The Namib: Detritus and Fog Dependence

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Biome Setting

Location and Geography – The Namib Desert follows the coast of Namibia for approximately 2000 kilometers and varies in width from 80 to 200 kilometers where it meets the Namib Escarpment. Characterized by extensive dunes, the sands that make up these prevalent features are thought to be a consequence of erosional processes that take place within the Orange River valley and areas further to the south. As sand-laden waters drop their loads into the Atlantic, onshore currents deposit them along the shore. The prevailing southwesterlies then picked up and redeposit them in the form of massive dunes and a widespread sand sea. In areas where the supply of sand is reduced because of dunes inability to cross river beds, the winds also scours the land to form large gravel plains (Walker 1986).

Climate and Weather – This is a very arid region whose weather patterns are dominated by several factors. In winter, easterly trade winds crossing South Africa from the Indian Ocean lose most of their moisture due to orographic lifting as air masses rise over the Drakensberg Mountains. When this air drops onto the Namibian lowlands, adiabatic heating further dries the air, producing hot and dry easterly winds. During the summer, humid southwesterly winds, cooled by passage over the cold Benguela current, trapped below the less dense hot air from the east, form an inversion layer which, although creates no precipitation, is responsible for the formation of dense coastal fog. This fog, and the moisture it brings to the desert, is vital to support the biological communities of the Namib. Traveling inland, the fog is less pronounced; rainfall and both daily and seasonal temperature ranges increase, while conversely, precipitation variability decreases (Walker 1986) (Figure 1).

Native Plant and Animal Species and Communities

Flora – The primary characteristic of the Namib Desert is its lack of surface water and the impact that places on biological communities. Several ephemeral river valleys cut through the desert from the east, but rarely do they contain flowing water (Figure 2). Beneath the sands of the river beds, however, interstitial water is available for use by vegetation, making these valleys crucial to the existence of resident organisms. Within the valleys a number of plant species can be found; *Sporobolus robustus* and *Eragrostis spinosa*, perennial grasses, grow along the dry river beds. Within the riverbeds grow one of the dominant trees from the southern African savannah, *Acacia erioloba* (Giraffe Thorn). Also growing are *Acacia albida* (Ana Tree), *Salvadora persica* (Mustard Tree), and *Nicotiana glauca* (Tree Tobacco), an invasive from South America (Christy 2005).

Dune slopes also provide habitat for several other species (Christy 2005). Although these areas are very sparsely vegetated, grasses such as *Stipagrosti sabulicola* and *Stipagrosti gonostachys* are found, and within the areas between the dunes, *Arthraerua leubnitziae* (Pencil plant), *Zygophyllum stapfii*, (Dollar plant), and *Acanthosicyos horridus* (Nara melon) grow (Victor).

Gravel plains support a variety of lichens, and in some areas they represent the only type of vegetation present (Figure 3). Growing on rocks and soils, they provide color to an otherwise bleak landscape. Some forms are called *Wanderflechten*, or vagrant lichens, which differ from more common forms in that they are not attached to the substrate (Lange et al 1994).

Undoubtedly the most interesting flora found within the region is an endemic that has become something of a symbol for the nation of Namibia. *Welwitschia mirabilis* is a plant that seems to defy categorization. It has been identified as both an angiosperm and a gymnosperm, and may live over 2,500 years. Its two strap-like leaves and a short, convoluted trunk make it unique in the plant kingdom (Figure 4). It grows in a number of low washes and gravel plains where it is able to extract soil moisture through an extensive network of shallow roots (Henschel & Seely 2000).

Fauna – Deserts often have a distinctive distribution of fauna, and the Namib is no exception. The greatest diversity is found among reptiles that have adapted to the arid conditions. Within the Namib there are over 60 species, with 5 considered endemic; the *Ptenopus kochi* (Barking gecko) and the *Meroles cuneirostris* (Wedge-snouted sand lizard) are two of these. Rodents are also found within a variety of habitats in the region. *Eremitalpa granti* (Grant's golden mole) is found in dune areas where it "swims" through loose sands in search of food and *Gerbillurus tytonis* (Gerbil) are resident within the sparse vegetation of the gravel plains (Spriggs 2001).

Megafauna are much less common in the desert; only *Antidorcus marsupialis* (Springbok) and *Oryx gazelle* (Oryx) are frequently seen (Christy 2005). The lack of water has excluded most large ungulates from the region, but both of these creatures are highly desert adapted (Alden et al 2004). For example, if Springbok are able to browse on vegetation that has at least 10% water content, they can go indefinitely without drinking.

Oryx are the second most desert adapted African antelope (after the Addax, a beast of the southern Sahara), and with their diet of melon and wild cucumbers, they are able to thrive (Figure 5). Other less common hoofed animals include *Oreotragus oreotragus* (Klipspringer), and *Equus zebra hartmannae* (Hartmann's zebra). Some predators are also found. In grasslands and river beds is the *Acinonyx jubatus* (Cheetah), and along the coast *Hyaena brunnea* (Brown hyena) are common (Figure 6). Smaller, less specialized animals such as *Vulpes chama* (Cape fox), *Otocyon megalotis* (Bat-eared fox), and *Canis mesomelas* (Black-backed jackal) are widely distributed (Christy 2005) (Figure 7).

Avifauna is poorly represented in the Namib; only 180 species have been identified in the region, a small number given the area. Commonly seen is *Struthio camelus* (Ostrich), but owing to their large size, they may only appear to predominate. Within the Namib, however, there are six endemic species, three of which are larks (Perlo 1999). Most bird activity is associated with the coast where the availability of water is greater than in other areas (Spriggs 2001).

A large number of beetle species belonging to the family Tenebrionidae live in the region. These creatures are able to extract water from the atmosphere during the frequent fogs. In a process called "fog-harvesting", they tilt their abdomens into the breeze, and drink the water that condenses on their bodies (Seely 2004).

Primary Productivity and Limitations

As with other deserts, primary productivity is limited by a shortage of moisture. Certain areas, however, will at times experience significant moisture events that allow for seed germination. Heavy sporadic rainfall or localized river flooding from upslope precipitation can introduce water to areas that may have been dry for some time resulting in rapid productivity. It has also been observed that in extreme deserts like the Namib, local topography is responsible for the distribution and vitality of primary producers. Areas that serve as catchments and allow for infiltration of water to concentrate, raise average productivity beyond what it would be had no concentration taken place; if water is evenly distributed over the landscape and allowed to infiltrate, productivity will be lower (Noy-Meir 1985).

The distribution and density of grasses has been shown to be dependant on several factors. Primarily a function of rainfall which increases with elevation, it has also been determined that sand movement and the availability of intersticial moisture are limiting factors for growth. The moisture gradient within dunes is not well understood, but at lower levels compaction reduces intersticial voids and increases runoff; the upper reaches of dunes tend to be dryer, so the result is greater grass density along the mid portion of dunes (Yeaton 1988).

Fog plays a significant role in the moisture regime of the Namib. It helps to support the limited primary productivity and in moderating temperatures it helps plants to avoid desiccation (Figure 8). But it is not beneficial to vegetation alone; a complex "fog web" is in place that reaches to the higher trophic levels (Seely 2004) (Figure 9).

Biotic Interactions

In a region with relatively low primary productivity, one may not expect to find the level diversity as in the Namib. There are several interesting components that serve to ameliorate what is otherwise an extremely harsh environment. Wind blown detritus has been found to be an important primary food source which has a tendency to collect on the lee sides of dunes, the bases of grass tufts, and at the bases of rocks. Generally consisting of small bits of plant, seeds, insect parts, and feces, detritus is a ready and nutritious source of food. As wind slows on the lee side of a dune this material is deposited. With dune slip-faces tend to be relatively stable, and this reliable food source, they have become a favored habitat and more densely inhabited than other microhabitats (Seely 2004). Tenebrionod beetles and fish-moths are the major detritivores and they, along with their eggs and larvae, function as a food source for other organisms (Figure 10).

The distribution of some plants is a consequence of a number of factors; seed dispersal, microhabitat, and competition each have a role in plant distribution and the communities formed. Variations in topography, substrate, and the availability of water within a limited area can in some situations dictate the makeup of plant communities; in other cases it would appear that these components of microhabitat are less of a factor. In the case of four coexisting plants (*Blepharis grossa, Petalidium setosum, Geigeria alata, and Geigeria oranativa*), the *Blepharis g*. and the *Petalidium s*. predominated in channels while both *Geigeria* were distributed regardless of microhabitat, indicating that abiotic factors play a diminished role in their distribution and that interspecific competition and seed dispersal strategies are more profound aspects of plant distribution (Gunster 1993). An interesting interaction can be found in areas inhabited by gerbils. As burrowers, they have the capacity to significantly alter their immediate environment. By digging they loosen otherwise hard packed soil, altering the moisture regime and providing opportunity for seedlings to take root. Thus, as a consequence of their activity, other organisms are able to take advantage of an area that would otherwise be unavailable as habitat (Louw & Seely 1982). Of course this has consequences for other organisms; wind carried seeds are trapped in this new vegetation and may germinate or act as a food supply for birds, small reptiles, or other rodents, as well as larger animals such as Oryx and springbok. In turn, the smaller of these animals become more easily accessible to predators such as raptors, jackals, and larger reptiles, and the larger for cheetah.

For some organisms, gender may also play a role in the likelihood of falling victim to predation. In the case of male tenebrionid beetles, increased surface activity that is a result of searching for mates can expose them to higher predation rates; as many as ten times the numbers of males taken as prey as females. Assuming a 1:1 male to female ratio at reproductive age, it appears that the smaller males are hatched in significantly greater numbers than females or that the number of males taken does not represent a significant portion of the population (Polis et al 1998).

Food selection appears to be important in the selection of habitat by some animals and the structure of the communities that they form. Both the *Gerbillurus tytonis* (Hairy-footed gerbil) and *Rhabdomys pumilio* (Striped mouse) show a preference and directly compete for nara melon; their niches however, do not overlap. In forming a sub-community of nocturnal gerbils and diurnal mice a larger community is developed with nocturnal predation of the gerbils by jackals and owls, and diurnal predation of mice by raptors and snakes (Hughes et al 1994).

Another striking example of a specific biotic interaction was viewed at the Cope Cross Seal Reserve. At this seal rookery *Arctocephalus pusillus* (Cape Fur Seal) provide a resource for large numbers of Black-backed jackals who scavenge among the seals. With few exceptions the seals appear to be oblivious to the jackals that travel among them feeding on the bodies of dead pups. Jackal density at this location was very high with dozens of individuals observed among several thousand seals. The jackals appear completely content; feeding, sleeping, and mating within feet of the much larger seals (Christy 2005).

Human Impacts and Management

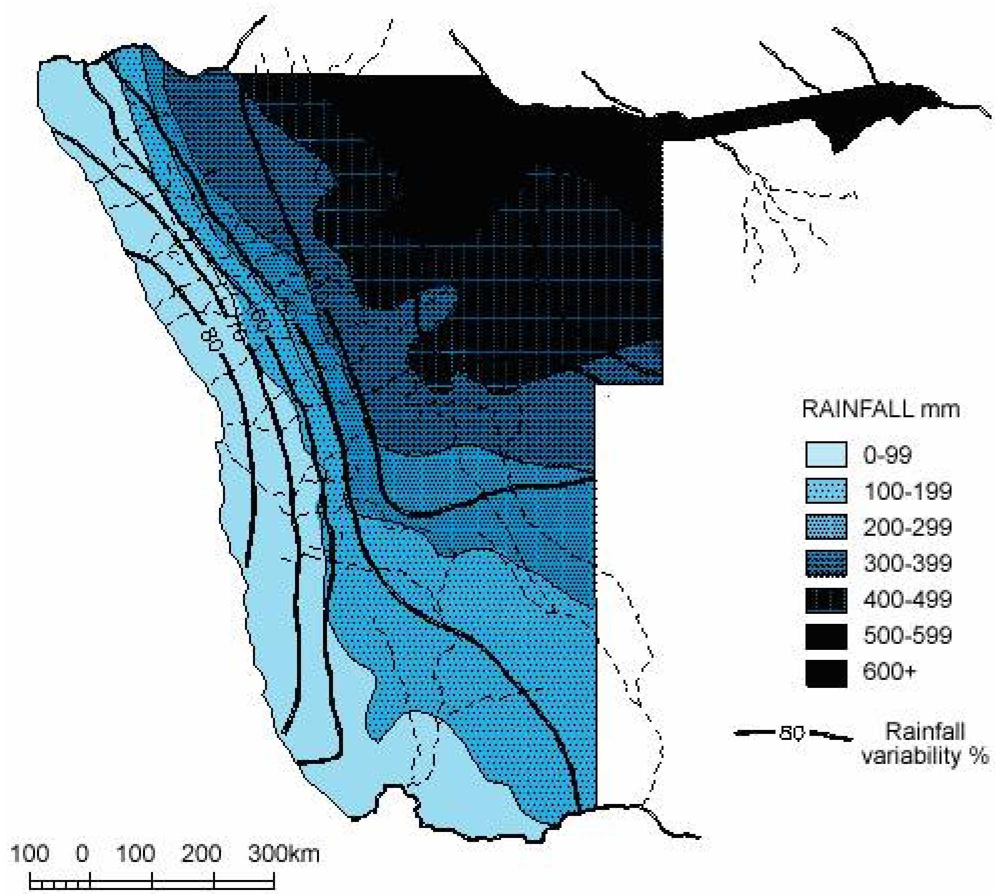
Namibia is the first nation on the planet to incorporate environmental protection into its constitution, and as a result, large areas of the country are protected from development or other human activities that may be environmentally harmful. As it stands, over 14% of the nation is protected, and many other areas fall under the stewardship of native conservancies. A majority of the Namib Desert lies within the Namib-Naukluft National Park where, unlike some other nations' parks systems, entrance is strictly controlled and limited. Non-government organizations working on conservation measures contribute a great deal in the way of scientific understanding to maintain ecologically fragile areas and in attempts to reinvigorate animal populations. Cheetah and rhino have been especially impacted by human activities such as poaching and poor agricultural management practices, but it would appear progress is being made. The Ministry of Environment and Tourism, the government department responsible for oversight, has shown that, with careful planning and the cooperation of local organizations, both man and the environment can benefit.

Several studies have been undertaken to identify levels of biodiversity and species richness in the region (Cumming 1999). Using this type of information it is hoped that not only scientific strides can be made, but that practical and efficient conservation and restoration methods can be developed (Burke 2000).

One significant step taken has been the creation of a research center in the heart of the Namib. A unique facility in Africa, the Gobabeb Training and Research Center provides training and research opportunities in science and technology specific to a hyper arid environment. Although biological and ecological disciplines remain the focus, building technology, water recycling, waste management, and energy efficiency methods have also been developed that have broad implications. Long term ecological research is also taking place in land management and agriculture (Henschel 2005).

There also can be little doubt as to the inherent fragility of desert ecosystems. Series of events and the location of the Namib have combined to create this unique environment that, despite its apparent hostility, nonetheless provides adequate habitat for a variety of organisms. Many of these organisms cannot be found elsewhere, making this place especially vulnerable to outside factors. It would seem, however, that the isolation and the difficulty of human habitation in the region, serve to provide a buffer against environmental degradation (Christy 2005).

Figure 1



Light blue areas indicate general location of Namib Desert Biome. Precipitation indicated by color and pattern. Dark lines indicate percent of rainfall variability from average annual rainfall. Broken lines indicate ephemeral streams. Modified from: Wardell-Johnson 2000. Biodiversity and Conservation in Namibia into the 21st Century (Spriggs 2001).

Figure 2

Typical Ephemeral River Valley
Sesriem, Namibia
Photo by Author

Figure 3

Lichen on Ventifact
Namib-Naukluft National Park, Namibia
Photo by Author

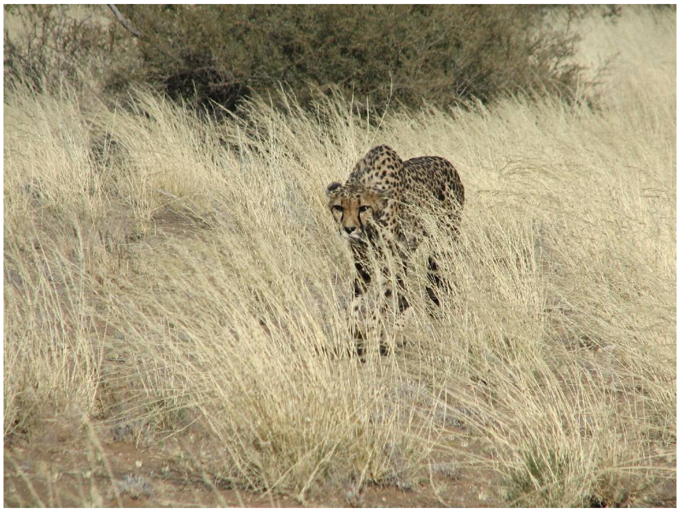
Figure 4

Welwetchia Mirabilis
Gogabeb Region, Namibia
Photo by Author

Figure 5

Orxy
Sossusvlei, Namibia
Photo by Author

Figure 6

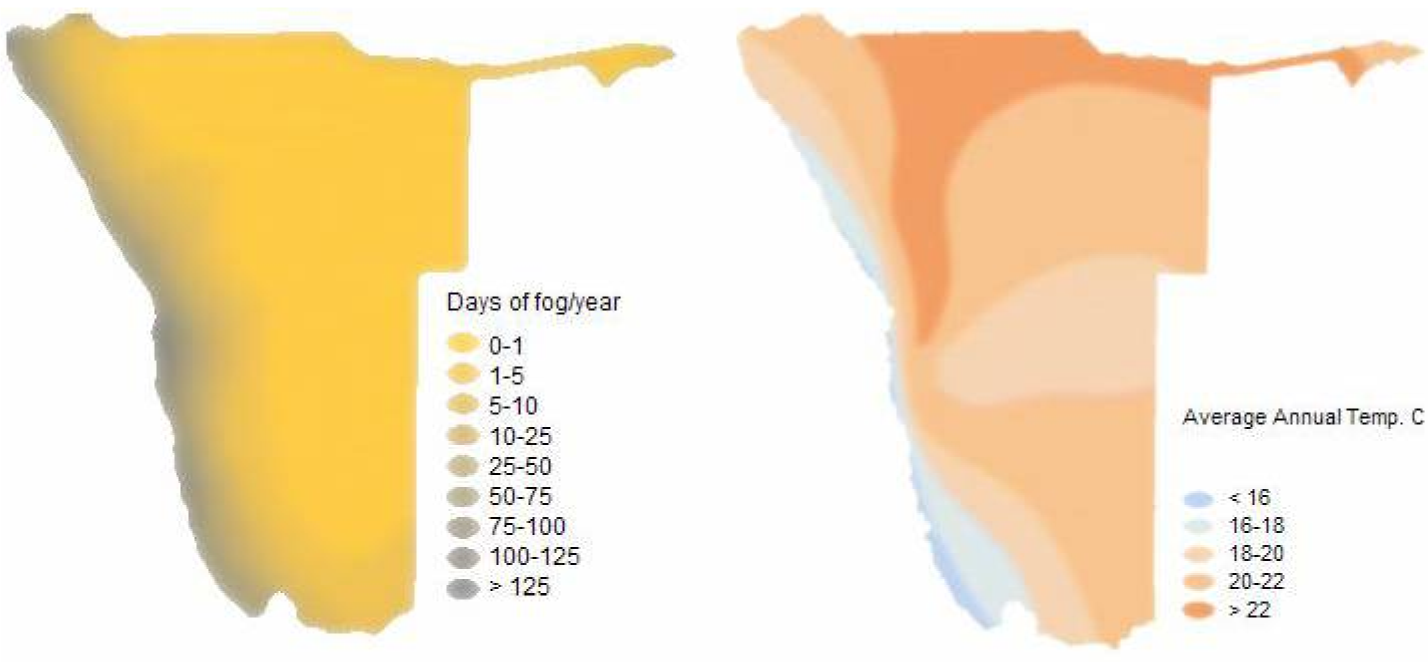


Cheetah
Keetmanshoop Region
Photo by Author

Figure7

Black-backed Jackals and Cape Fur Seals
Cape Cross, Namibia
Photo by Author

Figure 8



Maps showing number of days of fog per year and average annual temperature.
(Ministry of the Environment & Tourism – Republic of Namibia)

Figure 9

Fog Web

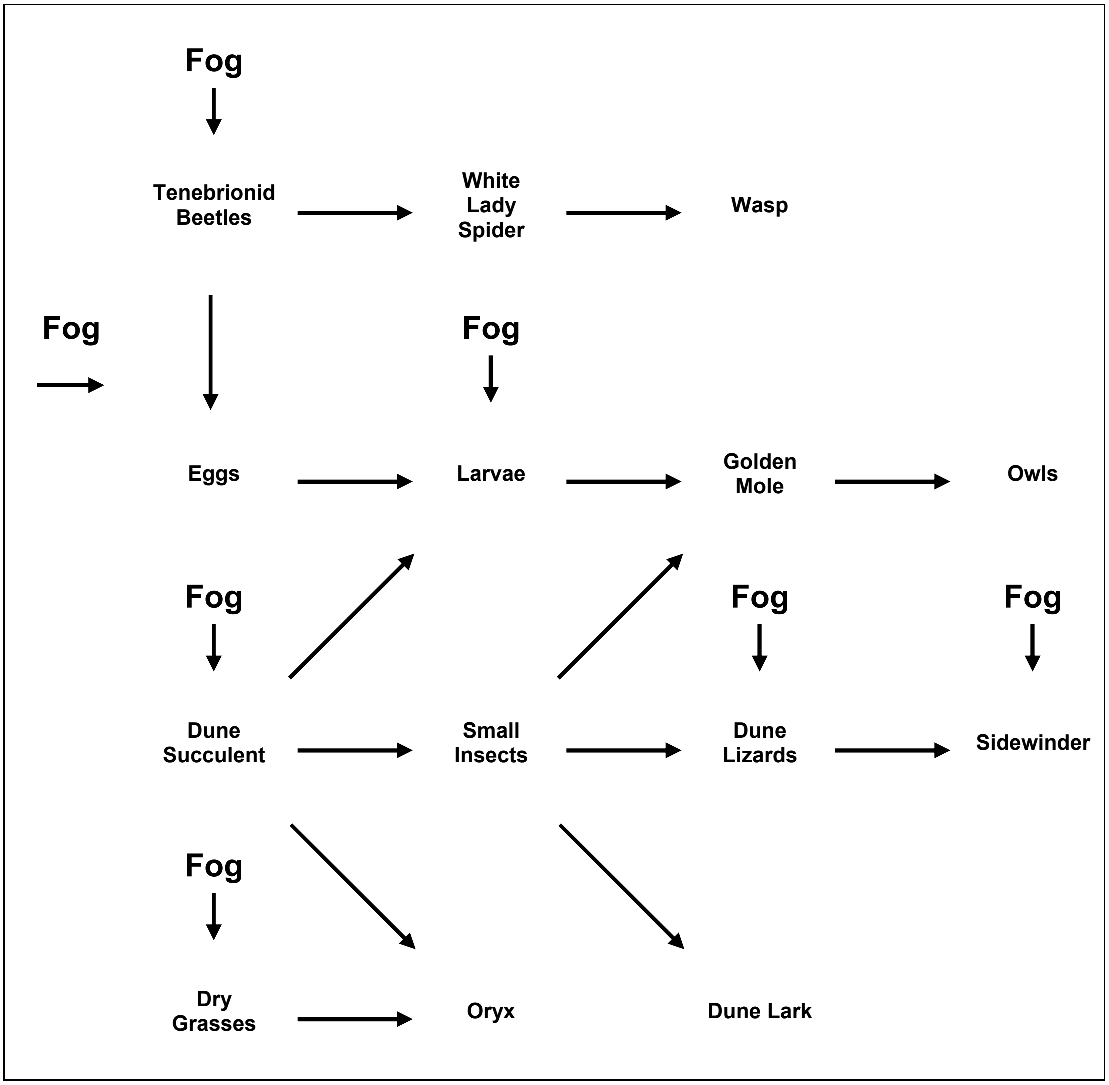
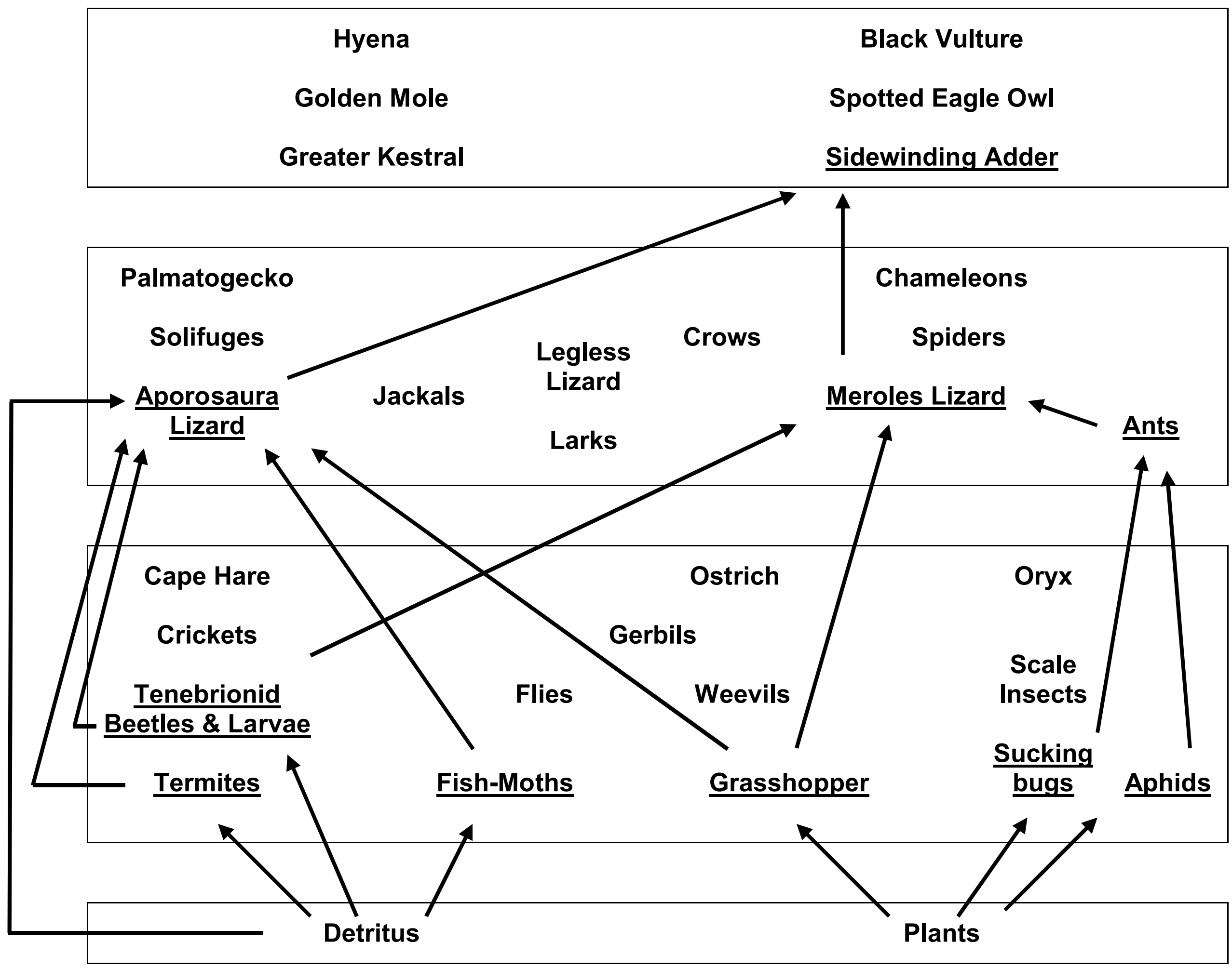


Illustration of Fog Web identifying some key relationships between fog, plants, and animals over a range of trophic levels (Seely 2004).

Figure 10

Food Web



Example of food web beginning with plants and detritus and shown ending with the Sidewinding Adder (Seely 2004).

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