Oliver, J. A. (1955). The Natural History of North American Amphibians and Reptiles. D. Van Nostrand Co., Princeton, N.J.

Oliver, J. A. (1956). Reproduction in the King cobra, *Ophiophagus hannah* Cantor. *Zoologica* **41**, 145-152.

Pope, C. H. (1935). The Reptiles of China. (Natural History of Central Asia Vol. X), American Museum Natural History, New York.

Spellerberg, I. F. (1982). Biology of Reptiles: An Ecological Approach. Blackie, Glasgow.

Vinegar, A. (1968). Brooding of the eastern glass lizard, *Ophisaurus ventralis*. *Bulletin of the Southern California Academy of Science* **67**, 65-68.

Vinegar, A. (1973). The effects of temperature on the growth and development of embryos of the Indian python, *Python molurus* (Reptilia: Serpents: Boidae). *Copeia* **1973**, 171-173.

Vinegar, A., Hutchison, V. H., and Dowling, H. G. (1970). Metabolism, energetics, and thermoregulation during brooding of snakes of the genus *Python* (Reptilia, Boidae). *Zoologica* **55**, 19-50.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 214-218 (1988)

HERPETOFAUNA OF THE LATE DEVENSIAN/EARLY FLANDRIAN COW CAVE SITE, CHUDLEIGH, DEVON

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(Accepted 24.3.87)

ABSTRACT

The late Devensian/early Flandrian Cow Cave Site, Chudleigh, Devon, yielded a herpetofauna consisting of *Bufo bufo, Bufo calamita. Rana temporaria, Anguis fragilis,* and *Vipera berus*. This is a depauperate *'Rana-Bufo'* fossil assemblage with *Rana* comprising 20 per cent and *Bufo* 77 per cent of the fauna. The endangered species *Bufo calamita* is reported for the first time as a fossil from Devon and for the second time only as a British fossil.

INTRODUCTION

Other than a recent report on the Ightham Fissures, Sevenoaks Area, Kent (Holman, 1985) and Stuart (1979) on *Emys orbicularis,* the late Devensian and Flandrian herpetofauna of Britain has largely been neglected since the late 19th Century (Newton, 1879, 1894; Woodward, 1880). Nevertheless, a knowledge of late Pleistocene British herptiles is essential for the interpretation of their biotic responses to late Pleistocene environmental oscillations. Recently, through the kindness of Dr. Angela Milner of the British Museum (Natural History), I was allowed the privilege of studying the late Devensian/early Flandrian herpetofauna of Cow Cave, Chudleigh, Devon. The fossil herpetofauna of this site forms the subject of the present paper.

THE DEVENSIAN AND FLANDRIAN STAGES

The Devensian is the last cold stage of the Pleistocene in Britain, and is thought to have begun about 110,000 years before the present (b.p.), and to have lasted about 100,000 years (Stuart, 1982). The Flandrian is that period of time in Britain that began about 10,000 radiocarbon years b.p., equivalent to the Holocene on a world-wide basis. Sutcliffe (1985, p.61) provides a chart that indicates terminology of Flandrian equivalents in different parts of the World. Quite important events that occurred in the Flandrian and strongly influenced the British herpetofauna include (1) British isolation from the European Continent early in the stage, (2) extinction of several large mammals through hunting and habitat changes by humans, and (3) later introduction of exotic species and further modifications of the environment of the native species.

The ecological history of the Flandrian, based on pollen, mollusc and beetle studies, indicates a change from Tundra about 10,000 b.p. to a rapid warming to a climate as warm as today in southern England by 9,500 b.p. The birch community was replaced by hazel scrub between 8,700 to 8,100 b.p.; then a hazel and pine mixture about 8,100 to 7,100 b.p.; and finally deciduous forest from 7,100 to 5,000 b.p. (Coope, 1977;

Hibbert *et al.*, 1971; Osborne, 1974; Pennington, 1977; and Yalden, 1982). After 5,000 b.p., the activities of humans caused great changes in habitats.

THE COW CAVE SITE, CHUDLEIGH, DEVON

The Cow Cave Site (National Ordinance Survey Grid Reference SX 864 787, Fig. 1) is one of a series of small caves in Chudleigh George, Devon, on the River Teign. The site was briefly mentioned by Sutcliffe and Kowalski (1976). Cow Cave is presently one of the few remaining roosting sites for the greater horseshoe bat (*Rhinolophus ferrumequinum*) J. W. Simmons, formerly of the British Museum (Natural History), made excavations at the site in 1962 and 1963 which yielded a fairly unremarkable late Devensian/early Flandrian mammal fauna (Andrew Currant, pers. commun., 9 March, 1987). The condition of the preservation of the fossil amphibian and reptile bones from Cow Cave is as good, and in many cases better, than those of the herpetological fossils of the Ightham Fissures, Kent, reported by Holman (1985).

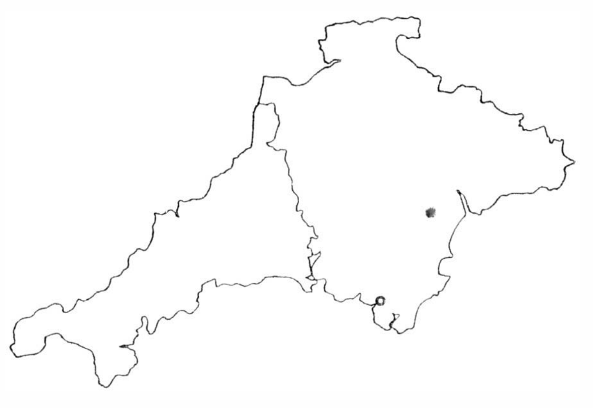

Fig. 1 Map of Devon and Cornwall showing location of Cow Cave Site at Chudleigh (closed circle) and the only historical record of *Bufo calamita* from Devon (open circle).

SYSTEMATIC PALAEONTOLOGY

In the accounts to follow the abbreviation 'B.S.' refers to the 'back-section' of the cave. The other abbreviations 'F.S.' and 'R.S.' refer either to the front (F.S.) or rear (R.S.) of the back-section (B.S.) of Cow Cave. The Roman Numerals refer to layers within the specific front or rear sections. All of the specimen numbers, BM(NH) R-, are of the British Museum (Natural History).

MINIMUM NUMBER OF INDIVIDUALS

Minimum numbers of individuals of each species are based either on the largest number of either non-paired bones or of left or right elements. For instance, if a species was represented by four skulls, and by six left and four right ilia, the minimum number of individuals would be six. On the other hand, if a species was represented by three skulls and two left and one right ilia, the minimum number of individuals would be three. A small lot of vertebrae (as in *Vipera berus*) is considered a minimum number of one.

Class Amphibia

Order Salientia

The anuran ilium is a very good fossil element upon which to base identifications (Böhme, 1977; Holman, 1985). It is numerous in the fossil record; tends to reflect the mode of locomotion of the animals and in many cases reflects specific differences (Böhme, 1977). Other anuran bones that could be identified at the specific level in the present study include the frontoparietal and the sacrum. Böhme (1977) has also demonstrated the usefulness of these bones in fossil studies.

Family Bufonidae

Bufo bufo Laurenti

Identified Material. ILIA: B.S.F.S.I two right BM(NH) R-11157; B.S.F.S.II 38 left and 37 right BM(NH) R-10182; B.S.R.S.IV one left and three right BM(NH) R-8903, 54 left and 64 right BM(NH) R-10184, nine left and 18 right BM(NH) R-10194. FRONTOPARIETALS: B.S.F.S.I eight left and four right BM(NH) R-11160; B.S.F.S.II 15 left and 12 right BM(NH) R-11158, pair of fused elements BM(NH) R-8899; B.S.R.S.IV two right BM(NH) R-11159. SACRA: B.S.F.S.I two BM(NH) R-11155; B.S.F.S. II and R.S. IV mixed 36 BM(NH) R-11156.

This is a minimum number of 124 *Bufo bufo* based on 124 right ilia.

Remarks. The ilia of *Bufo bufo* and *Bufo calamita* are readily distinguishable on the basis of an easily-observed character (Fig. 2). *Bufo bufo* has a low, rounded ilial prominence that develops a roughened area on it in some older individuals. *Bufo calamita* has a distinctive triangular ilial prominence.

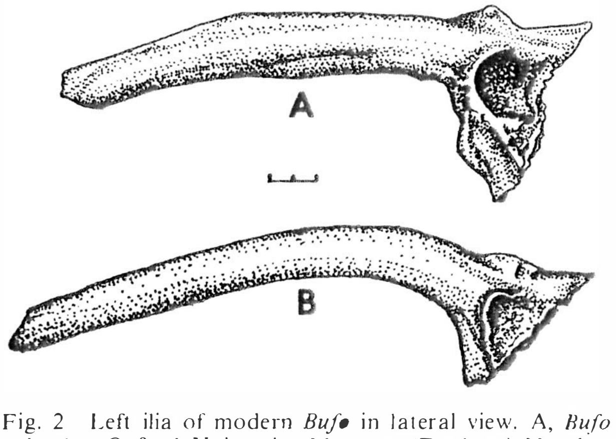

Fig. 2 Left ilia of modern *Bufo* in lateral view. A, *Bufo calamita*, Oxford University Museum (Zoology) Number 9532. B, *Bufo bufo*, Michigan State University Museum (Vertebrate Paleontology) Number 3380.

The frontoparietal has been shown to be a useful bone in distinguishing species of European *Bufo* (Böhme, 1977). The frontoparietal of *Bufo bufo* in dorsal view is distinct from *Bufo calamita* (Fig. 3) in lacking a linea transversalis (a curved linea transversalis is present in *B. calamita*), (2) in having a straight linea occipitalis (curved in *B. calamita*), (3) in having a smaller, more acute process occipitalis, (4) in having a truncate rather than an acute process occipitalis, (4) in having a truncate rather than an acute pars frontalis, and (5) in having the posterolateral edge of the bone indented just anterior to the process prooticalis (straight in *B. calamita*). Character 4 is the most obvious one in the fossils examined. Böhme (1977, Fig. 2, p.4) provides a figure that illustrates the above terms.

The sacrum has also been shown to be a useful bone in distinguishing species of European *Bufo* (Böhme, 1977). The sacrum of *Bufo bufo* in dorsal view is distinct from that of *Bufo calamita* in (1) having less flared sacral diapophyses, and (2) in having much more anteriorly directed condyles (Fig. 4). Character 2 is the most obvious one in the fossils examined.

Bufo bufo occurs in the area today (Frazer, 1983).

Bufo calamita Laurenti

Identified Material. ILIA: B.S.R.S. IV seven left and four right BM(NH) R-10183, seven left and seven right BM(NH) R-10188, one left and one right BM(NH) R-10197, and one left BM(NH) R-11161. FRONTOPARIETALS: B.S.R.S.IV one left BM(NH) 11163. SACRA: B.S.R.S.IV four BM(NH) R-11162.

This is a minimum number of 16 individuals of *Bufo calamita* based on 16 left ilia.

Remarks. Characters for distinguishing the ilia, frontoparietals, and sacra of *Bufo calamita* from *Bufo bufo* have been given in the section on *Bufo bufo*. *Bufo calamita* has only once before reported as a fossil from Britain from the Ightham Fissures Site in Kent (Holman, 1985).

Bufo calamita is probably extinct in Devon today, as the single record for the county is more than twenty-five years old (Frazer, 1983). Why the fossils are restricted to one level (B.S.R.S.IV) is not known, but it might be because of some selective taphonomic phenomenon. Fig. 1 shows the single historic record of *Bufo calamita*, as well as the location of the Cow Cave Site.

Family Ranidae

Rana temporaria Linnaeus

Identified Material. ILIA: B.S.F.S.II three left and two right BM(NH) R-10181, five left and one right BM(NH) R-11164; B.S.R.S.IV 18 left and 13 right BM(NH) R-8901, one left BM(NH) R-10193, one right BM(NH) R-10195, and 8 left and 15 right BM(NH) R-10196. FRONTOPARIETALS: B.S.F.S.I right BM(NH) R-11169; B.S.F.S.II left BM(NH) R-11168. SACRA: B.S.R.S.IV two BM(NH) R-11164.

This is a minimum number of 36 individuals based on 36 left ilia.

Remarks. The ilium of the genus *Rana* may be separated from that of *Bufo* on the presence of an ilial blade (vexillum of Böhme, 1977) in *Rana* and its absence in *Bufo* (compare Figs. 1 and 2 of Holman, 1985). The ilial blade of *Rana temporaria* differs from those of other species of European and American *Rana* in having the ilial blade depressed and reduced anteriorly.

The frontoparietal of *Rana* may be separated from that of *Bufo* in that it has the lateral edge of the bone (in dorsal view) gently curved, whereas in *Bufo* it forms almost an acute angle (Fig. 3). *Rana temporaria* appears to have one of the most gently curved lateral edges of this bone of any European species (see Fig. 5 of Böhme, 1977).

The sacrum of *Rana* is easily distinguished from that of *Bufo* (Fig. 4) in having an anterior condyle (a cotyle in *Bufo*) and in having cylindrical diapophyses (flared in *Bufo*). The sacrum of *Rana temporaria* has the sacral diapophyses directed more posteriorly than in other European species.

Rana temporaria occurs in the area today (Frazer, 1983).

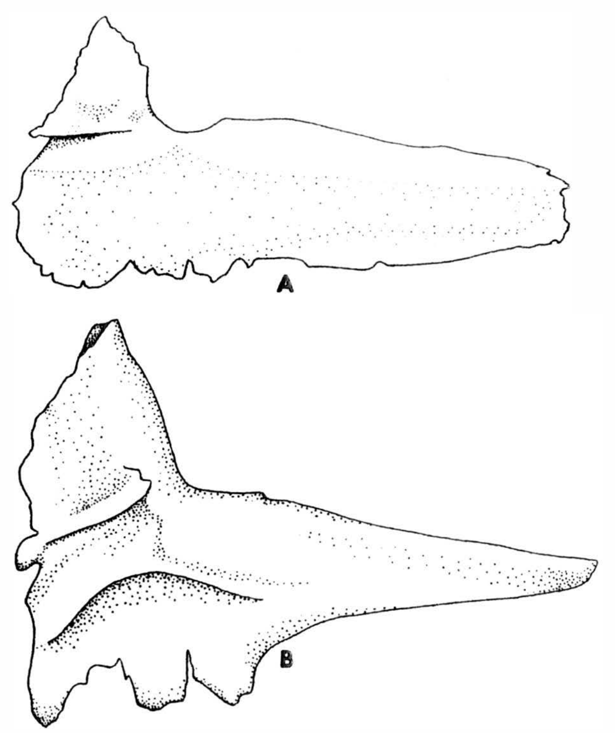

Fig. 3 Left frontoparietals of modern *Bufo* in dorsal view redrawn from Böhme (1977). A, *Bufo bufo*; B, *Bufo calamita*. No scale provided.

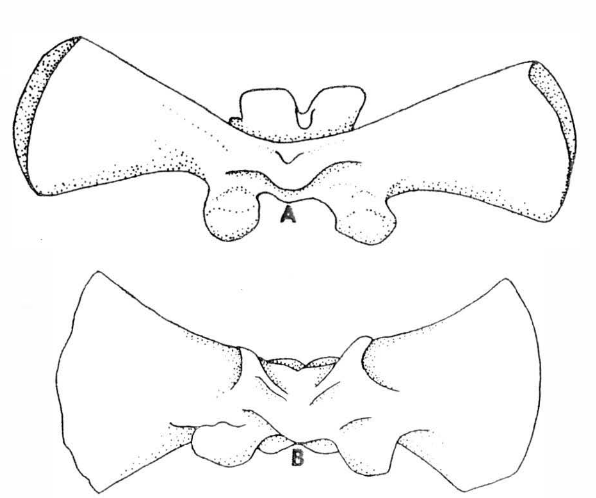

Fig. 4 Sacra of modern *Bufo* in dorsal view redrawn from Böhme (1977). A, *Bufo bufo*; B, *Bufo calamita*. No scale provided.

Class Reptilia
Order Squamata
Family Anguidae
Anguis fragilis Linnaeus

Identified Material. JAW ELEMENTS: B.S.F.S.II four left and two right dentaries and three maxillary fragments BM(NH) R-8907; B.S.R.S.IV one left dentary BM(NH) 8904. VERTEBRAE: B.S.F.S.II 26 BM(NH) R-10191; B.S.R.S.IV eight BM(NH) R-10199.

A minimum number of five individuals is indicated by the five left dentaries.

Remarks. Skeletal elements of *Anguis fragilis*, including skull bones, jaw bones, vertebrae, osteoderms, and even ribs are quite distinguishable from those of other British and European reptiles. This is due to the many modifications for a limbless, fossorial condition. Smith (1973, Fig. 58) provides fine illustrations of the skull, and another illustration (Fig. 57) of a middle caudal vertebra of *Anguis fragilis* compared with that of a *Lacerta vivipara*.

Anguis fragilis occurs in the area today (Frazer, 1983).

Family Viperidae
Vipera berus (Linnaeus)

Identified Material. VERTEBRAE: B.S.F.S.II one BM(NH) R-11154; B.S.R.S.IV two BM(NH) R-10198.

A minimum number of one individual is indicated.

Remarks. Vipera berus has a longer, more slender hypapophysis and a lower neural spine than in *Natrix natrix* (see Fig. 3 in Holman, 1985). Szyndlar (1984) discusses additional vertebral characters that separate *Vipera berus* from other snake species.

Vipera berus occurs in the area today (Frazer, 1983).

DISCUSSION AND SUMMARY

The late Devensian/early Flandrian Cow Cave Site, Chudleigh, Devon, has yielded a rather depauperate '*Rana-Bufo*' dominated, fossil herpetofauna. *Bufo bufo* (Table 1) is clearly the dominant faunal element, with *Rana temporaria* being the next most abundant species.

Cow Cave Species and Minimum Number of Individuals		Ightham Fissures Species and Minimum Number of Individuals	
Bufo bufo	124	*Triturus* sp.	3
Bufo calamita	16	*Bufo bufo*	12
Rana temporaria	36	*Bufo calamita*	12
Anguis fragilis	5	*Rana temporaria*	391
Vipera berus	1	*Anguis fragilis*	19
		Natrix natrix	8
		Coronella austriaca	2
		Vipera berus	2
TOTAL	182	TOTAL	449

TABLE 1: Fossil herpetofauna of Cow Cave, Devon, compared with that of Ightham Fissures, Kent.

This is only the second record of the endangered species *Bufo calamita* as a British fossil. This species has been collected in Devon from only one locality during historic times, and this was over twenty-five years ago.

Table 1 compares the Cow Cave, Devon, herpetofauna with that of the Ightham Fissures, Kent, herpetofauna. Dr. A. S. Cooke (pers. comm.) has informed me that it would be unusual to find a herpetological assemblage in Britain today as large as that of the Ightham Fissures. Holman (1985) suggested that the Ightham Fissures herpetofauna might indicate a time very early in the Flandrian when the climate had just become about as warm as it is in southern England today.

It is tempting to suggest that the depauperate Cow Cave herpetofaunal assemblage may suggest a somewhat earlier, cooler time than the Ightham Fissures fauna. But it also may be possible that the Cow Cave assemblage is the result of some unknown taphonomic event. Does the fact that *Bufo bufo* and *Bufo calamita* at Ightham Fissures have a one to one ratio to each other, and that Cow Cave *Bufo bufo* is about 10 times as abundant as *Bufo calamita* bear on any climatic or ecological changes, or was this situation also produced by unknown taphonomic events? Only additional stratigraphically-controlled studies are likely to answer these questions.

ACKNOWLEDGEMENTS

I thank Drs. Thomas Kemp and Gillian King of the Oxford University Museum, Dr. Angela Milner of the British Museum (Natural History), Dr. Jennifer Clack of the University Museum of Zoology at Cambridge, and Dr. Anthony J. Stuart of the Castle Museum at Norwich for allowing me to examine fossil and modern skeletal material used in this study. Dr. A. S. Cooke provided many interesting comments about the modern British herpetofauna. Mr. Andrew Currant and Dr. Anthony Sutcliffe kindly provided written information about Cow Cave. Rosemarie Attilio and Lisa Hallock made the figures. Michigan State University provided a small grant that aided in my work in Britain in 1984. The United States National Science Foundation provided a grant (NSF BSR-851-5665) that supported my work in Britain in 1986.

REFERENCES

Böhme, G. (1977). Zur bestimmung quartärer anuren Europas an hand von skelettelementen. *Wissenschaftliche Zeitschrift der Humboldt-Universität zu Berlin, Mathematik-Naturwissenschaft* **26**, 283-300.

Coope, G. R. (1977). Fossil coleopteran assemblages as sensitive indicators of climatic changes during the Devensian (last) cold stage. *Philosophical Transactions of the Royal Society of London B* **280**, 313-340.

Frazer, D. (1983). *Reptiles and amphibians in Britain.* Collins, London.

Hibbert, F. A., Switsur, V. R., and West, R. G. (1971). Radiocarbon dating of Flandrian pollen zones at Red Moss, Lancashire. *Proceedings of the Royal Society of London B* **177**, 161-171.

Holman, J. A. (1985). Herpetofauna of the late Pleistocene fissures near Ightham, Kent. *Herpetological Journal* **1**, 26-32.

Newton, E. T. (1879). Note on some fossil remains of *Emys lutaria* from the Norfolk Coast. *Geological Magazine* **6**, 304-306.

Newton, E. T. (1894). The vertebrate fauna collected by Mr. Lewis Abbott from the fissure near Ightham, Kent. *Quarterly Journal of the Geological Society of London* **50**, 183-204.

Osborne, P. J. (1974). An insect assemblage of early Flandrian age from Lea Marston, Warwickshire and its bearing on the contemporary climate and ecology. *Quaternary Research* **4**, 471-486.

Pennington, W. (1977). The late Devensian flora and vegetation of Britain. *Philosophical Transactions of the Royal Society of London B* **280**, 267-272.

Smith, M. A. (1973). *British amphibians and reptiles*, 5th edition. Collins, London.

Stuart, A. J. (1979). Pleistocene occurrences of the European Pond Tortoise (*Emys orbicularis* L.) in Britain. *Boreas* **8**, 359-371.

Stuart, A. J. (1982). *Pleistocene vertebrates in the British Isles.* Longman, London and New York.

Sutcliffe, A. J. (1985). *On the track of Ice Age mammals.* British Museum, London.

Sutcliffe, A. J. and Kowalski, K. (1976). Pleistocene rodents of the British Isles. *Bulletin of the British Museum of Natural History (Geology)* **27**, 33-147.

Szyndlar, Z. (1984). Fossil snakes from Poland. *Acta Zoologica Cracoviensa* **28**, 1-156.

Woodward, H. B. (1880). Discovery of the remains of *Emys lutaria* in Mundesley River-Bed. *Transactions of the Norfolk and Norfolk Nature Society* 3, 36-37.

Yalden, D. W. (1982). When did the mammal fauna of the British Isles arrive? *Mammal Review* **12**, 1-54.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 218-222 (1988).

DATA ON AGE AND LONGEVITY IN *GALLOTIA GALLOTI* (SAURIA, LACERTIDAE) ASSESSED BY SKELETOCHRONOLOGY

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(Accepted 7.4.87)

ABSTRACT

Femurs of 73 *Gallotia galloti* caught in different localities and belonging to two subspecies living in Tenerife (Canary Islands) were analysed by skeletochronology. The bones possessed annual rings like in many other lizards. For a high percentage of individuals, a remnant of the embryonic bone and a birth line of arrested growth remained present throughout life because cortical resorption never completely removed the first annual rings. Thus the age of an individual can be directly calculated from the number of lines of arrested growth. In the sample studied here, the oldest lizards were at least 8 or 9 years old. They reached sexual maturity during their second or third year of life.

INTRODUCTION

There are many papers on distribution, systematic, phylogeny, microevolution (e.g. Böhme & Bings, 1975, 1977; Böhme & Bischoff, 1976; Böhme *et al.*, 1981; Molina Borja, 1981; Bischoff, 1982, Castroviejo *et al.*, 1985; Baez & Thorpe, 1985; Thorpe *et al.*, 1985) and some behavioural aspects (Böhme *et al.*, 1976) of the extant lizards of the genus *Gallotia* (Arnold, 1973) from the Canary Islands. In a special symposium, recently held in Germany (Böhme & Hutterer, 1985), on the herpetofauna of Canary Islands, more than half of the twenty six papers presented dealt with the extinct and living species of *Gallotia*. Studies on the ecology of these lizards are still scarce though.

In this preliminary paper, the subspecies *G. g. galloti* from the south slope of Tenerife Island and *G. g. eisentrauti* (Bischoff, 1982), from the north slope of the Island were studied. The species occupies the most diverse habitats on the island, from the seashore up to the highest peaks (maximum altitude: 3717 m). The density of the populations is normally very high. These lizards are omnivorous although adults are predominantly frugivorous, whilst young are predominantly insectivorous. The reproduction in *G. galloti* begins in spring and continues throughout the summer when the first young animals appear. The number of eggs laid by the two subspecies studied varied between three and six.