

Conservation of amphibians and reptiles in Aruba, Curaçao and Bonaire

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Abstract. Curaçao and Bonaire form part of the Netherlands Antilles, while Aruba has a “status aparte” within the Kingdom of the Netherlands. All three islands are relatively arid compared to a typical Caribbean island, with mean annual rainfall of 409-553 mm, and experience several periods of drought lasting two or more years each century. A short history of the islands is given, and protected areas are described. The laws and regulations protecting amphibians and reptiles are complex, with general laws originating from the Kingdom of the Netherlands participation in international conventions (such as CITES) together with supplemental laws of the Netherlands Antilles and individual islands. Sea turtles are generally well protected, although their nesting beaches would be vulnerable to a rise in sea level. Among the terrestrial herpetofauna, only the Aruba Island rattlesnake (*Crotalus unicolor*) is on the IUCN Red List, being Critically Endangered. The status of this species and others of particular interest is described. The Curaçao Island snake (*Liophis triscalis*) should probably be included as Vulnerable or even Endangered, though there is insufficient information at present. *Iguana iguana* populations on the different islands, and the Curaçao whiptail (*Cnemidophorus murinus murinus*) on Klein Curaçao, are distinctive and significant for conservation. An overview is given of introduced amphibians and reptiles and their possible effects on the native fauna. The arid climate of the islands may hinder the establishment of invasive species, which are often not able to survive in the bush and thus reduces their impact on native species.

Key words: *Boa constrictor*; *Cnemidophorus murinus murinus*; *Crotalus unicolor*; drought; invasive species; Klein Curaçao; *Liophis triscalis*; Netherlands Antilles; *Osteopilus septentrionalis*; sea turtles.

Introduction

General ecology

The islands of Aruba, Curaçao and Bonaire lie in the southern Caribbean Sea. Their climate is rather arid compared to most Caribbean islands, with mean annual rainfall of 409, 553, and 463 mm respectively (Meteorological Service of Netherlands Antilles and Aruba, average 1971-2000), and mean temperature of about 28°C. The

hilly areas receive slightly more rain, and rainfall can be quite variable from year to year. Dry years have only 200-300 mm of rain, while the maximum is about 1100 mm. The dry season normally runs from March to June, and October and November have most rain; a dry year has a longer dry season. The period 1830-2004 experienced 12 extended dry periods; eight of 2 years, three of 3 years, and one of 4 years (1902-1905, when food importation from Venezuela was necessary). The last droughts were in 1986-1987 and 2001-2002. Mean annual rainfall was only 341 mm in Curaçao during these 12 extended dry periods.

The vegetation is typically xeric with candelabra cacti, opuntias, and acacias. At the end of long dry periods even the opuntia cactus starts to shrivel, the bush loses its leaves and becomes “transparent”, and emaciated iguanas cling to trees or fall on the ground. Soils are either of volcanic origin or calcareous — the latter can store water better and have a somewhat different vegetation. Aruba has lower rainfall and is more arid than the other islands, but also has less permeable soil so that pools of surface water (tankis) last much longer there.

Aruba, Curaçao and Bonaire together with the Venezuelan islands of Los Monjes, Islas Aves, Los Roques, La Orchila and La Blanquilla form an island archipelago north of the Venezuelan coast. Biogeographically, these islands do not belong to the West Indian region; their flora and fauna are mainly of South American origin (Wagenaar Hummelinck, 1940). However, there are many endemic and some West Indian elements, which justify the view that these islands form a small but distinct zoogeographical sub-region belonging to the South American realm. Several organisms introduced in the past turned out to be invasive species, some of which had detrimental effects on the local flora and fauna (van Buurt, 1999).

History and political structure

For general information on the history of Aruba, Curaçao and Bonaire see Hartog (1957, 1961, 1968). The earliest human remains on the islands, dating from 4500 years Before Present, were found in Curaçao. On the other islands the earliest are 4000 BP in Aruba and 3300 BP in Bonaire. These people are now termed Archaic Indians (Haviser, 1987). The Caquetío Indians, a tribe belonging to the Arawak language family, reached the islands from South America around 500 AD. The group “indios Aruba” were living in Aruba and the “indios Curaçao” in Curaçao and Bonaire. In 1499 the Spanish came to the islands, and the population was raided to get slaves for mines on Hispaniola. In 1634 the islands were captured by the Dutch who used Curaçao as a naval base to raid Spanish shipping and obtained salt, dyewood (*Heamatoxylon brasiletto*) and some “lignum vitae” (*Guaiacum officinale*). Later when the Dutch obtained the Asiento (a contract to deliver African slaves to the Spanish main), the island became a slave depot. Aruba was used as a horse farm by the Dutch West-India Company, and Bonaire produced salt. The introduction of slaves from Africa led to the development of Papiamentu, a Creole language with an African grammar with Spanish, Portuguese, Dutch and in more recent times also English words. The islands were occupied by the British from

1806 to 1816. During the colonial period the slave trade, smuggling, and salt were the most important economic activities, and some agriculture existed. Sugar was planted for local use in Curaçao, and to produce rum, but being too arid the island never exported sugar. Thus, it was not necessary to introduce the cane toad or the mongoose. In the 17th century indigo (*Indigofera tinctoria*), and in the late 19th and early 20th century aloë (*Aloe vera*) and sisal (*Agave sisalana*), were cultivated for export, but the islands were very poor (Renkema, 1981). In 1916 the Shell oil company started a refinery on Curaçao, and Standard oil of New Jersey started a refinery a few years later in Aruba, both to process Venezuelan oil, thus starting the modern age. In 1954 the islands became autonomous, and in 1986 Aruba seceded from the Netherlands Antilles; the “status aparte”. Nowadays tourism, the service sector, offshore banking, transshipment and bunkering, and oil refineries form the mainstay of the economy. Bonaire is almost totally dependant on tourism, especially dive-tourism.

Currently the Netherlands Antilles consist of the islands of Curaçao and Bonaire, together with the Windward Islands of St. Maarten (Dutch part), Saba and St. Eustatius. Aruba is a separate autonomous entity within the Kingdom of the Netherlands. Political negotiations on the future status of the other islands are presently being held. It has been agreed that these should result in a “status aparte” for Curaçao and St. Maarten, while the other islands Saba, St. Eustatius and Bonaire will maintain a more direct link with the Netherlands.

Nature Conservation Legislation

Legal system, constitution and nature conservation

According to the “Eilandenregeling Nederlandse Antillen”, 1954, which forms part of the present constitution of the Netherlands Antilles, nature conservation is a responsibility of the island governments. However, international treaties are a central government function, and in practice there is often some overlap of responsibilities. The same holds true for fisheries. Consequently the central government of the Netherlands Antilles has enacted general legislation to comply with international treaties, but where not constrained by treaties the islands are free to enact (or not to enact) their own nature regulations. Thus in addition to the central government laws, most islands have their own nature and/or fisheries regulations, which were often copied from one to another and thus similar, but in some cases quite different. Aruba as a separate autonomous entity is not hindered by these constitutional constraints, and has combined all nature conservation into one piece of legislation.

Treaties which are of significance for the conservation of amphibians and reptiles, of which the Netherlands Antilles (NA) and/or Aruba (A) are a party through the Kingdom of the Netherlands (N) are:

- CITES (N, NA, A).
- Cartagena Convention (NA, A) and SPAW protocol (NA).

- Inter-American Convention for the Protection and Conservation of Sea Turtles (NA).
- Convention on Biological Diversity (N, NA, A).
- Convention on Migratory species or Bonn Convention (N, NA, A).
- RAMSAR Convention (N, NA, A).

National legislation of a general nature

In the Netherlands Antilles the most important piece of nature legislation is the National Nature Conservation Ordinance “Landsverordening grondslagen natuurbeheer en bescherming” (PB 1998, 49; modified PB 2001, 41). The full text of this and other legislation described below (in Dutch, some with English translation) is available at the website: <http://www.mina.vomil.an>. This law follows CITES and the SPAW protocol and is the national legislation which enacts these treaties. In some respects this law goes further than CITES, which is applicable only to trade across national borders. Species listed under CITES Appendix I and the Annexes I and II of the SPAW protocol, and other species listed in the other treaties mentioned above, are automatically protected and cannot be killed or kept without a permit. Since the law refers to the CITES and SPAW protocol lists, new species added to these lists are automatically protected.

There is a national register of all captive specimens listed under CITES Appendix I, including captive native species. Illegal animals are confiscated and their holder is fined and/or jailed. Legal animals were either registered when the law was enacted, the offspring of registered animals, or were legally imported with proper CITES documentation. Aruba has the almost identical “Natuurbeschermingsverordening” (AB 1995, 2; modified AB 1997, 34) which includes species listed under CITES Appendix I and II. Thus in Aruba all sea turtles, *Iguana iguana*, and *Crotalus unicolor* are protected.

Fisheries laws

Sea turtles in federal waters outside the 12 mile zone are protected under the Netherlands Antilles Fisheries Ordinance or “Visserijlandsverordening” (PB 1991, 74) and the National Fisheries Decree or “Visserijlandsbesluit” (PB 1992, 108), which contains the actual fisheries regulations. These regulate fisheries in the waters of the Exclusive Fisheries Zone from ships larger than 12 m or 6 gross registered tons. Aruba has the almost identical “Visserijverordening (Aruba)” (AB 1992, 116; modified AB 1997, 34).

Island regulations on Curaçao and Bonaire

Other amphibians and reptiles not listed under CITES Appendix I are only protected under separate island laws. Thus on Curaçao and Bonaire *Iguana iguana* is not protected. Sea turtles within the 12 mile zone are protected under island regulations

on all of the Netherlands Antilles. In Curaçao sea turtles and their nests are protected under the “Eilandsbesluit bescherming zeeschildpadden” (PB 1996, 8) which is part of the Reef Management Ordinance “Rifbeheerverordening” (PB 1976, 48). In Bonaire sea turtles within the 12 mile zone are protected under the “Eilandsverordening Marien Milieu” (A⁰1991, 8; modified A⁰2001, 13).

Protected areas

Parke Nacional Arikok (Aruba). This park has a surface area of 34 km² and was established in 1997. A large part of the range of *Crotalus unicolor* is contained within its boundaries (Reinert et al., 2002). Persons who find rattlesnakes near their homes can call the park snake catchers who will release the snakes in the park. There are also some sea turtle nesting beaches within the park.

Christoffelpark and Shete Boca Park (Curaçao). The former is a large terrestrial park in the northwestern part of Curaçao, established in 1978. The adjoining Shete Boca Park runs along the northwestern coast, and has some loggerhead and hawksbill turtle nesting beaches. Most of the lands belong to the Curaçao island government and are managed by an NGO.

Washington and Slagbaai Park (Bonaire). A large park covering the northwestern part of Bonaire, established in 1968 and expanded in 1979. This park includes several sea turtle nesting beaches. Although this park was not instituted by island legislation it is nevertheless effectively protected by conditions that are incorporated into the title deeds to the lands, established by the will of one of the former owners and by the funding agencies which financed the purchase of additional lands.

Klein Bonaire (Bonaire). This 7 km² uninhabited island was added to the Bonaire Marine Park in 2001. There are nesting beaches of hawksbill and loggerhead turtles on the north and west coasts of the island. The island is protected under the “Eilandsverordening Marien Milieu” and also by conditions in the title deeds, established by the agencies which financed the purchase of the island.

Sea Turtles

Hawksbills, loggerheads, green turtles and leatherbacks are found around the islands. The olive ridley (*Lepidochelys olivacea*) is an occasional visitor or vagrant (Sybesma and Hoetjes, 1992). Hawksbills, loggerheads, green turtles nest on all the islands, including Klein Curaçao and Klein Bonaire. The leatherback (*Dermochelys coriacea*) nests on Aruba and has occasionally nested in Curaçao (Knip) and Bonaire (Lagun bay). In Aruba the nests of leatherbacks and other turtles are monitored and protected. These activities are part of the activities described in the WIDECAS/Sea Turtle Recovery Action Plan for Aruba (Barnes et al., 1993). A

similar WIDECAS/Sea Turtle Recovery Action Plan exists for the Netherlands Antilles (Sybesma, 1992).

An overview of nesting records for the Netherlands Antilles is given in Debrot et al. (2005). In recent years, turtles are seen more frequently than in the past (pers. obs.). Up to the early 1960's they were fairly common; in the 1970's they became increasingly rare, but recently populations seem to be recovering. This suggests that their legal protection (Bonaire in 1991, Netherlands Antilles in 1992, Aruba in 1995, Curaçao in 1996) and the regional projects to conserve them have had results. In Bonaire the organisation Sea Turtle Conservation Bonaire (formerly Sea Turtle Club Bonaire) has been instrumental in promoting sea turtle conservation through educational campaigns, cleaning debris from beaches and a satellite-tracking program in cooperation with WIDECAS (see www.bonaireturtles.org).

Rising sea levels will affect turtle nesting beaches. A study by Fish et al. (2005) on Bonaire indicates that a 0.5 m rise in sea level could lead to a 32% loss of existing sea-turtle nesting habitat. Some beaches will simply shift landward and new nesting habitat will be formed. This is not possible where the landward movement of the beach is impeded by physical barriers, or will result in changing characteristics of the beach, and thus a net loss of nesting habitat.

Terrestrial Reptiles of Special Conservation Interest

Table 1 lists the terrestrial amphibians and reptiles of Aruba, Curaçao and Bonaire, and the lesser islands of Klein Curaçao and Klein Bonaire, with their status as endemic, native or introduced. Those species of special conservation interest (all reptiles) are considered in detail below.

Aruba Island rattlesnake (Crotalus unicolor)

This is the only species of terrestrial herpetofauna on the islands currently included on the IUCN Red List (IUCN, 2004), where it is classed as Critically Endangered. In 1992 the American Zoo and Aquarium Association in cooperation with the Department of Agriculture and Fisheries in Aruba (DLVVM) published a Conservation Action Plan for the Aruba Island rattlesnake, updated in 1995 (Reinert et al., 1995). At the time field studies suggested a population of less than 225 adults, and indicated that mortality was quite high. Snakes were killed by goats, donkeys, cats, humans and cars. One of the results of the Conservation Action Plan was the establishment of the Parke Nacional Arikok in 1997. In recent years it appears that the population has recovered somewhat, probably as a result of the protection afforded by the new park, increased public awareness, and other conservation measures (Dr. H.K. Reinert, pers. comm.). DLVVM, the Aruba Veterinary Service and Parke Nacional Arikok also support research and projects to educate the general public.

Table 1. Terrestrial amphibians and reptiles of Aruba, Curaçao and Bonaire. E = endemic; Ep = E pluralis, endemic to more than one island; I = Introduced; N = Native; pN = probably native.

	Aruba 190 km ²	Curaçao 444 km ²	Klein Curaçao 1.2 km ²	Klein Bonaire 7 km ²	Bonaire 282 km ²
Amphibians					
<i>Pleurodema brachyops</i>	N	I		I	I
<i>Osteopilus septentrionalis</i>					I
<i>Eleutherodactylus johnstonei</i>	I	I			I
<i>Bufo marinus</i>	I				
Reptiles					
<i>Gonatodes antillensis</i>	I	N	N	N	N
<i>G. albogularis albogularis</i>		I			
<i>G. vittatus vittatus</i>	N				
<i>Phyllodactylus martini</i>		Ep		Ep	Ep
<i>Phyllodactylus julieni</i>	E				
<i>Hemidactylus mabouia</i>	I	I		I	I
<i>Thecadactylus rapicauda</i>	N	N			N
<i>Iguana iguana</i>	N ¹	N ¹		N ¹	N ¹
<i>Anolis lineatus</i>	Ep	Ep	I ²		
<i>Anolis bonairensis</i>				Ep	Ep
<i>Ameiva bifrontata</i>	pN				
<i>Cnemidophorus arubensis</i>	E				
<i>Cnemidophorus lemniscatus</i>	I				
<i>lemniscatus</i>					
<i>Cnemidophorus murinus murinus</i>		Ep	Ep ³		
<i>Cnemidophorus murinus ruthveni</i>				Ep	Ep
<i>Gymnophthalmus lineatus</i>			N	?	N
<i>Gymnophthalmus speciosus</i>	N				
<i>Tretioscincus bifasciatus</i>	N				
<i>Liotyphlops albirostris</i>		N			
<i>Leptotyphlops albifrons</i>					I
<i>Ramphotyphlops braminus</i>	I				
<i>Boa constrictor</i>	I				
<i>Leptodeira bakeri</i>	N				
<i>Liophis triscalis</i>		E			
<i>Crotalus unicolor</i> ⁴	E				

¹ Distinct populations.² Introduced 2 November 2005 by Dr. A.O. Debrot, CARMABI.³ Klein Curaçao population distinct.⁴ Critically Endangered.

Curaçao Island snake (*Liophis triscalis*)

The Curaçao Island snake must certainly be considered a highly vulnerable species, possibly even endangered, although it is not included on the IUCN Red List as no population studies exist on which to base such judgment. Many people still kill it, even though many know it is not dangerous. Politically it will be difficult to give

this snake legal protection; an educational campaign would certainly be needed to create support first. If the island develops further and more habitat is lost, its survival could well depend on the national park and other protected areas. This snake could also be vulnerable to an invasive species such as the corn snake (below) or African dwarf hedgehog (recently sold in local pet shops).

Cnemidophorus murinus murinus on Klein Curaçao

The 1.2 km² coral island of Klein Curaçao lies about 9 km southeast of Curaçao. A population of *C. m. murinus* is found there that differs from that on the main island (pers. obs.). Both sexes are smaller, and there is greater sexual size dimorphism. The colors of the males are more intensely blue-grey and the line near the eye in the males is usually broken up in a pattern of dots (fig. 1). The population is in good shape. The island receives a maximum of about 600 visitors a week and the lizards congregate near people and receive supplementary food. Goats were removed from the island in January 1998 and the vegetation, although sparse, has recovered considerably. Since *C. murinus* is a largely herbivorous lizard, the removal of goats has eliminated much competition for food. A population of feral cats was extirpated by Dr. A.O. Debrot.

Even so, any population of lizards found only in such a small area must be considered vulnerable. Most of the island is less than 2 m above sea level, with a maximum of 4.7 m in the east where there is a ridge of coral rubble. In the past the island had a low limestone ridge with a maximum height of about 7 m, but the island was mined for phosphates from 1871 to 1913 and the ridge was levelled (Stienstra, 1991). Klein Curaçao lies at the southern edge of the hurricane range and it is known that the island was completely swept by waves during the large hurricane of 1877 (Hendrikse, 2005). Part of the higher ridge still existed at the time. With sea levels rising due to global warming, a similar hurricane could be even more damaging now. Nevertheless, many even smaller keys with populations of *Cnemidophorus nigricolor* exist in Las Aves and Los Roques (Venezuela), that must have been subject to similar hurricanes in the past, yet these populations apparently survived.

Iguana iguana on Aruba, Curaçao and Bonaire

The iguanas on these islands are considerably smaller than those from the mainland, not exceeding 1 m in length (Marken Lichtenbelt and Albers, 1993; Marken Lichtenbelt et al., 1993), while the mainland iguana can reach a length of about 1.7 m. They are much less arboreal and behave more like ground iguanas. There are some differences between the iguanas on Aruba, Curaçao and Bonaire. In Aruba many individuals are found with the striped pattern on both the body and tail well developed; in Bonaire the stripes on the body are subdued and not clearly visible; while those from Curaçao tend to be in between (van Buurt, 2001, 2005). In the Curaçao iguanas dominant males have substantial blue on the head.



Figure 1. Upper: young male *Cnemidophorus murinus murinus* from Curaçao — note the lines on the head. Lower: male *C. m. murinus* from Klein Curaçao — note the dots on the head. These males also have a more bluish-grey colour (colour originals — see www.ahailey.f9.co.uk/appliedherpetology/cariherp.htm).

Iguanas are protected in Aruba, and are plentiful, almost garden pests. Iguanas are not protected on Curaçao and Bonaire, but are quite common and certainly not endangered. It is forbidden to use catapults, air guns and firearms on government

lands, and firearms are strictly regulated. Nowadays iguanas are hunted much less than in the past when the islands were very poor and iguanas were needed as food.

Introduced Amphibians and Reptiles

Species of amphibians and reptiles introduced on one or more of the islands are included in table 1. Their effects on the indigenous species, as far as can be ascertained, are described below.

Amphibians

Whistling frog. *Eleutherodactylus johnstonei* was imported with plants from Venezuela (van Buurt, 2001, 2005), to Curaçao in the 1970s, later on Aruba and Bonaire. It is dependant on gardens; the bush (locally called *mondi*) is too arid. Since the whistling frog cannot penetrate into the *mondi*, local species are not threatened by its presence.

Cuban treefrog. *Osteopilus septentrionalis* (fig. 2) has recently been introduced in Bonaire (van Buurt, 2005), with plants from Florida. It is too early to tell whether these frogs are also dependant on gardens. Since they climb trees they may be a threat to the endemic *Anolis bonairensis* and may also compete with them for food. They almost disappeared in the 2005 dry season, but some surely found refuge in gardens. There are few cisterns left since the advent of piped water, and there is now almost no standing fresh water to be found in the dry season. It is known that such cisterns are used by the Cuban tree frog in other islands (Meshaka, 2001). Bonairians were indignantly complaining that the Cuban tree frog had been seen to eat their local “Sapu di Boneiru” (Bonaire frog) *Pleurodema brachyops*. This frog was introduced in Bonaire in 1928 (below); however most people consider it a local species. *Pleurodema* is adapted to an arid environment and can survive two or three years of drought. It remains to be seen whether the Cuban tree frog can be a threat to it in drier areas away from gardens.

Cane toad. *Bufo marinus* was introduced to Aruba in the 1960’s from Colombia (van Buurt, 2001, 2005). It has negatively affected the populations of the local *Pleurodema brachyops*. The fact that it managed to establish itself on an arid island like Aruba indicates that it could also establish itself on Curaçao and/or Bonaire.

Four-eyed frog. *Pleurodema brachyops* was introduced in Curaçao and Bonaire from Aruba where it is native (Wagenaar Hummelinck, 1940). It seems to have occupied an empty ecological niche in these islands, and does not threaten any local species. In Curaçao it is now an extra source of food for *Liophis triscalis*. With the introduction of *Bufo marinus* on Aruba, *Pleurodema brachyops* is now more common in Curaçao and Bonaire than in its native Aruba (van Buurt, 2005).



Figure 2. Cuban tree frog *Osteopilus septentrionalis* on Bonaire. The Netherlands Antilles guilder has a diameter of 24 mm.

Reptiles

Cosmopolitan house gecko. *Hemidactylus mabouia* was introduced in Curaçao in the late 1980's; it is now found in houses all over the island. In Bonaire it came in around 2000, and in Aruba it was first reported (by Mikael Lundberg) in January 2002 (van Buurt, 2005). It is found exclusively in houses and gardens where it has displaced *Phyllodactylus martini* (in Curaçao and Bonaire) and to a certain extent also *Gonatodes antillensis*. It seems that *H. mabouia* cannot penetrate into the mondi or displace *P. martini* in this environment, but the reason is not apparent.

Rainbow whiptail. *Cnemidophorus lemniscatus lemniscatus* was first found in Aruba in 1953 (Lammarée, 1970). It is found only in the south-eastern part of the island, where it is not common. It competes with the Aruba Island Whiptail (*Cnemidophorus arubensis*), which also occurs throughout the same area and is very common. Within its general range the rainbow whiptail is found only in areas

with a more sandy soil, and seems able to compete only in these areas (van Buurt, 2005).

Boa (*Boa constrictor*). Boas have been regularly caught on Aruba since 1999, and in subsequent years their numbers have increased considerably. 273 *B. constrictor* were reported to and captured by personnel of the Arikok National Park and the DLVVM between April 1999 and December 2003. The Aruba Veterinary Service is also involved in efforts to eradicate boas and protect the Aruba Island rattlesnake. *Boa constrictor* is now an established species on Aruba (Quick et al., 2005). It is likely that they arrived with the pet trade, as was the case in Curaçao, where in previous years boas were reported quite regularly, but fortunately did not manage to establish themselves (van Buurt, 2005). In recent years CITES regulations started to be enforced by customs and nowadays sightings of boas are rare in Curaçao. In Aruba some specimens with white blotches are found, which points to a pet ancestry. The boa is very likely a competitor to the Aruba Island rattlesnake, and a new predator for the iguana. Planned research by Dr. Howard Reinert (College of New Jersey, USA) and R. Andrew Odum (Toledo Zoological Society) will follow boas by telemetry and use the information obtained to trap them more effectively.

Corn snake. *Elaphe guttata* nearly became established in Curaçao (Perry et al., 2003). Since 2001 corn snakes from North America were found on both Curaçao (2001, 2002 and 2003) and Bonaire (2002). In Curaçao they were all in an area called Kwartje where plants imported from Florida were stored. The snakes could also have been escaped or released pets as corn snakes had been sold by a local pet shop. Some were trapped and killed in February 2004 but no more sightings have been reported from the area since. Even so, we cannot be sure they were extirpated as corn snakes were almost certainly reproducing, several juveniles being found. It is conceivable that the Corn snake could be a serious threat to the endemic Curaçao snake. It is strange that a species with a normal range in temperate zones can survive and reproduce in a harsh purely tropical environment, although corn snakes are established on Anguilla which is fully tropical. They have also been reported from St. Thomas (US Virgin islands), Antigua and St. Barth's (Perry et al., 2003). Compared to these islands Curaçao is a more arid and a warmer island. Possibly the snakes came from southern Florida and were already adapted to a more or less tropical climate.

Flowerpot blindsnake. Several individuals of *Rhamphotyphlops braminus* were found at and near a plant importer in Aruba, reported by Mr. Facundo Franken of the DLVVM. The first snake was found in 2003 in an area called Bakval, near Malmok. Later on several more were encountered. This introduction probably will not have a detrimental effect as Aruba does not have any native typhlopids with which it could be in competition.

Discussion

Protecting against invasive species

The Department of Agriculture and Fisheries in Curaçao has developed a Power-Point presentation giving an overview of past introductions and their effects. More importantly, it describes the “alert species”; those that can pose a new threat to the flora and fauna of the islands, and which could conceivably come in. This presentation is used to increase awareness of this problem and is given to Customs, Aero-cargo and Department of Agriculture personnel, importers of plants, nature groups and the public in general. Examples of such “alert species” that could become established and which are likely to be a problem are; the opuntia cactus borer (*Cactoblastis cactorum*), agave borer weevils (*Scyphophorus acupunctatus*), fire ants (*Solenopsis invicta*), *Ganoderma zonatum* fungus on palms, and others. An “alert list” also includes species which have already established themselves on one of the islands, but can still be kept out of the others.

The “alert list” includes the following amphibians and reptiles: the cane toad, the Cuban tree frog, the boa, and the corn snake. Usually species are most affected by new species that compete with them, or by new predators. In the case of amphibians and reptiles, the most likely threats would often be other amphibians and reptiles. Of course, species like fire ants, if introduced, could also pose a threat to local herpetofauna. Then there is always the unknown; any new introduction could potentially have totally unforeseen consequences which could also affect amphibian and reptile populations. In my opinion new invasive species are potentially the most serious threat to local indigenous species of amphibians and reptiles. However, regulations regarding exotic species and/or “alert species” are still lacking on all three islands.

Influence of prolonged dry periods

Even though some parts of the vegetation of Aruba, Curaçao and Bonaire look very similar to the drier parts of some of the West Indian islands, especially during the rainy season, they are in fact much more arid. Not only is rainfall lower, the rate of evaporation is higher and extended dry spells occur. For example in St. Maarten the average annual rainfall is 1047 mm. The driest year on record (since 1879) is 1967, with 689 mm, which is still above the 553 mm average and more than three times the driest year in Curaçao (with 208 mm). In Anguilla, an island where both the Cuban treefrog and the corn snake became established (Hodge et al., 2003) the average rainfall is 1089 mm. The Cuban treefrog is also established on St. Maarten, (Powell et al., 2005). In these islands there is nothing comparable to the long dry periods occurring in Aruba, Curaçao and Bonaire. Any newly introduced species has to be able to survive such dry periods in order to establish itself on the islands permanently.

Bufo marinus survives in Aruba by burrowing under drip systems and potted plants in gardens and under the outlets of air conditioners (van Buurt, 2005). In

Aruba the tankis almost always contain water, and fall dry only at the end of very long dry periods. For some species this may facilitate survival, even though Aruba is even more arid than Curaçao and Bonaire. The corn snake arrived in Curaçao during the 2001-2002 dry period. It was found in gardens and in small plots of land irrigated for horticulture, where it stood out so that many were captured and killed. It is possible that survival of the corn snake would have been much better in years with a good rainy season, which would have enabled it to spread out and find refuge in areas with less human presence, where mortality would likely be lower. The extended drought may thus have had an important role in our being able to eradicate the corn snake.

Acknowledgements. Paul Ch. Hoetjes, Eric Newton, Facundo Franken and Dr. Howard K. Reinert provided comments and information.

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Accepted: July 17, 2006 (AH).