

ISSN 0260-5805

HERPETOLOGICAL SOCIETY BULLETIN



**No. 27
Spring 1989**

KEEPING AND BREEDING OVIPAROUS CHAMELEONS

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INTRODUCTION

This paper presents basic requirements for the successful keeping of oviparous chameleons in the vivarium, based on long experience by the author. This is not to say that animals may not survive under differing regimes, but the conditions described here have been most successful in maintaining these animals in superb condition so that the full range of social behaviour can be observed, and also in obtaining regular captive matings and egg laying. Captive oviparous chameleons often do not dig a 'burrow' in which to deposit the eggs since proper facilities for nesting are not present in the vivarium. Such captive females often die without laying the eggs. Sometimes the eggs are dropped on the vivarium floor. These problems are totally unnecessary. Under the regime described below these problems have never been encountered, and the precise site of egg laying can also be controlled so that there is no problem in quickly locating the egg clutch for removal for incubation under controlled conditions.

Chameleons have a reputation for being 'difficult' vivarium subjects. This in my view is unjustified. If an attempt is made to understand their special requirements they can be as successful in the vivarium as most other lizards and infinitely more rewarding with their complex social behaviour and incredible repertoire and speed of colour change.

I kept my first chameleon some 35 years ago. It was a Common Chameleon (*Chamaeleo chamaeleon*) obtained as a three inch juvenile from a firm in the North-west - Robert Jackson. This chameleon thrived and grew speedily and most unfortunately was accidentally killed after about eighteen months. 'Casper', as I called him, firmly pointed me in the direction of chameleons, and I have never looked back. Food was a much more difficult problem 35 years ago than it is now in that only maggots and mealworms were available commercially. As outlined below chameleons have hearty appetites which must be catered for if they are to do well.

On the other hand the 'sandwich box brigade' of snake keepers will consider chameleons absurdly fussy about their surroundings. Whereas many snakes can be reared, live their lives, mate and produce fertile eggs, in turn producing healthy young, under the most 'unnatural' conditions, in sandwich boxes of varying sizes to allow for their growth, never see the sun (real or artificial), and be fed a monotonous diet, chameleons have a psychological need for a roomy environment with good light (natural sunlight wherever possible) and like to live among living plants, although many species prefer to rest on dead branches, a feature which is most noticeable in the 'giant' species. All my chameleons receive individual attention from me daily, as is described more fully under feeding below.

If one is prepared to devote time to them on a daily basis, to understand their psychological requirements, and to meet their hefty (and expensive) food requirements, they make fascinating vivarium inmates so completely different from all other reptiles.

This article is intended to be of practical use to both the beginner, who is about to embark on his first chameleon, and to the more advanced reptile keeper, who has so far either not got round to keeping chameleons, or would now like to attempt to breed them in the vivarium. By 'breed them' I do not merely mean having imported gravid females lay, but to rear the chameleons and have them mate on reaching sexual maturity and lay their eggs in due course. The real test, of course, is to raise one's own hatchlings and breed from them, an achievement so far restricted to only a small number of chameleon specialists.

Large numbers of chameleons are now being imported and it looks as if we could be in for the tortoise phenomenon all over again - 99.9% dead by the end of their first winter, largely due to ignorance of their requirements. Hence this article is timely, particularly as most accounts of chameleons in reptile keeping books do not give much *practical* advice,

nor do they indicate that the authors, with very few exceptions (e.g. Zimmermann, 1986), have practical experience of keeping/empathy for chameleons.

In a future article it is intended to deal with live-bearing (ovoviviparous) chameleons, a group which have also fascinated me from boyhood, and also with rearing the young in captivity. The requirements in this latter respect do not differ between those emerging from eggs and those that are born as baby chameleons.

CHAMELEON BIOLOGY

It is important at the outset to describe the special features of chameleons. The most remarkable of these are the eyes, the tongue and the remarkable colour changes undergone by many species.

The eyes. The eyes of chameleons are covered by skin except for a small opening over the pupil but the most amazing aspect is that they rotate independently, looking quite literally in two different directions at the same time, and they only come together when it is necessary to judge distance, as just before projecting the tongue to catch an insect. The lesson for the vivarium enthusiast is that chameleons are remarkably visual animals, and their surroundings in captivity should reflect this. They should be bright and spacious, and if possible well ventilated, but only if this can be provided without cold draughts. Many chameleons only feel secure when they think they are hidden from view among the foliage of a well planted vivarium. If they do not feel secure, feeding will either not take place, or be impaired.

The tongue. Chameleons have a very long, extensible, tongue, at least as long as the combined head and body length, which can be 'fired' very rapidly, and with great aim, to catch fast-moving insects on which chameleons predominantly feed. Food can also be picked up by protruding the tongue in the more normal lizard manner at food very close by, but this is only used for food within 1-2" of the mouth (depending on the chameleon's size). It also follows that chameleons do not lap water in the usual manner. In nature they lick droplets of dew or rain off leaves or occasionally 'fire' their tongues at drops out of reach.

Colour change. It is not possible to generalise about this among the approximately 90 different species of chameleons, but typically chameleons are greenish coloured, (some are always brown and never go green), and able to change from various shades of green to near black or whitish, with at various times, spots or blotches of different colours. Each species (and often each sex with a species) has its own repertoire of colours and this may even vary between individuals of a species. The habit of chameleons of remaining motionless for long periods of time, and the frequent tendency of the colour – in the absence of other over-riding stimuli – to blend in with the natural surroundings, means that they may be extremely difficult to see even in a well planted vivarium, i.e. that colour aids their camouflage. This trait certainly aids their survival in nature. But colour is also a reflection of their emotions (Common Chameleons, *Chamaeleo chamaeleon*, turn black with anger), and their sexual state, including, for instance, their readiness to mate, the fact that they are already gravid, that they are a territory holding male ready to mate, that they are a subjugated male and so on.

The feet. Chameleons have specially adapted hands and feet for climbing and holding on to branches. They prefer branches where the hands and feet can grasp the branch, so the size should be adjusted to suit the species. The toes of both hands and feet are divided into two opposing groups (three toes inwards and two outwards on the hands and three toes outwards and two inwards on the feet) fused for most of their length and ending in sharp claws.

The tail. The tail is usually at least as long as the combined head and body length, and in almost all species is prehensile, acting just like a fifth limb.

Movement. Chameleons are slow moving animals and very deliberate in their actions at all times. This behaviour also helps to camouflage them. Without their remarkable tongue they would never catch any food. Sometimes when moving they sway back and forwards. This is said to be imitating a leaf in the breeze (a side to side swaying movement, on the other hand, is part of female chameleon display, warning off another chameleon, often an amatory male).

Body shape and adornments. Chameleons tend to be laterally flattened, that is to have high sides and not be very wide from side to side. There is often a dorsal crest of some sort and the head is subject to adornment in many species either by the development of a casque covering the rear of the head (see plates), or by snout projections of some sort, culminating in the horns of some horned forms. Such snout appendages are usually lacking, or at least much reduced, in females.

OBTAINING YOUR CHAMELEON

Before obtaining your chameleon please read the section on 'Housing and Heating' and have the vivarium ready and adequately planted prior to the purchase. If you feel you cannot provide the very minimal requirements set out then please do not try to keep chameleons. Make sure also that you can cope with the food requirements.

Since breeding chameleons in captivity is a recent occurrence your chameleon will have been imported from the wild – should you be offered a captive bred juvenile, jump at it, of course.

In the wild many species of chameleons are solitary; those that are not, i.e. where several may share one bush, each have their own preferred basking and sleeping sites. Hence they do very badly under modern bulk collection methods where financial considerations seem to result in ever larger shipments. One must also consider how they are kept prior to shipment to Britain and of delays in getting them on to aircraft in Third World countries (where livestock is regularly offloaded in order to give the space to perishable fruit and vegetables!).

On arrival in this country the treatment they receive is critical. They have been jam-packed with many others of their kind, so they are 'upset'. They have also had nothing to drink for some time and are usually seriously dehydrated. They have also had no food. It is critical to rehydrate them before they may even consider food. The importers bundle them out to pet shops, who generally know nothing about their specialised requirements, and hope that they are sold before they die.

Of course, there are good importers, with modern facilities and 'know how' who rehydrate them individually on arrival, and set them up with a drip system so that they can drink at will, and who will also feed them well prior to despatch to retail outlets.

Since it is always better to get a good animal to start with, rather than try to get a poor individual back to health – and this is vital for the beginner – it is best to obtain your chameleons from the importer if at all possible, and to get them as soon as possible after their arrival in this country. There are a number of points to look for when choosing chameleons:

1. **The eyes.** These are a key clue to the animal's condition. *Animals with sunken eyes must be avoided.* This is not to say that these will necessarily die. They may do so or they may recover, but animals with sunken eyes include those that are 'irrecoverable', even to the chameleon expert, as well as those that are just badly dehydrated and which can recover under good husbandry regimes.

2. **The basal portion of the tail.** In chameleons which are in poor condition, such as those which have had poor feeding opportunities for a considerable time – they may have been collected in the dry season when food was scarce and then kept for some considerable time unfed – this area will be thin with longitudinal grooves clearly visible. I am not referring to the bulge at the very base of the tail, clearly noticeable especially on the ventral surface of the tail base in sexually active males, but more dorsally and laterally and also over a longer portion of the tail. In emaciated chameleons the dorsal tail region will have lost all its fat layer so that the tail vertebrae can be seen as can the spine along the animal's back.

3. **The animal should be alert (eyes open) and a good colour.** It is impossible to be precise about the latter point as colour varies so much between the species and also intraspecifically, but in a predominantly green species for example, select attractively marked, bright coloured individuals, not those that are drab or extremely pale or very dark.

4. **Do not select the largest individuals.** Rather select ones that are obviously juveniles. Large adults often suffer the most stress. Furthermore, juveniles will usually settle in much better



Sexual dichromatism in the Jewel Chameleon (*C. lateralis*), a male (larger, in foreground) being threatened by a gravid female in full gravid colouration.



A large male Oustalet's Giant Chameleon (*C. oustaleti*) being held by my eight year old daughter.



Mating position in *C. oustaleti* male colours are enhanced to reddish-brown to maroon in the breeding season



Female colouration in *C. johnsoni*. Note the typical orange markings on the head.



The vertical pale yellow bands indicate that this is a territory holding male of *C. johnsoni*.



Adult male *C. pardalis* in non-breeding season – drab colours, no green seen. The same individual as shown on the Cover Plate.



Female colouration in *C. pardalis*.



A young Flap-necked chameleon (*C. dilepis*) of the Tanzanian race, which almost doubled its length and quadrupled its weight in the preceding two months, displaying.

than large adults and are more adaptable. Large adults may anyway be old individuals, in an animal which may, even in nature in many species, be rather short-lived (compared to geckos for instance where longevities of ten years or over may not be unusual). Under proper husbandry conditions juveniles will grow extremely rapidly – they can double their size in a matter of months – and you will have the added advantage of seeing them develop, including changes of colouration to the adult pattern, often markedly different from that of juveniles.

Price is unfortunately no key to quality with chameleons and may reflect merely how far they have been passed along the line.

Recently giant chameleons from Madagascar have been available from time to time. It may be better to gain experience first with more normal sized species, as not only will such giant individuals (which I keep) require much more space, but their appetites are prodigious, and must be catered for. Such 'giant' chameleons in my collection, measuring up to about 20" in total length, regularly, day-in day-out, take 7-10 final instar locust hoppers at a meal or their equivalent in crickets. This can be expensive to provide if purchased (say 70/individuals per week) or time consuming to breed in sufficient quantities.

HOUSING AND HEATING

Chameleons are visual animals. As such they like roomy surroundings and do not like the feeling of being shut up in a box, i.e. solid walls on all sides except for a glass front. As a boy I designed an ideal chameleon greenhouse for the montane species from East Africa, *C. bitaeniatus* and *C. hoehnelii*, and this was also used for another montane species, *C. jacksoni* – all to be covered in the concluding article. This greenhouse, heavily planted to give maximum cover, had a glass front and roof (we get too much rain in Britain) but the sides were half height brick and the remainder fine wire gauze to create breeze and prevent over-heating. This greenhouse faced West. The plants provided good shade and there were no overheating problems in Scotland with the wire mesh sides. Copious supplies of food were always available and since *bitaeniatus* is not a quarrelsome species and *hoehnelii* has well marked dominant and submissive colours they did well as a sizeable colony. Young of both of these ovoviviparous species could be left in the chameleon greenhouse in the presence of regular large supplies of *Drosophila* and also house flies (*Musca*). I never observed any instance of cannibalism in these species, either in the greenhouse or in groups kept indoors for intensive study.

Such a greenhouse, ideal as it may be for such species, may not be within the realms of possibility. Furthermore, it has its drawbacks for species which are more or less solitary, and is totally unsuitable for very territorial species, as one cannot provide a greenhouse each and as long as sight contact can be maintained, conflict will continue. So that unless the greenhouse is very large, males will glare across at each other, and fights, with fatal consequences in some species, will constantly occur. Even where these are not lethal, constant challenges are very debilitating for the individuals concerned as they cannot escape – in nature such territorial behaviour serves to spread the animals out in the available habitat. Clearly such males must be housed separately and in such a way that they cannot see each other. Many species of chameleons do well housed individually just as many snake keepers keep their charges. The only problem is that of space, which may determine the number of chameleons that can be kept.

For an average-sized chameleon of say 8-10", I recommend a vivarium 3 feet long, two feet deep and four feet in height. A network of branches, size adjusted to the size of the inmates, so that they can grasp them with their hands and feet, should be arranged to utilise the area fully, and then growing plants added. For ease of cleaning out I prefer to grow the plants in pots so that they can be removed as necessary. The substantial food requirements of chameleons result in much faecal matter.

The substrate can vary with individual preference, plus whether or not egg laying is anticipated. If no breeding females are kept newspaper or paper towels can be used. I prefer bark chippings removed on a regular basis. Ordinary garden soil can also be used, preferably enriched with peat, and has the bonus that it can be kept moist and help maintain the humidity required by wet forest/rainforest species. I have had consistently good results using all three.

Where egg laying is expected, and a large area of moist soil is provided, any droppings which fall on this area can be removed manually without trouble.

Plants should be chosen so that they provide cover and also climbing facilities i.e. trees or bushes with stout branches. Some of the *Ficus* are ideal and like the warm, humid environment; others have such spindly branches as to be useless. *Camellia* do well as do *Magnolia* and have excellent climbing branches as well as large leaves which provide excellent cover as well as providing good surfaces for licking water droplets from. *Cissus antarctica* and *Rhombocissus natalensis* can both be grown to provide excellent cover and arranged over the dead branches. Both are vigorous growers.

Chameleons like good lighting conditions. Natural sunlight is unsurpassed due to its brightness and also UV content. The latter can perhaps be provided artificially, but it is difficult to simulate the brightness of natural sunlight. John Coburn (1987) makes this point well:

"When one considers that the intensity of light provided by a 40 watt tungsten bulb at a distance of one metre is only about one three-thousandth of that provided by the full summer sun, it can be seen that some difficulty will arise in finding a good substitute. Even the so called 'daylight' tubes provide only about one five-hundredth of natural sunlight intensity, while a high wattage mercury-vapour lamp will emit roughly one hundred and fiftieth. It is, therefore, an impossibility to artificially reproduce natural sunlight intensity."

For this reason I favour standing the large vivariums in a South, South-west or West facing window. This means, of course, that overheating has to be guarded against but the advantage of the bright light and sun provided to the animals far outweighs this. I am usually on hand during the key daylight hours, and, if absent, and it is a sunny day, I merely pull curtains over one half of the vivariums so that, although they will receive less sunlight during my absence, they are safe from overheating.

Artificial lighting is another factor in which choice has increased enormously in recent years. All my chameleon vivariums of the dimensions recommended above have a GEC (U.S.A. General Electric Company, not the U.K. company of the same name) two foot 'Blacklight' F20T12 situated high up but where the chameleons can sit close to it. They also have two x two foot or one four foot Thorn 'Artificial Daylight' tubes (which also have a UV output). Where two foot 'Artificial Daylight' tubes are used one is mounted high up and one at the middle height of the vivarium so that the animals get the maximum benefit. Where a four foot tube is used it is angled across the rear of the vivarium from top to bottom with care being taken to arrange the plants and branches so that there is a good emission close to where the chameleons can bask. Exactly as terrestrial sun-loving lizards will lie over a 'Blacklight' lying on the ground, some of my chameleons do likewise. The vivariums also have two spotlights, with fully adjustable mounts, generally mounted on a track so that they can be moved to suit the animals and the vegetation. The primary function of the spots is to provide warm basking areas. They, unlike the tubes referred to above, are controlled by a Microclimate thermostat (which dims the lights rather than putting them out). Hence, as the vivarium heats up, the lights do not go out, and the basking spots remain, but merely vary in intensity like the effects of normal intermittent cloud cover. The only time these actually go out is in bright sunshine when the temperature setting is exceeded. In the presence of sunlight they are redundant anyway. The thermostat is set at 84F (c29C) and the probe monitoring the temperature is suspended mid-way in the vivarium. All the lights are controlled by a time clock which switches them off at night. The 'Blacklights' and 'Artificial Daylight' tubes are on all day.

There is also a heater or heating cable in each vivarium, which for these, non-montane, egg-laying species cuts in to provide a minimum night temperature of 60-65F (c15-18C) depending on the species. It should be noted that some egg-laying chameleon species (e.g. *Chamaeleo chamaeleon* and *C. africanus*) are used to hot summers and cold winters and a quiescent period during the winter when temperatures should be allowed to fall to normal room temperature, and night time heating (unless the room is very cold) will not be required. An over-wintering temperature of 50-60F (c 10-15C) will be suitable. During this period the animals should be disturbed as little as possible and the vivarium moved out of the sunny window. Food should be offered whenever the animals appear active. This quiescent period will greatly increase the likelihood of breeding, as is known by snake breeders. The quiescent period will not, of course, be as long as our winter. A duration of 6-8 weeks will normally be adequate but can be extended if the chameleons remain inactive. As far as possible one should aim to copy the natural habitat of the species being kept, so as to provide a similar annual cycle

as well as daily temperature cycles. Extensive data on world meteorology is available at most Public Libraries. My own oviparous chameleons with night temperatures of 60-65 during the winter are all equatorial species. It is always a good idea not to treat the animals as severely as extremes of heat and cold which may occur in their natural habitat where they may have the means to ameliorate these in a way which is not possible in the vivarium.

The heating/lighting arrangement described above enables the chameleons to select temperatures between that of the background temperature (84F) and that attainable below the spots. Chameleons often do not orient as well to temperature as many sun-loving lizards, so it is important to have a basic vivarium temperature that is suited to the species concerned, and a background 80-84F is suitable as a day temperature for most egg layers (but see above). Any additional temperature required is then obtained by basking under a spot lamp. Many chameleons like high temperatures, a point that is usually overlooked in books dealing with reptile keeping. My *Chamaeleo lateralis* from Madagascar bask under the spots at temperatures of up to almost 40C on occasions, and regular basking under spots is a regular feature of the Madagascan giants – Oustalet's Chameleon (*Chamaeleo oustaleti*) and the so-called Panther Chameleon (*Chamaeleo pardalis*). After feeding I have noted a *C. pardalis* male, which in the breeding season has to be separated from another mature male, and at such times lives with my basilisks, not be content with the temperature high up in the vivarium (approx. 90F (32-33C) and to bask under a light bulb in order to raise its body temperature further. This individual is very tame and I have been able to record its rectal temperature without disturbing it – at 33.8C (92.8F), and this is a forest chameleon. Similarly my leaf chameleons (*Rhampholeon*) bask at temperatures of at least 33C.

It is crucial to *know* the range of available temperatures in the vivarium, which may be very different from what we *think* they are, hence one thermometer is totally inadequate. I have found the 'Maplin' indoor/outdoor thermometers excellent. They record max and mins (and 'remember' these) and show the current temperatures as a direct digital readout changed every 15 seconds and this can be switched to read either °F or °C at the flick of a switch. Each thermometer comes with one probe on a long cable so that the digital thermometer itself and the probe can each be used simultaneously to give constant temperature readings. The small probe is ideal for siting so as to give the temperature at a selected hotspot and can, of course, be moved around the vivarium with the minimum of disturbance at will in order to check on relative temperatures.

The materials from which the vivarium is constructed have not been mentioned. I stated at the outset that chameleons are visual animals liking light and space so an appearance of space is important. I use either clear plastic, which is glued together directly using plastic glue without any frame, or glass with minimum wood framing. The clear material is used for all four sides, making the vivarium very light. The appearance of space can be further enhanced by continuing the planting outside the vivarium on both sides. This also gives an additional feeling of security to the chameleons. The roof is generally made of plywood and has ventilation panels covered with fine gauze extending the total breadth of the vivarium and about six inches in depth. Finally, it goes without saying that chameleons should not be able to see chameleons in other vivariums.

FOOD AND FEEDING

I mentioned the prodigious appetites of chameleons in the Introduction. In the wild some species eat and digest several meals a day. Throwing some crickets into the vivarium twice a week will not be satisfactory for chameleons.

Chameleons, furthermore, will not feed if thirsty. So the first thing is to get the water regime correct. For those animals coming from humid forest areas I recommend spraying the vivarium twice a day. In nature there is often a heavy dew and chameleons drink at dawn before searching for food. It is good to emulate this in the vivarium. Much of the tropics has a rainstorm in the wet season in the heat of the afternoon and I provide this also. The vivarium should not remain damp but at the temperatures here recommended and with adequate ventilation this will not be a problem. Rather the vivarium may tend to dry out too quickly, and I sometimes use plants growing in deep moss to enhance the water retaining contribution of the plants and increase humidity. Typically chameleons lick drops of water from leaves. In captivity

they will also lick droplets of water from the sides of the vivarium, and many will also drink from a water dish, provided this is large enough and full to the brim. An ideal situation for a busy person who cannot have two 'storms' a day, is to instal a drip system, set up so that water slowly drips from the tube onto leaves at various heights, before ending up in the pot of one of the larger plants. Chameleons will quickly learn to lick the water drops from the end of the tube (provided this is positioned to give them easy access) and excess water dripping from leaf to leaf will increase the humidity.

Chameleons will also learn to drink from a hand held dropper. This can be useful when giving them medicine or vitamins. Tameless is a great advantage should an animal need treatment. I do not handle my animals unnecessarily but those that want such attention are always given it. For instance my largest *C. pardalis*, which is always hand fed, after some time always came to the front of the vivarium when it saw my approach. On opening the vivarium it at once comes to the front and if I hold out my hand it climbs onto this up my arm and perches, apparently very content, either on my shoulder or top of my head! I have never had a chameleon show such behaviour before. Remarkably another large male *C. pardalis* has also adopted this precise trait. Chameleons do not like to be grasped or have their bodies touched (nor do they like the water spray to land on their bodies when the vivarium is being sprayed). They should always be allowed to climb onto a hand rather than being grasped.

I strongly recommend food supplements, and vitamins should be given twice a week with the water. With chameleons it is a simple matter to hand feed these to them, either from a dropper and they will lick up the required amount, or to get them to gape their jaws, when the correct amount can be dropped in varying from 0.5ml for a small chameleon to up to 5 ml for a giant rain forest chameleon.

There is bound to be a marked drop in sunshine level for captives in Britain compared to their native countries. Some chameleons seem to suffer from this, especially on arrival, and your veterinary surgeon can get you calcium/vit. D tablets which may be useful. I have obtained chameleons in very poor shape and in time they have made a complete recovery. I consider that vitamin supplements and possibly the calcium/vit. D tablets played an important role in this recovery and that in the absence of any such supplements these animals would not have started feeding and merely starved to death (which chameleons can do very quickly).

Some individuals have been obtained in such poor shape that I have had to resort to getting them feeding by getting them to gape their jaws and inserting a freshly *killed* cricket or pink mouse. This was slowly chewed and if repeated with an insect(s) twice daily (pink mice never more than twice weekly, and only then for medium to large species) the animals often made a complete recovery and even went on to mate and lay eggs. Clearly great patience – and time – is required with such individuals initially.

The readily available books are generally unhelpful concerning food, making only very general statements. For instance Zimmermann (1986) says 'Insects, spiders' with the addition of 'pillbugs' (woodlice) for *C. jacksoni* and Coburn (1987) states 'a great variety of small invertebrate food'. Obst *et al.* (1988) says 'various arthropods are acceptable'. Mattison (1987) gives the best feeding advice. Coburn, Obst *et al.* and Mattison all stress the need for variety in the diet. This is an over-simplification. Of course all animals, ourselves included, thrive best on a balanced and *varied* diet. But chameleons need *bulk* in their diet also. In nature many species feed extensively or even almost exclusively on one or a small group of food items and will prefer these over all other food items. But chameleons are opportunistic feeders and will select from what is available. It is perfectly satisfactory for one or a couple of food items to make up 80-90 per cent of the total diet. Incidentally, none of the above books recommend pink mice for chameleons. As all snake keepers know mice are a superb food with all necessary supplements contained within them! They are a very good food for all chameleons large enough to accept them. Although my 'giant' chameleons can swallow half-grown mice, due to the fast digestion of food by the chameleons, I prefer to feed them smaller ones which are unfurred – pink rats as well as pink mice. These are well chewed by their powerful jaws and sharp teeth prior to swallowing. I try to give all large chameleons a pink mouse/pink rat twice a week. I once had a *C. africanus* which would take strips of raw meat caught on the tongue in the usual way. I found this out by accident when a piece of meat on a stick was moved past the front of its vivarium and it projected its tongue in an attempt to secure it. Pink mice are, of course, much preferable.

There are marked individual food preferences as well as interspecific ones.

Apart from pink mice my chameleons are fed mainly on four food items which together comprise 90 per cent of the diet: black field crickets (*Gryllus bimaculatus*), locusts (*Schistocerca gregaria*), house crickets *Acheta domestica* and the larvae of the waxmoth (*Galleria mellonella*). The first two of these items comprise at least two-thirds of the diet of most of the chameleons by weight and are hand fed. Waxmoth larvae are a treat which most chameleons are particularly fond of, and can often be used to coax a new arrival in poor condition into feeding. They are given about once a week. In addition to the above, blowflies, purchased as pupae which hatch in the vivarium, are provided from time to time. Again all chameleons are attracted to the newly emerged flies before they have expanded their wings. Mealworms are rarely given although readily eaten and provide under five per cent of the annual food supply by weight. Any other harmless insects which come to hand, including moths and butterflies, are fed to the chameleons.

Most locust hoppers and house crickets are liberally dusted with 'Cricket Plus' vitamin/mineral supplement prior to feeding. I find this excellent as the very fine particle size adheres superbly to the insects and it is, therefore, most economical to use and most nutritious.

I feed house crickets two or three times a week. They are ignored by some very large chameleons (all of which accept the much larger field crickets, *Gryllus bimaculatus*, but readily eaten by most. At each feed I deliberately over-feed as chameleons will feed throughout the day and *there should always be live food available*. I hand feed large field crickets (which are not coated in 'Cricket Plus') but any of the 'ration' not eaten are liberated in the vivarium for later capture and I see both sorts of crickets being taken throughout the day. Locusts I hand feed only but this purely reflects the damage that they do to the vegetation if left in the vivarium.

Under vivarium conditions both cricket species do well and live until eaten. Some food can be kept in a corner for them, and as John Pickett first pointed out to me, the *bimaculatus* crickets thrive under the same conditions as reptiles so make excellent vivarium inmates.

One word of warning. Chameleons do not like insects crawling over them, nor do they like their bodies to be touched. Hence excess food should always be kept within proportion. If it is so numerous as to become a nuisance and to be seen by them at all times they will not take it and may not feed at all.

STOCKING RATES

My personal preference is to keep several chameleons together wherever possible. Although they do well kept individually, one then loses the chance to watch their superb social behaviour, and I have not found any deterioration in their condition when several are kept together. This may mean that during the (restricted) breeding season only one male can be kept in the vivarium with the females or that males must be kept apart at all times. This depends on the species, and sometimes even the individuals, concerned. As an animal behaviourist, interested in their behaviour and ecology, I naturally prefer to keep them in groups. The best guide is to do this and remove individuals if there are problems.

By way of practical example, I have a male *lateralis* (from Madagascar) which has been with me for over a year now, which is very quarrelsome with other males, and tends also to 'harass' females. This male is, therefore, kept away from others of its own species. It lives with several adult *pardalis* for whom it shows scant respect, but at least it does not trouble them. The *pardalis* group includes two adult males which live together happily outside of the breeding season. When one male assumed breeding colours this situation persisted, but when the second male came into breeding condition and tried to show breeding colours, it was persecuted by the dominant male in often subtle ways, so that it tended to hide, was obviously unhappy, and was removed. Oustalet's chameleon, on the other hand, is a quiet species and seems perfectly happy with other adults of its own species of both sex and I have kept up to four together. This group includes two adult males which never quarrel even during the breeding season. There is no obvious dominance of one by the other, indeed both males successfully court and mate with the adult female, and this has happened on many occasions.

Males of *C. johnsoni* inter-act aggressively during the breeding season, but in a well planted 3 x 4 x 2' vivarium, as described, I have found that two males can live successfully with a number of females and avoid each other without stress. The possible encounters, where they fight with their three horns, only occur during the breeding season, when sexually active colours are 'worn', and one male will take on drab subjugated colours and any attacks will cease. Outside the breeding season both males are drabber coloured and no harmful interactions occur.

A further reason for my wishing to keep a number together when possible is that ideal sunny sites are limited and I want to make the best use of the best sites. In this connection chameleons can often be kept with other lizards, provided these are not too large, or too boisterous, and will not try to climb all over the chameleons – especially at the basking sites. As an example of ideal lizards to share a large chameleons' vivarium I have kept my Chinese crocodile lizards (*Shinisaurus crocodilus*) with my Oustalet's chameleons. There is no interaction. Although the crocodile lizards climb the branches they do so slowly and deliberately in a way that does not disturb the chameleons and they do not bask under the spots. Like chameleons they remain motionless for long periods of time and do not appear to mind when the chameleons climb right over them as if they were a branch. In this large, sunny, vivarium, the crocodile lizards display mating behaviour almost daily and eat surplus food on the ground. Another lizard which does excellently with forest chameleons is *Corytophanes* and another the forest dragon *Acanthosaura*. Both remain stationary for long periods of time and neither use the hotspots.

BREEDING

Animals kept according to the regime described here will come into breeding condition naturally in the due season. As a possible aid to this I vary the day length using solar dial time clocks to control the lighting. These are set to the British seasons but the day length is of tropical duration – varying only from 12 to 15 hours daylight/day.

My chameleon vivarium of 'maximum interest' is in my office window where I seem to observe most of the key happenings such as mating behaviour. But even with those elsewhere I am lucky and I have actually observed most egg-layings, often purely by chance.

As every snake breeder knows, it is important to have your females in good condition, i.e. very well nourished *prior* to mating them. The fairly rapid growth of the eggs depletes the female's reserves and as the time of egg laying approaches, the females of many reptiles may refuse all food. In lizards this is often due to all available space in the body cavity being filled with eggs/embryos, so that it is physically impossible to 'process' food. Hence it is doubly important that the chameleon starts off its pregnancy in first class condition.

Among chameleons of mine laying in the first two months of this year, was a young female *oustaleti* which was hand tame, having been reared up last summer and which fed excellently every day. Several weeks prior to egg laying it refused all food and on 28th January it laid thirtyeight eggs. Post-laying care is most crucial with chameleons, especially those which lay large egg clutches. Even in the wild such animals may die in the days following egg laying (Bustard, pers. obs.). My formerly plump female *oustaleti* had a very thin tail after egg laying and the skin was wrinkled in folds along its flanks. It was given the usual vitamin treatment and had to be hand fed by gaping its jaws to get it to feed again quickly. Within a week, however, it was looking better, and taking a few hearth crickets. Soon it had regained its normal appetite and by early March had mated three times again and was ravenous. A further eggclutch is now awaited.

Chameleons which lay smaller clutches may be less affected by breeding. For instance a group of gravid *C. johnsoni* all fed normally up to and including the day that egg laying occurred, and those within the group that laid smaller clutches appeared little different before and after egg-laying. This species averages 10-12 eggs/clutch.

It is the need to provide good care during the egg developing period that makes it inadvisable to purchase animals that are obviously gravid, at least until one has gained experience.

Egg laying facilities

Chameleons, which are almost all arboreal animals, descend to the ground to lay their eggs. This they do by digging a hole or burrow in which they make a wider egg laying chamber at the end. They must have facilities to do this in captivity.

Always allow gravid lizards to give birth in their normal vivariums where they feel at home. Hence the egg-laying area should be supplied in their normal home and *well in advance* of expected egg-laying. Schifter (in Grzimek, 1984), in an excellent account of chameleons, refers to a short-horned chameleon (*C. brevicornis*) of his laying its eggs in a flower pot. No young hatched from these eggs. There is no excuse for eggs being laid in plant flower pots. Such areas are not sterile. Much more desirable areas from the chameleon's viewpoint should be available elsewhere in the vivarium.

I build a nesting area using good loam mixed with peat, which is moisture retentive, and also easy for the chameleons to excavate. The depth of this depends on the size of the chameleon but for 8" chameleons it is between six and eight inches deep.

It is useful to be able to pin-point the area where the eggs will be laid so that if one is absent during the actual egg laying the vivarium does not have to be extensively excavated to locate the eggs. I achieve this by building on the basic tendency of the animals to nest in a corner, by making one corner site very attractive, which means secluded. The area of soil occupies one-third of the vivarium floor area running from front to back. The rear corner which is soil covered I cover on the outside, using cardboard coming in from the corner in each direction for a distance of 15" and two feet in height. There is little chance of the clear-fronted corner being used. I then arrange plants to give it a secluded appearance. In recent nesting by *Chamaeleo johnsoni*, in which I kept the gravid females prior to egg laying in a melamine-sided vivarium with glass at the front only, I planted a small *Hibiscus* to 'hide' the corner by sinking its pots into the compost and arranged a *Cymbidium* orchid's strap-like leaves to project over this to virtually 'roof in' the corner. This provided just the 'edge of cover' site that chameleons of many species choose for egg-laying in the wild. I have found *johnsoni*, which is a little-known species, to be very adaptable, and even females moved into the above vivarium only a few days prior to egg-laying (this necessitated by the sheer number of females which were gravid at the same time) all laid in this same spot identically. Indeed nine clutches of eggs were all laid in this secluded corner allowing minimum disturbance and immediate removal of the egg clutch before it could be destroyed by digging by the next nesting female!

Incubation

Eggs should always be removed from the vivarium to an incubator where careful control of humidity and temperature is possible at all times. I use 'Brinsea' chicken incubators and an incubation temperature of 27 or 30C for chameleon eggs. But any arrangement which permits thermostatic control of temperature is suitable. Indeed a forced air incubator would be preferable, as mine show considerable temperature differences at different levels, which must be guarded against if egg containers are arranged in two layers. The temperature should not exceed about 33C nor drop below 25C for prolonged periods and between 27-30C is, I feel, ideal.

The incubation medium depends on personal preference. Chameleon eggs are soft-shelled which means they will dessicate if not kept moist – in contact with a moistened medium. Vermiculite is widely used for soft-shelled or parchment-shelled reptile eggs, but any compost which is water retentive, and relatively 'open', and which can be heat sterilised, is suitable. It is important that the mass of the incubation medium is many times that of the mass of the egg clutch so that the medium is setting the environment and is able to release moisture to the developing eggs.

The eggs can be buried as a clutch as the mother does, but this does not facilitate inspection, nor does it allow for removal of any eggs which have gone bad/been infected by mould, so is not recommended. I place the eggs singly in a slight depression only, on the surface of already moistened vermiculite, or other medium, and space them approximately 1" apart in each direction, so that each egg remains completely separated from its neighbours, and the eggs can easily be checked visually. This method results in about 40% of the egg surface

being in contact with the moistened vermiculite. I start off with equal weights of water and vermiculite. The container is a sandwich lunch box with small ventilation holes at one end. I record the weight of the container containing the medium and the eggs so that water can be added to keep this up. If the eggs appear at all shrivelled on the regular inspections, then I spray a little water around them. Similarly if the container is up to weight and the vermiculite appears too dry I spray this. This latter situation is possible as the eggs absorb water and increase in weight, so in order to keep the medium at the same moisture level, slight additional amounts of water will be necessary. Healthy eggs should 'grow' during the incubation period, especially in breadth, but also in length. This is perfectly normal. Egg shrinkage, on the other hand, is a bad sign and if definitely not due to lack of available water and wrong temperature conditions indicates that all is not well within the eggs. Such eggs should be watched closely and removed at the first sign of collapse or appearance of mould.

The main problem with hatching chameleon eggs is the length of time that they must be carefully watched. This is frequently 9-11 months as in nature the female may only be able to lay during the annual monsoon season when the ground is workable (at other times it may be as hard as concrete) and the female chameleons usually benefit from the abundant food in the wet season to mature the eggs. The young in such habitats hatch about a year later, when escape from the nest is relatively easy with the soil moist, and there is again an abundance of insect food.

A clutch of fiftyeight *C. senegalensis* eggs laid last October, now after about five months have well developed embryos but these are still some months off hatching.

To date (14th March) ten clutches of chameleon eggs have been laid this year and all ten have been laid in normally constructed nests dug by the females and all ten clutches appear to be developing well in incubators.

THE FUTURE

As a result of captive breeding, captive-bred juvenile chameleons will become available to reptile keepers for the first time. This will revolutionise the keeping of chameleons, exactly as it has done for many species of snakes, where even the more difficult species are now being bred in Britain (for instance Simon Townson's breeding of the Emerald Tree Boa (*Corallus canina*) for the first time in 1988). Captive bred chameleons, as is the case with snakes, will be much more desirable than wild caught individuals, as the trauma of capturing, shipping and retailing, together with accustoming them to the very different conditions in captivity will be avoided. The availability of reasonable numbers of captive-bred chameleons will revolutionise the keeping of chameleons even more than it has done for snakes.

The concluding article will discuss the keeping and breeding of live-bearing montane chameleons and the rearing of both oviparous and ovoviviparous species.

TABLE 1

Oviparous chameleon species available in Britain with comments on their suitability for the vivarium.

SPECIES	AVAILABILITY	SUITABILITY
<i>C. africanus</i>	sometimes	very good; over-winter
<i>C. chamaeleon</i>	now difficult to obtain	a species complex good to very good
<i>C. dilepis</i>	frequently	good/very good
<i>C. fischeri</i>	frequently	good
<i>C. gracilis</i>	frequently	AVOID
<i>C. johnsoni</i>	available now	appears good, no long-term experience, however
<i>C. lateralis</i>	sometimes	very good
<i>C. oustaleti</i>	sometimes) good for experienced
<i>C. pardalis</i>	very occasionally) herpetologists with space and able to meet
) their food requirements
<i>C. senegalensis</i>	frequently	AVOID

ACKNOWLEDGEMENTS

I am greatly indebted to John Pickett for supplying me regularly with field crickets and locusts without which I would not have been able to maintain – let alone breed – the large and varied chameleon collection which forms the basis of this article. Also to Dave Lester (of the Serpentarium, Walsall) and Stuart Worth who have taken very great trouble to get me rare and unusual chameleons for my research work.

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