebeest, Blue	Horn	2
	Connochaetes sp.	Wildebeest, unidentified	Horn	6
			Skin	3
			Skull	2
			Tail	1
Unidentified bovids				
	-	-	Bone	20
	-	-	Hoof	29
	-	-	Horn	105
	-	-	Leg	5
	-	-	Skin	8
	-	-	Skull	9
SUIFORMES				
Suidae	*Potamochoerus larvatus*	Bushpig	Skin	2
	Phacochoerus africanus	Warthog, Common	Bone	21
			Skin	5
			Skull	16
			Tooth/tusk	26
	Sus domesticus	Pig	Skin	3
TUBULIDENTATA				
Orycteropodidae	*Orycteropus afer*	Aardvark	Foot	3

(continued)

Table 19.4 (continued)

AMPHIBIANS, REPTILES, BIRDS and MAMMALS				
Classification (**CLASS**, **ORDER**, **Family**)	Species	Common name	Animal part	Number of parts
			Skin	3
			Skull	1
			Whole	1
WHIPPOMORPHA				
Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	Bone	2
			Skin	3
			Skull	1
			Tooth/tusk	19
Unidentified mammals				
	-	-	Bone	1222
	-	-	Carcass	5
	-	-	Foot	2
	-	-	Intestine	1
	-	-	Skin	15
	-	-	Skull	4
	-	-	Tooth	50
	-	-	Vertebra	239

The classification based on Hockey et al. (2005; birds); Skinner and Chimimba (2005, mammals); Zug et al. (2001) and Alexander and Marais (2007; for reptiles)

Table 19.5 Quantity of material and percentage of 32 traders recorded selling marine fish and invertebrate taxa

Phylum	Class	Common name	Part	% of traders	No. of pieces
Chordata	Actinopterygii (ray-finned fish)	Fish spp. (ray-finned fishes, eels)	Whole	56.3	166
	Chondrichthyes (cartilaginous fish)	Fish spp. (sharks, rays and skates)	Whole	12.5	6
Arthropoda	Malacostraca	Crab: marine	Whole	6.3	4
	Insecta	Beetles, grasshoppers	Whole	9.0	225
Cnidaria	Anthozoa	Coral	Coral	6.3	3
Echinodermata	Asteroidea	Starfish	Shell	40.6	34
	Echinoidea	Shell: urchins	Shell	18.8	140
Mollusca		Shell: molluscs	Shell	31.3	955
	Bivalvia	Shell: clams	Shell	3.1	5
	Cephalapoda	Octopus	Whole	9.4	3
		Cuttlefish	Whole	9.4	45
	Gastropoda	Shells: cowries, limpets and snails	Shell	21.9	120
		Snail: giant land	Shell	43.8	72

trader for birds. When the vertebrate classes were combined (All), the curve was less asymptotic and indicates that 1.8 new species were recorded per trader sampled. Avian species richness was higher than that of reptiles, despite birds having been recorded at the stalls of fewer traders (Table 19.1, Fig. 19.3).

At least 232 species of vertebrates (excluding domestic animals) have been recorded as being used or traded for traditional medicine from the Faraday survey (S_{obs}) and the other surveys conducted in South Africa ($S_{literature}$) combined (Table 19.6). The species identified in Faraday hence represent 63% of the total number of species identified in use or trade in South Africa to date.

The richness estimates generated for all (All) vertebrates ranged from 172 species for the bootstrap estimator to 233 species for the second-order jackknife estimator (Jack 2) (Fig. 19.4, Table 19.6). Both bootstrap and Jack 2 were consistently the lowest and highest estimators respectively of species richness for all data sets. Because ICE and Chao 2 gave unrealistically high estimates for a smaller number of traders (>300 species for "All" after two traders) and MMRuns predicted >6,000 species after 10 traders, the curves of these estimators were not presented and are not considered to be good predictors of species richness. Only the Jack 2 estimator consistently predicted within 0 to +3 species the total number of species recorded to date ($S_{total\ recorded}$) (Table 19.6); the remainder of the estimators underestimated $S_{total\ recorded}$ by 30–50 species. The Jack 2 estimator thus predicted an "upper-bound" estimate for the total number of species that might be recorded in the Faraday market over time (Table 19.6), including opportunistically harvested species that have low use and commercial values.

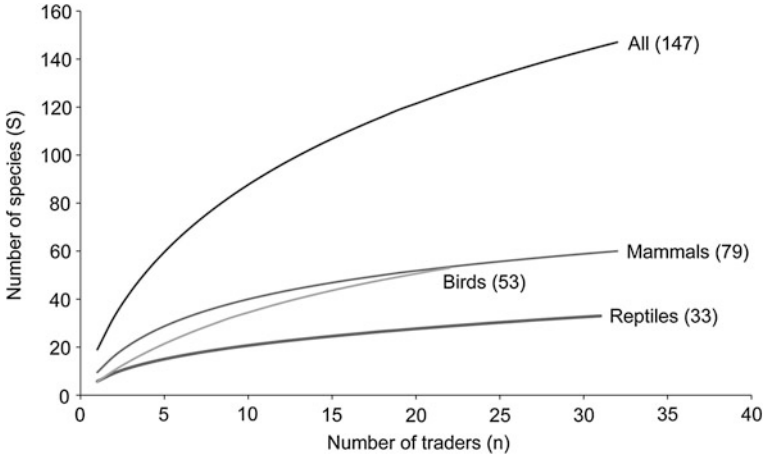

Fig. 19.3 Species accumulation curves for vertebrate animals traded at the Faraday market. Parentheses indicate sample sizes

Table 19.6 Comparison of observed species richness in the Faraday market (S_{obs}), the number of additional species observed/recorded in other surveys ($S_{literature}$) and the estimated species richness predicted by the second-order jackknife (Jack 2) estimator from EstimateS

	Observed species richness			Estimated species richness
	S_{obs}	$S_{literature}$	$S_{total\ recorded} = S_{obs} + S_{literature}$	Jack 2
All	147	>85	≥232	233
Mammals	60	>23	≥84	87
Reptiles	33	>17	≥50	52
Birds	53	>40	≥93	93
Amphibians	1	>4	≥5	–

19.3.5 Species Diversity

The overall diversity of the species identified in the Faraday market is medium–high (Shannon $H' = 4.49$; Simpson's $-\ln \lambda = 4.23$) (Table 19.1, Figs. 19.5, 19.6). The cumulative diversity curves have reached asymptotes, indicating that the diversity index values would change very little with additional sampling effort (Figs. 19.5, 19.6). Within the vertebrate groups, diversity values indicate that there is a greater diversity of birds traded in the markets compared to mammals and reptiles, even though the overall species richness of birds is lower than that for mammals (Table 19.1, Figs. 19.5, 19.6). The higher bird diversity is partly indicative of the higher number of singletons recorded (Table 19.1).

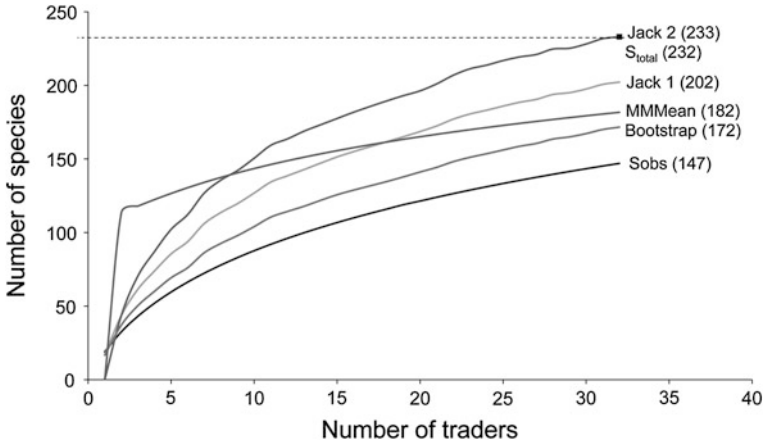

Fig. 19.4 The performance of four incidence-based species richness estimators compared with the observed species accumulation curve (S_{obs}) for "All" animals identified in the Faraday market (mammals, reptiles, birds and amphibian). The Jack 2 estimator predicts within one species the total number of species recorded from 10 other surveys (S_{total}) and also the total number of species likely to be recorded in Faraday over time

Overall, evenness values are high, indicating that most species were evenly dispersed throughout the market and that relatively few species were very dominant (Table 19.1, Table19.7). The predominance of crocodile, python and monitor parts within the market accounts for the lower evenness values for reptiles compared to mammals and birds. Of the 33 reptile species identified, eight species (24%) were dominant and were frequently sold at traders' stalls (Table 19.7). Bird fauna exhibited the least dominance of all the vertebrates with only 15% of the species being of very common occurrence. Forty-nine percent of bird species were identified only once in the market (Table 19.7), further confirming the reason for the high diversity values for avian fauna despite the slightly lower species richness values compared to mammals.

19.3.6 Quantity Traded and Consumption Levels

The number of traders selling a species and the quantity of that species in Faraday was significantly positively correlated ($r = 0.91$; $n = 138$; $P < 0.00001$) (Fig. 19.7). Hence, the more traders that sold a species, the more pieces of it there were likely to be. The correlation excluded 30 eggs, 51 ostrich feathers, 388 porcupine quills, 76 pangolin scales, 266 bovine horns and 84 teeth, as well as 65 crocodile osteoderms. When the aforementioned animal parts were included, the correlation was lower, but still significant ($r = 0.56$; $n = 146$; $P < 0.00001$). Table 19.4 lists the quantities of each animal part sold per species.

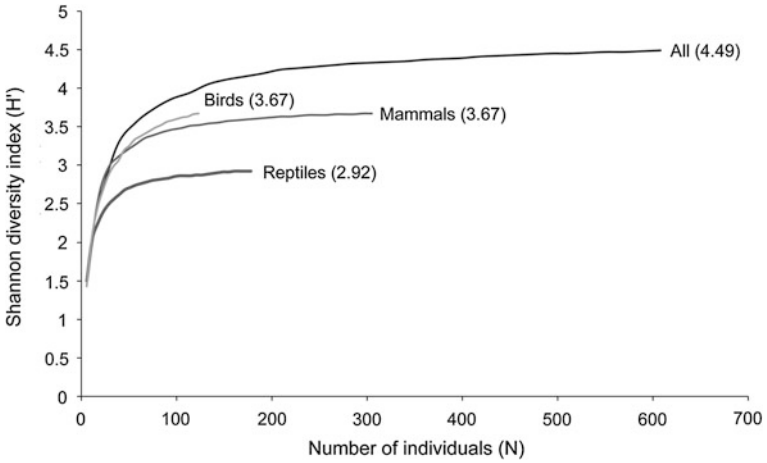

Fig. 19.5 Cumulative diversity curve for the Shannon diversity index (H')

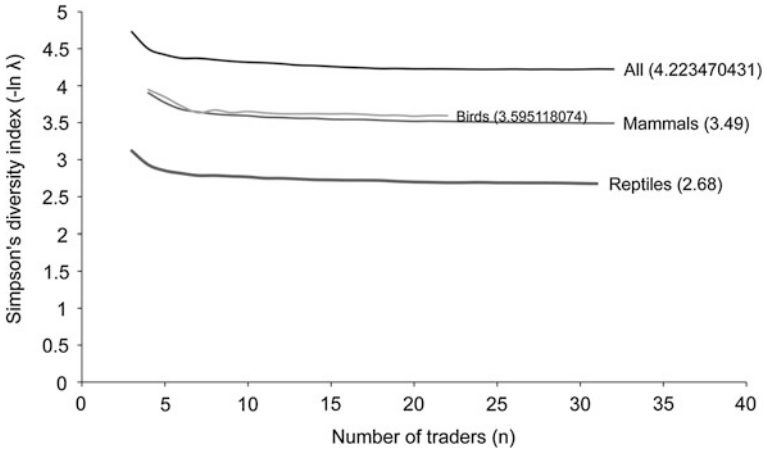

Fig. 19.6 Cumulative diversity curve for the Simpson's diversity index (–ln λ)

Table 19.7 Number and percentage of species of rare, intermediate and common occurrence within the Faraday market

	All	Mammals	Reptiles	Birds
Total S	147	60	33	53
Very common occurrence	28 (19%)	12 (20%)	8 (24%)	8 (15%)
Intermediate occurrence	62 (42%)	30 (50%)	12 (36%)	19 (36%)
Rare occurrence	57 (39%)	18 (30%)	13 (39%)	26 (49%)

The categories are derived from Hill's numbers N_0, N_1 and N_∞

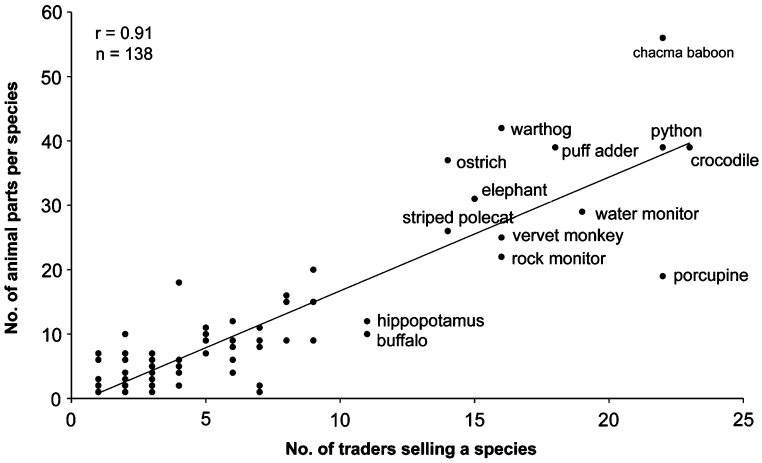

Fig. 19.7 Relationship between the number of traders selling a vertebrate species and the total number of animal parts per species (excluding ostrich feathers, porcupine quills, pangolin scales, bovine teeth and horns, and crocodile osteoderms). Species sold by more than 10 traders are labelled

Mammal body parts and bones were present in the largest quantities (2453 pieces, excluding porcupine quills and pangolin scales), followed by reptiles (394 pieces, excluding osteoderms), birds (193 pieces, excluding feathers and ostrich eggs) and amphibians (6 parts) (Table 19.8). Mammal bones were the most prevalent body part recorded. Of the vertebrates, fishes were the most likely to be sold as an intact carcass ($n = 172$, 100%) followed by birds ($n = 152$, 55.7% of all body parts), reptiles ($n = 163$, 35.5%) and mammals ($n = 140$, 4.8%). Conversely, mammals were the most likely to be sold as individual body parts and mammal bones were the most frequently documented item ($n = 1528$), followed by porcupine quills ($n = 388$), horns ($n = 266$), pieces of skin ($n = 214$) and skulls/heads ($n = 133$). For the reptiles, body parts that were traded in significant numbers included skins ($n = 107$), crocodile osteoderms ($n = 65$), and pieces of chelonian shells ($n = 55$). Feathers ($n = 51$) and eggs ($n = 30$) were the most frequently traded items of bird origin.

On average, traders ($n = 10$) sold to 5–10 customers a day, but this ranged from 2 to 15 customers and went as high as 25 customers on a very busy day.

19.3.7 Conservation Status

Most ($n = 119$, 87.5%) species traded ($n = 136$) in Faraday were of LC (Table 19.2, Table19.9). Of the 17 taxa of conservation concern, we recorded a single individual (skull) of a CR species (Hawksbill Turtle), and a single individual (skull) from an EN species (Wild Dog). Two traders had parts of a Samango

Table 19.8 Number of body parts recorded for vertebrates in the Faraday survey

Mammals		Reptiles		Birds	
Body parts	No. of pieces	Body parts	No. of pieces	Body parts	No. of pieces
Bones: unidentified	1528	Whole (lizards, monitors and snakes)	163	Whole	152
Porcupine quills	388	Skin (Squamata)	107	Feathers	51
Horns	266	Osteoderms (crocodile)	65	Eggs	30
Skin (whole or pieces)	214	Shell/plastron/carapace (Testudines)	55	Skull	13
Whole body/carcass	140	Eggs	22	Leg	11
Skull/head	113	Skull/head	23	Foot	6
Teeth/tusks	84	Python body parts	16	Beak	4
Scales (pangolin)	72	Foot	6	Head and neck	3
Hooves	35	Neck	1	Skin	2
Legs	34	Tail	1	Wing	1
Foot/paw	27				
Intestine	3				
Penis/scrotum	3				
Tails	3				
Jaw	2				
Nose	1				
TOTAL	2913		459		273

Monkey (Table 19.4), which, depending on the subspecies, is considered either VU or LC (Kingdon et al. 2008). Of the remaining 14 taxa, six were VU (1 lizard, 2 birds, 3 mammals) and eight (2 birds, 6 mammals) were NT (Table 19.9).

Twenty (62.5%) traders sold at least one species of conservation concern (mean = 1.59 ± 1.79, range: 0–6, $n = 32$ traders), which was significantly more than expected (Fisher's exact test $P = 0.067$). However, the proportion of traders selling a particular species was unrelated to its conservation status ($\chi^2 = 0.63$, d.f. = 1, $P > 0.1$; Table 19.2, Table19.9). Furthermore, species of conservation concern were not significantly more abundant ($\chi^2 = 1.37$, d.f. = 1, $P > 0.1$; Table 19.4, Table19.9) than species of LC.

19.4 Discussion

We provide the first quantification of the trade of animals for use in traditional medicine at the Faraday market in South Africa. Most animals traded were vertebrates, although significant quantities of marine molluscs were also on sale. We identified 147 species of vertebrate, most of which were mammals (41%, 60 taxa), followed by birds (36%, 53 taxa), reptiles (22%, 33 taxa) and a single species of frog. All together, this species richness constitutes *c.* 8.7% of the total

Table 19.9 Vertebrate species of conservation concern according to 2001 IUCN Red List Categories and Criteria version 3.1 that were traded at the Faraday market

Common name	Species	IUCN category	Number of traders	Number of parts
Reptiles				
Hawksbill turtle	*Eretmochelys imbricata*	CR	1	1
Sungazer (lizard)	*Cordylus giganteus*	VU	5	11
Birds				
Southern ground-hornbill	*Bucorvus cafer*	VU	3	3
Caspian tern	*Sterna caspia*	NT	1	1
White-backed vulture	*Gyps africanus*	VU	3	5
Great white pelican	*Pelecanus onocrotalus*	NT	1	1
Mammals				
Samango monkey	*Cercopithecus mitis* ssp.	VU/LC	2	2
South African hedgehog	*Atelerix frontalis*	NT	8	9
Ground pangolin	*Smutsia temminckii*	VU	2	74
Brown hyaena	*Hyaena brunnea*	NT	1	1
Spotted hyaena	*Crocuta crocuta*	NT	4	4
Unidentified hyaena	–	NT	5	5
Lion	*Panthera leo*	VU	3	3
Serval	*Leptailurus serval*	NT	2	2
African wild dog	*Lycaon pictus*	EN	1	1
Honey badger (Ratel)	*Mellivora capensis*	NT	1	3
Blesbok/Bontebok	*Damaliscus pygargus*	VU (Bontebok)	1	6

We did not identify marine organisms and invertebrates to a sufficient level to assign IUCN categories. See Table 19.2 for detail on the specific parts of the animal that were for sale. Note that the number of parts sold does not equate to the number of animals sold. In the case of the Samango monkey, there are two southern African subspecies, one of which is Vulnerable while the other is Least Concern. We could not distinguish between Bontebok (VU) and Blesbok (LC) skulls. We also include unidentified hyaena because both species in southern Africa are NT. *LC* Least Concern, *NT* Near Threatened, *VU* Vulnerable, *EN* Endangered, *CR* Critically Endangered

frog, reptile, bird and mammal fauna of South Africa (1,685 + species total). If frogs (128 species) are excluded, this percentage increases marginally to 9.4%. We separately quantified domestic animals, invertebrates and marine fishes. Parts of seven domestic animals were for sale, but generally only a few individuals of each species and from only a few traders. Therefore, they are likely to be relatively unimportant as a source of medicine. Of the fishes, sole (*Austroglossus pectoralis*) were the most abundant, followed by box fish and an assortment of dried marine ray-finned fishes that we were unable to identify. Marine molluscs, chiefly gastropods, were sold by about a third of traders and were abundant in the market ($n = 955$). We only documented two species of insect. One trader had a large (> 200) batch of CMR Bean Beetles (*Mylabris oculata*) (Table 19.4) while three traders had grasshoppers (*Taphronota*) for sale.

Species richness at Faraday was relatively high for a single source for traditional medicine in South Africa. In comparison to the 147 species of vertebrate that

were for sale at Faraday, Simelane and Kerley (1998) reported 44 species (eight reptiles, six birds, 30 mammals) being sold in 19 herbalist shops in the Eastern Cape Province of South Africa. Cunningham and Zondi (1991) examined the trade in animals for traditional medicine in KwaZulu-Natal Province and also review literature reports for South Africa. They report at least 79 species of vertebrate (18 reptiles, 16 birds, 45 mammals), excluding domestic mammals and various marine invertebrates and fishes. More recently, Ngwenya (2001) recorded 132 species of vertebrate (21 reptiles, 32 birds, 79 mammals) in trade across KwaZulu-Natal Province, of which 50 species were in high demand, especially vultures, chacma baboon, green mamba, southern African python, Nile crocodile, puff adder, striped weasel and black mamba. In these studies, mammals are the most commonly sold group, followed by similar numbers of birds and reptiles. At Faraday, mammals were also the most commonly traded group, but we found a higher proportion of bird species than reptiles. In contrast to these studies, Herbert et al. (2003) focused on the invertebrate trade at a large traditional medicine market in Durban. They report a much greater diversity of marine invertebrates (seven phyla compared to four phyla in our study), which can be explained in large part by Durban's coastal location.

The second-order jackknife estimator (Jack 2) predicted that 233 species (an additional 86 species) could be identified with further sampling in the Faraday market over time (Fig. 19.4, Table 19.6). Based on the Jack 2 estimate, the Faraday survey has identified 63% of the total number of species recorded in South Africa to date. Given that samples should aim to record 50–75% of the total richness in a region (Heck et al. 1975), we believe the sampling strategy and the number of traders interviewed to be sufficient and representative. However, estimates of species richness at traditional medicine markets are always conservative because of the large proportion of unidentified material. Of the 3,716 animal parts documented at Faraday, 42% were not identifiable at the level of order, 45% not identifiable to family and 53% not identifiable to species. Most (41%) of the unidentified animal parts were various mammal bones and teeth, while 72% of the fish and invertebrates could not be identified at the level of order, 79% were not identified to family and 87% could not be identified to genus. Therefore, species richness is likely to be higher than what we report here since we took a conservative approach to estimating species richness and diversity by not including "morphospecies" in the analyses (i.e. typological species that could only be identified as mongoose sp., monitor sp., owl sp., etc.). A consequence of this action was a reduction in the total number of singletons and doubletons, variables that are usually positively correlated with diversity and estimates of species richness. The more singletons there are in a sample, the higher the diversity and the greater the total estimated species richness is likely to be. When we included the morphospecies in the analyses, the richness estimate generated by Jack 2 for all (All) vertebrates increased from 233 species (Table 19.6) to 289 species and the Jack 1 estimator predicted 247 species in trade. Hence, Jack 1 and Jack 2 can be viewed as good lower- and upper-bound estimators, respectively, of vertebrate species richness traded commercially in the Faraday market over time, including

opportunistically harvested species. In the absence of morphospecies in the analyses, however, Jack 2 was the only estimator that predicted (within three species) the total number of species that have been identified in South African markets to date. Williams et al. (2007c) also found that the Jack 1 and Jack 2 estimators were the best lower- and upper-bound estimators, respectively, of plant species richness at Faraday. Furthermore, the diversity and species accumulation curves were all asymptotic or near asymptotic respectively, indicating that further sampling would not significantly change the diversity index nor the species richness results with further sampling; hence, a sufficient number of traders were interviewed overall.

In general, there was little overlap in what animal species traders had for sale. Any two traders would generally have less than a third of their species in common and this number was also dependent on taxonomic group. For example, traders had about 33% of reptile species in common but only about 13% of bird species in common. Nine species of vertebrate were traded by more than 50% of traders, five of which were reptiles (rock and water monitor, Nile crocodile, southern African python, puff adder) and four of which were mammals (chacma baboon, Cape porcupine, vervet monkey, warthog). In the case of birds, there were relatively low numbers of any one species, with the exception of ostrich (44% of traders) and to a lesser extent, owls. A low abundance of any particular bird species coupled with relatively high species richness meant higher species diversity and evenness. By comparison, mammal and reptile diversity indices were lower because of the relative abundance of certain species.

Establishing the impact of traditional medicine on wildlife is notoriously difficult because traders are reluctant to reveal the source of their stock. At Faraday, we were unable to explore this issue and we only obtained a very rough estimate of the number of customers that bought animal parts per day, from 10 traders. Therefore, we had no data on the actual turn-over of specific species and the rate at which stock was replaced. In addition, many traders sell individual bones or pieces of skin making it impossible to determine how many individual animals are being traded in a particular market. For example, at Faraday, traders frequently sold small pieces of elephant skin. Only prohibitively expensive DNA analysis would allow an estimation of how many individual elephants were present in the market and such an undertaking might only be valuable for the most critically endangered species. Another confounding issue is that because traders are also willing to use animals recovered dead from the wild (death by natural causes or for example, by a vehicle) we also had no data on the proportion of live animals that were harvested from the wild specifically for traditional medicine. However, in one instance we observed a live hedgehog (IUCN NT) and a batch of recently killed Sungazer lizards (VU). Regardless of these constraints, we were still able to provide a crude assessment of the potential impact of the Faraday market on species of conservation concern by enumerating all parts belonging to threatened species. We documented a single CR species (Hawksbill Turtle) and one EN species (Wild Dog), both consisting of a single skull. The remaining 15 species of conservation concern consisted of a single reptile (VU), four birds (2 VU, 2 NT) and 10 mammals. Of the mammals, six horns were identified as belonging to either

Blesbok (LC) or Bontebok (Vulnerable). While the widespread distribution and greater abundance of Blesbok make them a likely candidate, we cannot exclude the possibility that one or more might be Bontebok. In the case of the Samango Monkey, we were unable to establish the subspecies, one of which is a threatened species. Of the remaining mammals, six were NT and two were VU. The 17 species of conservation concern all occurred at relatively low frequency (excluding pangolin, <4 parts/species). In the case of Pangolin, 74 scales were recorded which could potentially come from a single individual. Therefore, the trade of species of conservation concern at Faraday is unlikely to pose a significant threat to the viability of any one species. However, our study is a snap-shot in time and given the extensive country-wide trade in animals for traditional medicine, future monitoring is necessary to prevent over-exploitation of threatened species. This is particularly true for animals such as vultures, which are highly prized for traditional medicine, and which can and have been killed in significant numbers during a single event such as poisoning (Cunningham and Zondi 1991; Mander et al. 2007). While we need to respect the individual's need to access traditional medicine, it is in everyone's interest to ensure that these age-old practices are sustainable.

Acknowledgments This study was funded by a National Research Foundation grant to M.J.W. In addition, V.L.W. was funded by a Postdoctoral Fellowship from the University of the Witwatersrand during the write-up of this paper. We are very grateful to Tebogo Mothupi, Zuko Mafani, Mdu Seakamela and Simphiwe Khuluse for collecting a significant portion of the data presented here. We also thank Solomon Mvubu, chairman of the Faraday Traders Committee, and all the Faraday traders for their co-operation, without whom, this study would not have been possible. We are grateful for updated species counts for South Africa from Bill Branch (reptiles), Louis du Preez (frogs), Trevor Hardaker (birds) and Chris Chimimba (mammals). The protocol for this research was approved by the University of the Witwatersrand Human Research Ethics Committee (Medical) (Protocol M0500945).

References

Alexander G, Marais J (2007) A guide to the reptiles of Southern Africa, 1st edn. Struik, Cape Town

Barnes KN (ed) (2000) The Eskom red data book of birds of South Africa, Lesotho and Swaziland, 1st edn. BirdLife, South Africa

Begossi A (1996) Use of ecological methods in ethnobotany: diversity indices. Econ Bot 50(3):280–289

BirdLife International (2009) World bird database (WBDB). Cambridge. http://www.birdlife.org/datazone/index.html. Accessed 10 July 2009

Branch B (1998) Field guide to snakes and other reptiles of southern Africa, 3rd edn. Struik, Cape Town

But PPH, Lung LC, Tam YK (1990) Ethnopharmacology of rhinoceros horn. I: antipyretic effects of rhinoceros horn and other animal horns. J Ethnopharmacol 30:157–168

Bye SN, Dutton MF (1991) The inappropriate use of traditional medicines in South Africa. J Ethnopharmacol 34:253–259

Chiarucci A, Enright NJ, Perry GLW, Miller BP, Lamont BB (2003) Performance of nonparametric species richness estimators in a high diversity plant community. Divers Distrib 9:283–295

Cocks M, Dold A (2000) The role of 'African Chemists' in the health care system of the Eastern Cape Province of South Africa. Soc Sci Med 51(10):1505–1515

Colwell R (2006) EstimateS: statistical estimation of species richness and shared species from samples, version 7.5.1. http://viceroy.eeb.uconn.edu/estimates. Accessed 10 July 2009

Crump CM (2003) Need to assess animals used by traditional healers in South Africa. In: Williams VL (ed) Hawkers of health: an investigation of the Faraday Street traditional medicine market in Johannesburg, Appendix 4. Unpublished Report to Gauteng Directorate for Nature Conservation, DACEL

Cunningham AB, Zondi AS (1991) Use of animal parts for the commercial trade in traditional medicines, 1st edn. Institute of Natural Resources, Pietermaritzburg

Derwent S, Mander M (1997) Twitchers bewitched. The use of birds in traditional healing. *Africa: Birds & Birding* 2(1):22–25

Ehrlich PR (2009) Cultural evolution and the human predicament. TREE 24:409–412

Friedmann Y, Daly B (eds) (2004) Red data book of the mammals of South Africa: a conservation assessment. CBSG Southern Africa, conservation breeding specialist group (SSC/IUCN). Endangered Wildlife Trust, South Africa

Hanazaki N, Tamashiro JY, Leitão-Filho HF, Begossi A (2000) Diversity of plant uses in two Caiçara communities from the Atlantic forest coast, Brazil. Biodivers Conserv 9:597–615

Hayek LC, Buzas MA (1997) Surveying natural populations, 1st edn. Columbia University Press, New York

Heck KL, van Belle G, Simberloff D (1975) Explicit calculation of the rarefaction diversity measurement and the determination of sufficient sample size. Ecology 56(6):1459–1461

Herbert DG, Hamer ML, Mander M, Mkhize N, Prins F (2003) Invertebrate animals as a component of traditional medicine trade in KwaZulu-Natal South Africa. Afr Invertebr 44(2):327–344

Hockey PAR, Dean WRJ, Ryan PG (eds) (2005) Roberts birds of southern Africa, 7th edn. The trustees of the John Voelcker Bird Book Fund, Cape Town

IUCN (2009) 2009 IUCN Red list of threatened species. IUCN, Gland, Switzerland. http://www.iucnredlist.org. Accessed 24 Aug 2009

Kingdon J, Butynski TM, de Jong Y (2008) *Cercopithecus mitis* ssp. *albogularis*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. http://iucnredlist.org/. Accessed 10 July 2009

Lev E (2003) Traditional healing with animals (zootherapy): medieval to present-day Levantine practice. J Ethnopharmacol 85:107–118

Li YW, Zhu X, But PPH, Yeung HW (1995) Ethnopharmacology of bear gall bladder: I. J Ethnopharmacol 47:27–31

Ludwig JA, Reynolds JF (1988) Statistical ecology: a primer on methods and computing. Wiley, Toronto

McKinney ML (1997) Extinction vulnerability and selectivity: combining ecological and paleontological views. Annu Rev Ecol Syst 28:495–516

Magurran AE (1988) Ecological diversity and its measurement, 1st edn. Princeton University Press, Princeton

Mander M, Diederichs N, Ntuli L, Mavundla K, Williams V, McKean S (2007) Survey of the trade in vultures for the traditional health industry in South Africa, 1st edn. FutureWorks, Durban

Marshall NT (1998) Searching for a cure: conservation of medicinal wildlife resources in east and southern Africa, 1st edn. TRAFFIC International, Cambridge

Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ, Kloepfer D (eds) (2004) Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB Series 9. Smithsonian Institution, Washington

Ngwenya MP (2001) Implications for the medicinal animal trade for nature conservation in Kwazulu-Natal. Ezemvelo KZN Wildlife Report No. NA/124/04

Simelane TS (1996) The traditional use of indigenous vertebrates. PhD. Thesis, University of Port Elizabeth, Port Elizabeth

Simelane TS, Kerley GIH (1998) Conservation implications for the use of vertebrates by Xhosa traditional healers in South Africa. S Afr J Wildl Res 28(4):121–126

Sinclair I, Hockey P, Tarboton W (1997) Sasol birds of southern Africa, 2nd edn. Struik, Cape Town

Still J (2003) Use of animal products in traditional Chinese medicine: environmental impact and health hazards. Complement Therap Med 11:118–122

Skinner JD, Chimimba CT (2005) The mammals of the southern African subregion, 3rd edn. Cambridge University Press, Cambridge

Stuart C, Stuart T (2001) Field guide to mammals of southern Africa, 3rd edn. Struik, Cape Town

Toti DS, Coyle FA, Miller JA (2000) A structured inventory of Appalachian grass bald and heath bald spider assemblages and a test of species richness estimator performance. J Arachnol 28:329–345

White RM, Cocks M, Herbert DG, Hamer ML (2004) Traditional medicines from forest animals. In: Lawes MJ, Eeley HAC, Shackleton CM, Geach BGS (eds) Indigenous forests and woodlands in South Africa: people, policy and practice, 1st edn. University of Natal Press, Pietermaritzburg

Williams VL (2003) Hawkers of health: an investigation of the Faraday street traditional medicine market in Johannesburg. Unpublished Report to Gauteng Directorate for Nature Conservation, DACEL

Williams VL (2007) The design of a risk assessment model to determine the impact of the herbal medicine trade on the Witwatersrand on resources of indigenous plant species. PhD thesis, University of the Witwatersrand, Johannesburg

Williams VL, Witkowski ETF, Balkwill K (2005) Application of diversity indices to appraise plant availability in traditional medicine markets in Johannesburg, South Africa. Biodivers Conserv 14:2971–3001

Williams VL, Balkwill K, Witkowski ETF (2007a) Size-class prevalence of bulbous and perennial herbs sold in the Johannesburg medicinal plant markets between 1995 and 2001. S Afr J Bot 73:144–155

Williams VL, Witkowski ETF, Balkwill K (2007b) Volume and financial value of species traded in the medicinal plant markets in Gauteng, South Africa. Int J Sustain Dev World Ecol 14:584–603

Williams VL, Witkowski ETF, Balkwill K (2007c) The use of incidence-based species richness estimators, species accumulation curves and similarity measures to appraise ethnobotanical inventories from South Africa. Biodivers Conserv 16:2495–2513

Wilson EO (ed) (1988) Biodiversity. National Academy Press, Washington

Zug GR, Vitt LJ, Caldwell JP (2001) Herpetology: an introductory biology of amphibians and reptiles, 2nd edn. Academic Press, California