The habitat, threats and future of the African Chameleon, *Chamaeleo africanus* in Peloponnese, Greece

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Abstract

The African chameleon, *Chamaeleo africanus*, is widely spread in Africa but can only be found at one location in Europe – southwestern Peloponnese in Greece. The population is small, consisting of approximately 350 animals which makes it sensitive for changes in both the habitat and the population. This thesis aims to research the status, habitat and threats of *C. africanus* in the area. The chosen methods were literature studies and field work in Greece. Dominating vegetation species were researched in three areas; Divari beach, the habitat of *C. africanus*, Voidokilia Bay and Romanos beach, all sandy areas in connection to the Mediterranean Sea. The results show similarities in vegetation between the researches areas whereas Divari beach and Romanos beach are the most similar. There are many threats for the survival of *C. africanus*, for example; traffic, human activity and the habitat structure. A possibility could be to introduce *C. africanus* to other areas and more research is needed on the genetics of *C. africanus.* It is of importance to extend information and cooperation with local people, politicians and tourist to create an understanding which can help in the preservation of *C. africanus.*

Sammanfattning

Den afrikanska kameleonen, *Chamaeleo africanus* har en bred spridning i norra Africa men kan endast hittas på en plats i Europa – sydvästra Peloponnesos i Grekland. Populationen är liten och består av ungefär 350 djur vilket gör den känslig för förändringar i både habitatet och inom populationen. Denna avhandling har som syfte att undersöka *C. africanus* status, habitat, dess hot och framtid i området. Metoden bestod av litteraturstudier och en fältstudie i Grekland. Dominerande vegetationsarter undersöktes i tre områden; Divari beach, som är kameleontens habitat, Voidokilia Bay och Romanos beach som alla är sandiga områden i anslutning till Medelhavet. Resultatet visar att det finns en likhet i växtsammansättning i alla tre områden och att Divari beach och Romanos beach var mest lika. Det finns många hot för *C. africanus* framtid där bland annat trafik, mänsklig aktivitet och habitatets struktur är bidragande orsaker. En möjlighet skulle kunna vara att introducera arten till nya habitat och forskning krävs kring genetiken hos *C. africanus.* Det är viktigt att uttöka information och samarbete med lokalbefolkning, politiker och turister för att skapa en förståelse och trygga framtiden för *C. africanus.*

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Abbreviations

TCAP - The Chamaeleo africanus Project
HOS - Hellenic Ornithological Society
CITES - Convention for International Trade in Endangered Species
G.E.P - Google Earth Pro

1. Introduction

1.1 Background

Chameleons are a diverse group of slow-moving reptiles with a scaled body. There are almost 180 species and subspecies that all vary in shape, colour and size (Le Berre, 2009). Half of these species live on Madagascar and many species are connected to specific biomes with microclimates on which they depend for their survival (Le Berre, 2009). Their feet are well adapted for their sedentary life and gives the animals a good grip on the vegetation when feeding on insects with their long projectile tongue (Le Berre, 2009). Chameleons are often known for their independently moving eyes and the ability to change colour, which depends on specialized pigment cells in their skin (Le Berre, 2009). This is an adaptation to avoid predators which are relying on vision when hunting (Ricklefs, 2008) as well as for thermoregulation (Le Berre, 2009; Endler, 1978). As other reptiles chameleons are ectothermic animals that depend on the environment for adjusting their body temperature. Changing the colour of their skin can help controlling the body temperature (Le Berre, 2009; Hickman *et al.*, 2012). It is known that chameleons can inhabit many different types of habitats depending on the species habitat preferences but all species require solar energy and humidity to survive (Le Berre, 2009). The sun is needed for all ectothermic animals but the need for water is more important to chameleons than to other lizards. Most chameleons prefer a humidity rate between 65 and 80 percent (Le Berre, 2009).

Chameleons among other reptiles have long been popular to keep as pets (Bodson, 1984; Le Berre, 2009) which has given human the opportunity to study their needs and behavior. Since 1973, all chameleon species are protected by CITES, the Convention on International Trade in Endangered Species (Le Berre, 2009; CITES, 2014-06-10) as these species are not endangered today but may become so. All chameleons are listed in Appendix II and means that trading with these species is controlled (CITES, 2014-06-08). The global trade of chameleons was researched in 2003. Between the years 1977 and 2001, 845 000 exports were made, with Madagascar, Tanzania and Togo dominating the exports with 96 % of all trades. The biggest importer was USA with 69 % (Carpenter *et al.*, 2003).

1.2 *Chamaeleo africanus*

Until 1998 it was believed that there were only one species of chameleons in Europe - *Chamaeleo chamaeleon.* A new population of chameleons was found after seeing photographs of a big chameleon in the hands of a hotel owner in southwestern Peloponnese, Greece (Böhme *et al.*, 1998). The German herpetologist Wolfgang Böhme went to Greece in 1997 to study the habitat of the chameleons, only to discover that these chameleons could belong to a new species for the Greek herpetofauna (Böhme et al., 1998). In 1999 Böhme's *et al.* thesis was confirmed by Kosuch *et al.* (1999) by testing sequences of mitochondrial DNA and once again by Dimaki *et al.* (2008) who concluded the population to be closest related to specimen from the Nile Delta. The chameleons found on the Greek mainland was not *C. chameleon* as earlier thought but *Chamaeleo africanus*.

The African chameleon, *Chamaeleo africanus*, is common in both north and central Africa. It is widely spread from Mali in west to the Red Sea in the east (Böhme, 1985 in Dimaki *et al.*, 2008). In Europe it is still only found at one location, Divari beach in Gialova, Peloponnese (Dimaki *et al.*, 2000). The population's origin is unknown but human introduction is the most likely explanation (Böhme *et al.*, 1998; Le Berre, 2009) as it was common to keep reptiles in captivity in early Egypt, Greece and Rome (Bodson, 1984). The chameleons are often found in the dense shrubs and strands of *Phragmites* where they feed on arthropods (Dimaki, *et al.*, 1999) and from where they rarely move more than 1- 1,5 meters (Natura Hall, 2014).

The mating occurs in August for *C. africanus* and the males starts to actively search for a female to copulate with during this time (Le Berre, 2009). *C. africanus* is an oviparous species and the time for ovipositioning is in September-October, a time after copulation (The Chamaeleo africanus project, 2014-06-10). During these months females climb down to the ground and migrate to the beaches, often to the same place they were born themselves (The Chamaeleo africanus project, 2014-06-10). Here they dig a burrow in the sand and deposit a clutch of eggs which hatches 11 months later with juvenile chameleons that are not bigger than 3 centimeters. (Natura Hall, 2014; Le Berre, 2009; The Chamaeleo africanus project, 2014-06-10).

1.3 Problematic

Fluctuations within a population are common and can follow seasonal or yearly changes. These types of fluctuations in wild chameleon populations are a part of the population dynamics and can depend on birth and death rates, which often are directly or indirectly implicated by changes in the environment. For example; A change in temperature could cause an increase or decrease of food for the population (Le Barre, 2009; Ricklefs, 2008). The dynamics of small populations are becoming more relevant as human activities tend to fragment habitats into smaller and often isolated patches (Ricklefs, 2008). Although fluctuations are normal, the fragmentation of habitats is increasing which can cause limitation of movements within the habitat, followed by other negative aspects. For a small populations even smaller changes in the habitat can cause a decrease in population size or even extinction (Ricklefs, 2008)

The established Greek population of *C. africanus* is small with 350 adults counted in 2009 (The Chamaeleo africanus project, 2014-06-10). The Chamaeleo africanus project have been monitoring the population of *C. africanus* in Peloponnese at least since 1997 (The Chamaeleo africanus project, 2014-06-10) with the supervision of the Hellenic Ornithological Society (HOS). Members of the project have been securing and counting the nests and solving conflicts regarding a mobile beach bar "the Kantina" that have been located at the beach during summer time since 1998 (Maneas, 2014; Lymperopoulos, 2014). TCAP was terminated in 2009 due to conflicts with the supervisors at HOS (The Chamaeleo africanus project, 2014-06-10). Since the abortion of the project there are no information about the population's size or status.

1.4 Aim of the study

This study aims to research the possibilities of maintaining a stable population of the *C. africanus* in Peloponnese. *C. africanus* is a unique species for the Greek herpetofauna and a part of the ecosystem in Peloponnese. This thesis could create a better understanding of *C. africanus* way of life, habitat preferences and how human activity can affect the species. This is of importance when analyzing its future and creating a possible action plan.

Following questions have been guidelines for this study:
- What is the status of the African chameleon, *C. africanus* in Peloponnese?
- What threats are there and what does the future look like for the Greek population of *C. africanus*?
- Are there some possible actions to be made to strengthen the population?
- What does the habitat of *C. africanus* look like? Are there similar areas to in the surroundings and could these be inhabited?

1.5 Restrictions

As the study is made in Greece, there have been difficulties to take part of all the information available due to limitations in language and translation. Research of the Greek legislation and its methods for preserving species would have been interesting to include but have been excluded due to difficulties of finding information that is not in need of translation. The studies in field could also been extended and more detailed if there had been more time for field work and preparations. The vegetation study have been made only on the most dominating species as my knowledge of Mediterranean species is limited and a more detailed vegetation study would have needed more time and help.

2. Method

This study is made with two methods; literature studies and field observations. These methods were selected due to time and already available resources. As the study researches the status, threats and future of the *C. africanus* in Greece, it was necessary to find articles and literature that could provide me the basic information concerning *C. africanus*, its habitat preferences and the present situation in the area. To help analyze the possible future and occurred events I studied population dynamics and the ecology of how species interact with each other and their environment.

2.1 Literature studies

The literature studies begun in the end of April, 2014, preparing for field work and the following analysis. I wanted to know more about the African chameleon before studying their habitat in Peloponnese. “The Chameleon Handbook” (Le Barre, 2009) provided the basic information needed about chameleons and their different behaviors and habitat preferences. Thereafter I read articles of studies made about the small population of *Chamaeleo africanus*

in Greece, some of them written by people who have done several studies on *C. africanus* as well as other chameleon species. Many articles were found when first searching for information about *C. africanus* on the internet and other literature was found in the reference lists of these articles.

I have strived towards objectiveness in this study but sometimes failed due to limited information about the present situation in this area. The website of "The Chamaeleo africanus project" have been of great help for understanding the, in some ways, infected situation where field work have been done. The website is informative but the opinions are many and have not been given any part in this study. When reading this information, a critical view have been of importance. Ricklefs' (2008) "The Economy of Nature" have been used as required reading in the university courses addressing ecology and involves interactions, disturbances, threats and distribution. A full list of literature used for this project can be found under "6. References" on page 18.

2.2 Field work

Field research was made in Peloponnese, Greece during one week in May, 2014 when staying at the Navarino Environmental Observatory, also known as NEO. During this time I studied the dominating vegetation types and floral species in three different areas, one of them being the habitat of the African Chameleon. The first two days were spent on Divari beach were the African chameleon have established the only European population. On this location I studied the type of vegetation that was dominating in the area and taking notes of how the habitat was structured. I also studied if and how the area was affected by human activity. Voidokilia Bay and Romanos beach were also researched for the composition of flora as well as the overall plan of the locations. The three locations were then compared to each other for similarities and differences.

In Peloponnese I also visited Navarino Natura Hall which is an exhibition center in Costa Navarino. This is a cooperation in which both Hellenic Ornithological Society (HOS) and Stockholm University, among others, take part in. At the center the visitors can learn more about the nature in the area and how the environment can be protected (Natura Hall, 2014). The visit at Natura Hall provided useful information about *Chamaeleo africanus* and its habitat.

During my stay in Greece I came in contact with Giorgos Maneas and Nikos Lymperopoulos, who both have been working with the TCAP. Nikos Lymperopoulos was supporting the project in many ways during several years and Giorgos Maneas was working as a project manager for a different project called "Conservation and Awareness in Gialova Lagoon, a Natura 2000 area" between 2010 – 2012 and supporting and helping TCAP when needed. They both provided me with relevant information which answered many of my questions during this study.

Fig. 1. *The habitat of Chamaeleo africanus is situated between Navarino Bay (to the right) and Gialova Lagoon (to the left)*
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2.3 Study area

The research area consists of three different areas, one of them being Divari beach, the habitat of *C. africanus.* The habitat of *C.africanus* is oblong and consists of 20 ha and is situated between the beach of Navarino Bay and Gialova lagoon and just east of Koryphasion Hill (21° 40’ E, 36° 58’ N) (Dimaki *et al.*, 2009). The habitat lies within the borders of a Natura 2000 area (Natura 2000 viewer, 2014-06-16) which is a network of protected areas under legislation of the European Union (European Commission, 2014-06-18). These areas are constituted “to assure the long-term survival of Europe's most valuable and threatened species and habitats” (European Commission, 2014-06-18). The HOS have been working since 1997 to protect and promote the area around Gialova lagoon (HOS, 2014-06-11). Volunteers working with HOS arrange tours around the area of Gialova lagoon and a nature trail has been set up in the area to educate visitors of the surrounding nature and its species (Pylos, 2014-06-10). An established road runs along with the beach through the area to make the area accessible for visitors and residents.

Fig. 2 *Map of the area around Gialova lagoon, Peloponnese with the three studied areas. 1. Divari beach, 2. Voidokilia Bay and 3. Romanos beach.*
© G.E.P, 2014

Voidokilia bay is situated approximately 1 kilometer northwest of Divari beach beneath Koryphasion Hill (G.E.P, 2014) and 12 km from the city of Pylos (Voidokilia, 2014-06-12). This place is a popular beach due to its beauty and is surrounded by sand dunes. The area is also included in the Natura 2000 network of Gialova lagoon (Natura 2000 viewer, 2014-06-16).

Romanos beach is a 2.7 kilometer long (G.E.P, 2014) beach situated approximately 3.5 kilometers (G.E.P, 2014) from Divari beach and inside the borders of the Natura 2000 area (Natura 2000 viewer, 2014-06-16). The beach is located in connection to a large hotel complex, Costa Navarino. The hotel guest and local people are common visitors of the beach (Maneas, 2014). This area is also used by the loggerhead sea turtle, *Caretta caretta* for nesting and preservation work is done to protect the species and its nest on Romanos beach (Costa Navarino, 2014-06-14)

Fig. 3. *Left: Divari beach overviewing Navarino Bay.*
Fig. 4. *Right: The sand dunes around Voidokilia Bay.*

Fig. 5. *Romanos beach*

2.4 Measurements

All distances without other reference have been measured in Google Earth Pro (G.E.P.) v7.1.2.2019. Maps, coordinates and distances are all taken the 15th of June, 2014 and may not be exact.

3. Results

3.1 Vegetation study

The vegetation study of the locations Divari beach, Voidokilia bay and Romanos beach shows that there are similar species in the areas but the number of dominating floral species differs between the locations (**Table 1**). *Juniperus pheonicea* is represented in all locations as well as *Pistacia lentiscus* and one species of *Helichrysum* (Blamey & Grey-Wilson, 2004). Divari beach is the most diverse location according to this study.

Table 1. *A list of dominating species of flora in the three studied areas, Divari beach, Voidokilia sand dunes and Romanos beach (Blamey & Grey-Wilson, 2004). Species highlighted in green can be found at all three locations. Species highlighted in grey can be found at both Divari beach and Romanos beach.*

Location 1, Divari Beach	Location 2, Voidokilia	Location 3, Romanos beach
Ammophilia arenaria	*Ammophilia arenaria*	*Cakile maritima*
Anthyllis hermanniae	*Helichrysum sp.*	*Eryngium maritimum*
Eryngium maritimum	*Hordeum murinum*	*Euphorbia paralias*
Euphorbia paralias	*Juniperus pheonicea*	*Helichrysum sp.*
Helichrysum arenarium	*Juncus maritimus*	*Juniperus pheonicea*
Juniperus pheonicea	*Lagarus ovatus*	*Othanus maritimus*
Juncus maritimus	*Pistacia lentiscus*	*Phyllirea latifolia*
Myrtus communis	*Rubia peregrine*	*Pistacia lentiscus*
Ohtanthus maritimus		*Tamarix sp.*
Phragmites sp.		*Ulex sp.*
Phillyrea latifolia		
Pistacia lentiscus		
Quercus coccifera		
Smilax aspera		
Tamarix sp.		
Ulex sp.		

3.1.1 Divari beach - The habitat of C. africanus

The habitat at Divari Beach is a coastal area on sandy soil, connected to the Mediterranean Sea from Navarino Bay. The vegetation is varied with salt marshes, reed beds of *Phragmites sp.* and agricultural land but the dominating vegetation type is Mediterranean maquis, a dense and impenetrable scrub land (Dimaki *et* al., 2000; Natura Hall, 2014). The maquis in this area consists mostly of 2-3 meter tall bushes of *Juniperus pheonicea*, *Tamarix sp.*, *Quercus coccifera*, *Phillyrea latifolia* and *Pistacia lentiscus* (Blamey & Grey-Wilson, 2004).

When visiting the area in May, 2014, the beach is covered with drift wood and some litter. There are no signs of the beach bar “the Kantina”, which earlier have been a problem. According to Giorgios Maneas, the bar was closed and removed in 2012 after several complaints from HOS to the Ministry of Environment (Maneas, 2014). There are several traces of vehicles in the sand and the asphalt road running through the area separates the habitat in two. The road leads to a parking lot and continuing to the west as a gravel path. In connection with the parking, there is a sign describing the area as a part of the Natura 2000 network with a guide for visitors of the Gialova lagoon but without information of the chameleons in the area. The nature trail founded by HOS is hard to find as the path is overgrown and the signs are in need of restoration. The signs describes the different types of vegetation and some species that can be found in the area. *C. africanus* is shortly described in

one of the signs with basic information of the species.


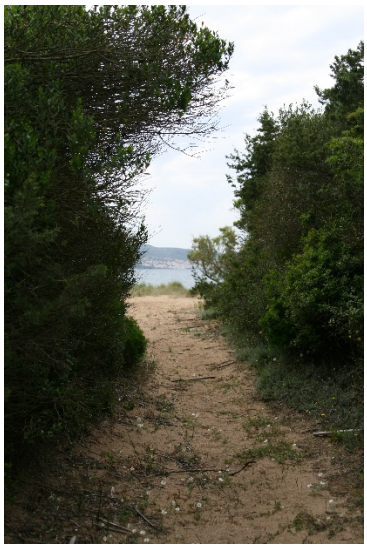

Fig. 6*. Left: The road running through the habitat of C. africanus at Divari beach.*
Fig. 7. *Right: Paths of sand going through the vegetation on Divari beach.*

The differences between the two sides of the road cannot be seen from the road as both sides are covered with the Mediterranean maquis (**fig. 6**) When walking in the dense vegetation closer to Gialova lagoon, the winds are mellow or even hard to detect and the ground is covered with *Juncus maritimus,* a grass which grows in tussocks (Blamey & Grey-Wilson, 2004). On the south side of the road, towards the beach, the winds are stronger which affects the vegetation. It consists of smaller salt and sand tolerant plants as *Eryngium maritimum* and *Otanthus maritimus* (Blamey & Grey-Wilson, 2004) without the ability to spread as much as *Juncus maritimus* (Natura Hall, 2014). Where the maquis bushes are not as dense there are small paths of sand going through the vegetation (**fig. 7**) which creates good nesting places for the chameleons in the sand piles on the sides (Natura Hall, 2014).

3.1.2 Voidokilia bay

In the sand dunes surrounding Voidokilia bay, the vegetation is sparse. Closer to Gialova lagoon, in the outer parts of Voidokilia, the sand dunes are high and the wind is weaker than on the beach. In this area the vegetation is more expanded with dense shrubs of *Juniperus pheonicea* and *Pistacia lentiscus* (**fig. 8 & 9**) (Blamey & Grey-Wilson, 2004). The densely vegetated area consists of a strip which is approximately 1 kilometer long and 50 meters wide. Most species are psammophytic and adapted to live in sandy soils (Korakis, 2006). Voidiokilia is known for its beauty and attracts tourist. Even if the beach is popular, the sand dunes surrounding it seem more undisturbed and lower in human activity than the beach.


Fig. 8 & 9. *Two specimens of dense growing shrubs of Pistacia lentiscus in the surroundings of Viodokilia bay.* © Veronica Johansson, 2014

3.1.3 Romanos beach

The 2.7 kilometers long beach is varied in both vegetation and usage. The sand is granulated and the beach is approximately 60 meters wide in most parts. The most southern parts of Romanos beach are low in disturbances from human activity and are almost unvegetated. The vegetation increases towards north and from the middle of the beach dense shrubs of *Phyllirea latifolia* and *Juniperus pheonicea* (Blamey & Grey-Wilson, 2004) lines the ending of the beach, separating it from the buildings of the hotel Costa Navarino (**fig. 10**). The sunbeds belonging to the hotel are placed in the middle of Romanos beach. The disturbances in this area are high as a result of the touristic usage of this part of the beach. The northern parts are again densely vegetated by high scrubs and other beach vegetation as *Eryngium martimum* (Blamey & Grey-Wilson, 2004). The northern part of the beach is covered with drift wood.

Fig. 10. *Left: The vegetation at Romanos beach creates a boundary between the beach and the hotel buildings.*
Fig. 11. *Right: View of the beach from the middle of the beach towards south.*

3.2 The threats of *C. africanus*

3.2.1 Habitat structure

A population lives primarily within a habitat that is suitable for that species. Fragmentation is a great threat for each population (Le Berre, 2009, Ricklefs, 2008) as it divides the habitat into smaller patches that are differently well connected to each other. This means that many populations are separated into subpopulations, a concept known as metapopulations (Ricklefs, 2008). Due to the factors dividing the population, the individuals in subpopulations cannot move between each other as frequently or good as they would if the habitat was whole (Ricklefs, 2008). The habitat of C. africanus is limited due to its placement in the landscape. Its oblong shape makes many parts of the habitat close to the habitats borders or the factors dividing it, for example, roads. These edges are more exposed to weather or predation (Ricklefs, 2008) which in the case of C. africanus consists of foxes, cats, dogs and snakes, among other things (Böhme et al. 1998; Natura Hall, 2014). Due to the road which separates the Divari beach habitat, the edges are several and forces the chameleons to move further away from their security in the bushes when seeking for a mate or a place for oviposition (Böhme et al., 1998). If individuals of a population are finding it hard to find mates or migrate in the habitat, this could lead to loss of genetic material (Ricklefs, 2008).

3.2.2 Human activity

The members of TCAP did not only see the road as a limitation for the population to relocate within the habitat. They witnessed that the increasing amount of tourist led to an increase of cars in the area. The cars were often speeding, resulting in road killed animals (The Chamaeleo africanus project, 2014-06-10; Dimaki *et al.*, 1999). In 2008 the project members positioned speed bumps on the road which made a big difference and leading to a decreasing number of killed animals. The road killed chameleons was 10 % in 2008 and after the speed bumps were positioned the number had decreased to 4 % the following year, considering a population size of 350 animals. (The Chamaeleo africanus project, 2014-06-10). The increasing number of cars is directly connected to the increase of tourists in the area, a development that in 2009 partly depended on a promotion campaign for the beach bar “the Kantina” (The Chamaeleo africanus, 2014-06-10). The rapid touristic development with

increasing human activity on the beach puts pressure on both flora and fauna (Böhme *et al.*, 1998).

To extend the beaches it is common to remove vegetation and nesting places of chameleons are in great danger of being trampled on as the amount of people on beaches are increasing (The Chamaeleo africanus project, 2014-06-10). During the summer months the threats are several against the chameleons and this is also the time when the chameleons are the most sensitive. Mating and oviposition demands that the chameleons migrate to each other or to sandy areas (Le Barre, 2009; Böhme, *et al*, 1998; The Chamaeleo africanus project, 2014-06-10). During hatching there is a great risk for the small (3 cm) newborn chameleons to be confused by lights, noises and therefore not make it to the safety in the shrubs (The Chamaeleo africanus project, 2014-06-10, Le Barre, 2009)

3.2.3 Species protection

A worry of Böhme *et al.* (1998) when visiting the habitat in 1998 was the legal protection of species. Originally the chameleons in Peloponnese was thought to be *C. chamaeleon* and if determining the species as *C. africanus* they would lose its protection in Greece and the world as *C. africanus* is common in Africa and not endangered (Böhme *et al.* 1998). CITES supervises the trade of endangered species and as *C. africanus* is not listed as an endangered species, there are no jurisdictions for not trading with this species but the trades are still controlled by CITES (CITES, 2014-06-08). The habitat lies within the borders of a Natura 2000 area and should therefore be protected to ensure a long term survival of protected species (European Commission, 2014).

4. Discussion

4.1 Vegetation study and habitats

The vegetation study was made to research the habitat of *C. africanus* in flora and composition for two reasons. One; for finding threats for the survival of this species and two; for researching if there were similar areas which could make possible habitats. The study was simple in is construction but showed that there are similarities between the researched locations Divari beach, Voidokilia bay and Romanos beach. Divari beach and Romanos beach are most similar in terms of dominating vegetation (**table 1**) but that Voidokilia would be easier to colonize due to the shorter distance to this location from Divari beach. All three areas are sandy Mediterranean coastal areas with access to much sunlight and are situated within 5 kilometers from each other (G.E.P, 2014). These factors are most likely the reasons for the similarity of the locations as many species are psammophytic and adapted to a life in sandy soils. This result means that more research of the sites is necessary to determinate weather Voidokilia Bay or Romanos beach would be suitable habitats for *C. africanus.*

In my opinion, neither of Voidokilia Bay or Romanos beach are optimal habitats for *C. africanus* as these areas also are small with many edges, popular among humans and are situated in areas which makes movement within the habitat problematic, to say the least. They

have many of the same problems that are a threat to the population at Divari beach. Voidokilia bay is a tourist magnet situated between the Mediterranean Sea and Gialova lagoon which makes the area limited in size (**fig. 4**). Romanos beach is instead big but most of the beach are used by human or is in close connection to buildings. These factors do not necessary need to be negative and further research could determine how they would affect *C. africanus* and if introduction to a new habitat could be an option to preserve the species in Greece.

Human introduction of chameleons is common (Le Berre, 2009) and other species have established stable populations in several places other than Peloponnese, Greece. The *C. chamaeleon* lives in many areas in southern Europe (Le Berre, 2009) and *Furcifer pardalis* can be found on small patches on La Réunion Island (Necas, 1999 in Carpenter *et al.*, 2004; Glaw & Vences, 1994 in Andreone *et al.*, 2005) though it is a species endemic to Madagascar (Carpenter *et al.*, 2004). Two species have also been introduced to the Islands of Hawaii, *Chamaeleo (Triceros) jacksonii xantholophus* and *Chamaeleo calyptratus* (Le Berre, 2009). *C. jacksonii xantholophus* was introduced on Maui in 1972 but have with human transportation spread to all of the Hawaiian Islands except Kaui (McKeown, 1996 in Chiaverano *et al.* 2014). As species from the genus *Chamaeleo* have the greatest range of habitats and it is common to find them in different types of habitats (Le Berre, 2009), it would be interesting to research if human introduction to other areas could expand the population and extend the genepool of *C. africanus* and therefore make the population in Greece stronger or more stable.

4.2 Threats of *C. africanus*

Already when Böhme, *et al.* (1998) discovered what was a new species for the Greece herpetofauna, they were concerned of its future. To protect the species, the suggestion was to immediately restrict human access to the area as the biggest threat for *C. africanus* was thought to be the tourism leading to more traffic, illegal campers and their dogs. The increase of cars was believed to be a danger for those chameleons who tried to cross the road for mating or oviposition in the sand (Böhme et al., 1998). Ten years later the increasing traffic was still a problem, mostly due to the visitors of the beach bar “the Kantina”. The members of TCAP, however, showed that small action can make big changes as building road bumps lowered the number of road killed animals, not just chameleons between 2008 and 2009 (The Chamaeleo africanus project, 2014-06-10). TCAP means that these results was achieved during a time when the promotion of “the Kantina” was high and traffic increased (The Chamaeleo africanus project). The results could be connected to other factors or a miscalculation of the population size, but the results are most likely connected with the efforts done by TCAP which could mean that other actions can give good results.

One solution could be to limit the presence of humans on parts of the beach during time when the chameleons are most sensitive, during mating, oviposition and the hatching of the eggs which occurs during tourist season. I do not believe that forbidding human activity during this time is a long term solution as it can lead to the type of conflicts that was a problem with “the

Kantina" and that caused the end of TCAP whose members worked for the preservation of *C. africanus.* Tourism is commonly an important source of income and to prohibit tourists from a popular beach due to protection of the chameleons could decrease its chances of survival. My opinion is that successful preservation work for *C. africanus* needs to be in cooperation with local people, politicians and tourists and to create an interest and a dialog for preserving *C. africanus*. To involve more people, restore the nature trail and in every way increase the knowledge of both the area and its species can benefit others than just *C. africanus.* There is also a need of investigating how the area around Gialova lagoon works as a Natura 2000 area and what

The information of *C. africanus* in its habitat at Divari beach is minor. There are no signs that makes visitors aware of the chameleons and therefore cannot be cautious when moving in the area. The nature trail was probably once a good source of information but since it today is overgrown and in an overall bad shape, it cannot be used by those who would need or want to use it. When visiting the habitat I got a feeling that the chameleons' existence was a secret as I was instructed not to tell anyone where I had seen specimens of *C. africanus.* I do not know if the absence of signs is intentional but regardless the reason, it can one be a threat for *C. africanus.* I can see why their locations are kept secret as the trade of chameleons is extensive in the world but *C. africanus* does not seem to be a popular species to keep in captivity according to both Le Berre (2009) and Carpenter *et al.* (2004). I believe that it is more endangering for *C. africanus* to hide it than to involve local people, tourists and politicians who can help with both preservation work and founding. TCAP have been worried that the preservation work is done in a way that could harm the chameleons, for example, the trampling around the nests when trying to do an inventory (The Chamaeleo africanus project, 2014-06-10), but in my opinion these things can be avoided with the right type of information and guidance.

There are several difficulties of trying to predict the future development of a species since a population can either be increasing, decreasing or stable (Ricklefs, 2008). In the case of *C. africanus* the population size is unknown since 2009 and needs further research and inventory to determine its size so that a proper action plan can be done. As the Greek population have lived and evolved far from the African population for a long time, there is a possibility that there could be genetic differences between these (Hickman *et al.* 2012) and that the Greek specimens could be a subspecies to *C. africanus*. To be able to protect the chameleons at Divari beach, further research regarding the genetic differences between the parted populations should be done. This could lead to both new protection by law and a greater cause for its preservation.

As populations are dynamic and in constant change, my recommendation would be to research the possibilities of starting a new project, similar to TCAP, for monitoring the chameleons at Divari beach. One thing to begin with could be to research if and how the removal of "the Kantina" has affected the area in tourism and the population size of *C. africanus.* Today's uncertainty of its status can be one of the biggest threats for *C. africanus* as it means that nothing is done to provide the help it might be needed for their future

prosperity and survival.

4.3 Sources of error

Time and translation have limited the choice of sources which could have affected the result and analysis of this thesis. The usage of the website of "The Chamaeleo africanus project" can be doubted as it is everything but objective. As explained in "3.1 Literature studies" this website contains information about the situation at Divari beach and has also the most recent population numbers I have found. I believe that these numbers have not been affected by the conflicts of TCAP and therefore are reliable. The population size should be more of an estimation as all specimens are hard to count and have probably increased or decreased since 2009 which makes more detailed analysis difficult. The field study was small and limited by my knowledge of Greek flora which makes is more of an addition for this thesis.

5. Conclusion

The protection of a small population as the one of *C. africanus* at Divari beach demands a thorough research of the populations' size and its interactions within the habitat. An awareness of fragmentation and the situation of *C. africanus* is of importance when trying to preserve this species as well as others. I believe that a cooperation between project members, locals and tourists is a must for creating an action plan for the preservation of *C. africanus* and the habitat at Divari beach.

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