localities previously recorded; Pasteur and Bons, 1959) and *Alytes obstetricans* (previously only observed in the Rif mountains and since found by Libis, 1984, in Middle Atlas). Reptiles include *Hemidactylus turcicus*, before only cited in three places: Casablanca, Ouezanne (Pasteur and Bons, 1960) and *Lixus* (Stemmler and Hotz, 1972). *Stenodactylus petriei*, was only known from three localities: Meski, Bou Denib and to the north of Erfoud (Bons, 1967; Stemmler and Hotz, 1972). *Tarentola annularis* was present in a single place (close to Tarfaya; Joger, 1984). *Ophisops occidentalis* and *Psammodromus blanci*, each previously recorded in only two localities respectively (Bons, 1967). *Varanus griseus* was previously present in only six places (Bons, 1959). Amongst snakes, *Boaedon fuliginosum* only had three previous recordings (Bons, 1967). *Psammophis sibilans* has recently been discovered in a single Moroccan locality (Valverde, 1989a) whereas *Bitis arietans* had only two previously known locations (Bons, 1967).

Included finally are a group of localities confirming the presence of some species in previously poorly surveyed zones within their distribution ranges. Such is the case with *D. pictus*, *B. bufo*, *Quendenfeldtia trachyblepharus* and *Ptyodactylus oudrii* in the central High Atlas, with *Tropiocolotes tripolitanus* in the Souss valley and with *V. griseus* in the upper Draa valley.

ACKNOWLEDGEMENTS

We gratefully acknowledge the information provided by F. F. Parreño (FFP), M. Garcia (MG), C. Ibañez (CI), A. Jimenez (AJ), L. Jimenez (LJ), E. Kramer (EK), L. F. Lopez Jurado (LLJ), A. Manzanares (AM), G. Olmedo (GO), A. Pardo (AP), I. de la Riva (IR), R. Tapiador (RT), J. Ulpiano (JU), M. Ulpiano (MU) and J. A. Valverde (JAV). We also thank F. McHugh for his assistance in translating the manuscript. The name order of the authors was randomly decided by the toss of a coin.

REFERENCES

Bons, J. (1959). Les lacertiliens du Sud-ouest marocain. *Trav. Inst. scient. chérif. ser. Zool.* **18**, 1-130.

Bons, J. (1967). *Recherches sur la Biogeographie des Amphibiens et des Reptiles du Maroc.* Thése, Univerversité de Montpellier.

Destre, R., Roux, P., Geniez, P., Thevenot, M. and Bons, J. (1989). Nouvelles observations sur l'herpetofaune marocaine. *Bull. Soc. Fr*. **51**, 19-26 .

Doumergue, F. (1901). *Essai sur la faune erpetoloqique de l'Oranie.* Oran: Fouque.

Joger, U. (1986) . Taxonomische Revision der Gattung *Tarentola* (Reptilia: Gekkonidae). *Bonn. zool. Beitr.* **35**, 129-174.

Libis, B. (1984). Nouvelle donnée sur la repartition au Maroc du Crapaud accoucheur *Alytes (obstetricans) maurus* Pasteur et Bons 1962. *Bull. Inst. Scient., Rabat.* **8**, 172.

Mellado, J., Caputo, V. and Nascetti, G. (1987). Sobre las poblaciones de *Chalcides* (Reptilia, Scincidae) del Nordeste de Marruecos. *Rev. Esp. Herpetol.* **2**, 183-186.

Mellado, J. and Dakki, M. (1988). Inventaire commenté des Amphibiens et Reptiles du Maroc. *Bull. Inst. Scient., Rabat,* **12**, 171-181.

Mellado, J. and Olmedo, G. (1990). El género *Acanthodactylus* en Marruecos: problemas de identificación en los grupos de especies *A. pardalis* y *A. scutellatus*. *Amphibia-Reptilia* **11**, 131-146.

Pasteur, G. and Bons, J. (1959). Les Batraciens du Maroc. *Trav. Inst. scient. chérif. sér. Zool.* **17**, 1-241.

Pasteur, G. and Bons, J. (1960). Catalogue des Reptiles actuels du Maroc. *Trav. Inst. scient. chérif. sér. Zool.* **21**, 1-134.

Schouten, J.R. and Thevenot, M. (1988). Amphibians and Reptiles of the Tarfaya region, Province of La'Youne, Morocco. In *Khnifiss Lagoon and its surrounding environment. Trav. Inst. Scient., Rabat* (Mém.hors série) 105-113.

Stemmler, 0. and Hotz, H. (1972). Bericht über eine herpetologische sammelreise nach Marokko im Juli 1969. *Verhandl. Naturf. Ges. Basel.* **83**, 125-160.

Valverde, J.A. (1989a). Notas sobre vertebrados. VI. *Psammophis sibilans teknae* (Colubridae, Serpentes) una nueva forma del Marruecos occidental. *Actas IX Bienal de la R.S.E.H.N.,* 207-213.

Valverde, J.A. (1989b). Notas sobre vertebrados. VII. Una nueva cobra del NW de Africa, *Naja haje legionis*, ssp. nov. (Elapidae, Serpentes). *Actas IX Bienal de la R.S.E.H.N.*, 214-230.

HERPETOLOGICAL JOURNAL, Vol. 2, pp 61-63 (1992)

MYCOPHAGY IN A FOSSORIAL MICROHYLID *COPIULA FISTULANS* IN NEW GUINEA

RUPERT STOCKS*

Department of Applied Physics, University of Technology, Lae, Papua New Guinea.

**Present address: 21 Church Road, Dartmouth, Devon, TQ6 9HQ, UK.*

(Accepted 31.8.90)

This work resulted from the observation of a captive *Copiula fistulans* (Menzies and Tyler) eating carrion. The diet of microhylids is generally unknown but frequently hypothesised to include small arthropods such as ants and termites (Emerson, 1985; Menzies, 1976; Zweifel and Tyler, 1982; Zweifel, 1972). Frogs usually only eat live moving prey, using the prey's movement as the stimulus to the feeding response (Ingle, 1971; Tyler, 1976). It therefore appeared that *C. fistulans* was using a stimulus other than movement and that its diet could be unusual. Examination of the stomach contents of other specimens revealed large quantities of non-animal matter.

Frogs were collected at various locations within 30 kilometres of Lae (Morobe Province, Papua New Guinea) and killed by freezing as soon as possible after capture (usually within 30 minutes, but occasionally up to two hours after capture) to halt digestion of stomach contents. Stomach contents were examined under a binocular microscope with an ocular micrometer. Relative masses of stomach contents were estimated visually, and arthropods were measured, counted and identified as far as possible.

Observations on captive frogs were made over a period of approximately one year, during which time the frogs were housed in a glass aquarium 70cm x 30cm x 40cm high furnished with soil and rocks and a bowl of water. Observations were made at night in a darkened

room using a flashlight. The frogs became accustomed to the flashlight and disturbance.

In captivity the frogs were observed to eat live grasshoppers, dead grasshoppers, a dead decomposing earthworm, small unidentified arthropods (1mm long), fungi and butcher's saw-mince. Butcher's saw-mince comprises the particles of meat and bone which are a by-product from sawing up frozen meat.

The stomach contents of 10 frogs were examined (Table 1). "Stomach full" is a subjective judgement. However it is considered to be an accurate evaluation of the frog's feeding state as the spherical shape of a full stomach is easily distinguished from the elongated shape of an empty stomach. In view of the small sample size the relative volume of animal to vegetable matter was not measured or estimated with any degree of accuracy. However, the quantity of non-animal matter was such that it is most unlikely to have been ingested accidentally. Furthermore, most of the vegetable matter could be identified as gill-fungi (Order Agaricales, Class Hymenomycetes, Subdivision Basidiomycotia), with a cap diameter of from 3 to 22mm. Four out of ten frogs had large quantities of fungal tissue in the gut, while another two had much mucous material in the gut, which was probably partly-digested fungus.

These observations raise two points worthy of discussion, firstly the use of olfaction as a feeding cue, and secondly the adoption of herbivory or omnivory by an adult anuran.

The existence of the ability to detect odours in adult anurans has been demonstrated for different species by different workers, (Martof, 1962; Shinn and Dole, 1978; Shinn and Dole, 1979), and the use of odours in prey selection and the feeding response has also been demonstrated (Shinn and Dole, 1978; Shinn and Dole, 1979). Feeding on non-moving prey has also been documented (Ingle, 1971; Freed, 1988) although in Freed (1988) it is not clear whether the frog had previously perceived the prey's movement and then subsequently consumed a stationary food item. Similarly Poulson and Hutchison (1987) mention feeding Xenopus on "frog brittle". The consumption of carrion and saw-mince observed in captive *C. fistulans* demonstrate that it does not invariably use prey movement as the feeding cue. Fungi in particular do possess distinctive odours and small mammal mycophagists probably locate fungi by odour (Fogel and Trappe, 1978). Therefore it seems likely that *C. fistulans* is using odour as the feeding cue.

It is well known that anuran larvae consume plants, carrion, etc., however the consumption of non-animal food by adult anurans has only rarely been reported (Winston, 1955; Tyler, 1958; Alexander, 1964; Zug, Lindgren, and Pippet, 1975; Simon, 1983; da Silva, de Brittopereira, and Caramaschi, 1989). The evolution of herbivory in an adult anuran should not be surprising as it simply represents a shift in one character from one stage in the life cycle to another. Ruibal and Thomas (1988) report such a shift, describing how larval *Lepidobatrachus laevis* are carnivorous, possessing a gut which has a gross morphology resembling the adult gut. Therefore both morphologically and behaviourally these tadpoles resemble adults in some aspects of their feeding. *C. fistulans* adults may be evolving in the opposite direction towards herbivory, although there was no gross morphological evidence to support this. Indeed until the diet of other microhylids has been investigated comparison of gut morphology between species would be inconclusive. Alexander (1964) notes that *Bufo marinus* ate both cooked and raw vegetables and canned dog foods. He also refers to other reports of *Bufo* eating vegetable matter. Simon (1983) noted that brooding male *Cophixalus parkeri* (Microhylidae) had significantly more vegetable matter (mainly moss) in the

Record number	1	2	3	4	5	6	7	8	9	10
Date	12/12/85	16/01/86	23/01/86	29/01/86	05/06/86	29/07/86	08/08/86	18/06/87	24/06/87	29/03/88
Snout to vent length	?	?	35mm	16mm	29mm	24mm	?	29mm	22mm	29mm
Calling Yes/No	Yes	Note 1	Yes	No	Yes	No	No	No	No	Note 2
Stomach Full-Note 3	Full	Full	Full	Full	Full	Full	Full	Full	Half	Full
Stomach contents										
Arthropods										
Ants	1		1	2			5	1	21	3
Beetles				2			1			
Wasps									1	
Unidentified Insects	Parts	1 or 2		Parts		6	2		Parts	Parts
Unidentified Other		3						1		
Snails		1								
Nematodes		Several			2					
Plants										
Fungi (Agaricales)		2 or 3	3 or 4		Much					1 or 2
Other		Some		Little		Much				
Stones/Soil	Some	Some	Little				Little	Some	Some	
Mucous	Much							Much		
Unidentified							2	Much	Some	Some

TABLE 1. *Copiula fistulans* — stomach contents

NOTES

1. Found on surface, probably disturbed by writer.
2. Gravid Female.
3. Stomach full is a subjective judgement.

stomach than non-brooding frogs. He refrained from drawing any conclusions from this observation in the absence of further behavioural and physiological studies. *Hyla truncata*, a neotropical treefrog, has been reported to eat fruits, (da Silva, de Brittopereira and Caramaschi, 1989) and their observations parallel these in many ways (the frogs had to be killed soon after capture to halt digestion, some specimens had only eaten fruits, others only arthropods).

The consumption of fungi by anurans has not to the writer's knowledge been reported previously. A large volume of literature exists on mycophagy, summarised by Fogel and Trappe (1978) and more recently by Bennet and Baxter (personal communication). Insect mycophagy was discussed by Martin (1979), who also summarised the nutritive characteristics of fungal tissue. In terms of energy content fungal tissue compares favourably with many fruits and vegetables, but contains less energy than seeds, nuts or animal tissue. It also possesses some problems of digestibility due to the fungal wall polysaccharides, mainly chitin (Martin, 1979). Arthropod exoskeletons also include chitin, but these are not normally broken down by vertebrate digestive systems. Judging from the formless stomach contents observed in *C. fistulans* when digestion has proceeded somewhat the fungal cell walls do not present a serious obstacle. Fogel and Trappe (1978) note that fungal cell cytoplasm is readily digested by small mammals, while cell walls are sometimes digested. Fungal tissue is a good source of protein, choline, the B-vitamins, contains many enzymes and provides an ample supply of water (review in Martin 1979). Therefore it is generally agreed that fungi form a readily available and nutritious food. The high water content of fungi may be especially important to *C. fistulans* which is a terrestrial microhylid (Menzies and Tyler 1977) normally found in well drained localities where free water may be scarce (personal observation). It has been postulated that the absence of free water has contributed to the evolution of terrestrial eggs (Goin and Goin 1962) and it may well also be a factor in the evolution of mycophagy in this terrestrial microhylid.

REFERENCES

Alexander, T.R. (1964). Observations on the feeding behaviour of *Bufo marinus* (Linne). *Herpetologica* **20**, 255-259.

Emerson, S.B. (1985). Skull shape in frogs-correlations with diet. *Herpetologica* **41**, 177-188.

Fogel, R. and Trappe, J.M. (1978). Fungus consumption (Mycophagy) by small animals. *Northwest Science* **52**, 1-31.

Freed, A.N. (1988). The use of visual cues for prey selection by foraging tree frogs (*Hyla cinerea*). *Herpetologica* **44**, 18-24.

Goin, O.B. and Goin, C.J. (1962). Amphibian eggs and the montane environment. *Evolution* **16**, 364-371.

Ingle, D.J. (1971). Prey-catching behaviour of anurans towards moving and stationary objects. *Vision Res. Suppl.* **3**, 447-456.

Martin, M.M. (1979). Biochemical implications of insect mycophagy. *Biol. Rev.* **54**, 1-21.

Martof, B.S. (1962). Some observations on the role of olfaction among salientian amphibia. *Physiol. Zool.* **35**, 270-272.

Menzies, J.I. (1976). *Handbook of common New Guinea frogs.* Wau Ecology Institute, Handbook No. 1.

Menzies, J.I. and Tyler, M.J. (1977). The systematics and adaptations of some Papuan microhylid frogs which live underground. *J. Zool.* **183**, 431-464.

Poulson, B.K. and Hutchison, V.H. (1987). Origin of the stimulus for muscular spasms at the critical thermal maximum in anurans. *Copeia* **1987**, 811-813.

Ruibal, R. and Thomas, E. (1988). The obligate carnivorous larvae of the frog, *Lepidobatrachus laevis* (Leptodactylidae). *Copeia* **1988**, 591-604.

Shinn, E.A. and Dole, J.W. (1978). Evidence for a role for olfactory cues in the feeding response of Leopard frogs, *Rana pipiens*. *Herpetologica* **34**, 167-172.

Shinn, E.A. and Dole, J.W. (1979). Lipid components of prey odours elicit feeding responses in Western Toads-*Bufo boreas*. *Copeia* **1979**, 275-278.

da Silva, H.R., de Brittopereira, M.C. and Caramaschi, U. (1989). Frugivory and seed dispersal by *Hyla truncata*, a neotropical treefrog. *Copeia* **1989**, 781-783.

Simon, M.P. (1983). The evolution and ecology of parental care in a terrestrial breeding frog from New Guinea. PhD thesis, University of California, Davis.

Tyler, M.J. (1958). On the diet and feeding habits of the edible frog (*Rana esculenta* L.). *Proc. Zool. Soc. Lond.* **131**, 583-595.

Tyler, M.J. (1976). *Frogs.* Collins.

Winston, R.M. (1955). Identification and ecology of the toad *Bufo regularis*. *Copeia* **1955**, 293-302.

Zug, G.R., Lindgren, E. and Pippet, J.R. (1975). Distribution and ecology of the marine toad, *Bufo marinus*, in Papua New Guinea. *Pac. Sci.* **29**, 31-50.

Zweifel, R.G. (1972). Results of the Archbold expeditions. No. 97. A revision of the frogs of the sub-family Asterophryinae family Microhylidae. *Bull. Am. Mus. Nat. Hist.* **148**, article 3.

Zweifel, R.G. and Tyler, M.J. (1982). Amphibia of New Guinea. In *Monographiae Biologicae* **42**. Gressit, J.L. (ed.). W. Junk, the Hague.